

WP5.4

Criteria for river vulnerability mapping

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Summary

SHORT DESCRIPTION

This document intends to describe a set of methodological criteria for river vulnerability mapping in relation to hydropower exploitation.

This document proposes:

- **a river ecosystems vulnerability profile definition for each river typology**
- **a common definition of criteria to identify more vulnerable typologies of alpine areas in relation to HP management**
- **a definition of river types more vulnerable to HP and relative GIS mapping based on administrative layers.**

The report comes out from the selection of a wide amount of scientific and gray literature referred to mountain and alpine areas.

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Introduction

Hydropower operation is the primary renewable energy source to generate electricity in the Alpine region due to topography and the high precipitation rates. Thus, most of Alpine river systems are nowadays in use for hydropower production, and show section wise or along their whole course significant disturbances of the hydrologic regime, riverbed shape, and the aquatic biota. Unregulated rivers and river stretches in natural conditions became very rare in the Alps.

Regarding the need to reduce CO₂ emissions and to produce environmental sound energy, the EU Directive 2001/77/EC promotes the further development of sustainable hydropower. To meet also the demands of nature and river conservation the Water Framework Directive (2000/60/EC), Birds Directive (79/409/EEC) and Flora Fauna Habitat Directive (92/43/EEC) are obliged for the EU Member States. To meet these contrasting objectives means a big challenge for administrators.

Taking into account for these requirements, the Alpine Space Project SHARE seeks to develop tools for finding the balance between river ecosystems conservation and restoration, and the necessity and suitability of further development of hydropower in the Alpine region and to provide decision makers with applicable tools.

One of these tools will be a methodology for mapping those Alpine areas and river ecosystems more vulnerable towards hydropower operation. Therefore this document elaborates:

- a river ecosystems vulnerability profile definition for each river typology
- a common definition of criteria to identify more vulnerable typologies of alpine areas in relation to HP management;
- a definition of river types more vulnerable to HP and relative GIS mapping based on administrative layers.

The Communication of the Commission (COM (2005) 627) recommended the development of mechanisms to allocate suitable areas for new hydropower projects. The designation of 'go and no-go areas' has been discussed and was NOT found appropriate in the Common Implementation Strategy Workshop 'Water Framework Directive & Hydropower' held 2007 in Berlin (CIS 2007).

River vulnerability

General view

The vulnerability of a river type is strongly connected to the sensitivity of different biological and hydromorphological quality elements. The biological and hydromorphological quality elements consists taxa/communities which are sensitive to different pressures. These criteria and indicators detect the differed kinds of pressures (WALLIN et al.2003). In this special case these pressures induced by the hydropower explorations in alpine rivers. The following points describe the criteria to evaluate the vulnerability profile of alpine river typologies.

Categorizations of river vulnerability typology

The degree of vulnerability regards hydropower operation of alpine areas and river typologies will be expressed in tree classes. This classification is based on the “Common guidelines for the use of small hydropower in the Alpine region (Alpine Convention)”. The assessment method is adapted to the SHARE project specific questions to balance the river quality and hydropower requirements:

- Highly vulnerable river ecosystem. Natural rivers with high ecological importance.
- Moderate vulnerable river ecosystem. Low influenced rivers with moderate ecological importance.
- Less vulnerable river ecosystem. Heavily influenced rivers with minor ecological importance.

Method to define the vulnerability profile

The method for the river vulnerability mapping is build up in a two step approach. Table 1 shows the general flow diagram, this includes Step 1 and Step 2 for the vulnerability mapping approach.

The Step 1 approach defines the highly vulnerable river stretches by step-by-step the categories 1 to 7 shown in the table 1. The criteria 1 to 4 in the step 1 define the highly vulnerability mapping are the protect areas, FFH natural habitats, FFH species, and rear river types by a YES or NO approach. This means, if one of the categories of the step 1 designate as YES (e.g. the river stretch lies in a protected area) is the river section automatically a highly vulnerable river. If the river is not located in a protected area the data set should be check for other category (e.g. FFH natural habitat/species or rear river types).

The next step is to check for very good status of the hydro morphology, ecology and biotic components (criteria 5, 6, and 7). If all those river sections are evaluated as very good, river section are automatically considered highly vulnerable. If the river assessment shows other statuses for hydro morphology, ecology and biotic components (e.g. good, medium, and bad status) it's necessary to calculate the vulnerability score by the multi criteria analysis in the step 2.

The second step (Step 2) of the vulnerability mapping calculates the moderate and less vulnerability by a multi criteria analysis. The description of the multi criteria analysis can be found on the chapter: "Step 2: Score system to define the moderate and less vulnerability classification of Alpine river ecosystems".

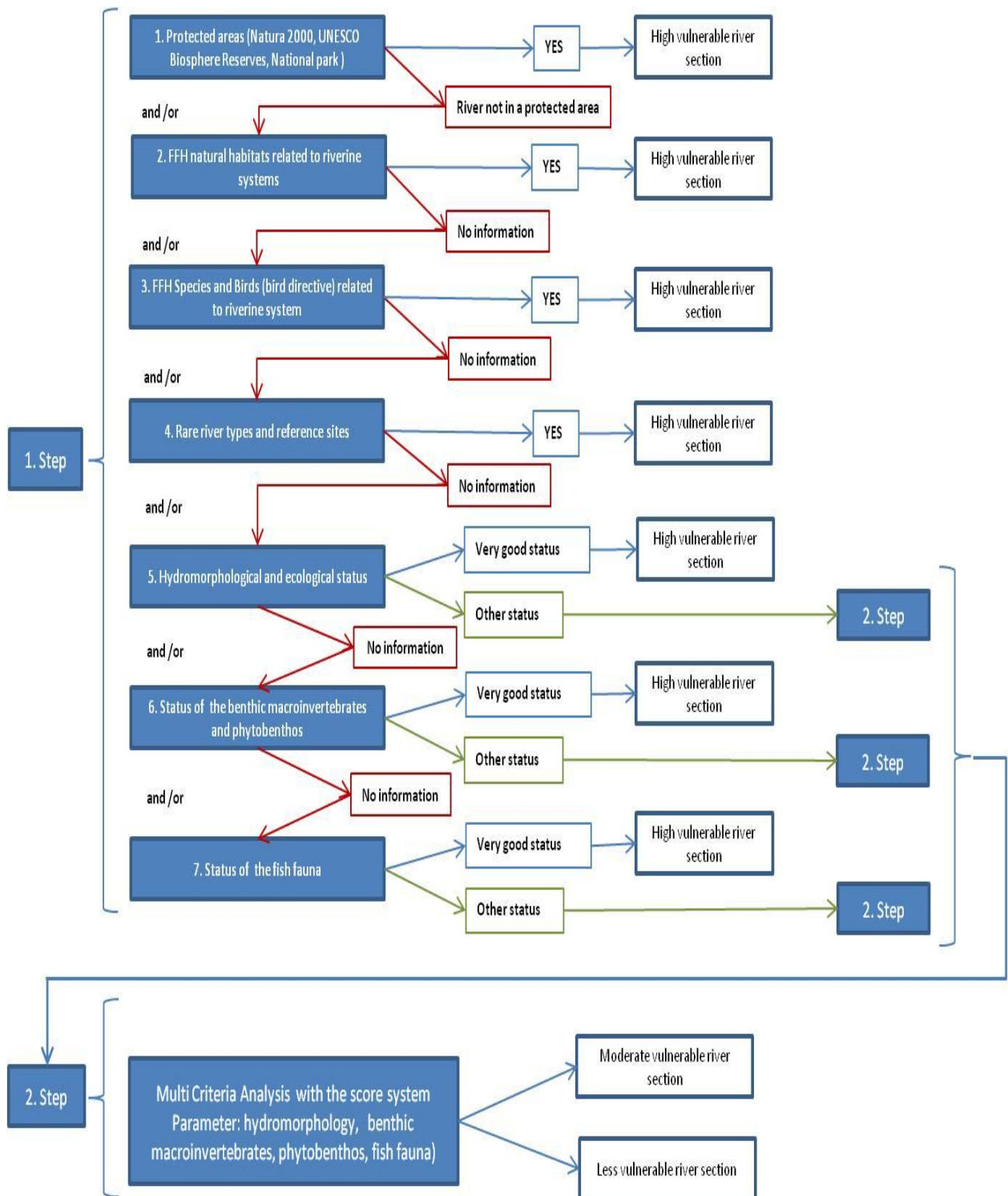


Table 1: Flow diagram for the vulnerability mapping procedure. The step 1 describes the procedure to define the high vulnerability river stretches, and the step 2 of the diagram shows the multi criteria analysis used to evaluate other vulnerability status.

Step 1: Criteria to define the high vulnerable river ecosystems

The following chapter pointed out the criteria to define the high vulnerability of river ecosystems. This includes areas and organisms protected by international and national law. A river is classified automatically as high vulnerable if it lies within a conservation area. Furthermore, if any of the criteria ecological status, hydromorphological status, benthic macro invertebrates, phytobenthos, and fish are rated as very good, it is automatically a high vulnerable water course.

Protected areas

This criterion describes the protection by law of landscapes and the conservation of organisms. Rivers and brooks located in protected areas can also be included in a “no go area” for hydropower exploitation. A no go area can also occur in case of protected animals or plants.

- UNESCO Biosphere Reserves (Man and the Biosphere Programme)
- Natura 2000 areas
- UN List of Protected Areas (IUCN – The World Conservation Union)
- National protected landscapes

FFH natural habitats related to riverine systems

Following river types in the annex 1 (Natural habitat types of community interest whose conservation requires the designation of special areas of conservation) of the Fauna-Flora-Habitat Directive 92/43/EC are protected.

- 32. Running water — sections of water courses with natural or semi natural dynamics (minor, average and major beds) where the water quality shows no significant deterioration
 - 3220 Alpine rivers and the herbaceous vegetation along their banks
 - 3230 Alpine rivers and their ligneous vegetation with *Myricaria germanica*
 - 3240 Alpine rivers and their ligneous vegetation with *Salix elaeagnos*
 - 3250 Constantly flowing Mediterranean rivers with *Glaucium flavum*
 - 3260 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation
 - 3270 Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation
 - 3280 Constantly flowing Mediterranean rivers with *Paspalo-Agrostidion* species and hanging curtains of *Salix* and *Populus alba*
 - 3290 Intermittently flowing Mediterranean rivers of the *Paspalo-Agrostidion*

FFH Species and Birds (bird directive) related to riverine system

Following aquatic animals and plants species in the annex II (Animal and plant species of community interest whose conservation requires the designation of special areas of conservation) and annex IV (Animal and plant species of community interest in need of strict protection) of the Fauna-Flora-Habitat Directive 92/43/EC are protected

- Annex II (Animal and plant species of community interest whose conservation requires the designation of special areas of conservation)
 - Mammals
 - *Castor fiber*
 - *Lutra lutra*
 - Fish species
 - *Aspius aspius*
 - *Barbus peloponnesius*
 - *Chalcalburnus chalcoides*
 - *Cobitis taenia*
 - *Cottus gobio*
 - *Eudontomyzon mariae*
 - *Gobio albipinnatus*
 - *Gobio uranoscopus*
 - *Gobio kessleri*
 - *Lampetra planeri*
 - *Leuciscus souffia agassizi*
 - *Misgurnus fossilis*
 - *Rhodeus sericeus amarus*
 - *Rutilus frisii meidingeri*
 - *Rutilus pigus virgo*
 - *Sabanejewia aurata*
 - *Zingel streber*
 - *Pelecus cultratus*
 - *Hucho hucho*
 - *Umbra krameri*
 - *Gymnocephalus baloni*
 - *Gymnocephalus schraetzer*
 - *Zingel zingel*
 - Crustacea
 - *Austropotamobius pallipes*
 - *Austropotamobius torrentium*

- Water birds in the annex I of the Bird Directive 2009/147/EC are protected (in particular Charadriiformes)
- Protected species regarding national law of each PP country including local species variation (autochthonous species)

Rarity of river types and reference sites

The definition of the rarity of river types is done regarding the Austrian Water Catalogue published in January 2012¹ The Catalogue is intended to aid each individual power station project in determining whether it is suitable in terms of energy management, ecological aspects and water management. The report has been elaborated by the Ministry of Agriculture, Forestry, Environment and Water Management in co-operation with the 9 Länder (regional administrations) and with the involvement of the stakeholders (energy sector, NGOs).

The elements considered are listed below.

- **Rarity of the good ecological status classes of the river type related to the**

High ecological significance: Proportion of water bodies with high ecological status below 20% in the water type, or the proportion of water bodies with good ecological status under 33% in the river type.

- **Rarity of river types: general types**

High ecological significance: Total length of type below 750 km²: These are river segments with near-natural morphology over 1 km length, and water stretches over 1 km length with morphological status 1 or 2 with no hydromorphological stresses (residual water, hydropeaking)

- **Rarity of river types: special types**

High ecological significance: The presence of special river types such as:

- glacial streams,
- big streams,
- lake feeding streams,
- spring water and groundwater-fed streams,
- marsh creeks,
- brooks hot,
- intermittent streams with very good and good morphology.

¹ http://www.lebensministerium.at/wasser/wasser-oesterreich/wasserrecht_national/planung/Kriterienkatalog.html

² This river typologies have been set for Austria but they are proportionally adaptable to other countries river network length

- **Rarity in terms of (free) flow path (without residual water pollution and flood stress, no transverse structures)**

High ecological significance: Remaining flow path of the particular types such as:

- large rivers,
- large hyporhithral,
- large and medium epipotamal stretches,
- epipotamal and metapotamal stretches with a length above 5 km.
- every free flow path (without residual stress and flood water pollution, no transverse structures) of the type's epirhithral, metarhithral, hyporhithral small, and epipotamal small with a length above 5 km.

- **Definition of the rarity of river types regarding the "Tyrolean Criteria Catalog"³**

River typologies considered are:

- Very rear river type: River length of a river type below or equal 8 km per type⁴.
- Rear river type: River length of a river type below or between 8 km and 20 km per type⁴.

- **Sensible water types according to the "Tyrolean criteria" and the "Checklist for hydropower plants and 15 MW peak capacity from a conservation point of view"⁵**

River typologies considered are:

- Branched high mountain / mountain stream,
- Meandering high mountain /mountain stream,
- Extended mountain river,
- Branched mountain river,
- meandering mountain river,
- meandering mountain river,
- Lake fed stream,
- Marsh stream,
- Calc-tuff stream,
- Groundwater-fed stream,
- Infiltration stretches (Versickerungsstrecken),
- Waterfalls,
- Glacier streams,
- Source streams.

3

http://www.tirol.gv.at/fileadmin/www.tirol.gv.at/themen/umwelt/wasser/wasserrecht/downloads/Kriterienkatalog_Version-07-04-2011_3.0.pdf

⁴ This value has been set for Tyrolean area but it is proportionally adaptable to other regions river typology

⁵ http://www.tirol.gv.at/fileadmin/www.tirol.gv.at/themen/umwelt/naturschutz/downloads/Checkliste_KWKW_final.pdf

Ecological and hydromorphological status

Each river section with very good ecological or hydromorphological classification should be defined as a high vulnerable water course. The method for the evaluation of streams is based on national legislation.

River stretches with other assessment values (e.g. good, moderate, and bad) should be evaluated with the score system (→ Step 2, multi criteria analysis).

Status of biotic components (benthic macro invertebrates, fish, phytobenthos)

Each river with very good status of benthic macro invertebrates, fish fauna, and phytobenthos should be classified as high vulnerable water ecosystems. The method for the evaluation of streams is base on national legislation.

River stretches with other assessment values (e.g. good, moderate, and bad situation) should be evaluated with the score system (→ Step 2, multi criteria analysis).

Step 2: Score system to define the moderate and less vulnerability classification of Alpine river ecosystems.

This chapter describes the score system to define the moderate and less vulnerability classification of Alpine river ecosystem.

The vulnerability assessment based on the multi criteria analysis is fed by normalized values. These standardized values are necessary to compare and calculate different environment assessments (e.g. hydro morphology status, biotic status and ecological status of the river) in a multi criteria analysis. Table 2 shows an example of the evaluation of the criterion ecological status and the normalized value for the vulnerability assessment. The calculation of each normalized parameter in the multi criteria analysis results in a score. The larger the value of the score, the higher is the vulnerability of the river system. For example a score between 0 and 0.33 define a less vulnerable situation, 0.34 to 0.66 define a moderate vulnerable situation, and the score between 0.67 and 1 result a high vulnerable situation of the river. Table 3 shows the score range of each vulnerability classification.

CRITERION (E.G. ECOLOGICAL STATUS)	STANDARDIZED VALUES FOR THE MULTI CRITERIA ANALYSIS
very good	1
good	0.75
moderate	0.5
bad	0.25
very bad	0

Table 2: Example for the ecological status and the standardized values for the multi criteria analysis

VULNERABILITY CLASSIFICATION	SCORES FOR THE VULNERABILITY ASSESSMENT
Vulnerable river ecosystem	0.67 to 1
Moderate vulnerable river ecosystem	0.34 to 0.66
Less vulnerable river ecosystem	0 to 0.33

Table 3: Score range of the vulnerability classification

Hydromorphological and/or ecological status

Almost all pressures of hydropower related to hydro morphology are caused by damming, water abstraction, power peaking and canalization. The different effects can be assessed according to the intensity of their impact on different river components developed in specific SHARE reports⁶.

As already mentioned, the very good assessment for the hydromorphological and/or ecological status of a river section drives automatically to a high vulnerable river stretch designation. All other assessments are calculated by the multi criteria analysis. The evaluation of the hydromorphological and/or the ecological status of a river underlie the national legislative. For example, the definition of the ecomorphological classification is described by WERTH (1987) and EGARTER (2009), and the normalization process is shown in table 4.

CRITERION ECOMORPHOLOGICAL STATUS	SCORES FOR THE VULNERABILITY ASSESSMENT
Status classes 1	1
Status classes 2	0.66
Status classes 3	0.33
Status classes 4	0

Table 4: Score for the vulnerability classification for the criterion Ecomorphological status

Status classes 1: Natural Rivers

Meandering and branched rivers with natural discharge, and well developed river bed. Furthermore, the river includes alternation between riffles and pools with good fish habitats. The riverine vegetation shows the typical shrub and tree vegetation.

Status classes 2: River system with minor ecomorphological alternation

This category shows a slightly anthropogenic influence. The river bed and the river shore have near natural and biological engineering constructions. The shore line is often stabilized by natural vegetation and shows more or less the typical natural river shape.

Status classes 3: River system with strong ecomorphological alternation

These rivers are characterized by strong alternation of the river bed and shore line. The river bed and the shore are stabilized by engineering structures. The river bed shows often a uniform shape with more or less natural substrate.

⁶ Hydropower impacts on river status components. Media support to represent the cause-effect relationships between status and pressure/impact and cross link. The report is available on the project website <http://www.share-alpinerivers.eu/tools-and-resources/online-handbook-links/hydropower-impacts-on-river-status-components>

Status classes 4: Not natural rivers

These categories are mostly straight river channels stabilized by concrete or engineering structures. The river vegetation is mostly absent.

Fish assessment methods

The fish fauna stands out due to the adaptations and sensitivity of the different species and life stages to specific habitat conditions and due to their longevity and long life cycle, which makes it possible to determine pressures and impacts over periods of time.

Most indicators using the fish fauna assess the species composition (ecological guilds, character species, typical companion species, fish region index) and the population structure (age classes, young of the year, biomass) (HAUNSCHMID et al. 2006). The most of the indigenous fish species have a strong structure bounded mode of life, and a high potential to detect hydromorphological alternation. Fish are mobile organisms, and thus a good indicator for the continuum, and certain aspects of pollution indications (eg, point and no-point pollution) (SPINDLER 1997).

The following table is described by the Austrian Objectives Ordinances Ecology - Surface Waters (QZV Ökologie) considered to be useable in whole alpine area.

CRITERION ECOLOGICAL STATUS FOR FISH FAUNA	SCORES FOR THE VULNERABILITY ASSESSMENT
very good	1
good	0.75
moderate	0.5
bad	0.25
very bad	0

Table 5: Score for the vulnerability classification of fish fauna

Benthic macroinvertebrates assessment methods

Benthic macroinvertebrates are the most used indicator group for assessing the biological status of rivers. They are especially suitable because of their easy availability and their diversity and their adaptations to specific conditions.

Many indices are used as the saprobic index to assess the water quality in terms of organic pollution. But also methods exist that indicate the general degradation of ecosystems. Some methods are composed of several indices or metrics within a multimetrics analysis. In general a higher correlation between index value and organic

pollution or general degradation can be achieved. However, the use of a multimetric system for general degradation makes it very difficult to draw a line to one specific pressure. Individual metrics are for example:

- Species richness or diversity;
- Percentage of Ephemeroptera,
- Plecoptera and Trichoptera taxa (EPT %);
- Percentage of Oligochaeta and Diptera taxa;
- Species composition acc. feeding groups, litoral or profundal colonizers (OFENBÖCK et al. 2010).

The benthic macroinvertebrates can detect organic pollutants and hydromorphological stressors like the degradation of the river morphology, impoundment, residual water, and different use in the catchment (OFENBÖCK et al. 2010).

CRITERION BENTHIC MACROINVERTEBRATES - MODULE SAPROBIC	SCORES FOR THE VULNERABILITY ASSESSMENT
very good	1
good	0.75
moderate	0.50
bad	0.25
very bad	0

Table 6: Score for the vulnerability classification of the criterion benthic macroinvertebrates - module saprobic

CRITERION BENTHIC MACROINVERTEBRATES - MODULE GENERAL DEGRADATION	SCORES FOR THE VULNERABILITY ASSESSMENT
very good	1
good	0.75
moderate	0.5
bad	0.25
very bad	0

Table 7: Score for the vulnerability classification of the criterion benthic macroinvertebrates - module general degradation

Phytobenthos assessment methods

Aquatic plants are important primary producers and grow on inorganic nutrients. Thus they mainly react to changes of the trophy, which must not be related to HP.

Other physical factors as current, light and substratum may, however, favour biomass or a specific species composition. Measures of diversity don't allow a linkage to the trophic state, because high, intermediate and low species diversities are found to grow at the same amount of nitrogen and phosphorous.

Many species of flora and fauna have been classified in a saprobic system, and especially diatoms and benthic invertebrates react to the pollution with organic compounds. The species are valued according to their tolerance or preference towards organic pollution and the associated decrease of oxygen. Depending on the species composition and the saprobic index calculated from all classified taxa the water quality can be classified from heavily to un-polluted, but only valid for organic pollution.

The phytobenthos is indicator for the material pollution of running water. In part it can also give information on the hydrological alternations like water abstraction, hydropeaking, and impoundment (PFISTER P. & PIPP E. 2010). The following tables show the scores for the vulnerable classification.

CRITERION PHYTOBENTHOS - MODULE TROPHIC	SCORES FOR THE VULNERABILITY ASSESSMENT
very good	1
good	0.75
moderate	0.5
bad	0.25
very bad	0

Table 8: Score for the vulnerability classification of the criterion phytobenthos - module trophic (all taxa)

CRITERION PHYTOBENTHOS - MODULE SAPROBIC	SCORES FOR THE VULNERABILITY ASSESSMENT
very good	1
good	0.75
moderate	0.5
bad	0.25
very bad	0

Table 9: Score for the vulnerability classification of the criterion phytobenthos - module saprobic (all taxa)

Mapping of the vulnerability river ecosystems in the Alpine area

Determining the river vulnerability

Determining the vulnerability occurs through a multi-step approach. There are space-based criteria and river-based criteria available. The first include protected areas, like Natura 2000, UNESCO Bio-sphere Reserves and National Parks, as well as areas of the Habitats Directive and the Birds Directive. If a water body flows through such a protected area it classifies as a highly vulnerable river. In this case the ecological state of the river is determined by the environment and the landscape.

The other criteria are river-based. The state of a water body is specified by various ecological criteria, as the hydromorphological status, the status of the benthic macro invertebrates or phytobenthos or the status of the fish fauna. If these criteria are available, they can be used for the determination of the sensitivity and the vulnerability of the river. These criteria are not recorded on every river or stream, often just on the more important ones. For these rivers the analysis is more complex and detailed.

In the first step the river sections which are “highly vulnerable” are determined. These are all the intersections of the river with protected areas. Additional ecological criteria are used to determine a “highly vulnerable” river. Where one of the criteria has a very good rating, the river gets classified as “highly vulnerable”.

The second step serves to identify the other scales of vulnerability. If more ecological information criteria are valuable for a water body a multi-criteria analysis is carried out. The multi-criteria analysis differs slightly from the one explained in the paper for the WP5.4. The second highest class of vulnerability, the “very vulnerable” rivers, is assigned, if more of the criteria have a “good” state. If just one criterion is considered “good” the vulnerability class is defined simply as “vulnerable”. All the river sections which are not in one of the above described categories are defined as a class with “no rating”.

VULNERABILITY CLASS	DESCRIPTION
highly vulnerable	water body in protected areas, as Natura 2000 areas, areas of the Habitat or the Birds directive OR one ecological criteria is very good
very vulnerable	water body with more than one ecological criteria that are good
vulnerable	water body with one ecological criterion that is good
no rating	water body has a bad ecological state or does not have an ecological assessment

Table 10: vulnerability classes

Maps for project areas

Mapping of river vulnerability has been strongly influenced from affordable information availability: this situation is well represented in the project cooperation area.

Firstly, different countries involved in SHARE hold a not homogenous level of EU Water Framework Directive implementation due to several occurrences: this situation meant a variable level of river monitoring of WFD standards adoption and related information availability⁷.

Secondly, the information needed to assess vulnerability as described in the report is not openly and immediately available on national scale. Very often the data obtainable are managed by national and regional technical services diffusing them only in aggregated formats not useable for elaboration. The direct access to cartographic formats (such as shape files or kml) is not evident at all, in particular considering the very different profile of project partners and their different backgrounds and professional networks.

These conditions have influenced the vulnerability mapping in the frame of SHARE: for these reasons following maps are neither exhaustive nor official but represent a method output to localise and qualify river capital potentially exposed to HP pressure.

⁷ See also SHARE report concerning Technical review describing WFD, Floods and other EU directives implementation in Alpine SPACE available in the project website: <http://www.share-alpinerivers.eu/tools-and-resources/online-handbook-links/technical-review-describing-wfd-floods-and-other-eu-directives-implementation-in-alpine-space>

Germany

For the rivers in the German territory of the Alpine Area several ecological information criteria are available. In nearly all the water bodies the ecological state has been assessed, so every river gets a classification in the vulnerability analysis.

First the rivers which are in one of the protected areas, the Natura 2000 areas, areas of the Habitat or the Birds directive, are determined. The ecological criteria include the ecological state of fish fauna, benthic macroinvertebrates saprobic status and degradation and macrophyte and phytobenthos. Four criteria are used to determine the minor classes of vulnerability through the above described multi-criteria analysis.

France

For France no ecological criteria are available, so the vulnerability assessment has been made just by the space-based criteria. All the rivers in protected areas, especially areas of Natura 2000 network, are classified as “highly vulnerable”. All other rivers have no rating.

Italy (Aosta-Valley and South Tyrol)

For both areas, the region of Valle d’Aosta respectively the autonomous province of Bozen-Südtirol/Bolzano-Alto Adige there are no ecological criteria like in Germany but for the rivers of both regions another index has been evaluated: the IBE. The IBE (Indice Biotico Estesio, GHETTI, 1997) is based on the analysis of the composition of the benthic macro invertebrate community, considering its diversity and the sensitivity of the different systematic units considered. The index appraises how the present macro invertebrates community is far from the attended one. So this is suitable for the ecological assessment. Due to the lack of other criteria this is the only criteria the analysis is based on. All the rivers, which flow not in a protected area, are classified following the IBE classification because it is considered as strongly related to the classification of vulnerability. If the IBE reaches the first degree of quality, the vulnerability classification has been “highly vulnerable”, if the IBE reaches only the second degree of quality the vulnerability score assigned is “very vulnerable” and so on. So, three classes of vulnerability and a class of the remaining rivers have been shaped.

Piedmont

In Piedmont the Natura 2000 areas and the areas of national parks have been used for the vulnerability analyses. The river based monitoring includes the state of the diatoms, macro benthos and macrophytes. These three criteria have been used for a multi-criteria analysis. Where one of the criteria is classified “very good” the vulnerability class assigned has been “highly vulnerable”. If more than one criteria are “good” the score assigned has been “very vulnerable”, if only one criteria reached the level “good” the score assigned has

been “vulnerable”. The remaining rivers have been classified as “no rating” due to lack of information.

Slovenia

For Slovenia no digital spatial data were available for the analysis and just maps with the ecological state of the more relevant rivers are obtainable, which have been digitalized. The rivers in Natura 2000 areas compose the highest class of vulnerability. The ecological condition, where this information exists, is used similar to the rivers in Italian regions. The vulnerability classification takes over the values of this ecological state.

Maps

SHARE - Sustainable Hydropower in Alpine Rivers Ecosystems

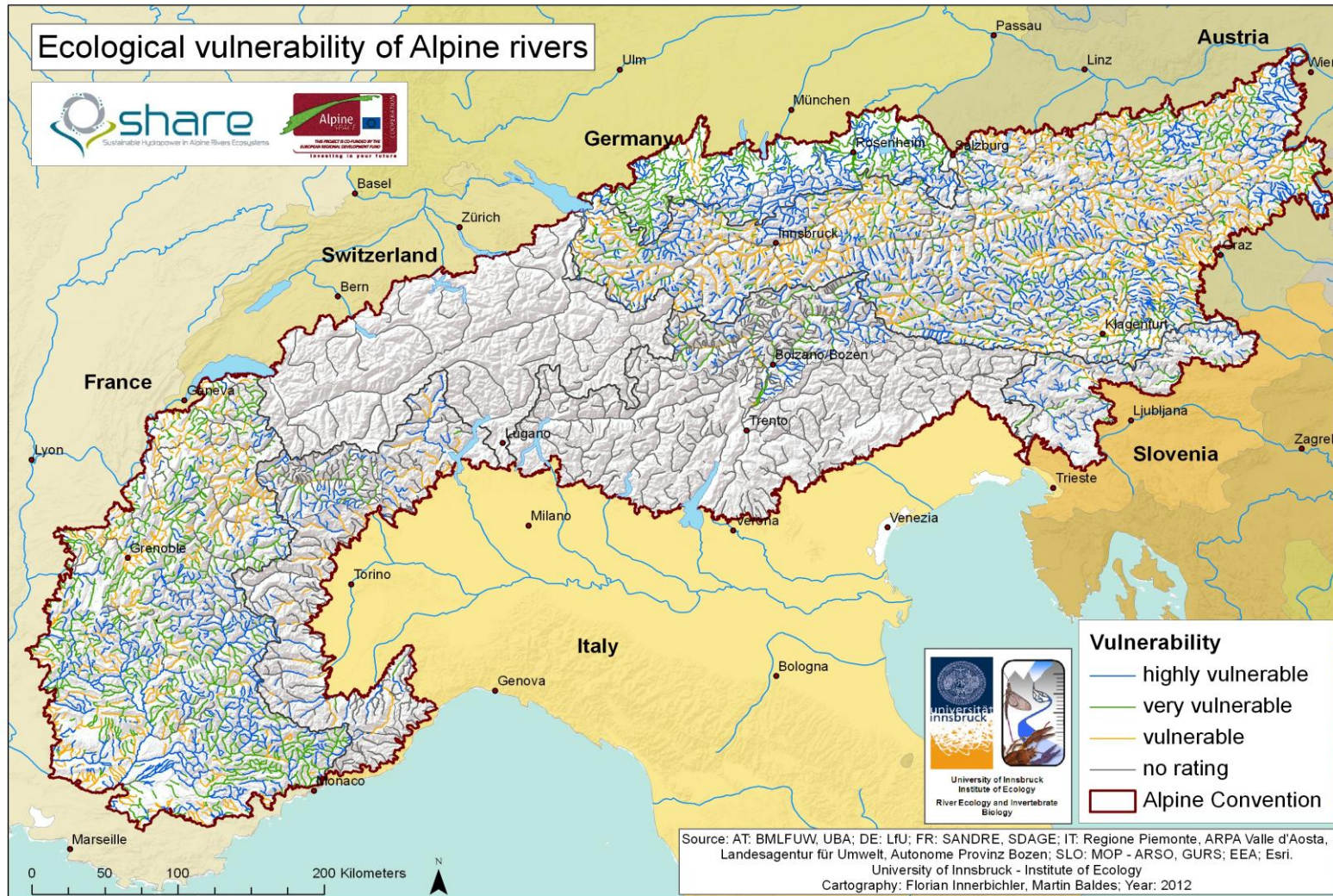
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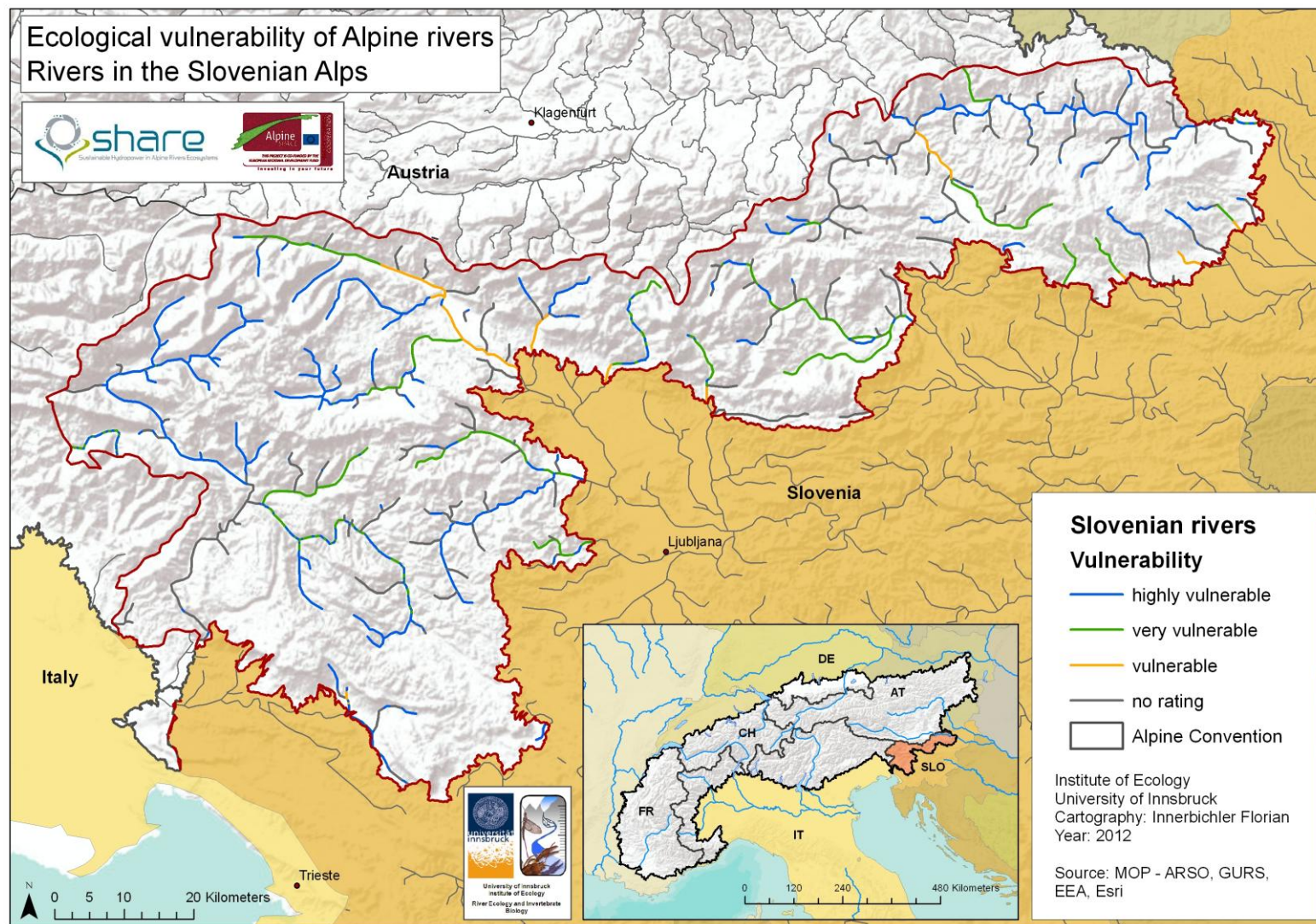
Priority 3 – Environment and Risk Prevention

Project duration: 36 months – 1/08/2009 – 31/07/2012

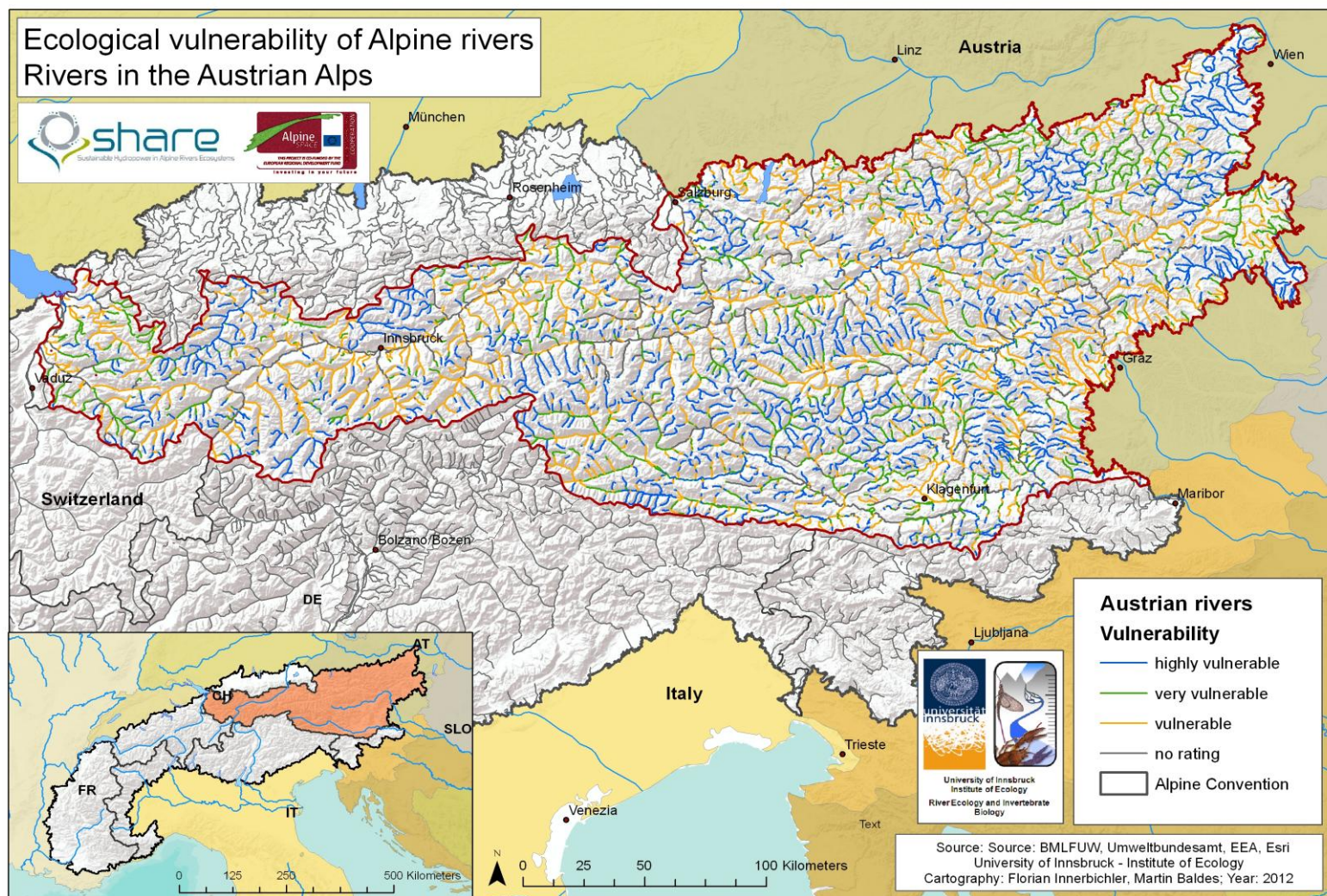




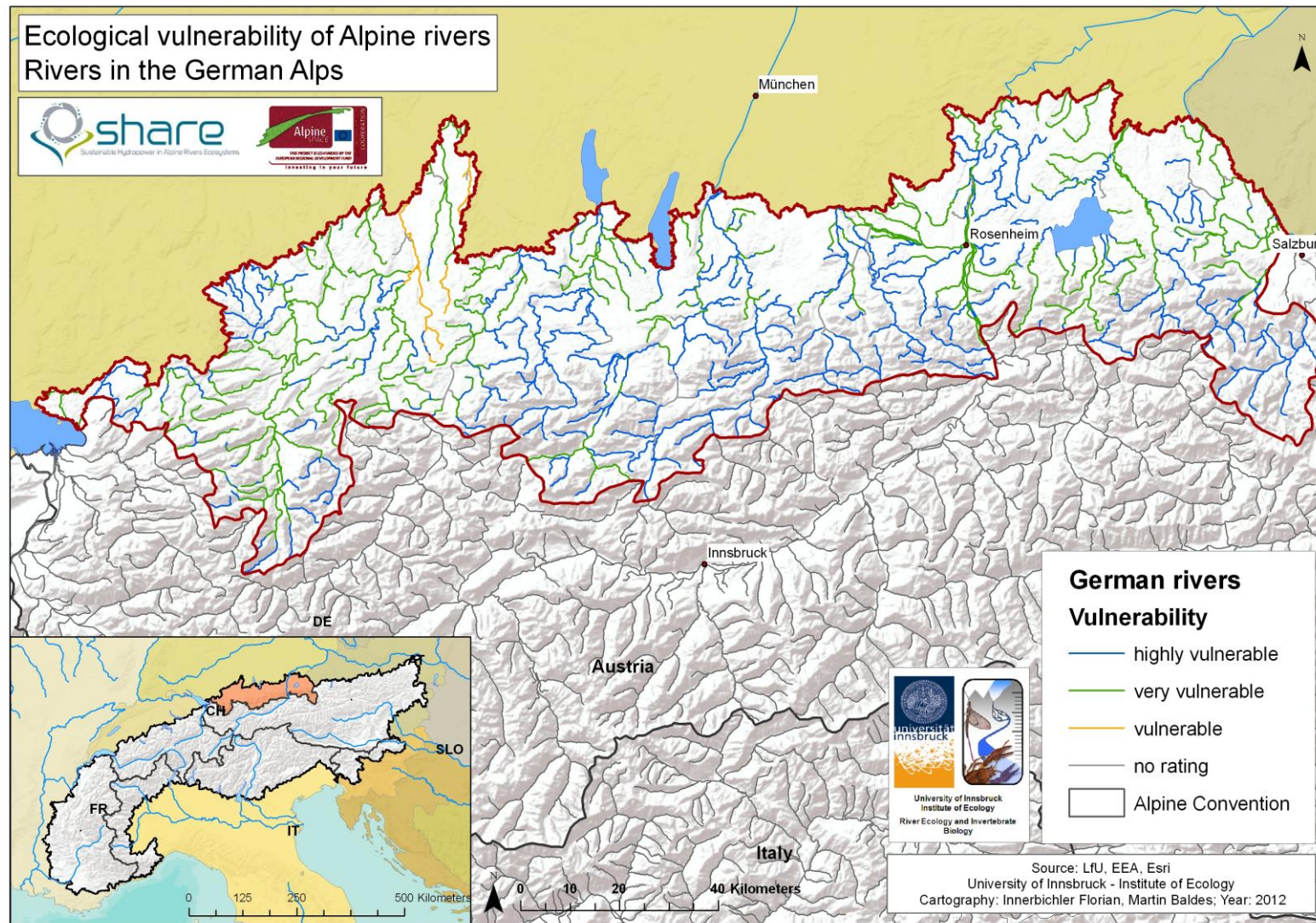
Map 1: Ecological vulnerability of Alpine rivers



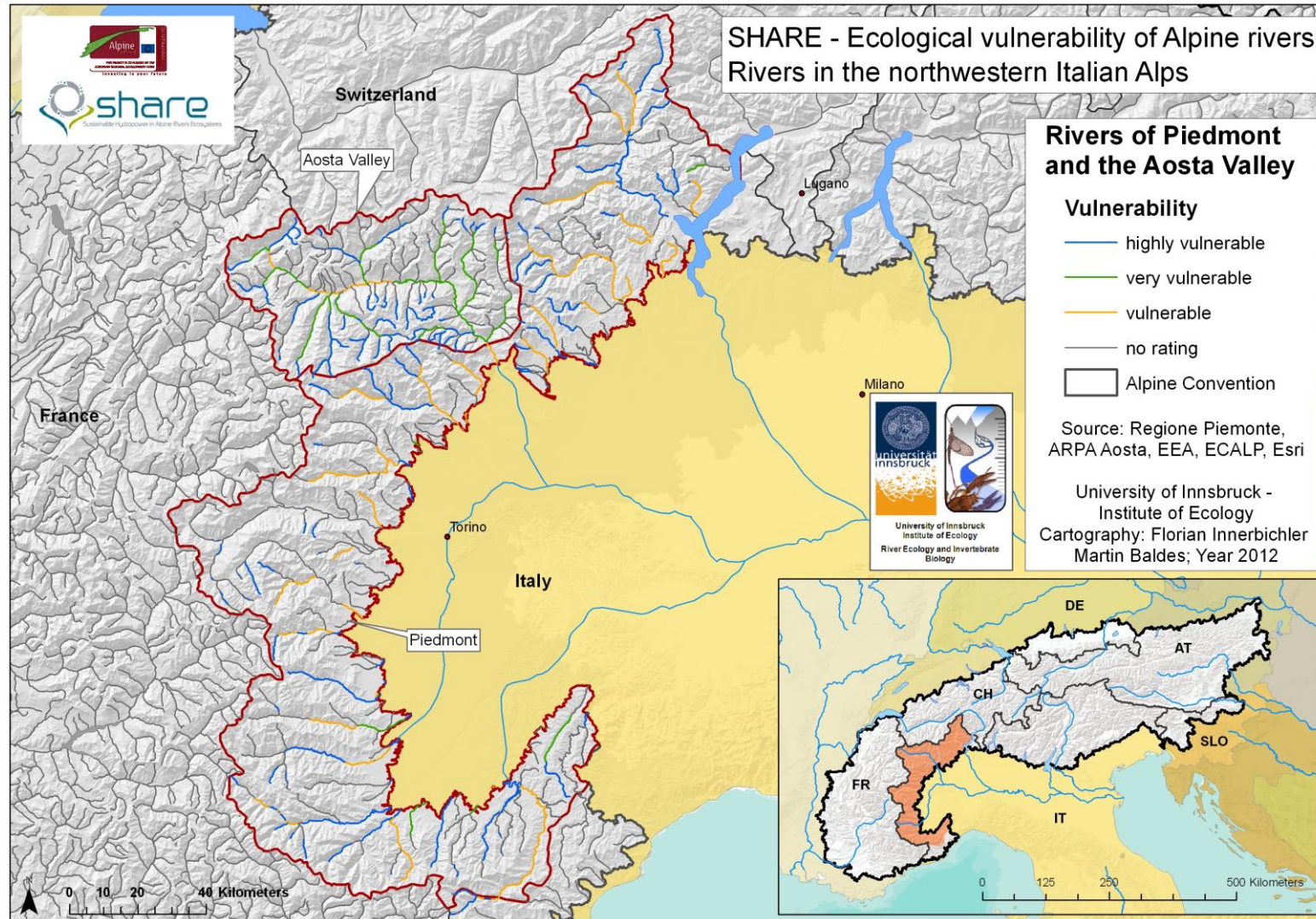
Map 2: Ecological vulnerability of Alpine rivers in Slovenian Alps



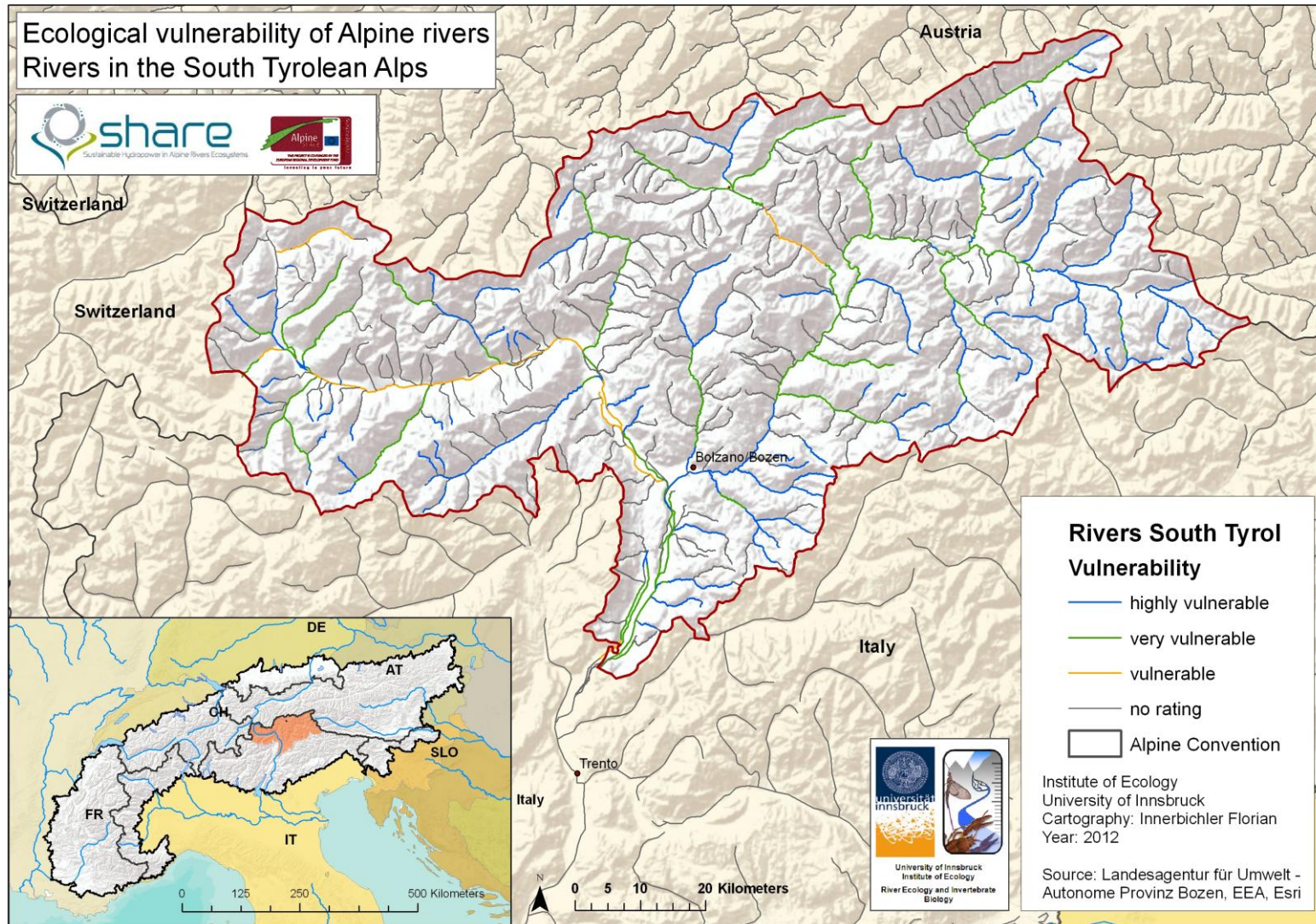
Map 3: Ecological vulnerability of Alpine rivers in Austrian Alps



Map 4: Ecological vulnerability of Alpine rivers in German Alps



Map 5: Ecological vulnerability of Alpine rivers in Italian Alps



Map 5: Ecological vulnerability of Alpine rivers in South Tyrolean Alps

River vulnerability checklist

To allow the vulnerability assessment at local scale (where very often the HP and river issues are concretely managed) and, at the same time, to give evidence to natural capital and ecosystem services represented in a river stretch potentially interested by hydropower exploitation a vulnerability checklist has been set.

The list includes above mentioned criteria and describes a set of useful and practicable criteria for the whole Alpine region to be considered to assess a generic level of river vulnerability to HP exploitation.

Checklist outline

The checklist aims to furnish a form for an early general assessment of the vulnerability of the river in relation to HP exploitation potential pressures considering:

- the ecological status / intactness
- the hydro(eco)morphology characters
- the presence of protected areas, animals and plants
- the river rarity
- the landscape categories in the surrounding of the river

The list is composed by six main criteria inserted in Excel spreadsheet form to be used to evaluate the "environmental capital exposed"; each of them has been detailed by several subcriteria. To fill in the form, the first step is to flag or deflag the criteria and subcriteria to consider in each specific case, using the Excel "filter" tool.

SHARE - Sustainable Hydropower in Alpine Rivers Ecosystems

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Criteria	Subcriteria	Evaluation
Ecological status / intactness	Fish fauna conditions (how the conditions of fish fauna are in relation to the reference ones?)	Poor
	Benthic macroinvertebrates conditions (how the conditions of benthic macroinvertebrates community are in relation to the reference ones?)	Poor
	Phytobenthos conditions (how the conditions of phytobenthos are in relation to the reference ones?)	Medium
	Riparian vegetation conditions (how the conditions of riparian vegetation are in relation to the reference ones?)	Medium
	Arthropod communities conditions (how the conditions of arthropod communities are in relation to the reference ones?)	Medium
Ecological status / intactness		
Hydro(eco)morphology	River type (is the river a braided channel, a wandering channel, or a meandering channel?)	Meandering channel
	Protection Structures (presence or necessity) (has it been necessary, in the past, to build structures to protect against important erosion?)	No/Poor
	Other Erosion Marks (are there obvious erosion marks along the river bed?)	No/Poor
	History of morphological changes during high flows (has the river shown sudden, important deposition/erosion, following floods?)	Yes/Very evident
	Hydrological regime (how much the hydrological regime of the river is far from the natural one?)	Totally altered
Hydro(eco)morphology		
Protected areas	International protection areas/categories (is the river inserted into an international protection area, such as "Biosphere Reserves", "Natura 2000", "Habitat Directive 92/43/EEC", ... ?)	Not included
	National protection areas/categories (is the river inserted into a national protection area?)	Not included
	Regional protection areas/categories (is the river inserted into a regional protection area?)	Not included
Protected areas		
Protected animals and plants	International protection for animals and/or plants (there are some protected species living in river ecosystem and included in international protection listes/directives?)	More than one species included
	National protection for animals and/or plants (there are some species protected species living in river ecosystem and included in national protection listes and/or national laws such as "red listes"?)	More than one species included
	Regional protection for animals and/or plants (there are some species protected species living in river ecosystem and included in regional protection listes and/or local normatives?)	More than one species included
Protected animals and pants		
River rarity	Frequency of river types (how much this river typology is rare?)	Rare
River rarity		
Landscape categories in the surrounding of the river	Natural wetlands (there are some natural wetlands in the surrounding of the river?)	Present
	Forests and semi-natural areas (there are some forests and/or semi-natural areas in the surrounding of the river?)	Present
	Other natural landscapes (there are some other natural landscapes in the surrounding of the river?)	Present
Landscape categories in the surrounding of the river		
Total Vulnerability Assessment		high vulnerability

Figure 1. River vulnerability checklist Excel spreadsheet

The second step is to flag for every question of each subcriterion, the option that better fits in the specific case choosing among the ones available in the "Evaluation" column.

Finally the last row shows a generic score and a short definition of the vulnerability degree of the river.

The checklist is available in Excel format in the project website⁸ in the section "Criteria and indicators to identify vulnerability of Alp areas and river ecosystems"



⁸<http://www.share-alpinerivers.eu/tools-and-resources/online-handbook-links/criteria-and-indicators-to-identify-vulnerability-of-alp-areas-and-river-ecosystems>

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