



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



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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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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



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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



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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/>



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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



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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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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.

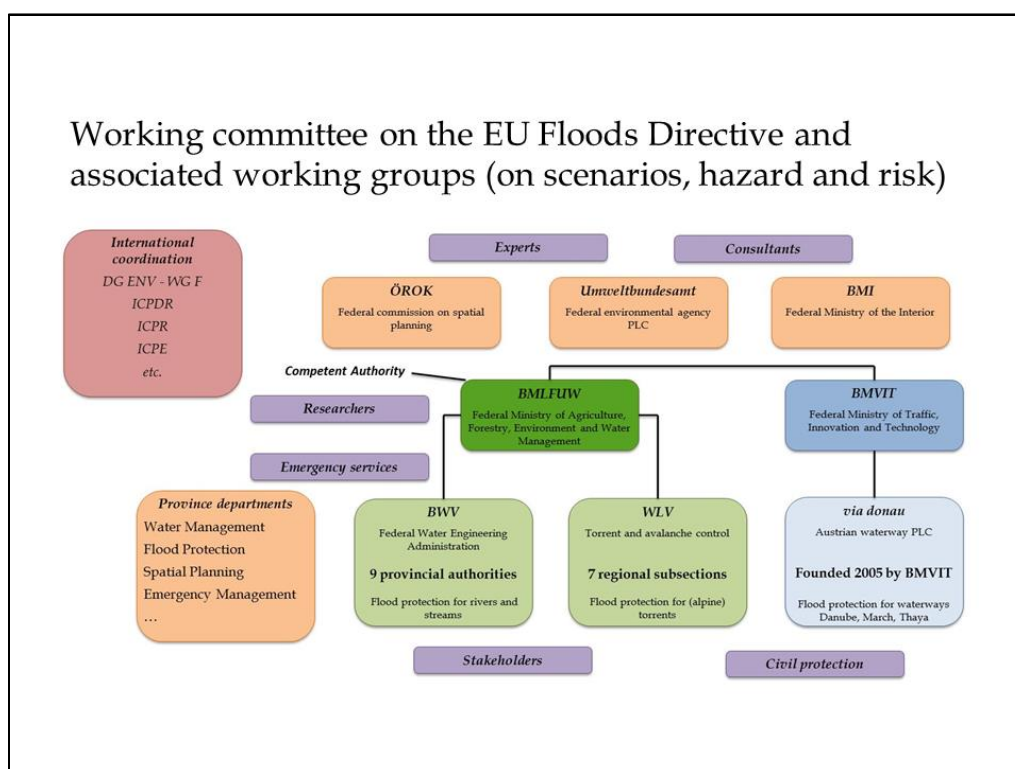


Figure 1: Composition of the Austrian working committee on the implementation of the EU Flood Directive

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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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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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.



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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.



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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.



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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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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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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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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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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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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.



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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>



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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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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.



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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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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.



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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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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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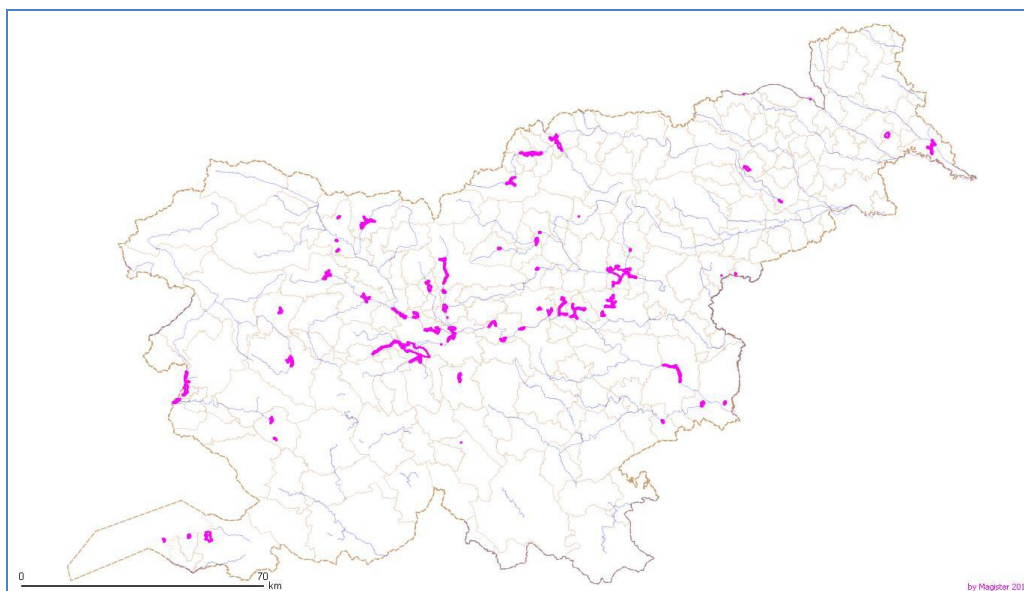


Figure 2: Map of the Slovenian APSFRs

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):

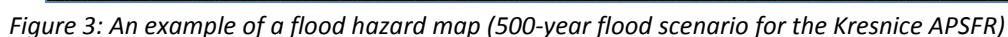
<http://www.mko.gov.si/fileadmin/mko.gov.si/pageuploads/podrocja/voda/opvp/OPOPO.xls>



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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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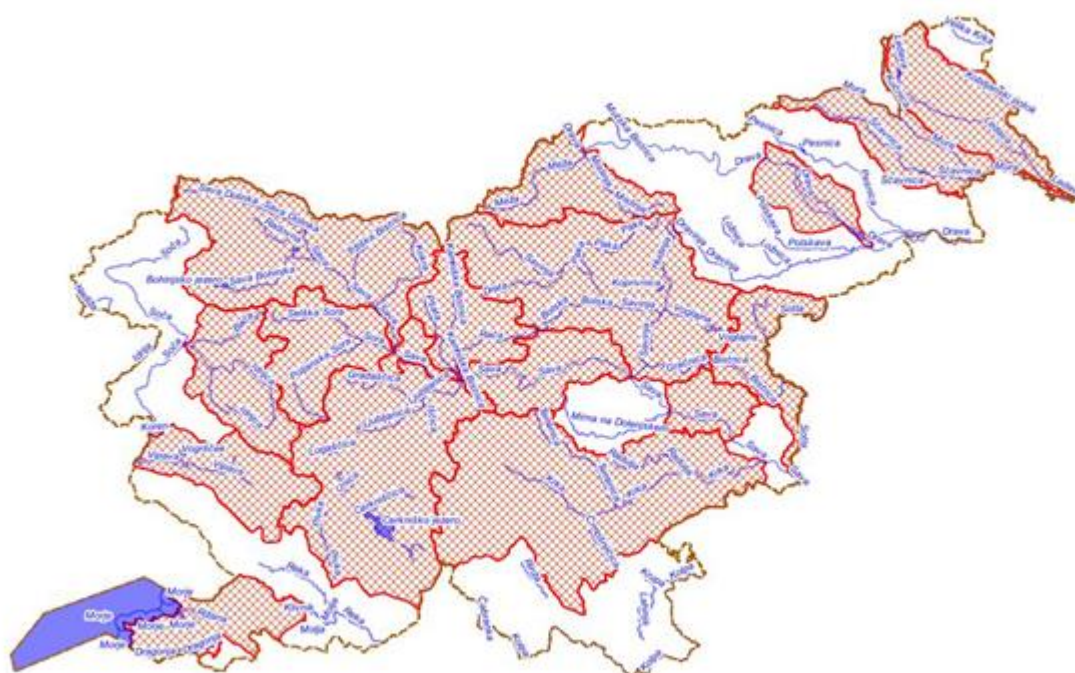


Figure 4: A map of 17 Slovenian river basins with APSFRs.



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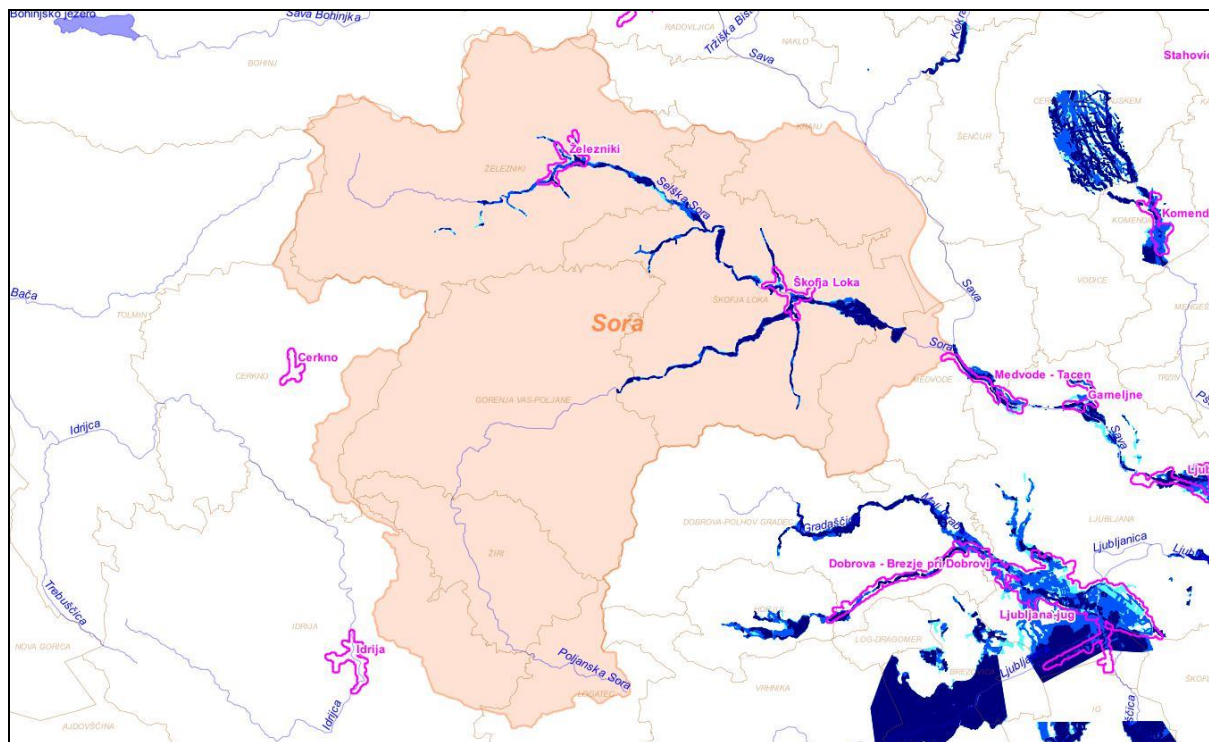


Figure 5: A map of the Sora River Basin with two identified APSFRs (Zelezniki and Skofja Loka).

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/>).

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<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.

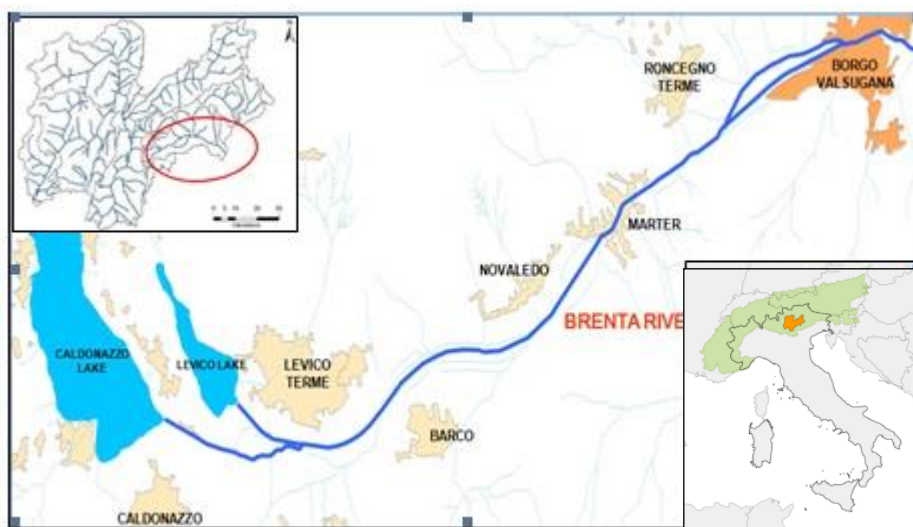


Figure 6: Course of the Brenta River from Lake Caldonazzo to the town of Borgo Valsugana. Upper left picture: Localisation of Trentino (red circle). Right picture below: localisation of Trentino (orange area) within the Alps (green area).



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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.

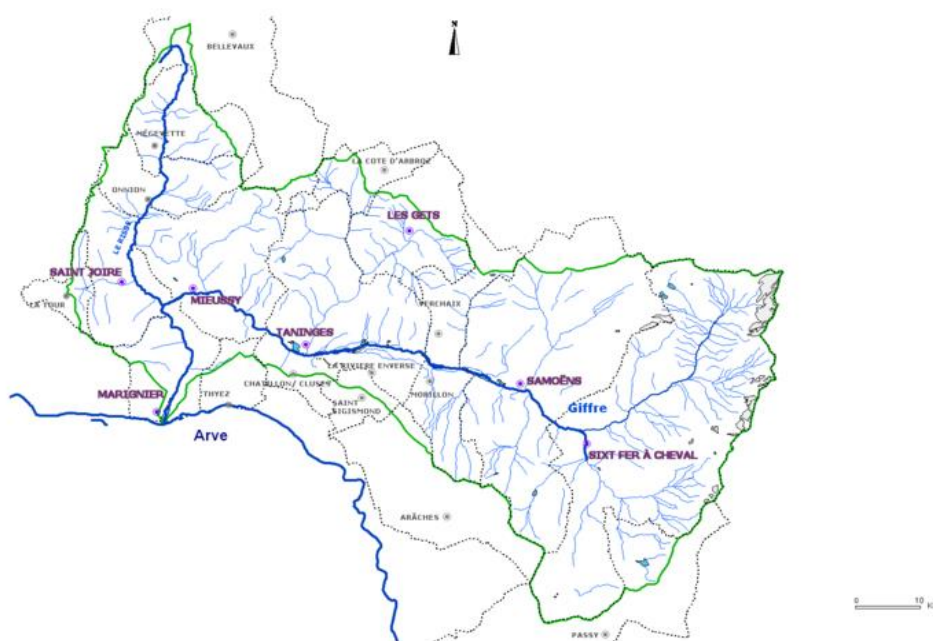


Figure 14: Location plan

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