

Tagung der Alpenkonferenz
Réunion de la Conférence alpine
Sessione della Conferenza delle Alpi
Zasedanje Alpske konference

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Water Platform: activity report on the mandate 2013-2014

Evaluation of the current mandate

The mandate is in the final state of implementation.

The Platform organised three interdisciplinary international workshops, respectively concerning: 1) Plans for local adaptation to climate change for water management: experiences and existing strategies, 2) Prevention of hydrological hazards in the Alpine area: The risk of flood events and the European Directive 2007/60, 3) River management and geomorphological processes. The first two workshops were successfully organised, while the workshop on sediment transport that was scheduled to be held in Lyon (France) in March 2014 was not organised due to the limited interest of the hosting and other countries¹.

Following the workshops of Brescia and Aosta, the Water Platform decided to develop two documents, one on the "Application of the Flood Directive 2007/60 in Alpine Countries", stressing the interferences with the 2000/60/EC Directive and suggesting case studies, and another workshop on the "Guidelines on Local Adaptation to Climate Change in the Alpine Countries", aimed at proposing potential adaptation actions and describing initiatives present at local level. These documents have been completed and will be presented at the 57th Permanent Committee for approval.

Furthermore, on 25-26 September the 5th Water Conference was held in Trento (Italy), as a joint initiative of the Italian Presidency of the Alpine Convention and the UNECE Water Convention with high participation and high-level speakers.

Moreover, the joint meeting with PLANALP, held in Brescia on 9 October 2013, set up the first official collaboration between the two platforms. Coordination with other Working Groups and Platforms dealing with water-related impacts, including PLANALP, was one of the objectives of the mandate 2013-2014. This eventually led to a fruitful collaboration in the organisation of the 5th Water Conference and in the coordination of the activities for the next mandate in the field of flood management.

On average, all the activities have been undertaken with good commitment from the parties and have brought good results. The quality of the contributions was usually adequate. Minor inadequacies in responsiveness and timeliness of communication were occasionally met and caused small delays in the preparation and revision of the documents.

The participation and contribution of the members has been generally satisfactory, but heterogeneous among different partners². █

¹ Despite the Water Platform Presidency's availability to hold a substitute workshop in Italy, the 55th and 56th Permanent Committee meetings agreed to postpone the workshop and hold it within the next mandate.

² Austria and Germany provided commitment, punctual response and proactive involvement in the activities of the PF. Switzerland granted good participation in the first year of the activities, but eventually backed out in the second year. Slovenia scarcely contributed to the activities in the first year, both in the workshops and in the contribution to the documents. However, during the second year, Slovenia participated very actively in the meetings of the Platform and in the 5th Water Conference. France was scarcely present in the meetings and provided a minimal contribution to the activities, and thus its situation was handled insufficiently within the documents of the Platform.

The objectives for the next mandate were defined in the last meeting of the Platform held in Trento and include the organisation of two thematic workshops and the investigation of two cross-cutting issues.

Thematic workshops

1) Fluvial geomorphology and the interactions with sediment transport. The objective of this workshop is underlining the difficulties and to illustrate how to maintain a good ecological status of the rivers and, at the same time, to guarantee the hydraulic safety of the villages in mountain areas. The impacts of the mitigation structures and new analysis tools will be highlighted, with the aim of proposing innovative integrated basin management approaches, where all the objectives and bounds are incorporated. The workshop will be organised in France in 2015.

2) “Dialogue” between the Water Framework Directive and the Flood Directive: Activities in relation to the interconnections between Directives 2000/60 and 2007/60 will be widely based on the documents and on the activities developed during the previous mandate, contributing to integrate and disseminate the good practices collection of joint application of the two directives.

Cross-cutting themes:

1) Communication of water-related issues aimed at the dissemination of solutions and the feedback collection from the population in Alpine areas.

2) Strengthening of “Open Data Technology”, aimed at sharing relevant data (meteorological, hydrological and water, environmental, etc.) in an open and accessible way.

Summary of Activities

Participation in Alpine Conference meetings

DATE	DESCRIPTION
26-27/06/2013, Cortina d'Ampezzo	54° Permanent Committee
20/03/2014, Gorizia	55° Permanent Committee
24/06/2014, Brescia	56° Permanent Committee

Organisation of Platform-internal meetings

In accordance with the mandate the following meetings of the Platform were organised, in particular:

DATE	DESCRIPTION
18/03/2013, Aosta	1 st platform meeting
9/10/2014, Brescia	2 nd platform meeting
24/03/2014, Graz	3 rd platform meeting
24/09/2014, Trento	4 th platform meeting

Organisation of Workshops/Conferences

The Water Platform has continued its activities, aiming at collecting good practices and examples of Water Management in the Alps and at supporting the dissemination of the results of scientific research to experts, practitioners and policy makers. In this regard a few workshops and conferences have been organised during 2013-2014.

DATE	DESCRIPTION
4/03/2013, Bolzano	Water Change in Climate Change: threat or opportunity? Changing business in a changing climate
19/03/2013, Aosta	Experiences and paths in the implementation of the Flood Directive (2007/60/EC) in Alpine areas
10/10/2013, Brescia	Water and risk management facing climate change: towards local adaptation
25-26/09/2014, Trento	5 th Water Conference, Water in the Alps - and beyond. Adapting Alpine and mountain river basins to climate change

Participation in Workshops/Conferences

Pursuant to article 4, comma 1 and 3 of the Framework Convention, the Contracting Parties facilitate and promote the exchange of legal, scientific, economic and technical information that is relevant for the Convention. They cooperate with international organisations, governmental or non-governmental organisations, where necessary, for an effective implementation of the Convention and Protocols with which they are associated.

In this regard, the Water Platform has taken part in several workshops and conferences organised by other bodies to represent the results of the Platform, as well as it has cooperated with the activities of other task forces.

DATE	DESCRIPTION
8-9/04/2013, Geneva	1st meeting of the Task Force on the Water-Food-Energy-Ecosystems Nexus
11/10/2013, Bolzano	Presentation of Water Platform Activities at the International Cipra event
25/03/2014, Graz	PLANALP conference “Breaking fresh ground in protecting Alpine Environments – Flood Risk Management Plans”
5/06/2014, Sarajevo	World Environment Day organized by UNEP
23/06/2014, Brescia	The Guidelines for local adaptation in mountain regions: which prospects for the Alps and beyond?
8-9/09/2014, Geneva	NEXUS: Meeting of the Task Force on the Water-Food-Energy-Ecosystems Nexus
10-12/09/2014, Prague	22nd Economic and Environmental Forum OSCE

13-15/10/2014, Geneva	7th meeting of the Task Force on Water and Climate and 5th Workshop on Adaptation to Climate Change
14/10/2014, Gorizia	Conference "Isonzo: a river to be loved"

Documents prepared

Reports on Workshops/Conferences

- Summary report on the workshop: Water Change in Climate Change: threat or opportunity? Changing business in a changing climate
- Summary report on the workshop: Experiences and paths in the implementation of the Flood Directive (2007/60/EC) in Alpine areas
- Summary report on the workshop: Water and risk management facing climate change: towards local adaptation
- Flood Risk Management Plans, contribution to PLANALP conference "Breaking fresh ground in protecting Alpine Environments – Flood Risk Management Plans", 25 March 2014
- Summary report on the 5th Water Conference (in preparation)

Documents produced as integration to the mandate

- Flood Directive (2007/60/CE) and Water Framework Directive (2000/60/CE) in the Alpine context
- Guidelines on local adaptation to climate change for water management and natural hazards in the Alps



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Flood Directive (2007/60/CE) and Water Framework Directive (2000/60/CE) in the Alpine context



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Paper prepared and published by the Platform “Water Management in the Alps” of the Alpine Convention (<http://www.alpconv.org/it/organization/groups/WGWater/default.html>), document PC57_A5 of the Permanent Committee of the Alpine Convention and ACXIII_A4 of the Alpine Conference, November 2014.



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italian presidency 2013-2014
alpine convention

Table of Contents

Introduction.....	5
Member state position: Italy.....	6
Implementation of the FD in mountain context.....	7
Research aspects.....	8
Combined application of the FD and WFD.....	8
Member state position: Austria	11
Combined application of the FD and WFD.....	12
Research aspects.....	12
Member state position: Germany	13
Member state position: Slovenia	14
Member state position: France	15
Application, methodologies and details on the FD implementation in coordination with the WFD	16
Italy.....	16
Po river district.....	16
PFRAs.....	16
HRMs.....	17
FRMP.....	19
Eastern Alps district.....	19
PFRAs.....	19
HRMs.....	19
FRMP.....	20
Austria.....	22
PFRAs.....	22
HRMs.....	22
FRMP.....	23
Germany (Bayern).....	25



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

PFRAs.....	25
HRMs.....	25
FRMP.....	26
Switzerland.....	28
HRMs.....	28
FRMP.....	28
Slovenia.....	29
Case studies of application in mountain areas.....	34
Austria.....	34
Planning restoration while ensuring rivers security: the case of the Brenta river in Trentino (Italy).....	35
A flood event starts a river restoration project: Lindenbach (Germany).....	40
Undertaking ecological river restoration and flood protection on a very dynamic river: the Giffre (France).....	43



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E DELLA TUTELA DEL TERRITORIO E DEL MARE

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INTERNATIONAL
TREATY FOR
THE PROTECTION
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OF THE SUSTAINABLE
DEVELOPMENT
OF A CROSS-BORDER
MOUNTAINOUS
REGION
italian presidency 2013-2014
alpine convention

Introduction

With the 2000/60/EC Water Framework Directive (WFD), the European Commission launches an innovative approach on the management of water resources, proposing a unique framework that includes safeguarding, the defence 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 article 9 of the Flood Directive that defines the “coordination with the WFD, public information and consultation”.

The results of the workshop held in Aosta on March 19th 2013¹ (<http://www.alpconv.org/en/organization/groups/WGWater/flooddirective/default.html>) 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, velocities...) and on the scale of representation of the results.

This heterogeneity creates 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 9 October 2013 (<http://www.alpconv.org/en/organization/groups/WGWater/workshopplanalp/default.html>), decided to produce a document that summarizes the experience of coordinated implementation of the FD and the WFD in the Alpine Countries.

1 Event realised by the Platform on Water Management in the Alps of the Alpine Convention with the cooperation of the Platform Natural Hazards of the same Convention.



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OF THE SUSTAINABLE
DEVELOPMENT
OF A CROSS-BORDER
MOUNTAINOUS
REGION
italian presidency 2013-2014
alpine convention

Member State position: Italy

Before issuing the 2007/60/EC Directive, the hydrogeological risk management was handled through the “Hydrogeological Arrangement Plans” (Piani per l'Assetto Idrogeologico: PAI) in Italy, introduced by the law 267/1998.

The territory was divided into 41 river basin authorities, which were aimed at localising and delimitating the areas prone to flood, landslides and snow avalanches according to multiple probability scenarios and at determining the necessary mitigating actions (planning and structural measures).

The transposition of the 2007/60/EC Directive (Decree n. 49 dated 23 February 2010) states that the redaction of the Flood Risk Management Plan develops in three steps:

- 1) Preliminary assessment of the risk [art. 4 and 5 2007/60/EC; art. 4 and 5 Decree n. 49/2010 to be completed by 22 December 2011].
- 2) Issuing hazard and risk maps [art. 6 2007/60/EC Directive; to be completed by 22 December 2013 according to the 2007/60/EC Directive; deadline postponed to 22 June 2013 by the Decree 49/2010]
- 3) Organising the Flood Risk Management Plan [art. 7 2007/60/EC Directive; art. 7 Decree n. 49/2010; to be completed by 22 December 2015 according to the 2007/60/EC Directive; deadline postponed to 22 June 2015 by the Decree 49/2010]

In regard to the redaction of the Flood Risk Management Plan and the three steps indicated by the 2007/60/EC Directive to build it up, it is possible to assert that the different river basin authorities adopted similar approaches to face the tasks. The mapping of the hazard has reached indeed a sufficient level of homogeneity, but they did not follow standard common criteria. For instance partitioning of the elements in classes was lead in order to make the number of classes vary from 2 to 8. Dealing with vulnerability, the most common approach was assuming a vulnerability value equal to 1 for all elements, supposing that all the elements exposed to disastrous events were subject to maximum damages. Some differences are observed on the calculation methodologies, too (e.g. modelling tools and evaluation of the peak hydrographs) as well as on the scale of representation.

As far as the risk is concerned, there is not a complete homogeneity on the number of risk classes (from 2 to 6 classes) at national level; these classes reflect various criteria, e.g. the number of



MINISTERO DELL'AMBIENTE
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inhabitants, the presence of strategic infrastructure (highways, hospitals, schools, etc.), the presence of cultural heritage, the presence of industrial plants that could cause pollution in case of flooding and the areas subject to debris flow or solid transport. The heterogeneity lies on the vulnerability calculation: the methodology most used was to assume a value equal to 1 for all the “exposed” elements. In some basins, however, different approaches lead to calculate the vulnerability as a function of the exposure and the number of inhabitants.

The ongoing work directed to homogenisation of the various methodologies in order to produce a national standard for the representation of the hazard and risk maps, in particular regarding:

- 1) Strict methodologies to evaluate the territory vulnerability;
- 2) Implementation of new models for the risk evolution.

Nowadays, the hazard and risk maps are completed as requested by the established deadlines.

Implementation of the FD in mountain context

As far as the implementation of the directive in mountain areas is concerned, the following aspects of the FD may be addressed:

- For the first update cycle of the application of the FD, the hazard has been mainly analysed with hydraulic models for streams at the closure of medium to large basins. For smaller streams a historical analysis was conducted in order to detect all the areas affected to flood or debris flood.
- Many flood disasters happen in very small basins or in alluvial fans, where localised extreme rain events trigger solid transport and mass-waste phenomena. Furthermore, “the indication of areas where floods with a high content of transported sediments and debris floods can occur” (FD art. 6.5 d) is explicated just for risk maps, whereas debris flow and solid transport also affect the production of hazard maps.
- The Alps have been identified as one of the most vulnerable area to climate change in Europe. In particular, as far as water resources are concerned, the combination of temperature increase and change in the precipitation pattern produces a big change of the



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



hydrological regime². The inclusion of climate change impacts on the occurrence of flood (FD article 4.2) is therefore extremely complex and should be better clarified in order to avoid different interpretations and discrepancies in the Alpine context.

Research aspects

The following research aspects in the context of the FD may be addressed:

- the effects on flood occurrence and flood extension that sediment and large woody debris may produce in small Alpine basins;
- the uncertainty in the weather forecast for the production of decision support systems and of flood management plans;
- the appropriate communication technique for educating the population on physical phenomena dynamics and announcing to the population the actions of the management plans, in terms of priorities of countermeasures;
- good examples on the cost-benefit analysis aimed at identifying the correct measure based on limited economical resources.

Combined application of the FD and WFD

As the Blueprint to Safeguard Europe's Water Resources³ outlines, “the current EU legal framework on water is extensive, flexible and essentially fit to address the challenges faced by the aquatic environment. However, there is a need for better implementation and increased integration of water policy objectives into other policy areas, such as [...] the integrated disaster management”.

In general, the Italian legislation prescribes the inclusion of the flood risk management planning rules into the other plans; moreover, it is up to the same authorities to assess the interaction between River Basin Management Plans in the WFD and plans in the FD, so that the mutual impact of measures can be assessed.

² Beniston, M.; Stephenson, D. B.; Christensen, O. B.; Ferro, C. A. T.; Frei, C.; Goyette, S.; Halsnaes, K.; Holt, T.; Jylhü, K.; Koffi, B.; Palutikoff, J.; Schöll, R.; Semmler, T. and Woth, K., 2007: Future extreme events in European climate: An exploration of regional climate model projections. Climatic Change 81: 71–95.

³ <http://ec.europa.eu/environment/water/blueprint/>



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

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OF THE SUSTAINABLE
DEVELOPMENT
OF A CROSS-BORDER
MOUNTAINOUS
REGION
italian presidency 2013-2014
alpine convention

Also the very same environment of mountains would require some specific treatment.

In particular, the following aspects should be addressed:

1. The objective of human life defence (FD) and good ecological status maintenance (WFD) appear sometimes conflicting. The use of green infrastructure (e.g. restoration of riparian areas, wetlands and floodplains to retain water) may be an alternative to classical grey infrastructure (e.g. embankments, dykes and dams) for decreasing the dependency from flood protection structures. However, in the Alpine context, characterized by rough topography (by definition), highly urbanised valley bottom and with the exacerbation of events (by climate change), this option poses crucial questions about the effectiveness of the measures taken and forecasted to local administrators. An example of methodological framework aimed at analysing and evaluating some relevant aspects, such as hydromorphological processes in terms of ecological quality and flood mitigation, in order to better manage those processes and orient the choice of measures for both directives was developed by ISPRA (IDRAIM⁴). Moreover, specific workshops addressing critical aspects in applying the FD in Alpine rivers were carried out⁵⁶⁷⁸ jointly by ISPRA, the Province and University of Bozen, to support the competent authorities in the actual implementation of the FD. The European Centre for River Restoration (ECRR) has developed a pamphlet of case studies⁹ potentially relevant to the improvement of the ecological status by restoration/mitigation measures. Few of these case studies, however, are located in the Alpine context creating thus the need for a focus in the mountain environment.
2. The indicators used for the evaluations of the ecological status of Alpine waters should be better tuned to mountain streams. For example, some indicators of the biological status would not respond to morphological pressures and there would be sound inconsistency between biology and hydromorphology, inconsistently with annex V of the WFD. It may thus happen that whereas hydromorphological processes are not in a good status, biology is good and therefore no measures have to be taken. This reflects on lack of sediment downstream with impact on habitat and consequently on biology. A recent FP7 project, namely REFORM (<http://www.reformrivers.eu>), is addressing these issues and hopefully supports a more efficient river rehabilitation.

⁴ <http://www.isprambiente.gov.it/it/events/sistema-di-valutazione-idromorfologica-analisi-e-monitoraggio-dei-corsi-d2019acqua-idraim>

⁵ <http://www.unibz.it/en/sciencetechnology/events/EventsOverview.html?NewsID=65485>

⁶ <http://www.unibz.it/en/sciencetechnology/events/EventsOverview.html?NewsID=69647>

⁷ <http://www.unibz.it/en/public/press/events/EventsOverview.html?NewsID=77331>

⁸ <http://www.unibz.it/en/sciencetechnology/events/EventsOverview.html?NewsID=69644>

⁹ http://ecrr.org/publication/restgeom_doc9.pdf



MINISTERO DELL'AMBIENTE
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italian presidency 2013-2014
alpine convention

3. Nevertheless, some regions are implementing habitat modelling (mesoHABSIM) to detect actual deterioration of the overall river reach status (Aosta Valley; Piedmont) or carrying out restoration projects based on the rehabilitation of hydromorphological processes (Aurino River¹⁰¹¹; Mareta River¹²).

¹⁰ http://www.cirf.org/download/convegno_sarzana/sessd_ghiraldo.pdf

¹¹ http://www.cirf.org/rf2012/atti/monitoraggio_campana.pdf

¹² http://www.cirf.org/rf2012/atti/rischio_Hecher.pdf



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E DELLA TUTELA DEL TERRITORIO E DEL MARE

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italian presidency 2013-2014
alpine convention

Member State position: Austria

The implementation of the EU Flood Directive is in the responsibility of the Federal Minister for Agriculture, Forestry, Environment and Water Management (BMLFUW) in close cooperation with 9 Länder (federal provinces). All steps of implementation - preliminary flood risk assessment and delineation of APSFR, production of flood hazard and flood risk maps as well as establishment of the Flood Risk Management Plan - are performed at national and provincial level based on legal provisions. For implementation decisions a national working committee with associated working groups engaged in legal as well as technical aspects of implementation was established. The composition of the working committee is shown in figure 1.

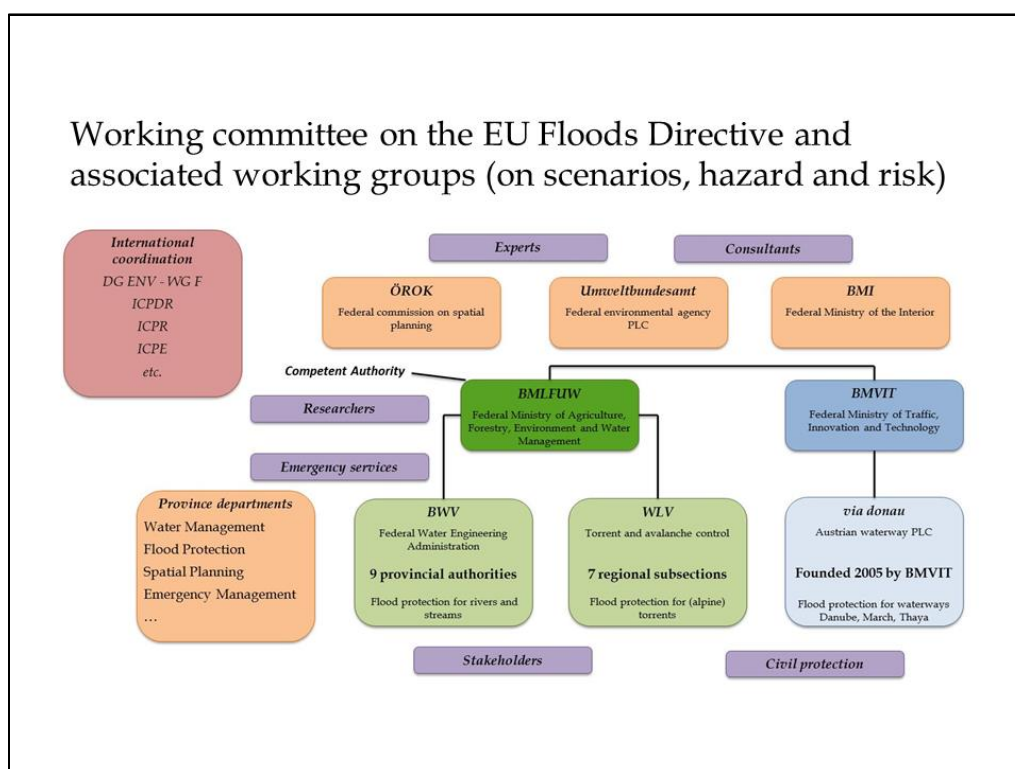


Figure 1: Composition of the Austrian working committee on the implementation of the EU Flood Directive

One of the heads of the national working committee is the Austrian representative in CIS Working Group F on Floods and international River Commissions to ensure international coordination.



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E DELLA TUTELA DEL TERRITORIO E DEL MARE

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AND PROMOTION
OF THE SUSTAINABLE
DEVELOPMENT
OF A CROSS-BORDER
MOUNTAINOUS
REGION
italian presidency 2013-2014
alpine convention

All stages of the implementation of the Flood Directive (preliminary flood risk assessment, establishment of flood hazard and risk maps) and associated documents are available on the WISA platform¹³ providing insight into methodological approaches and data sources used.

Currently, the draft of the forthcoming Flood Risk Management Plan is under preparation. Public participation is planned to start in December 2014 and closely linked to the public participation of the 2nd River Basin Management Plan.

Combined application of the FD and WFD

So far, no difficulties have been experienced in the joint application of both the Flood Directive and the Water Framework Directive since both directives provide scope for handling potential conflicts of objectives, which are resolved on case-by-case basis at local scale. It is inherent to the Austrian funding obligations to account for art. 4.7 of WFD in the frame of flood risk reduction. There is a clear prioritisation of measures to be implemented. Structural measures are funded only exclusively in those areas, where there is proof that non-structural measures do not have the same effectiveness and efficiency. It is of high priority in Austria to try to account for both directives in combining an increase of flood safety and ecological status.

Different aspects of the joint application of the Flood Directive and the Water Framework Directive are assembled and addressed by the recently published technical report 2014-078 of the European Commission (links between the Flood Directive (FD 2007/60/EC)¹⁴ and Water Framework Directive (WFD 2000/60/EC) containing inter alia best practices of joint implementation in selected Member States.

Research aspects

Research topics that should be tackled in the future cover all methodological aspects, like e.g. land use data, risk analyses, maps production, hydrological /hydraulic parameters.

13 <http://wisa.bmlfuw.gv.at/fachinformation/hochwasserrisiko.html>

14 <https://circabc.europa.eu/sd/a/124bcea7-2b7f-47a5-95c7-56e122652899/inks%20between%20the%20Floods%20Directive%20and%20Water%20Framework%20Directive%20-%20Resource%20Document>



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OF THE SUSTAINABLE
DEVELOPMENT
OF A CROSS-BORDER
MOUNTAINOUS
REGION

italian presidency 2013-2014
alpine convention

Member State position: Germany

The difficulties experienced in the application of the FD may be summarised in an enormous effort to perform all the necessary hydraulic calculations for mapping and in motivating all the stakeholders to be an active part in the implementation of the directive.

In regard to the joint application of the FD and WFD, at the moment there are no problems to tackle, but only some irrelevant issues in the implementation of each single directive.

A research topic that should be tackled in the future is the sedimentation and the sediment management as it is a major issue in both directives.



MINISTERO DELL'AMBIENTE
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THE PROTECTION
AND PROMOTION
OF THE SUSTAINABLE
DEVELOPMENT
OF A CROSS-BORDER
MOUNTAINOUS
REGION

italian presidency 2013-2014
alpine convention

Member State position: Slovenia

Regarding the interconnections between the Floods and Water Framework Directives implementation in Slovenia no big issues that could not be solved consensually have been identified so far. Even more coordination between the River Basin Management Plan (according to the Water Framework Directive) and the Flood Risk Management Plan (according to the Floods Directive) is expected and needed in year 2015.



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

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THE PROTECTION
AND PROMOTION
OF THE SUSTAINABLE
DEVELOPMENT
OF A CROSS-BORDER
MOUNTAINOUS
REGION
italian presidency 2013-2014
alpine convention

Member State position: France

The implementation of the EU Flood Directive is the responsibility of the Ministry of Ecology, Sustainable Development and Energy. On the Rhone and Mediterranean catchments, which include the Alpine area, the preliminary flood risk assessments were published in 2011 and 31 areas with potentially significant flood risk (APSFR) were identified until 12 December 2012. The production of flood hazard and risk maps (HRMs) for the identified APSFRs has also been completed.

To help in the joint application of the FD and WFD, a study has been carried out on the Rhône and Mediterranean catchments to identify particular sub-catchments, where the synergies to be found are the most compelling. A map showing these catchments that require special attention has been produced. In addition, the Rhône and Mediterranean WFD River Basin Management Plans and the Rhone and Mediterranean Flood Risk Management Plans share some common chapters to better intertwine both directives. Every flood risk study has to evaluate with priority the possibility to implement measures that respect hydromorphological functioning of the river (to set back flood defences - thereby restoring the erodible corridor or to implement measures of hydraulic dynamic slowdown etc...), to preserve and if possible and necessary to restore rivers. Conversely, river restoration studies also need to assess the impacts of different restoration scenarios on flooding, particularly within APSFR. The joint application of the FD and WFD is actually seen as an opportunity on the Rhône and Mediterranean catchment. Stakeholders have already proved to be more easily convinced for projects that meet the criteria for both directives and funding has also proved to be more easily secured.

One important research topic in the Alpine region to be tackled in future deals with the design of sediment management plans in catchments subject to torrential flooding. On those particular catchments, it appears absolutely essential to have sediment management plans that are part of the flood management plans. However, those sediment management plans are technically challenging to define.



MINISTERO DELL'AMBIENTE
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Application, methodologies and details on the FD implementation in coordination with the WFD

The FD is to be implemented in the Member States in three stages: 1) the Preliminary Flood Risk Assessments (PFRAs), due on 22 December 2011, that was intended to indicate the areas of potentially significant flood risk (APSFRs); 2) the production of flood hazard and risk maps (HRMs) for the identified APSFRs, due by 22 December 2013. These should identify areas prone to flooding during events with a high (optional), medium and low probability of occurrence, including those where occurrences of floods would be considered an extreme event. The maps will also have to include details of the expected flood extents and water depth (flood hazard maps) and economic activities that could be affected, the number of inhabitants at risk and the potential environmental damage (flood risk maps); 3) the production of catchment-based Flood Risk Management Plans (FRMPs) by 22 December 2015, thereby harmonising it with the WFD River Basin Management Plan (RBMP) cycle. The FRMPs will be focused on prevention, protection and preparedness (the integrated risk management cycle), setting objectives for managing the flood risk within the APSFRs and setting out a prioritised set of measures for achieving those objectives.

Italy

In the Italian Alps, two river districts are present: the Po River district, corresponding to the whole territory of Piedmont, Aosta Valley, Lombardy, part of Emilia Romagna, Trentino and Veneto and the Eastern Alps district that comprehends multiple river basins like Adige/Etsch, Piave, Tagliamento etc. and includes the territory of Alto Adige-Südtirol, part of Trentino, Veneto and Friuli-Venezia Giulia. The river Districts (Po, Eastern Alps, Tevere and Arno Rivers) manage the main river network, whereas the minor network (minor rivers in mountain and artificial channels in the plain) is managed at the regional level.

Po River district

PFRAs

The PFRA is already available and coincides with the flood and landslides hazard map (PAI: "Piano di Assetto Idrogeologico"), available since 2001 and thus, the Po River district decided to take advantage of transitional measures (art. 13).



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OF A CROSS-BORDER
MOUNTAINOUS
REGION
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alpine convention

HRMs

The great extension of the Po River and the high diversity of possible flood events along its network urge to follow different mapping approaches, differentiated according to the following river spatial ranges: a) primary network, defined by the main course of the river and by its most important affluent on the plain and in the valleys (total streams' length: 5000 km). b) secondary mountain network, defined by the secondary river streams in the mountains and by the main river streams in the valleys (total stream's length: 25000 km). c) secondary plain network: defined by the small streams used for agricultural purposes in the low plain basin. d) coastal sea area on the Adriatic sea, in proximity to the Po delta. e) coastal lake area along the main Alpine lakes (Lake Maggiore, Como, Garda etc.).

The confidence level of the results depends on the available input data and measures (e.g. hydrological and hydraulic data, topographical surveys, etc), whose quality and presence is very heterogeneous and depend on the various river ranges described above.

Climate change has not been taken into account as no study of the impacts of climate change on the discharge in the various streams was available. The possible impact will be integrated into the next update cycle of the directive.

The details of the map ranges between 1:10.000 and 1:25.000 for the primary and secondary river networks respectively, with variations depending on the details of the topographic input data.

The hazard map has been determined considering just the frequency of the event (return period), but not the intensity of the phenomenon. The prohibition on construction applies to all the river reaches defined by the PAI (2001). The criteria and methods used for the hazard mapping depend on the river range and are illustrated hereafter.

Primary network

The extension and localisation of the flooding area has been realised fulfilling the three scenarios defined by the directive (art. 6.3). The available data have been provided by previous studies (AdBPo 1996 and 2004) and further detailed analyses on specific parts of the river, produced by regions, provinces and other administrations).

The flood discharge peaks have been estimated on outlets of the main basins and on intermediate sections coinciding with important confluences and in various urban areas. The values have been estimated according to different methodologies: rainfall-runoff methods, statistical analysis of the



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E DELLA TUTELA DEL TERRITORIO E DEL MARE



historical measures along the river sections, regionalisation techniques. The flood for the medium-probability scenario has been estimated through 1-dimensional hydraulic modelling, whereas 2-dimensional modelling was exploited just in particular areas and in the most recent analysis. Hydrology was usually assessed through statistical models or suitable rainfall-runoff models. The topographical sections used in modelling refer to surveys dating back to 2003-2005 and occasionally before 2000. The flooding areas have been obtained through GIS techniques thereafter, interpolating the extreme flooding points and the digital elevation model (DEM). The flooded areas affected by the recent events have also been taken into account. The low probability (most extreme) scenario has been modelled through an envelope of different scenarios, comprising extreme events, historical events and residual probability. The possible collapse of the riverbanks has not been considered in the modelling.

Secondary mountain network

The extension and localisation of the flooding area has been realised fulfilling the three scenarios defined by the directive (art. 6.3). The available data have been provided by previous studies conducted by local regional administrations.

The delimitation of the flooding areas has been conducted through simplified approaches based on geomorphological and historical considerations; just in local and specific cases detailed hydrological and hydraulic modelling was used. Solid transport effect was taken into account and in the mountain area the alluvial fans have been included.

Secondary plain network

The delimitation of the flooding area has been referred to the medium - and elevated - probability scenarios of the directive (art. 6.3) and was conducted through a historical approach, based on the events that occurred in the past 20-30 years. In local and specific cases, mathematical modelling was used, integrated by expert judgement of the people in charge of the drainage system for agriculture, based on the capacity of the network to cope with extreme events. The medium-probability scenario resulted in the flooding area almost coinciding with the whole plain area.

The flooded area was integrated with information on the water level, velocity and with the duration of the event if available. The possible collapse of the riverbanks or the breakdown of pumping plants have not been considered in modelling.



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OF A CROSS-BORDER
MOUNTAINOUS
REGION
italian presidency 2013-2014
alpine convention

Lake coastal area

The extension and localisation of the flooding area has been realised fulfilling the three scenarios defined by the directive (art. 6.3) and coincide with the flooded area characterized by a progressive slow increase of the lake level. The lake level has been determined through a statistical approach based on historical data, and the flooded areas have been delimited through GIS techniques based on the DEM. The wave motion was not considered in modelling.

FRMP

The participation process has started through the production of a document defining the guidelines of the public participation called “Project of the communication and public participation process of the Flood Risk Management Plan” and of a “calendar, working plan and consultation for the elaboration of the Flood Risk Management Plan” (Decree 152/2006 art. 66 comma 7a). Then, on 14 November 2011 the workshop “The flood risk management” was organised, later followed by another workshop on “The language of the risk in various disciplines”.

On 21 June 2013 the “Provisional global assessment of the problems caused by the evaluation and management of the flood risk” was published, that represents the document on which the FRMP, the public attention and the discussion of the stakeholder will be focused.

In the meantime, the regional participation process has started, that prescribes the involvement of the administrations, citizens and stakeholders. The results of the participation process will constitute the crucial elements for the production of the final FRMP.

Eastern Alps district

PFRAs

The PFRA is already available and coincides with the flood and landslides hazard map (PAI: “Piano di Assetto Idrogeologico”), available since 2001 and therefore, the Eastern Alps river district has decided to take advantage of the transitional measures (art. 13).

HRMs

This district results from merging two national river authorities (Adige-Etsch and Alto-Adriatico) and different other regional river authorities. Therefore, the new authority is facing an enormous work of homogenisation of the various maps that were originally calculated according to unusual thresholds and guidelines. Furthermore, some basins have produced both hazard and risk maps,



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OF A CROSS-BORDER
MOUNTAINOUS
REGION
italian presidency 2013-2014
alpine convention

whereas other basins include just the hazard maps. The 10 km² threshold is used to define the minimum basin extension for the preliminary assessment. Also smaller basins are studied in case of known hazardous situations.

As far as the approach is concerned, new mathematical simulations are used just in rivers that were previously mapped for homogenisation purposes. One particular problem handled is whether to include the collapse of riverbanks in modelling, both because the results may be very different, and because some authorities have included and others have not. Furthermore, according to the available dataset, mathematical modelling is assigned with an uncertainty level. In fact, in some cases there are lots of data on the discharge, precipitation, topography etc., whereas in other cases the dataset is very scarce and so also the results are affected by a higher degree of uncertainty.

The extension and localisation of the flooding area has been realised fulfilling the three scenarios defined by the directive (art. 6.3). In particular, the low probability scenario coincides with the return period of 300 years, the medium probability is 100 years and the high probability 30 years.

The hazard maps, produced at a scale 1:25000, have been derived through a modelling approach that comprises 1D and 2D models on about 3800 km of river length. Mobile bed models have not been used as the APFRs are mainly located on the plain part of the river. Climate change effects have not yet been considered.

FRMP

The internet site: www.alpiorientali.it has been set up to host all the information about the hazard and risk maps and to publicise public consultations with the population and the stakeholder.

Furthermore, the Eastern Alps district, inside the framework of the FP7 financed project KULTURisk, has participated in an experimental laboratory on communication of the hydraulic risk in the international basin of the Vipacco-Vipava river (Italy, Slovenia). The risk communication has been faced according to the following phases:

- hazard and risk mapping: with the objective of deriving the most appropriate accuracy and representation modality from the information, together with the best communication channels.
- Structural mitigation interventions: the objective was to understand the criteria used by the auditory to evaluate the intervention. It emerges that the stakeholders are most



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italian presidency 2013-2014
alpine convention

interested in “how” and “where” the structure is posed rather than on the type (“what”) of the structure.

- Non-structural mitigation interventions: it is crucial that the information is provided by the technical representatives deriving from the local territory with a high reputation. Furthermore, the information should stress the “security conditions” rather than the “hazard conditions”.

The methodology developed by the project can be found with details on the project’s website (<http://www.kulturisk.eu/>), and constitutes the basis of the application of the FD in the North-East district as a whole.



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

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OF THE SUSTAINABLE
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MOUNTAINOUS
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alpine convention

Austria

PFRAs

The main criterion for defining areas of potentially significant flood risk was the number of population potentially exposed to floods per river kilometre (min. 200/km) with additional consideration of significant historical flood events. Furthermore, expert judgement has been taken into account particularly for risk by torrents.

Preliminary flood risk assessment was finalised in 2011. In total, about 37.360 km of water courses have been assessed. The assessment indicated high flood risk for about 1,480 km (4%) and very high flood risk for about 560 km (1,5%) of investigated water courses, moderate or low flood risk was indicated for about 14,770 km (39,5%) of investigated water courses, and about 20,550 km (55%) of water courses are not at risk for flooding.

HRMs

According to par. 55k of the Water Act WRG (1959) flood hazard maps have to be established until 22 December 2013. The main goal is to have an effective tool to communicate flood hazards of different probabilities to the public. To provide easy access to the data available all maps are published on the publicly available Water Information System Austria¹⁵ as a webGIS service .

Flood hazard maps need to cover (par. 55k (2) WRG) all areas of potential significant flood risk (APSFR) outlining inundation of low, medium and high probability of flooding. The maps refer to the flood extent, water depths and flow velocities. The flood extent of all scenarios is displayed in one map and referred to by different shades of blue colour. Water depth is categorised in clusters of <0.6 m; 0.6 – 1.5 m and > 1.5 m, respectively. Flow velocities are categorised in clusters of < 0.6 m/s; 0.6 – 2.0 m/s and > 2.0 m/s, respectively.

On the national level, methods have been agreed upon to obtain uniform maps for the entire federal territory. For Austria's APSFRs best available data has been consulted to calculate the flooding extent. Referring to the state-of-the-art digital terrain models based on laser scan data (high resolution on 1m*1m grids; elevation errors of a few cm) were used in connection with terrestrial measurement in the river stretch and two dimensional hydrodynamic models. In rare cases where these data were not available, information based on 1D models or HORA (natural hazard overview and risk assessment Austria, www.hora.gv.at) had been used. Based on Austrian

15 <http://wisa.bmlfuw.gv.at>



MINISTERO DELL'AMBIENTE
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standards scenarios of a 30-year flood, a 100-year flood and a 300-year flood had been considered.

The hazard maps have been derived through a 2D hydraulic simulation. In areas, where there are steep slopes, structural measures or lack of data, 1D simulation was also applied. However, best available quality has been used to produce HRM within a range from “expert estimation” to 2D hydrodynamic modelling. Different quality of data has been accounted for (by different shading and colours) in the maps. The hazard maps have been produced at 1:25000 scale.

Additionally to FHRM, an intensity-probability approach is applied in the frame of hazard zone planning in Austria.

Zones with prohibition on construction are addressed by spatial planning. Spatial planning is in the competence of the Länder, therefore, 9 – more or less – different approaches are applied. Some Länder refer to the 100-year flood extent (with some exceptions), some to hazard zone plans and some to the process itself (if areas are applicable for permanent settlement).

Climate change impacts have been assessed based on detailed studies¹⁶.

FRMP

The first draft of the FRMP is produced on national level by the BMLFUW and then forwarded to 9 Länder for revision. Finalisation of the FRMP is again at the BMLFUW. The same procedure applies for the establishment of the River Basin Management Plans (RBMP) and the Flood Risk Management Plan (FRMP).

Based on provisions of the Austrian Water Act the establishment and the revision of the FRMP has to be coordinated with the revision of the RBMP and will be integrated into the latter process. A combined public participation for both documents - the FRMP and the RBMP - is intended based on the provisions of the Water Act, too and realised using different platforms. WISA - Water Information System Austria¹⁷ - is the legally defined key platform providing all relevant background documents, maps and tables. This public participation process will be supported by public relation activities on the federal state level as well as at Länder level.

¹⁶

http://www.bmlfuw.gv.at/publikationen/wasser/hydrographischer_dienst/auswirkungen_des_klimawandels_auf_die_oesterreichische_wasserwirtschaft.html

¹⁷ <http://wisa.bmlfuw.gv.at/>



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italian presidency 2013-2014
alpine convention

Currently, the draft of the forthcoming Flood Risk Management Plan is under preparation. Public participation is planned to start with December 2014 and is closely linked to the public participation of the 2nd River Basin Management Plan.



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

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Germany (Bavaria)

PFRAs

The Preliminary Flood Risk Assessment (PFRA) is calculated by intersecting spatial information on the hazard and the vulnerability. The database for this calculation was the water body network, which also forms the basis of Directive 2000/60/EC – water bodies with a catchment larger than a 10 km² area (in Bavaria, out of about 100,000 km of water network, only 23,000 comply with this criterion) and also other potential areas, where experts consider it might also be the source of flood events with significant adverse consequences in the future. Potential flood areas deriving from soil mapping techniques, river valleys or, especially in the Alps, the alluvial fans, are taken into account in the assessment.

The vulnerability assessment utilises all available land-use data, i.e. protected areas (e.g. flora and fauna habitats, drinking water protection areas, nature-preserved areas), industrial sites characterised by the use of hazardous substances (166/2006/EC Directive) like large sewage treatment plants or chemical industries, and also historical areas or UNESCO heritage sites.

The criteria used in Bavaria to choose the areas at risk are: all major rivers, all rivers that have more than 66% vulnerability (or more than 50% vulnerability if also major urban areas are affected), all sections of the river characterised 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, also historical or recently flooded areas were added. If a river is considered as relevant, the whole river starting from the mouth up to the last place with vulnerability is regarded as being at risk. The goal was to get a connected river network instead of single hot spots. The output was then validated through the analysis of local experts.

The results show that, from 23,000 km of analysed river network in Bavaria, about 7,500 km are significant for the policy.

HRMs

The return periods included in the calculation of the maps are:

- floods with a high probability: 5-to 20-year flood;
- floods with a medium probability: 100-year flood;



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- floods with a low probability, or extreme event scenarios: 1.5 times the discharge of the 100-year flood.

As far as the modelling approach is concerned, 2D-hydraulic simulations with fixed bed are used in the calculations of the FD. Apart from the Flood Directive also a kind of hazard mapping for smaller basins especially in the Alpine region is intended with phenomena like debris flow and log jam. Actually, further investigations are performed to set up technical standards for this mapping.

The hazard maps are produced at a 1:10.000 scale and report the flow depth and velocities, which are results of 2D-hydraulic calculations.

Climate change is not included in the used design flood events for the hazard maps. But in case of a construction of a flood protection measure (like dikes, dams...) the design discharge (100-year flood) in Bavaria has increased by 15 % as a consequence of the climate change.

FRMP

Actually, the production of the maps is finished. The maps are available on the internet on http://www.lfu.bayern.de/wasser/hw_ue_gebiete/informationsdienst/index.htm.

For the watershed area of the Main River also the Flood Risk Management Plan is finished and is published on www.hopla-main.de.

There are different levels of participation. First, there is a pure informal participation to explain the centrally produced hazard maps. However, the most active participation is then designed for the next step, i.e. the creation of plans. This phase is also characterised by different levels: at the municipality level, the participation is only focused on choosing and discussing local measures. Other possible measures focusing on a more regional scale like for example "better training for architects at universities" are discussed with another group of stakeholders on the regional level. The NGOs for example are supposed to participate on the regional level.

The whole process for participation and setup of the management plans is described in the publication "Handlungsanleitung zur Erarbeitung von Hochwasserrisikomanagement-Plänen in Bayern" (guideline for the elaboration of Flood Risk Management Plans in Bavaria). This publication and a lot of information material for the population is available on http://www.lfu.bayern.de/wasser/hw_risikomanagement_umsetzung/hwrm_plaene/index.htm.

Actually the participation process for the setup of the management plans starts with 16 regional information events in May 2014. After these regional events the participation on local scale starts





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italian presidency 2013-2014
alpine convention

with an involvement of the municipalities. For the municipalities it is optional to play an active part in the setup of the management plans.

For one watershed area “Salle-Eger” this regional information event has already taken place. Eight technical authorities, eleven agencies for important infrastructure (like streets, energy...) and 23 NGOs provided input for the setup of the management plan. All of the 20 concerned municipalities were interested after the event to play an active role in the further setup of the plans in their municipal area.



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

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Switzerland

The Swiss approach to flood hazard 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 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.

HRMs

In Switzerland the directive requires the frequency-intensity diagram and not just pure frequency. Furthermore, such diagram may be derived for all hazards and not just to 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 exceeds the prognosis;

The scenarios are defined not just according to 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 riverbeds...).

The geomorphological approach is applied in all small streams, characterised by elevated hydrological uncertainties on solid transport that prevent a detailed hydraulic simulation. On the other hand, the hydraulic simulations are prescribed for the other streams characterised by high solid transport or debris flow.

Finally, for rivers in the main valley characterised by a considerable solid transport, the hydraulic simulations (1D or 2D) are required.

Switzerland uses two scales: 1:10000 (sometimes 1:5000) for the “potential hazard map” and 1:2000 (or sometimes 1:1000) for the detailed actual hazard maps as they have to provide the details for the single pieces of land. In fact, according to the cantonal (regional) law, the owner of the land must be eventually informed on the situation of his property and he may raise objections before the final approval.

FRMP

A comprehensive management plan does not exist 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.



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MOUNTAINOUS
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Slovenia

Introduction

The Republic of Slovenia has suffered some substantial direct damages after larger flood events in the last 25 years:

- 1990: ca 580 million EUR,
- 1998: ca 180 million EUR,
- 2007: ca 200 million EUR,
- 2009: ca 25 million EUR,
- 2010: ca 190 million EUR,
- 2012: ca 310 million EUR.

Based on the fact that these values represent only direct damages we can make a quick and simple estimation that average yearly flood damages in Slovenia amount to approx. 100 to 150 million EUR.

FRMP

The Preliminary Flood Risk Assessment (by applying article 4 of the Flood Directive) was published on 22/12/2011 and reported to European Commission on 22/03/2012. It is publicly available at the following link (only in Slovenian):

http://www.mko.gov.si/fileadmin/mko.gov.si/pageuploads/podrocja/voda/predhodna_ocena_poplavne_ogrozenosti.pdf



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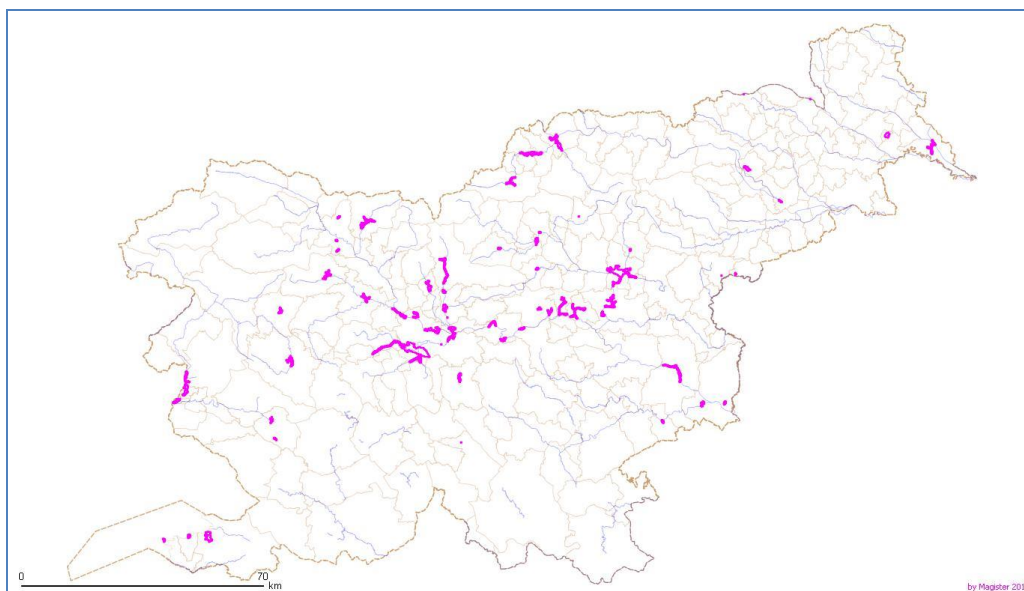


Figure 2: Map of the Slovenian APSFRs

Areas with Potential Significant Flood Risk (article 5 of the Flood Directive) were identified on 14/02/2013 and reported to the European Commission on 21/03/2013. A map of all 61 Slovenian APSFRs is published and available here:

http://www.mko.gov.si/fileadmin/mko.gov.si/pageuploads/podrocja/voda/karta_obmocij_OPVP.pdf

It is estimated that approximately 600 million EUR would have to be invested into the reduction of the flood risks in these 61 areas of potential significant flood risk. 600 million EUR of needed investments include both structural and non-structural flood protection measures.

Flood hazard and flood risk maps for most of the Slovenian APSFRs are created and can be viewed and accessed by browsing through the following table/framework (links to the 10-year, 100-year and 500-year flood scenario hazard maps and links to the flood risk maps are available on the right side of the table):

<http://www.mko.gov.si/fileadmin/mko.gov.si/pageuploads/podrocja/voda/opvp/OPOPO.xls>



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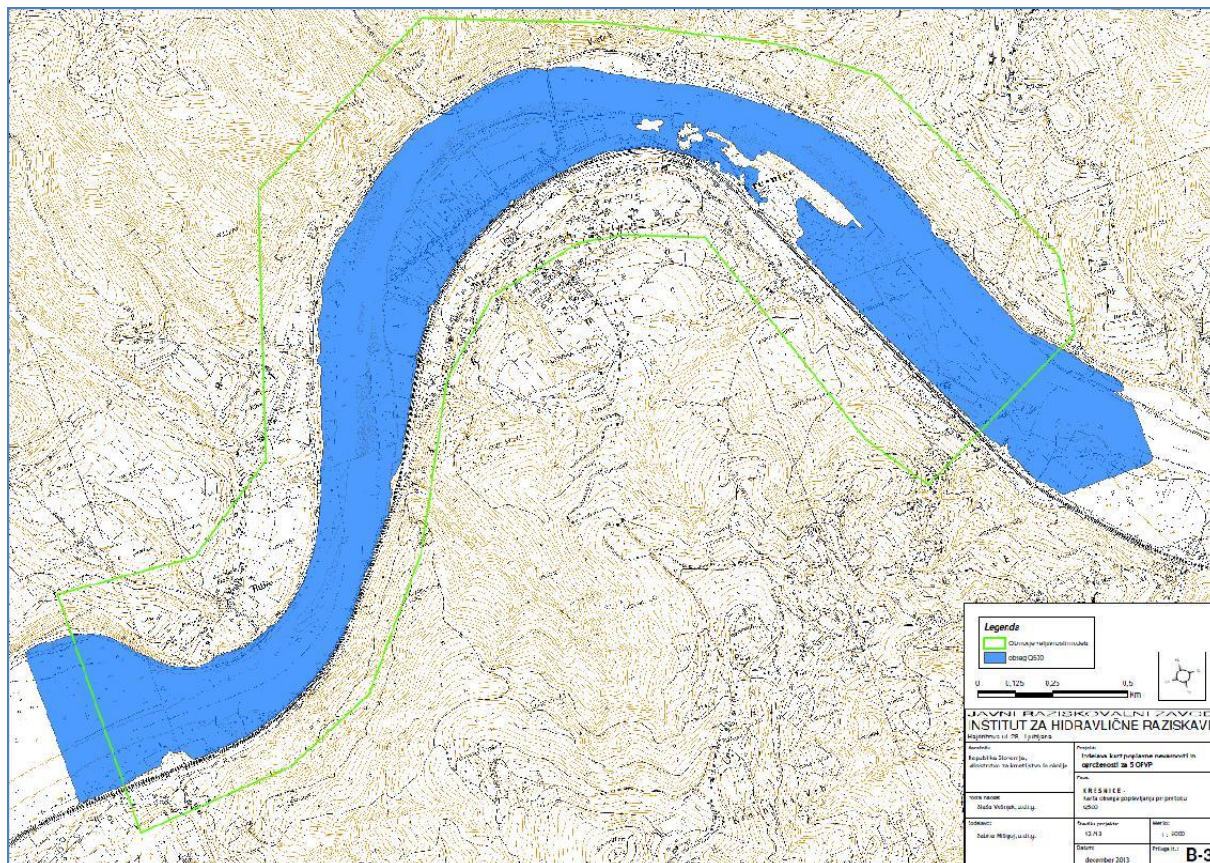


Figure 3: An example of a flood hazard map (500-year flood scenario for the Kresnice APSFR)

At the moment, Slovenia is intensively working on the preparation of the Slovenian Flood Risk Management Plan. The Slovenian FRMP will consist of 17 smaller river basin FRMPs, which also cover all of the identified 61 APSFRs.



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E DELLA TUTELA DEL TERRITORIO E DEL MARE

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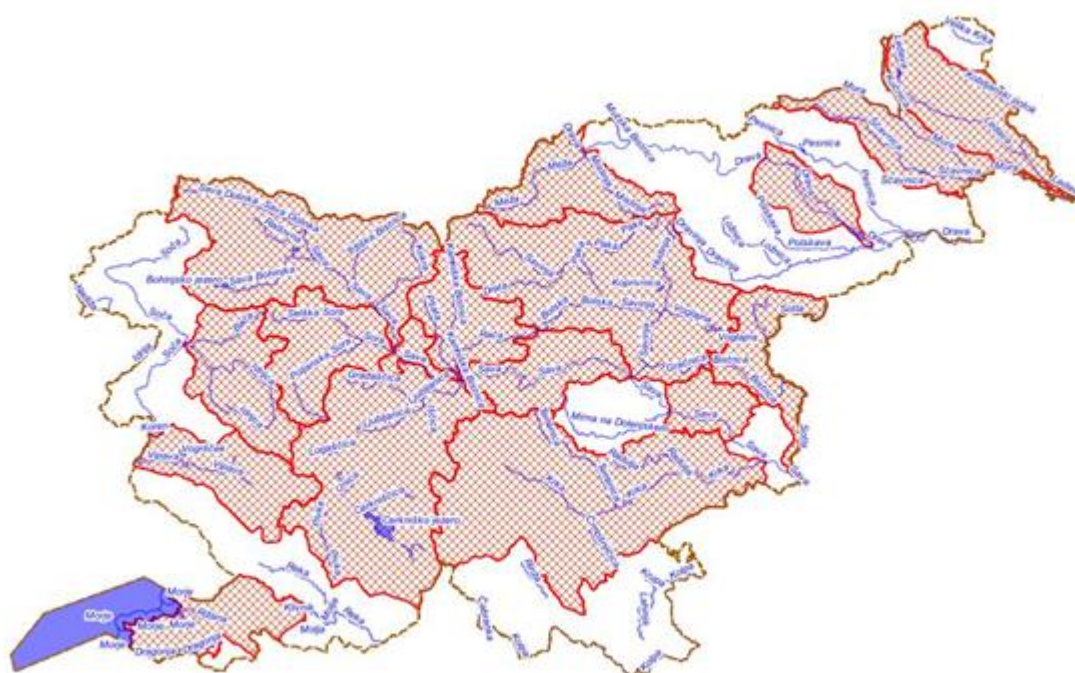


Figure 4: A map of 17 Slovenian river basins with APSFRs.



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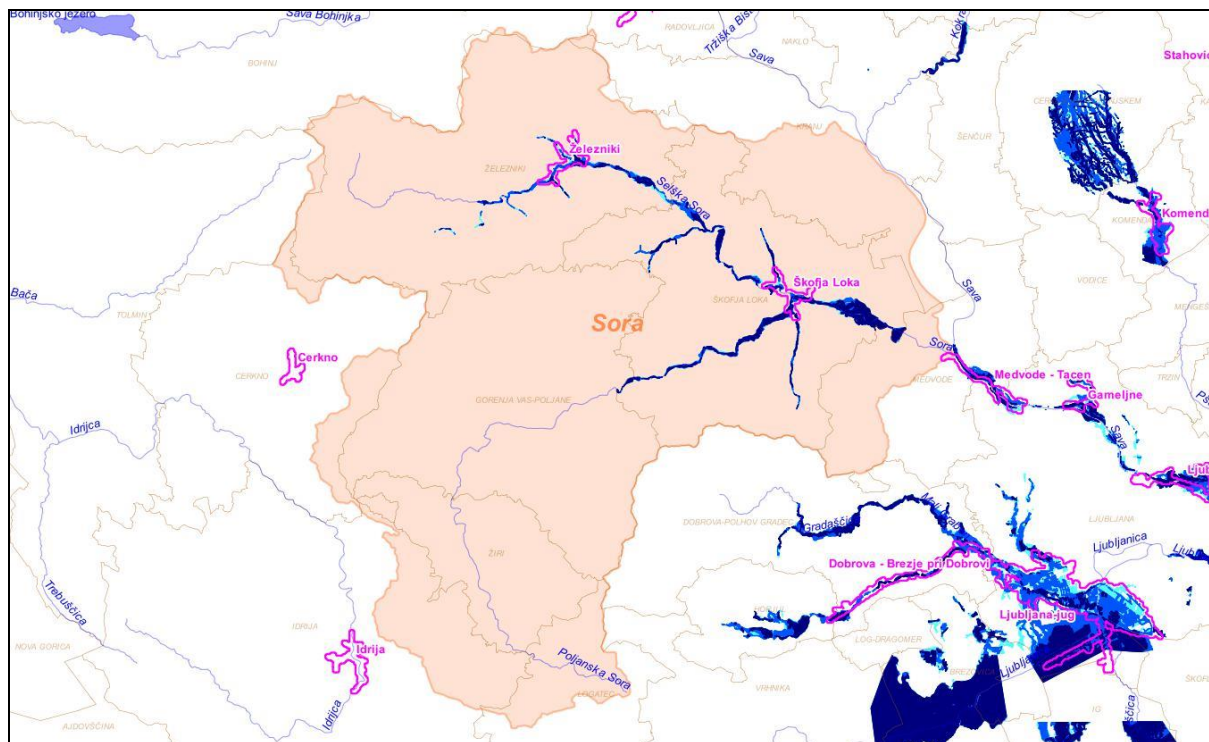


Figure 5: A map of the Sora River Basin with two identified APSFRs (Zelezniki and Skofja Loka).

Additional information regarding the Flood Directive implementation in Slovenia

Continuously updated additional information regarding the Flood Directive implementation in Slovenia can be found here:

http://www.mko.gov.si/si/delovna_podrocja/voda/poplavna_direktiva/

All relevant flood-related interactive maps (APSFRs, flood hazard maps, past flood events, etc.) can be viewed on the homepage of the Environmental Agency of the Republic of Slovenia:

http://gis.arso.gov.si/atlasokolja/profile.aspx?id=Atlas_Okolja_AXL@Arso



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Case studies of application in mountain areas

These sections intend to provide a case study of application/best practice concerning the coordinated implementation of the WFD and FD Directives, in particular in the case contemplated by the art. 4.7 of the WFD, where the mitigation of flood hazard (safety) has to comply with the preservation requirement given by the WFD (good ecological status).

Austria

The homepage of the European Commission LIFE Programme¹⁸ provides a powerful summary of projects by country carried out in the water sector and divided into different thematic groups. This summary contains some good Austrian examples on river restoration in line with the preservation of flood protection (e.g. <http://www.life-drau.at/>).

18

<http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.getProjects&themeID=75&subThemeList>



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Planning restoration by ensuring also river security: the case of the Brenta River in Trentino (Italy)

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Driving forces of river degradation	Urbanisation, 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 Lake Caldonazzo and the Borgo Valsugana town
Objective of the planning activity	Water quality restoration and flood protection

Current status of the Brenta River

Brenta is a river that originates from the Lakes Levico and Caldonazzo (in Trentino, Italy) and flows to 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 Borgo Valsugana (figure 1). The watershed extension at the outlet of Borgo Valsugana is about 212 km² and the river length is 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 (figure 2). Surrounding areas essentially have semi-permanent agriculture activities. From an ecological point of view, Brenta is a low-value river: the water quality is low or very low as well as the presence of biodiversity. It is subject to floods events, given that the section of the river can contain on average about 100-120 m³ s⁻¹ of water (that is lower than the discharge flowing for a return period



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of 100 years, i.e. $182 \text{ m}^3 \text{ s}^{-1}$). Flood events usually occur in agriculture areas, but also the town of Borgo Valsugana may be affected: in fact, a catastrophic event happened in 1966, when the town was totally inundated.

In order to guarantee safeguarding of the town, a project was carried out from 2001 to 2008. While different solutions came up (i.e. the creation of three detention basins together with thalweg reshaping in accordance with Borgo Valsugana, and the creation of one detention basin together with the construction of a hydraulic tunnel to bypass Borgo Valsugana), local authorities underlined the need to look at restoring the whole segment between Caldonazzo and Borgo Valsugana. Actually, the projected solutions appeared to be difficult to put into practice.

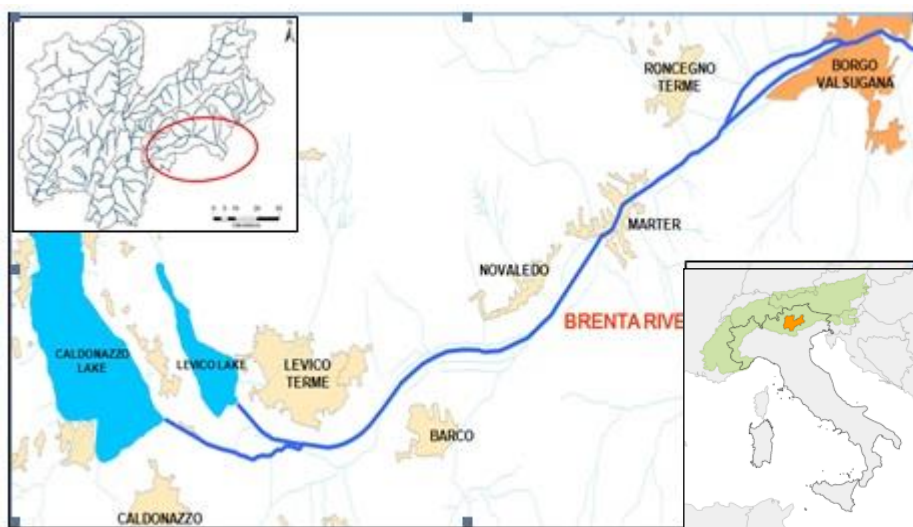


Figure 6: Course of the Brenta River from Lake Caldonazzo to the town of Borgo Valsugana. Upper left picture: Localisation of Trentino (red circle). Right picture below: localisation of Trentino (orange area) within the Alps (green area).



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Figure 7: The Brenta River and a scheme of its course

From a project to safeguard Borgo Valsugana to a plan to restore Brenta

In 2008, a restoration plan was started 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 Lake Caldonazzo up to the town of Borgo Valsugana and 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 flooding in the agricultural areas may strongly reduce flooding in Borgo Valsugana), at creating ecological connections to existing protected areas, at recovering the lateral areas for flooding, and at improving the water quality and leisure opportunities.

The plan implements the project solutions previously found for safeguarding Borgo Valsugana 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 long stretch), a water treatment plant, bridges and land ownership. The planned actions are intended to:

- Improve the provisional retention capacity of Lake Caldonazzo (an increase in height of 1 m in the lake means 5 million m³ of water retained) in terms of volume of retained water avoiding to damage local touristic activities.



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- 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 variable width (up to 15 m).
- Create a braided channel with cross sections that significantly change the morphological conditions of the river (figures 3 and 4).
- Use of banks in the proximity of the industrial areas and of the water treatment plant.
- Increase the capacity of the Brenta channel in Borgo Valsugana (up to $150 \text{ m}^3 \text{ s}^{-1}$ of water) by barriers at certain points and (if necessary) rebuilding 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 2000/60/EC are matched with 2007/60/EC: the protection – as well the recovering - of the water ecosystems and connected watersheds, the achievement of a good status of water quality and the mitigation of flood effects, and at the same time reducing the risks of flooding.

A major message came up in the planning phase: people must learn to coexist with floods and must recognise 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 with 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.



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Figure 8: Rendering of a braided channel (on the right)



Figure 9: Scheme of a restored section of the river



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A flood event starts a river restoration project: Lindenbach (Germany)

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Driving forces of river degradation	Urbanisation, 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 of the project

The torrent Lindenbach has a watershed area of about 20 km² and flows from west to east at the 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 Lindenbach River has been 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 in to the Murnauer Moos (flat moor region south of Lake Staffelsee).

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 a consequence, a prompt reconstruction of the damaged protection works was necessary.



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Figure 10: Location



Figure 11: Wood log jam destroyed a bridge; also several check dams are damaged

Start of a river restoration project

The Bavarian State represented by the water management agency Weilheim is responsible for the maintenance of the Lindenbach River and this project. Because this river was set as a preference faunistic river for fish and because of the problems of the existing protection works during the



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flood, the water management agency Weilheim decided in favour of an alternative reconstruction. The drops structures and check dams are redesigned and constructed as ramps. The goal was to guarantee on the one hand flood protection and on the other hand to realise a rehabilitation of the river continuity and migration possibilities for fish and aquatic animals of a length of about 17 km.

In total, about 16 check dams are replaced at some points by ramps with a height of over 3 m. In total, the ramp structures had a length of over 1 km. The project was financed by the state with total costs of about 850,000 €.



Figure 12: Before and after; a 3 m high check dam is replaced by a 120 m long ramp



Figure 13: During and after the reconstruction (ramp with a height of 1.6 m and a length of 70 m)



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Undertaking ecological river restoration and flood protection on a very dynamic river: the Giffre (France)

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Driving forces of river degradation	Mainly agriculture, some urbanisation and hydroelectricity
Pressures on the environment	Channelisation, with embankments built on riverbanks, gravel extraction
Impacts	River incision (loss of 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 Tannings confluence; in the Millière and Mégevette plains.
Objective of the planning activity	Flood protection, ecological river restoration

Situation and reasons of the project

The Giffre has a catchment area of about 475 km² 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 45 km long. This river is the river Arve's main right-bank tributary. Its annual rainfall is about 1650 mm 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 Nant



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d'Ant and the Giffrenant dam. Sediment supply to the Giffre River is extremely high in some areas, particularly from very steep tributaries. About 450,000 m³ of sediment lay in the Giffre main channel.

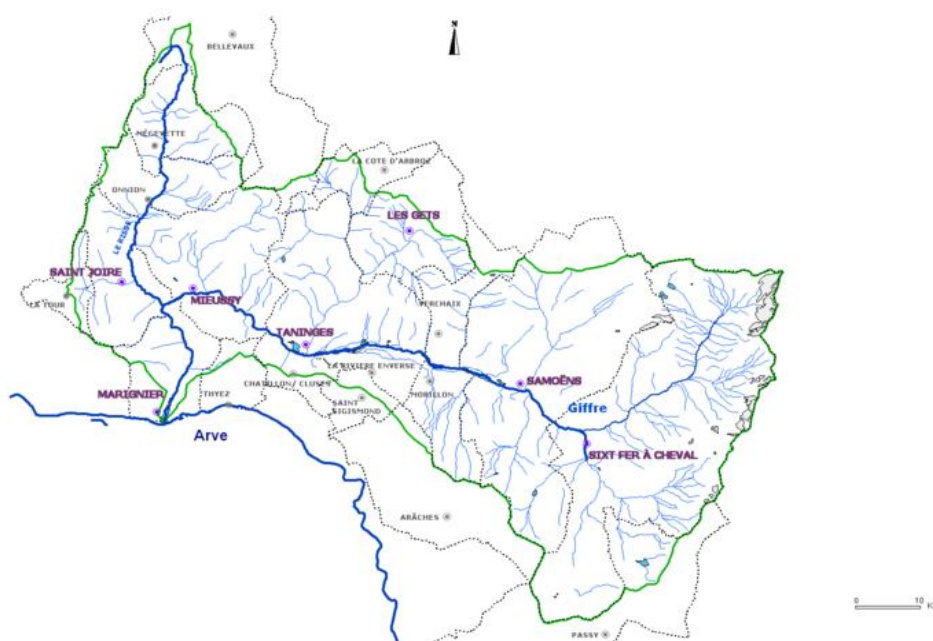


Figure 14: Location plan

Today, 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 has been estimated that approximately 1.87 mm³ of gravels have been extracted from the riverbed. This has had a very significant impact of the longitudinal profile as the river has incised by over 1.3 m on average with some reaches incised by over 3.5 m (along the Marignier reach). Without being the main cause, dams used to produce hydroelectricity have aggravated the incision of the riverbed.

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.



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In one of the restored reaches, the riverbed's active width contracted by over 50% between 1934 and 2004 and the channel incised by over 2.5 m. 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 reinjecting in areas, where channels had incised. Flood defences, where existing, are set back. The scenarios taken into account in 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 42 million euros.



Figure 15: Examples of river incision



Figure 16: Example of works carried out on the opposite riverbank to remobilise aggraded material



Figure 17 and 18: Views of the Giffre looking downstream of the restored reach



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GUIDELINES ON LOCAL ADAPTATION TO CLIMATE CHANGE FOR WATER MANAGEMENT AND NATURAL HAZARDS IN THE ALPS

Paper prepared and published by the Platform “Water Management in the Alps” of the Alpine Convention (<http://www.alpconv.org/it/organization/groups/WGWater/default.html>), document PC57_A5 of the Permanent Committee of the Alpine Convention and ACXIII_A4 of the Alpine Conference, November 2014.

Table of contents

Introduction	1
Vision: guidelines, overview and goal.....	2
Structure of local adaptation plans: key points (from risk assessment to specific actions).....	3
Climatic enforcement, trends and future scenarios: climatic variability in the Alps.....	3
Impacts and vulnerability	3
Impact on water resources	4
Impact on natural hazards	5
Policies and adaptation measures	5
Potential actions for the management of water resources.....	5
Potential research questions.....	8
Potential actions for the management of natural hazards.....	9
Potential research questions:.....	10
European projects	11
AdaptAlp	11
C3-Alps.....	12
Clisp	12
Alp-Water-Scarce.....	13
Alpstar Project.....	13
National initiatives.....	15
StartClim2005.A4 (Austria).....	15
Mountland (Switzerland).....	15
HydroAlp (Italy).....	15
Irri4Web (Italy).....	16
Bavarian climate adaptation strategy – BayKLAS (Germany)	18
Programme NRP 61: Sustainable Water Management Switzerland).....	20
References	22

Introduction

The role of mountains in the provision of indispensable water resources for municipal and industrial water supply, irrigation, hydropower production and other environmental services is well-known and unquestioned (e.g. Barnett et al., 2005; EEA 2009¹; Viviroli 2003, 2007, 2010). In particular, the Alps, with their seemingly vast water resources, are of immeasurable importance for the economic and social development of not only the Alps themselves, but also the lowlands and major urban areas. Although it may seem that drought events or water scarcity problems in the Alps have only occurred over short periods of time and in small, distinct areas in the past (PSAC 2009²), the severe droughts which affected much of Europe in 2003 also had a significant impact on the water resources of the Alpine regions. The creation of the European Drought Centre in 2005 can be seen as one of the results of this experience as well as communication by the Commission to the European Parliament and the European Council (EC 2007³) and several regional and local initiatives (e.g. drought committees in France). Efforts have been made not only on a legislative level to deal with the issue of water scarcity and droughts, but also on a scientific level, where many studies have been carried out to assess the effects of climate change and its impacts on the water resources of the Alps, resources that are also facing an increase in anthropogenic water abstraction.

The impacts of climate change are likely to vary between the respective countries, not only because of the different locations within Europe, but also due to different national legislation and national circumstances in terms of availability and utilisation of water resources or vulnerability in terms of natural hazards.

Almost all countries of the Alpine Convention are in the stage of either deriving or having already adopted national adaptation strategies to climate change (<http://climate-adapt.eea.europa.eu/web/guest/adaptation-strategies>).

Apart from the national adaptation strategies there are some existing guidance materials and reports available covering different aspects of climate change adaptation for water resources management, such as for example:

- a. ALPINE CONVENTION, PLANALP Platform: "Alpine strategy for adaptation to climate change in the field of natural hazards" (<http://www.planat.ch/de/infomaterial-detailansicht/datum/2013/01/03/alpine-strategy-for-adaptation-to-climate-change-in-the-field-of-natural-hazards/>)
- b. UNECE Water Convention: Guidance on Water and Adaptation to Climate Change (<http://www.unece.org/index.php?id=11658>)
- c. ICPDR Strategy on Adaptation to Climate Change (<http://www.icpdr.org/main/activities-projects/climate-change-adaptation>)
- d. ICPR Reports on Climate Change in the Rhine catchment (Climate adaptation strategy is in preparation) (<http://www.iksr.org/index.php?id=342&L=3&cHash=455fdab52ce6eafbf6f72632159564bf>)

¹ EEA (2009): Regional climate change and adaptation - The Alps facing the challenge of changing water resources. EEA Report 8/2009, Copenhagen, 2009.

² PSAC (2009): Water and water management issues - Report on the state of the Alps. Permanent Secretariat of the Alpine Convention, Bolzano, 2009.

³ EC (2007): Communication from the European Commission to the European Parliament and the Council: Addressing the challenge of water scarcity and droughts in the European Union, 414 final. Commission of the European Communities.

The Italian national adaptation strategy to climate changes, currently subject to approval, identifies the Alpine area as a highly vulnerable sector due to critical impacts of human activities on environmental ecosystems, landscape and economy; special attention is paid to changes in water resources management (consumption and availability), which also involves effects for the downstream areas.

Vision: guidelines, overview and goal

The main goal of an adaptation strategy is minimising the risks connected to climate changes, protecting public health, life quality, properties and preserving nature, by improving the adaptation capability of natural ecosystems as well as social and economic systems; in addition, a solid adaptation strategy should be able to take advantage of new opportunities. As reported in *the White Paper*⁴, the strategy tackling climate changes suggests two possible actions: 1) a reduction of greenhouse emissions with the objective of slowing down global warming (mitigation actions) and 2) an increase in the ecosystem's resilience and in human activities' resilience in order to tackle unavoidable impacts in the short terms (adaptation actions).

This document belongs to the second action; it aims in particular at defining guidelines, providing suggestions and criteria to adapt to climate changes related to water resources management and to natural hazards locally (at local scale). This is pursued in a context that encompasses both European and national legislations and local socioeconomic, environmental and climatic conditions.

⁴ White Paper "Adapting to Climate Change, towards a European framework for action", 2009 (<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0147:FIN:N:PDF> HYPERLINK "http://bit.ly/clilima0 HYPERLINK "http://bit.ly/clima04")

Structure of local adaptation plans: key points (from risk assessment to specific actions)

Climatic enforcement, trends and future scenarios: climatic variability in the Alps

The Alps have been identified as one of the most vulnerable areas in relation to climate change in Europe. As outlined in the following studies, impacts due to climate changes had already been reported in the past:

- the temperature increase recorded in the Italian Alps in the last 30 years is three times the average increase registered in the entire boreal hemisphere (OECD, 2008; Alcamo, 2007); in particular, an increase of 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 in 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 of a decrease of snowfalls of 18% with respect to the benchmark period 1959-2002; a minimum decline of 40% has been registered at stations with low elevations.

Variations forecasted for future years can be summarised as follows:

- temperature: a continuous rise in the average temperature is foreseen (IPCC, 2007, BENISTON, 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.). Long-term average rainfall amount will remain more or less constant, but with seasonal shifts from the summer to the winter season in all Austrian regions (BMLFUW 2012);
- snowfall: the minimum snow line will increase; Foehn (1990) and Haeberli and Beniston (1998) claim that an increase in air temperature by 1°C will result in an increase by 150 m in the minimum snow line;
- water and ice: continuous increase in water temperature as well the thawing of permafrost in wide areas (Massarutto, 2011); significant increase of flows in winter (up to 20%) and decrease of flows in 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).

Impacts and vulnerability

The impacts of the climatic changes mentioned above can be classified in two types: physical-biological and socio-economical. The first type of impact can be further classified into 1. impact on mountain forests, 2. impact on biodiversity and ecosystems; 3. impact on water resources; 4. extreme meteorological events triggering natural hazards; 5. soil conservation. The socioeconomic impact can be further classified into the following

subclasses: 1. urban planning; 2. energy; 3. tourism; 4. mountain agriculture; 5. transportation; 6. public health. The following part of the document will focus on impacts on water resources.

Impact on water resources

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

- changes in precipitation regimes, an increase in the snow line and a progressive loss of ice mass bring about a variation of the flow regime in Alpine torrents, consisting of a reduction in the summer discharge and an increase in the winter discharge, which is likely to result in an increase of flood hazard (Lautenschlager et al., 2008) and a decrease of water availability for agricultural activities and human consumption during summer (Weingartner et al., 2007).
- in the last 130 years, rainy days have decreased whereas dry days seem 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 twice more frequent in 2050 than now and three time more frequent in 2070. The increase in air temperature is accelerating glacier melting and permafrost degradation, and as a consequence, fresh water resources will be reduced and slope instability will increase (Mercalli et al., 2009 e Margottini et al., 2007). Zemp et al. (2006) estimates that an increase in the average air temperature by 3°C in summer can cause a decrease in glacier cover, i.e. by 75% in the Italian Alps.
- Van Vliet et al. (2012) claim that both in mountain torrent environment (streams and rivers) as well as in lakes and humid areas climate changes are causing an increase of water temperature; this, in addition to other secondary impacts, can deteriorate water quality and cause further problems for the ecosystem. In the large Alpine lakes, (such as Lake Maggiore, Lake Iseo, Lake Garda and Lake Como) the water temperature has increased roughly by 0,1-0,3°C every decade since the 1950s (Dokulil et al., 2006). In future decades greater additional rises are expected; for Alpine lakes this increase will be presumably higher in the superficial layers than in the deeper layers. This is likely to bring about 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).
- also evaporation is affected as a migration of flora and shift of the tree line is expected (Massarutto, 2011).

These findings are – with some regional differentiation and fine-tuning – mirrored in the national adaptation strategies (e.g. BMLFUW 2012).

Finally we would like 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 (Portoghesi et al., 2010). Some methodologies have been set up in order to reduce the bias.

Impact on natural hazards

The main impacts of climate changes on natural hazards can be summarised in the following points:

- climate change could cause a drift of the great atmospheric conditions on European scale: this could cause extreme weather conditions in certain parts of the Alps like heavy snowfalls, precipitations or droughts, that are difficult to forecast.
- steep permafrost areas are likely to become unstable and more prone to rockfalls and landslides (Margottini et al., 2007). Depending on the volumes of the mass involved in the thawing, on the potential energy, rockfalls can result in debris or icy avalanches, characterised by high propagation velocity and run-out potential. Therefore, permafrost degradation contributes to an increase of landslide processes (Gruber et al., 2004).
- Fuhrer et al. (2006) claim that the Alpine region, despite the differences between the north and south territory, will experience an increase of extreme events in winter, with subsequent risks in several fields (Beniston, 2007).
- the acceleration of the Alpine glaciers retreat (both in terms of area and volumes) is associated with a rapid release of sediment and debris (Davis et al., 2001). The phenomenon tends to modify the morphological and dynamical characteristics of the glaciers, creating the triggering conditions for successive geological instability situations, especially in the steepest slopes (Diolaiuti e Smiraglia, 2012).
- massive quantities of water and debris could be released by glacial lakes and non-consolidated moraines that could move downslope after the melting of the ice walls currently containing them (Smiraglia et al., 2008; Tamburini et al., 2009);
- snow avalanche hazard may probably decrease in frequency and intensity at medium-low elevations, in particular new-snow avalanches; wet-snow avalanches, on the other hand, may probably increase.
- infrastructures located at high elevations (shelters, cable car stations) may be subject to basis destabilisation due to permafrost degradation; mountaineers approaching elevated zones may be endangered because of the increased slope instability (see PermaNET project);.
- climate change may also have an impact on transportation infrastructure, especially streets or railways that connect mountain passes (see Paramount project).

Policies and adaptation measures

Because of the differences in expected impacts of climate change across the different Alpine countries a “one size fits all”- approach cannot be recommended. Therefore, a catalogue with a non-exhaustive list of potential measures/actions, which could be selected according to specific regional needs, will be proposed. Potential measures/actions will have to be tailored to the regional needs.

Potential actions for the management of the water resources

Based on 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 on the water availability, which will become more aleatory and will probably decrease. Furthermore, it is foreseeable that the

requests for defence of the environment and of the ecosystem will 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. Therefore, adaptation actions must be carried out. 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 a timely response to extreme events;
2. ecosystem-oriented measures ("green" measures): these measures are about environmental and fluvial requalification 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 consciousness and at influencing lifestyles of people. In the following pages a list of strategic adaptation actions will be given, on the basis of what was originally proposed by the Italian Ministry for the Environment, Land and Sea,⁵, the Lombardy Region⁶ and CIPRA Italy⁷, and subsequently discussed and shared with the delegations of the different Alpine countries.

Potential "grey" measures

1. Optimising use of the available water resources (adjustment of the offer, where appropriate, efficient irrigation, conservative agricultural system to increase water storing capacity, where needed, prevention of soil erosion, optimisation of distribution systems).
2. Structural interventions aimed at updating 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 run-off volumes.
6. Strengthening the interregional exchange of data and monitoring systems.
7. Technological upgrade of the measuring systems (e.g. remote sensing...), where appropriate.

⁵ Elementi per una Strategia Nazionale di Adattamento ai Cambiamenti Climatici, documento per la consultazione pubblica, 12 settembre 2013 (Italian Ministry of the Environment: public consultation process towards a National Strategy of adaptation to climate change - http://www.minambiente.it/sites/default/files/archivio/comunicati/Conferenza_29_10_2013/Elementi%20per%20una%20Strategia%20Nazionale%20di%20Adattamento%20ai%20Cambiamenti%20Climatici.pdf)

⁶ Linee Guida Piani di Adattamento ai Cambiamenti Climatici, Regione Lombardia (towards a regional adaptation strategy in Lombardy - http://www.reti.regione.lombardia.it/cs/Satellite?c=Redazionale_P&childpagename=DG_Reti%2FDetail&cid=1213581345956&pagename=DG_RSSWrapper)

⁷ Antonio Massarutto, Acqua e cambiamenti climatici, compact n. 03/2011, CIPRA Internationale Alpenschutzkommission (<http://www.cipra.org/it/pubblicazioni/4807>)

Potential “green” measures

1. Requalification of the rivers taking into account the minimum vital flow (MVF) and the ecological status;
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 area (transition zones) of the rivers, where possible, in order to strengthen their role of regulation in biogeochemical processes: a) Assuring protection of the area connected to water; b) minimising the disturbance associated with the uptake and release of water from hydropower plants; c) reactivation of the relict fluvial forms, where possible;
5. Multipurpose management of existing reservoirs.

Potential “soft” measures

Legislation and planning	<ol style="list-style-type: none"> 1. Development of a multiannual management attitude towards water resources, where not considered yet; 2. Recalculation of historical water requirement and water grant, where appropriate; 3. Development of an integrated programme for improving the efficiency of irrigation, optimised consumption of drinking water and industrial usage; ensuring the minimum vital flow (MVF) taking into account climate change predictions.
Management	<ol style="list-style-type: none"> 1. Creation of flood and, where appropriate, also drought management plans. Ensuring the attainability of water resources management objectives in case of severe drought and the design of a <i>warning system</i> based on the expected most frequent water scarcity (LAWA, 2007). 2. Ensuring progressive compliancy with the legislation on MVF and on the water quality standards based on the 2000/60 EC directive. 3. Optimisation of lake level management, where appropriate. Efficient water management in the irrigation sector. 4. Creation of plans for the management and utilisation of urban run-off, where appropriate. 5. Use of stored rainwater, joint use of resources with other big users, reuse of water (e.g. for toilet flushing or watering the garden).
Communication – Dissemination / Participation	<ol style="list-style-type: none"> 1. Collection and dissemination of available information on climate change. 2. Dissemination of information on the existence of good practices in agriculture, in the domestic sector and in industry through stakeholder cooperation. 3. Promotion of events for awareness raising in the area affected by the variation of the hydrological cycle (extreme events, drought, high run-off variability, etc.), e.g. extension and strengthening of participation with negotiation tools and increase of protection measures for available water in the mountain territory.
Economy / incentives	<ol style="list-style-type: none"> 1. Definition of incentives for products characterised by efficient water usage 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 research questions:

1. Monitoring of the environmental indicators and comparison to the actual values used to assess the reference sites.
2. Improving the database for surface and ground water availability in order to obtain more

reliable estimates on the resistance of the resources.

3. Improving comprehension of continuous feedback and the impact that the variation of climate (temperature and precipitation pattern) may have on soil moisture, ecology and vegetation.
4. Improving knowledge about paths and weather conditions of extreme rainfall events.

Potential actions for the management of natural hazards

As for the actions proposed in the context of water management, this chapter provides 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 to human life, the integrity of infrastructures and belongings. The actual hazard is sometimes exacerbated by the provision of infrastructure or urban expansion in hazardous zones and by the increase of extreme events due to climate change. As some hazards (e.g. glacial and hydrogeological hazards) may interact in a synergic way as a reaction to 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 described below.

Potential “grey measures”

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

Potential “green” measures

1. Enlarging the space for rivers and restriction of soil pavement in order to save the natural capacity of the riverbanks to balance the discharge peak;
2. Promotion of the recovery for mountain farming zones (e.g. terraces on the slopes) and ensuring correct maintenance of mitigation structures;
3. Privileged use of natural protection systems (e.g. water retention basins) if adding supplementary mitigation structures is necessary.

Potential “soft measures”

Planning	<ol style="list-style-type: none">1. Continuous update of cartography in relation to hazard maps by adding observations on climate change.2. Identification of the most critical areas subject to natural hazards and climate change.3. Increased use of territorial planning in order to reduce the demand of new infrastructures in hazardous zones and subsequent decrease of the vulnerability of the system.
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Management	<ol style="list-style-type: none"> 1. Reinforcement of the natural hazards management with the use of a multi-risk analysis. 2. Upgrading of the current alert/alarm systems and the emergency procedures, due to the increase of frequency of extreme meteorological events.
Communication – Dissemination / Participation	<ol style="list-style-type: none"> 1. Assuring continuous education and training on natural hazards directed at the population living in the mountains. 2. Increase of people's consciousness with respect to the main natural hazards and the residual risk. 3. Promotion of insurance systems on natural hazards. 4. Promotion of communication events directed at house owners on the type of hydraulic risk and on mitigation structures. 5. Promotion of the exchange of experiences and good practices (e.g. PLANALP database, PLANAT of Switzerland). 6. Promotion of cooperation with stakeholders. 7. Assuring transparent sharing of monitoring data, of the terminology and of the calculation methods of the integrated risk in the Alpine regions.

Potential research questions:

1. Reduction of the uncertainties in relation to the most critical risks, to the highest impacts and future predictions due to the glacial retreat.
2. Improving the basis for the evaluation and monitoring of natural hazards management actions, in cooperation with other Alpine countries.
3. Assuring assimilation of future climatic projections in hydrological models in order to improve the knowledge about mechanisms behind the increase of intensity and frequency of natural hazards in mountainous zones.
4. Assessing real-time monitoring and prediction systems for risk management.
5. Validation and integration of a meteorological radar analysis with the meteorological sensor network.

European projects

AdaptAlp⁸

Detecting climate-related trends in hydrological datasets is important in order to investigate the water resources in Alpine catchments. The recognition of this trend should be based on a reliable dataset of homogenous hydrological datasets representing undisturbed catchments. The project AdaptAlp aims at detecting trends in hydrological regimes of Alpine catchments based on a dataset of 177 run-off time datasets all over the Alpine space (see Figure 1). These series cover forty years of daily records. As a consequence, a set of hydrological indices is defined to characterise the hydrological regime in terms of low, medium and high flow. In particular, these indices describe the drought severity and seasonality, as well as the intensity and timing of snow melt flows. The work carried out by AdaptAlp partners led to capturing a hydrological dataset used to determine climate-related trends in the hydrological regime of Alpine catchments.

Statistical tests were applied to the stations of this dataset at the local and regional scales. The main significant trends can be summarised as follows:

- **Winter droughts:**

- Severity of drought tends to decrease for glacier and snow melt-dominated regimes.
- A slight shift (forward) is identified for snow melt and composite regimes in the Northern Alps.
- Mixed snow melt-rainfall regimes in the South-Eastern Alps (mostly Slovenian stations) show the opposite development: severity of drought tends to increase and seasonality seems shifted backwards.

- **Snow melt-related high flows** in spring

- An increase in the volume and a peak of snow melt flows is observed for glacier regimes.
- An increase in the duration of the snow melt season is observed for snow melt regimes, along with an earlier beginning of the snow melt season.

- **Medium flows:**

- Glacier regimes show an increasing annual flow and an increasing base flow index.

The consistency of observed trends at least suggests that the changes are unlikely to be linked to measurement issues, but are more likely climate-related.

⁸ www.adaptalp.org

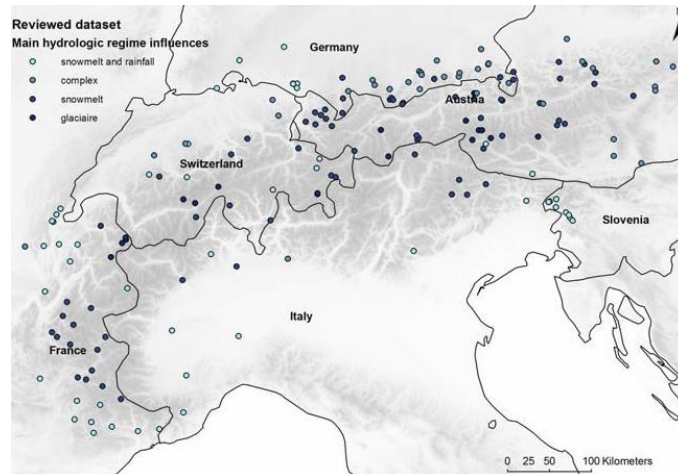


Figure 1: The AdaptAlp dataset (2011).

C3-Alps⁹

C3-Alps is a transnational capitalisation project. Based on the results of previous projects and initiatives on adaptation to climate change in the Alps, C3-Alps tries to synthesise, transfer, and implements the best available adaptation knowledge into policy and practice. Within the project a paper on the impact of climate change scenarios on water resources management in the Italian Alps was published (Ranzi et al., 2009). The paper deals with the simulated run-off in the current and future climate scenarios in two Alpine basins in Northern Italy relevant for irrigation, water supply and hydropower. The results say that in spite of a slight increase of precipitation, a decrease of about 5% of run-off 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.

Clisp¹⁰

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 impacts investigated are on flood-prone areas, avalanche-prone areas, rockfall- prone areas, torrential-process-prone areas. The adaptive capacity consists of the application of the directives (e.g. with the Flood Directive 2007/60/EC) in order not to 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

⁹ <http://www.c3alps.eu/index.php/it/>

¹⁰ www.clisp.eu

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 at increasing 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 formulated 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 for adaptation.

Alp-Water-Scarce¹¹

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 on the different pilot sites (Hohenwallner et al., 2011). What these recommendations have in common is the need to preserve the water resources of the Alps for future generations, to meet increasing water demand and to cope with climate change-induced stress. 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 transboundary water management exist for the main river basins of the Danube, the Elbe, the Meuse, the Mosel, the Oder and the Rhine. These agreements have definitely also an 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 (minimising water losses);
- optimising 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.

Alpstar Project¹²

Temperatures in the Alps have risen almost twice as much as the global average over the last century. And they are supposed to rise even more, especially if the Alps themselves continue to consume around 10% more energy per capita than the European average. However, clever and innovative adaptation or mitigation initiatives are increasing in local and regional Alpine areas facing climate change consequences. The challenge is thus to make best practice become minimum standard if we want climate neutrality in the Alps 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 the over the Alps.

The main objective of the Alpstar Project is to encourage the activation, diffusion and implementation of proven good practice measures in order to reduce climate change and

¹¹ <http://www.alpwaterscarce.eu/>

¹² <http://alpstar-project.eu/>

prepare cross-sectorial strategies and action plans with respect to carbon neutrality on regional and local level. The specific objectives are the following:

- Encouraging and supporting exchange of experiences, knowledge and know-how among pilot regions in order to facilitate their implementation and to use and spread local strategies and good practices for the reduction of GHG emissions.
- Searching for good practices in preparation and implementation of strategies, action plans and measures with respect to carbon neutrality and to make them become minimum standard.
- Improving transboundary, cross-sectorial and inter-policy level cooperation in coping with climate change.
- Promoting integrative and participatory approaches in development of cross-sectorial strategies and action plans and implementation of measures with respect to carbon neutrality.
- Empowering local and regional administrative actors and planners to become facilitators of a change process.
- Encouraging pooling, transfer and implementation of innovative and efficient good practices from and to other Alpine regions and beyond.

National initiatives

StartClim2005.A4¹³ (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 made. These arrangements are: disaster preparedness (organisational and technical arrangements), provisions at imminence, and a crisis and disaster management in case of emergency (drinking water emergency supply, information policy and cooperation with the media, collaboration with crisis and disaster management groups).

The comparison of different national concepts has shown that these concepts of water suppliers strongly depend on the support by the federal states (e.g. financial support).

Mountland¹⁴ (Switzerland)

Mountain regions provide essential Ecosystem Goods and Services (EGS). Global change, however, puts the capacity of mountain ecosystems for the provision of key services at risk. 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 political and natural sciences in order to analyse 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 prioritisation for adaption to climate and socio-economic changes, backcasting tolerable future states to match supply and demand for ecosystem services in mountain areas.

HydroAlp¹⁵ (Italy)

In Italy, the research centre Eurac wrote a report on climate¹⁶ 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 climate preservation and subsequently in defining 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

¹³ <http://www.austroclim.at/index.php?id=45>

¹⁴ http://www.wsl.ch/fe/walddynamik/projekte/mountland_home/index_EN

¹⁵ <http://www.eurac.edu/en/research/projects/ProjectDetails.aspx?pid=9221>

¹⁶ Eurac Research: Rapporto sul clima. Alto Adige

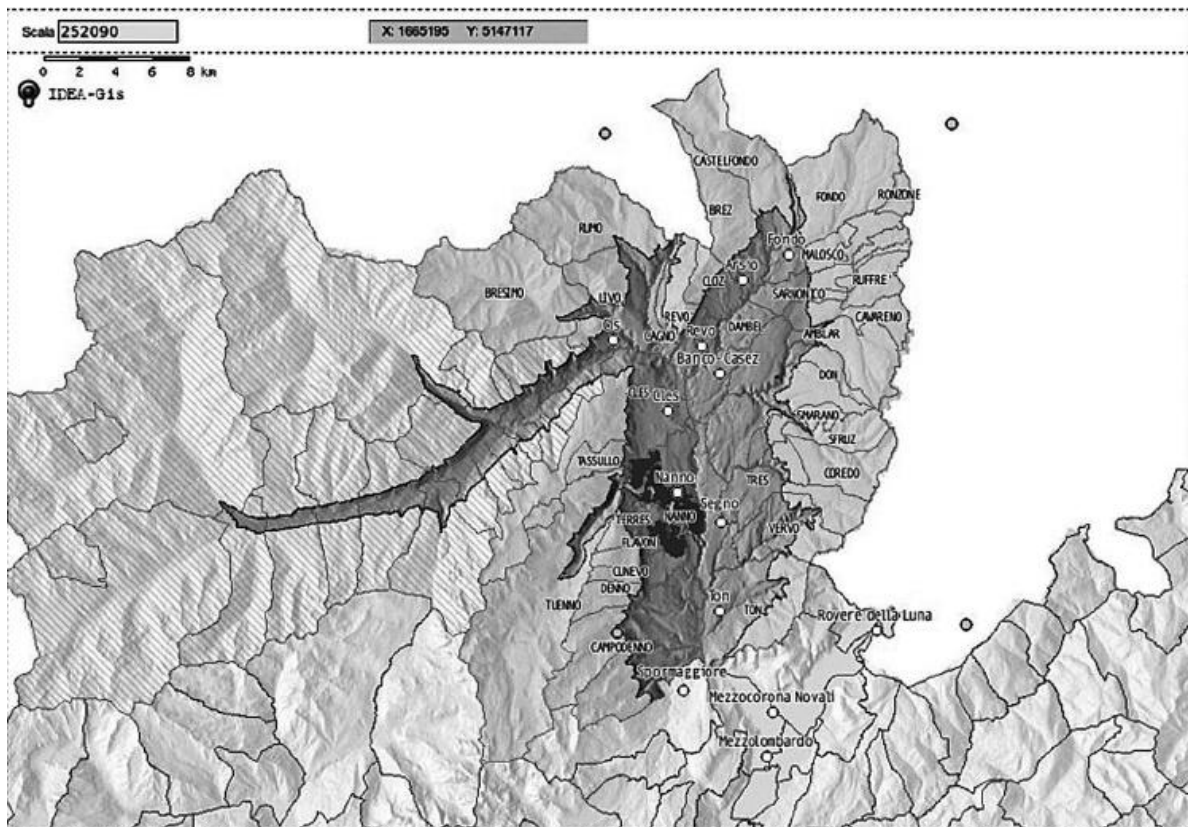
possible actions to mitigate climate change impacts on water are:

- Saving and reducing water consumption;
- Collecting water in basins;
- Implementing a more recent and better monitoring system and forecasting the availability of water with appropriate management plans.
- A project called Etsch Dialogue aims at recreating the complete equilibrium of the upper fluvial area of the Adige river via a dialogue between the different water users and the cooperation of the local population.

Irri4Web¹⁷ (Italy)

A decision support system for irrigation scheduling is proposed as a tool for improving 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 optimisation by setting up limits to soil moisture. The protocol entails the assessment of water content in a soil parcel, on the basis of its location and the history of the latest irrigation actions. The water balance is determined with rainfall and temperature values spatially interpolated and retrieved from the neighbouring meteorological stations (see Figure 2: the experimental area in the Non Valley). The Hargreaves equation (Hargreaves and Samani, 1985, Battista et al., 1994) is used for the calculation of evapotranspiration, and pedologic information is gained from a “(pedo-) landscape map” compiled for this purpose. An estimate 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 currently ready for its distribution to farmers and agricultural syndicates.

¹⁷ <http://meteo.iasma.it/irri4web/>



Bavarian climate adaptation strategy – BayKLAS (Germany)

In 2009, Bavaria launched the Bavarian climate adaptation strategy – i.e. the 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 set up, this programme and adaptation strategy lead to on-site measures in the municipalities.

Three examples are given below:

1) **Mountain Forest Initiative** ¹⁸

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 stabilise and 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, the 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 stakeholders. This strong focus on participation renders the 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 for the Alpine region in Bavaria, strengthening also 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 (Waldinformationssystem Nordalpen) in cooperation with partners from Austria (Tyrol, Salzburg).

¹⁸Alpine strategy for adaptation to climate change in the field of natural hazards – PLANALP 2013
www.forst.bayern.de
www.hswt.de

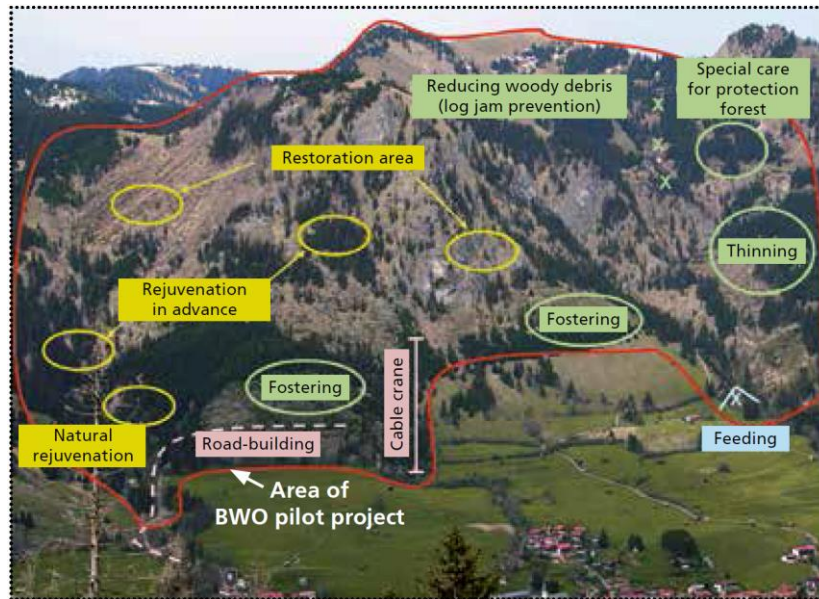


Figure 3: Example of measure combination within a Mountain Forest Initiative Area (Bavarian State Institute of Forestry).

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 in the 100-year flood is possible, experts assume that there is an increase of the discharge for 100-year flood events. Therefore, since 2009, Bavaria has been using 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 **Error! Reference source not found.**). For new constructions of flood protection the design discharge is increased by this factor.



Figure 4: 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 existing regional and foreseeable seasonal imbalance in the distribution of precipitation in Bavaria calls, in particular, for an increase in secure supplies of drinking water on local and regional level by networking plants or through alternative water production facilities, especially in those parts of Franconia and of the Upper Palatinate Forest and the Bavarian Forest that have water shortages. This also applies to climate change. Some case studies showed that about 3% of the water supply facilities of the investigation area are subject to degradation with respect to ensuring consumption due to climate change.

Programme NRP 61: Sustainable Water Management (Switzerland)¹⁹

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

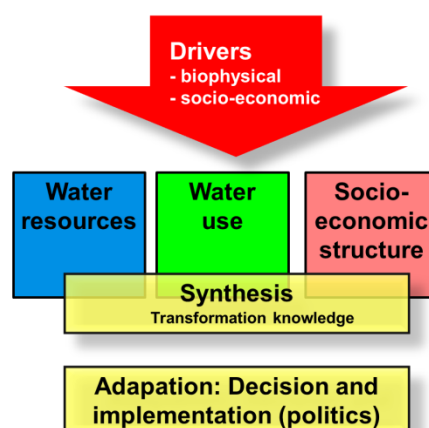


Figure 5: The inter- and transdisciplinary approach of the project.

We assessed the current water situation with quantitative and qualitative methods: A dense hydrometeorological network was built up, tracer experiments were conducted and communal water uses as well as the current water management system were analysed.

¹⁹ 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

These investigations paved the way for developing models in order to simulate possible changes in the immediate and more distant future. For this purpose, we used existing regional climate change scenarios and developed socio-economic scenarios together with the stakeholders.

The findings of MontanAqua can be summarised in five messages, each with a short recommendation:

1 – The socio-economic changes have a greater impact on the water situation in 2050 than the 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 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 clarification and negotiation of water rights at the regional level.

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

4 – Intercommunal measures on infrastructure can help to ensure sustainable water supply, provided that they are integrated into ambitious institutional reforms: A more equitable water management at the regional level requires a renegotiation of management principles and access rights to water resources.

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

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