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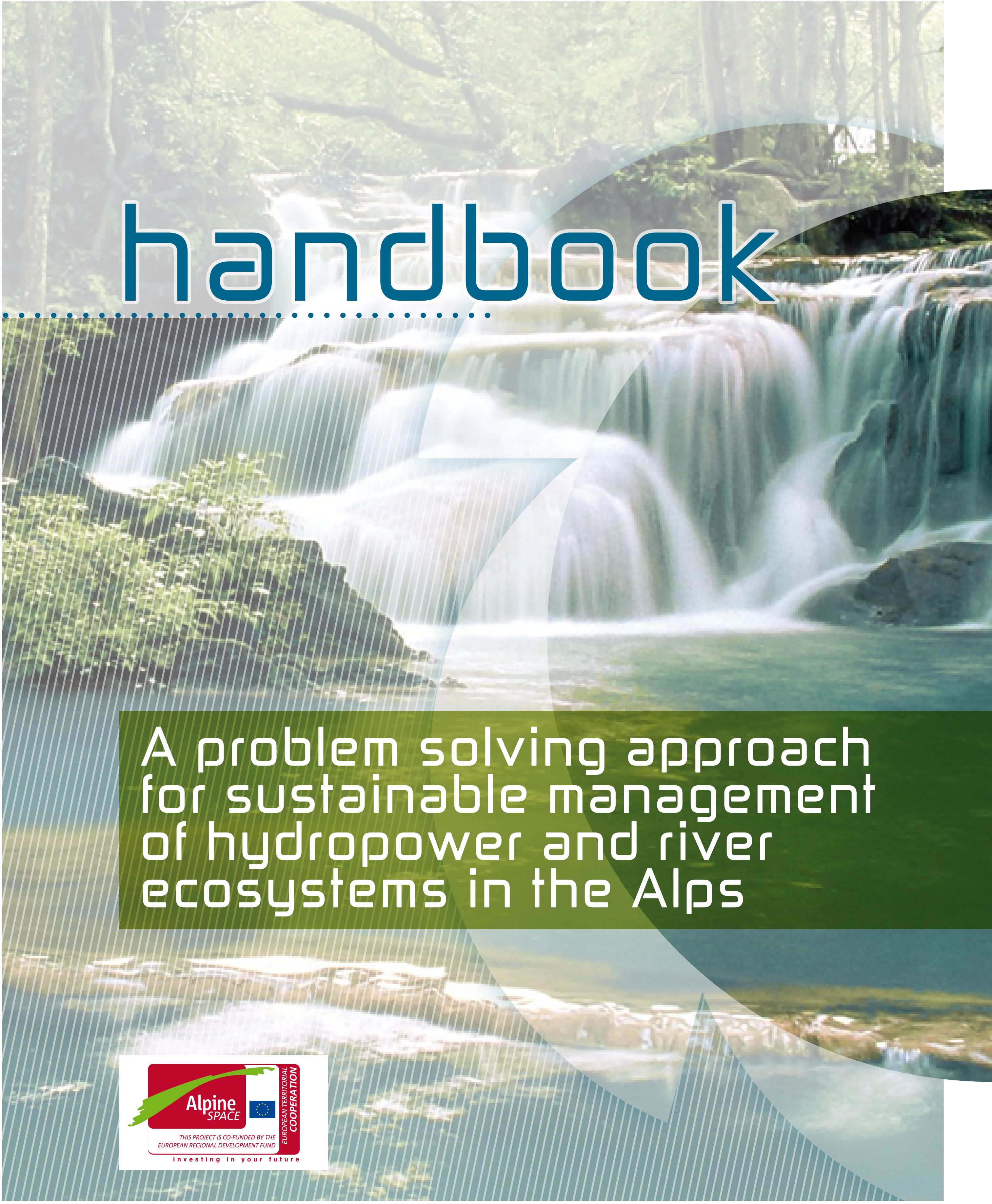
Sustainable Hydropower in Alpine Rivers Ecosystems



handbook

A problem solving approach for sustainable management of hydropower and river ecosystems in the Alps

Alpine Space
European Territorial Cooperation
This project is co-funded by the European Regional Development Fund
investing in your future

Foreword

- *Face à la gestion de l'eau suivez d'abord votre expérience puis votre raison.*
- *To cope with water follow your experience first, then your reason.*
- *Za obvladovanje vode zaupajte izkušnjam, šele nato razlog.*
- *Um Wasser zu bewältigen, vertraue Sie ihren ersten Erfahrungen, dann den Gesetzen.*

« Se t'avvien di trattar delle acque consulta prima l'esperienza, e poi la ragione »

Leonardo da Vinci

- **Is hydropower really "green"?**
  L' energia idroelettrica è "pulita" oppure danneggia l'ambiente?

- **How much hydropower potential still remains in the Alps?**
  Reste-t-il encore un potentiel de développement pour l'hydroélectricité dans les Alpes ?

- **Does hydropower receive enough economic incentives from national governments?**
  L'hydroélectricité est-elle suffisamment soutenue par les politiques gouvernementales ?

- **Does hydropower affect agriculture in the EU?**
  Glauben Sie, Wasserkraft beinflusst die EU Landwirtschaft?

- **Removing water from a river could really cause serious damage?**
  Ali odvzemi vode iz reke povzročajo realno/resno škodo?

- **Many small hydropower plants are better than few large plants?**
  Ali je bolje več manjših hidroelektrarn kot nekaj večjih?

- **Climate change could affect hydropower exploitation?**
  Kann Klimaänderung die Stromproduktion aus Wassekraft beinflussen?

- **To what extent is it useful to have a stream in natural conditions?**
  A cosa "serve" un torrente in buono stato?

- **How much do local communities earn from hydropower production?**
  Quanto "guadagnano" le comunità locali dall'idroelettrico ?

- **Who manages hydropower issues in the Alps and which criteria support the decision making?**
  Kdo je odločevalec s področja hidroenergije v Alpah in s kakšnimi merili so podprte njihove odločitve?

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Section 1: The problem to be addressed

The Alps, the "water tower" of continental Europe

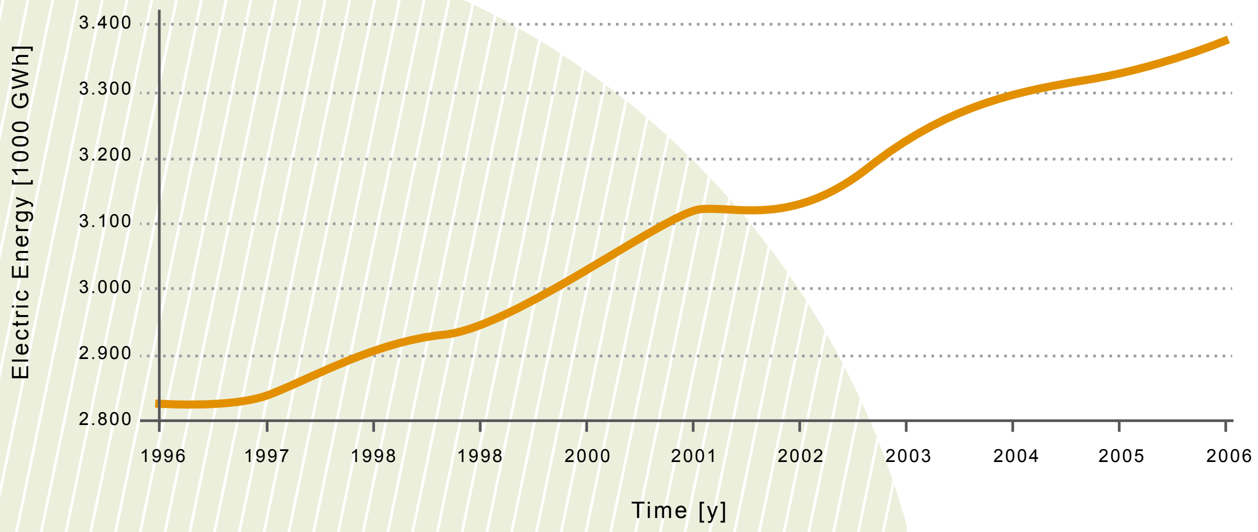
Rivers and hydropower are amongst the greatest assets of the Alps.
Hydropower is the most important renewable resource for electricity production in Alpine areas: it shows clear advantages for the global CO2 balance, but creates serious ecological impacts at a local scale. On the one hand, hydroelectric production has to be maintained and increased following the demand trend and EU directives' targets for 2020 leading to at least 20% of energy consumption coming from renewable energy sources.
On the other hand, hydropower can result in severe environmental impacts on river ecosystems: the 2000/60/CE Water Framework Directive therefore obliges member States to reach by 2015 (or maintain) a «good» ecological status in their water bodies.

Administrators daily face an increasing demand for water abstraction, but lack reliable tools to rigorously evaluate the effects of water withdrawal on mountain rivers and on energetic, economic and social factors over longer time scales: in the whole Alpine area, there is an evident need for a reliable and integrated approach for decision making related to hydropower and river management.

The Alps provide the most important freshwater supply of continental Europe: the Rhine, the Po, the Rhone and several tributaries of the Danube originate here. Various ecosystems and millions of European citizens depend on Alpine rivers for their drinkable water and their food supply, as well as economic activities (industry, tourism, forestry, navigation...).

A great source of hydropower

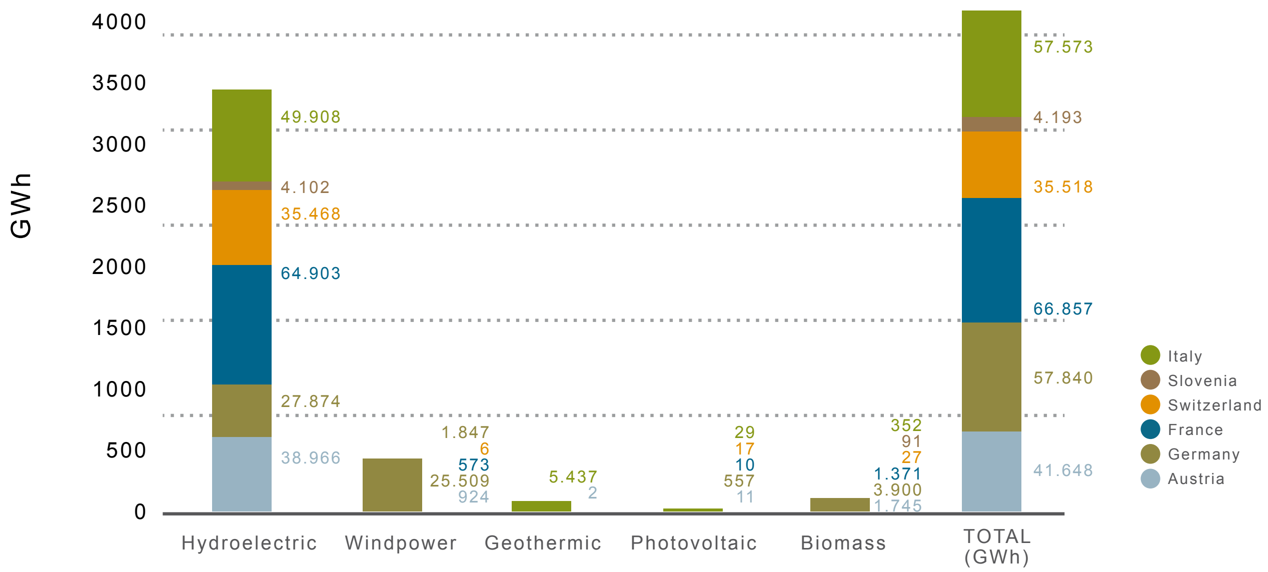
Europe is hungry for energy: over the last decade, electricity production has been steadily increasing in line with energy demand.



Electric energy production in the EU 27, 1996 – 2006

Source: Eurostat yearbook 2009

Hydropower is the most important renewable resource for electricity production in Europe: almost 84% of the electricity generated from renewable energy sources in the EU15, and 19% of total electricity production in the whole EU, is generated by hydropower (source: IEA, 2004).



Energy produced by renewable sources in EU 15

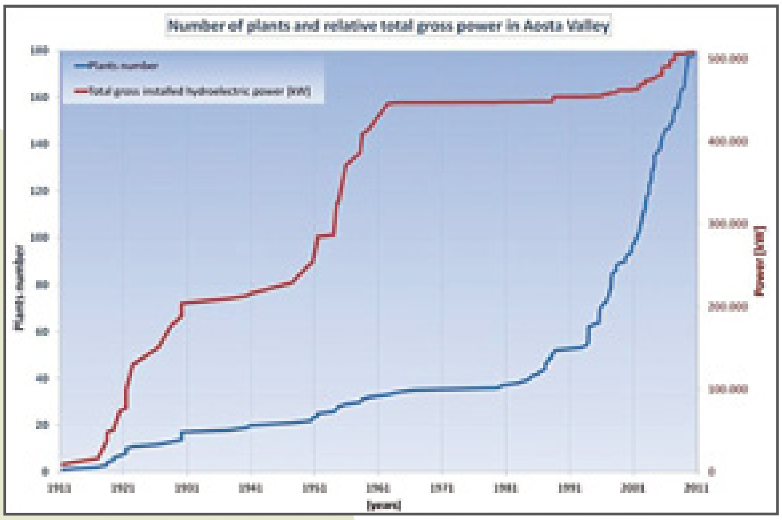
On the whole, hydropower provides a significant proportion of energy requirements in the Alpine countries, especially from big plants with dams and reservoirs, producing **peak current when electricity consumption peaks.**
Hydropower is a flexible and mature technology and creates jobs in mountain areas: Alpine territories have a highly strategic interest in developing and maintaining a high hydropower generation capacity.
The search for low carbon power generation, in combination with fluctuating prices and supplies of fossil fuels, are strong incentives for the development and maintenance of hydropower. **HP is a future-proof energy supply**, significantly improving energy resilience and providing socio-economic benefits.

Given the advantages of hydropower, there is a need for EU countries to increase their share of renewable electricity production according to the Directive on Electricity Production from Renewable Energy Sources (2009/28/EC): obligatory targets have been set for 2020, for the EU as a whole and for each Member State, leading to at least 20% of energy consumption coming from renewable energy sources.

▲ Roselend dam and reservoir, France
©Philippe Belleudy - University Joseph Fourier Grenoble

The Alps, the "water tower" of continental Europe

In addition to large hydropower stations, there are thousands of smaller hydropower stations with capacities of less than 10 Megawatts, contributing about 2% of the total electricity in the EU new small hydropower facilities: generally, the Alps have seen **a growth in the number of new small plants and a subsequent reduction of average power installed.**



Source: Aosta Valley Regional Administration, elaboration ARPAVDA, 2011

The trend in hydropower facilities and power generated in the Aosta Valley region (NW Italy). An increase in the number of plants and a decrease in average power generated is evident from the 1980s onwards.

Rivers' natural capital

The characteristics of mountain territories which provide an excellent basis for hydropower generation also constitute an exceptional environmental asset.

Hydropower cannot really ever be a «green» power: it often results in severe hydrological changes, damage to the connectivity of water bodies, destruction of river ecosystems and impairment of ecological functionality.

Alpine rivers, and their associated biodiversity, are often more vulnerable than those downstream or in lowlands. They have been subject to a long history of human exploitation, resulting in considerable impacts on biodiversity in river and riparian ecosystems. It is estimated that about 90% of Alpine rivers are no longer in their natural state: the remaining natural capital is under very high pressure!

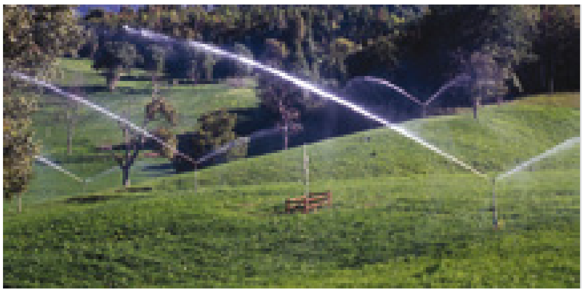
A hybrid of Marbled trout and Brown trout in the Chalamy River, Italy. Many Alpine fish species are facing threats, such as fragmentation (due to HP or other facilities) or hybridization. ►

©Erik HENCHOZ–Aosta Valley Autonomous region, Direction de la faune, de la flore, de la chasse et de la pêche

The Alps, the "water tower" of continental Europe

Climate change stresses these ecosystems, and threatens human communities that rely on them. Significant river modification caused by long-established HP developments are often considered "common & normal" and as such are often accepted as environmentally friendly. Furthermore, the 2000/60/CE Water Framework Directive obliges member States to reach by 2015 (or maintain) a «good» ecological status in their water bodies.

There are a lot of **ecological services** provided by a healthy river ecosystem to local community stakeholders involved in tourism and leisure activities, landscape conservation, mountain agriculture and angling.



Water sports on the Dora Baltea river basin
Modified from the Aosta Valley River Basin Management Plan, 2006

River Landscape in Aosta Valley
©Andrea Mammoliti Mochet , ARPAVDA

Aosta Valley (NW Italy)
Irrigation is very important for mountain agriculture especially in dry areas of the Alps.
Modified from the Aosta Valley River Basin Management Plan, 2006

The Alps, the "water tower" of continental Europe

Fishing and angling in Alpine rivers are cultural and touristic assets
©Antonio Crea, Aosta Valley Fichermen Association

Finally, river conservation and restoration are key issues for both biodiversity and local communities.

Conflict of use

Stretches of river that have a high environmental status are perceived as increasingly valuable since they have become more and more rare in the Alpine region: at the same time, these river stretches constitute an important share of the remaining potential for future hydropower generation.

Hot questions box

Is hydropower really "green"?
How much hydropower potential still remains in the Alps?
Does hydropower affect agriculture in the EU?
Reducing hydropower production means not only an economic loss, but also a denial of the consideration of the whole energy system and the continuous trend of energy demand.
Many small hydropower plants are better than few large plants?
How much do local communities earn from hydropower production?
Does hydropower receive enough economic incentives from national governments?
Removing water from a river could really cause serious damage?
Climate change could affect hydropower exploitation?
To what extent is it useful to have a stream in natural conditions?
Who manages hydropower issues in the Alps and which criteria support the decision making?
How to balance environmental protection targets for climate (through renewable energy production) with achieving a good status for all waters at the same time?
Hydropower potential has already been developed to a considerable extent in our Alpine regions?

Mountain administrators daily face an increasing demand for water abstraction, but **lack reliable tools** to rigorously evaluate its effects on mountain rivers and on energetic, economic and social factors over a longer time scale.

Section 1: The problem to be addressed

Chapter 1 - Different views of a single assets's future Hydropower as a renewable resource

Hydropower accounts for a substantial proportion of the Alpine area`s total renewable electricity generation. Balancing the economic interests of electricity generation with the environmental needs of the river ecosystem is essential for the Alpine region. Water plays an important role both as a key economic factor and as a life-sustaining force, since hydropower in the Alps relies on runoff from the mountains. Sustainable and appropriate use of water in support of integrated river management is one of the topic areas that the SHARE project seeks to develop.

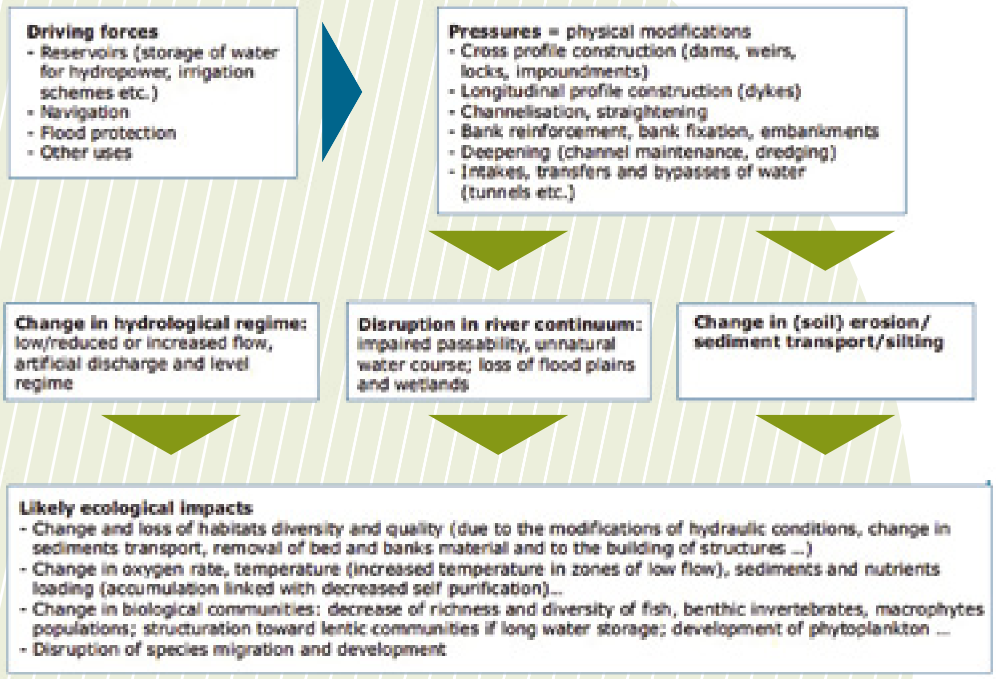
Increasing demand for water abstraction

Water abstraction constitutes a significant human influence on river ecosystems. Water resources are limited in quantity and changes in water availability are likely to lead to conflicts, since water availability and demand vary regionally. The appropriate steps have to be taken to meet demands whilst preserving the vital resource, water. Economic benefits must be balanced against water supplies to service vulnerable ecosystems.

The Alps play an important role in accumulating water to Europe's river basins. The following two questions are urgent for the Alpine region and can be expected to become even more important in the future:

- How can the growing demand for water be met?
- How will water resource demand in the Alps evolve in the future?

Uncertainty over the impact of abstraction on the environment can cause irreversible damage to river ecosystems, because river ecosystems are complex and subject to a variety of pressures.



Conceptual links between water uses and pressures related to physical modifications, resulting in changes to hydrological regimes, disruption of the river continuum and sediment transport

© European Environment Agency (EEA): The European environment - state and outlook 2010

Chapter 1 - Different views of a single assets's future
Hydropower as a renewable resource

▲ Effects of hydropeaking at the Sölkbach at Stein an der Enns
© BOKU Vienna, http://hydropeaking.boku.ac.at

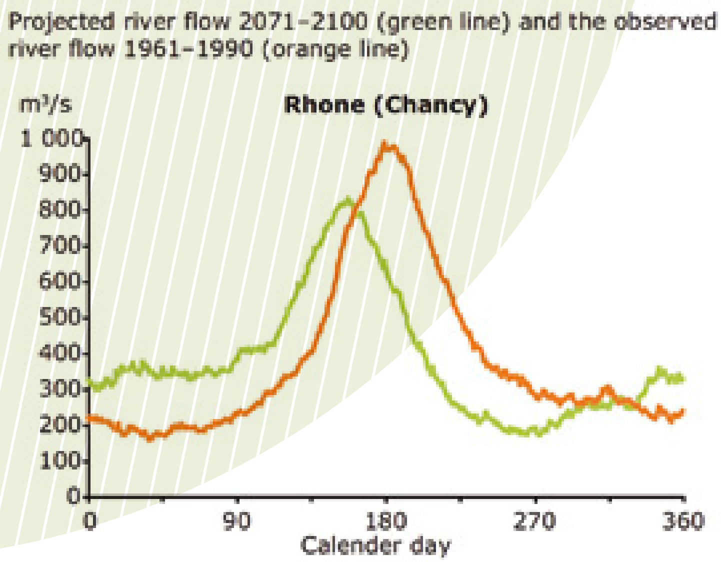
A certain amount of water needs to be retained in rivers to maintain their ecological integrity. River discharge has been changed in several Alpine streams by abstraction for hydropower (Source: Maiolini, Bruno 2007). The release of turbinated waters leads to sudden changes in water discharge, termed hydropeaking, which has negative effects on the river ecosystem.

Hydropower state and trends in the Alpine area

Because of their physical features (steep slopes, high levels of precipitation, glaciers as stores of water in the form of ice), the Alps are a key source of renewable energy. **Hydropower already has a long tradition in this region through the use of water mills over many generations.**

The Alpine region is an area of conflict between ecological and economical demands. On the one hand, a very high hydropower potential is located there, but on the other, the uniqueness of the remaining unexploited rivers is endangered by increasing hydropower development.

The trend of glacial retreat and higher temperature as a result of global climate change will definitely affect Alpine hydropower generation in the future. Climate change will lead to changes in the hydrological cycle, and thus poses numerous potential risks to river ecosystems in the Alps (decreased runoff, shift of timing and distribution of runoff), although it is difficult to predict the detail of the impact. The spatial and temporal variability of runoff will increase, with the resulting danger of potentially higher flood probabilities. As a consequence, hydropower reservoirs might be used increasingly for flood retention purposes. The figure below shows an example of how climate change is projected to lead to significant changes in yearly and seasonal river flow and water availability.



Relative change in annual river flow and change in seasonal river flow for the river Rhone between a future scenario of climate change (2071–2100) and reference period (1961–1990)

© European Environment Agency (EEA): The European environment - state and outlook 2010

Chapter 1 - Different views of a single assets's future Hydropower as a renewable resource

Most potential sites for hydropower plants in the Alps have either already been developed, or are within nature conservation areas. Equipping existing power plants with more efficient turbines can be a cost-effective way to realize efficiency gains.

The following two Tables show the power output of both small and large hydropower plants (HPP) in the Alpine region. The threshold between small and large hydropower plants is often defined with a bottleneck capacity of 10 MW.

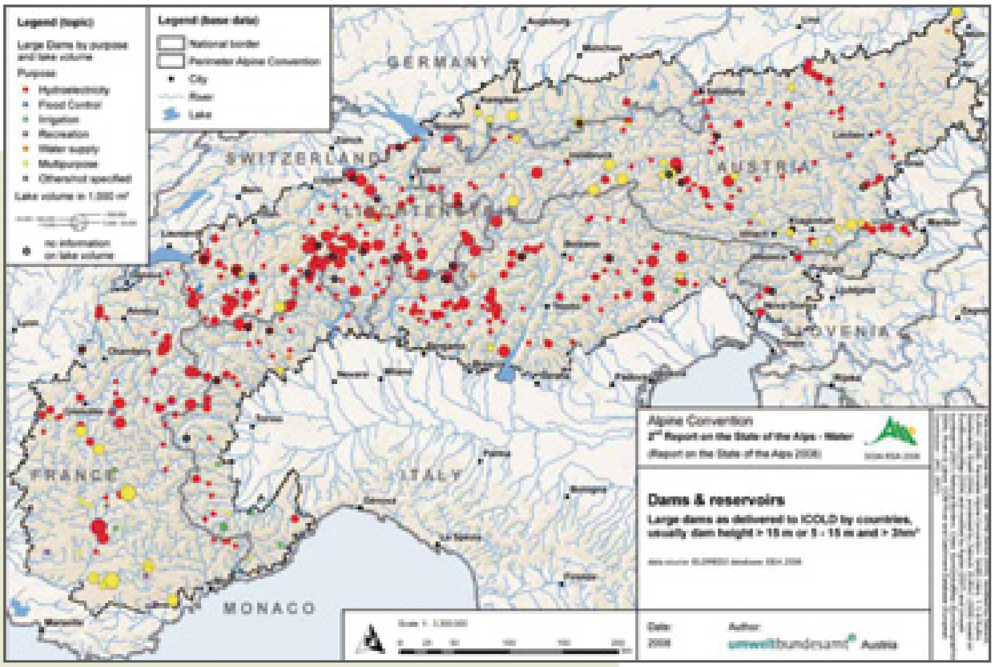
COUNTRY	2008	2009
Italy	2 542.0	2 588.0
France	2 079.0	2 082.0
Germany	1 552.0	1 590.0
Austria	820.0	842.0
Slovenia	155.0	159.0

COUNTRY	NUMBER OF HPP (POWER OUTPUT > 10 MW)	TOTAL POWER OUTPUT IN MW (POWER OUTPUT > 10 MW)
Italy	169	14.403
France	128	12.552
Austria	112	8.235
Germany	16	523
Slovenia	12	516

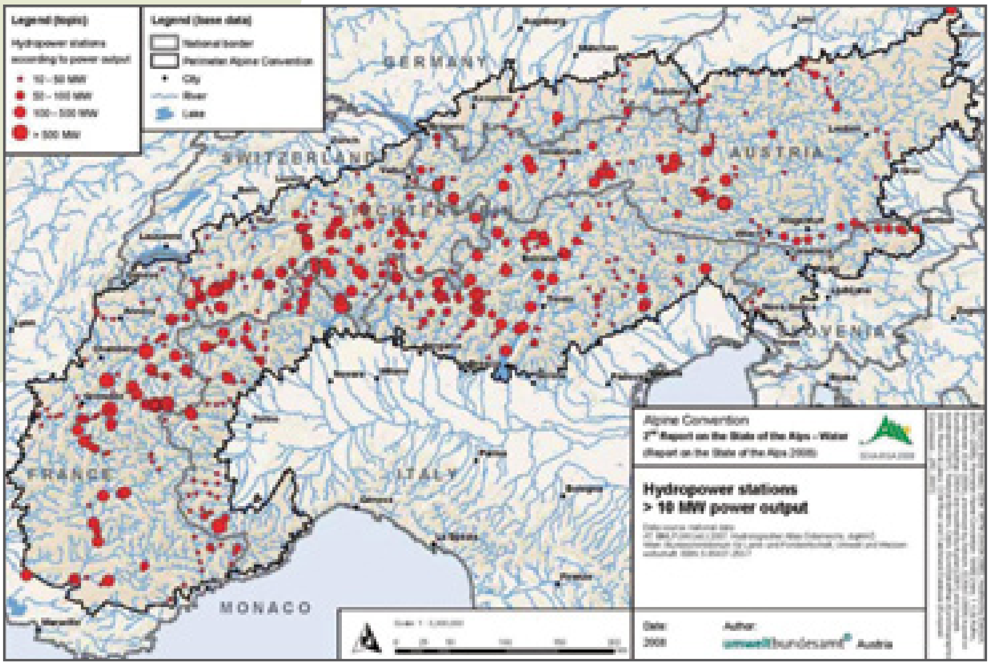
In the two maps below, the geographical distribution of large dams and hydropower plants in the Alpine region is shown. The data collected for the 2nd Alp Report amount to an installed capacity of the power plants of over 28 Gigawatt [GW], producing over 46 Terawatt-hours of electricity each year [TWh/yr] (Source: Alpine Convention 2009). In addition to this, there are also hundreds of smaller hydroelectric plants situated in the Alpine region.

Chapter 1 - Different views of a single assets's future
Hydropower as a renewable resource

▼ Large dams in the Alpine region
©Alpine Convention, 2nd Report on the State of the Alps



Large hydropower stations with capacities of more than 10MW in the Alps ▼
©Alpine Convention, 2nd Report on the State of the Alps



Chapter 1 - Different views of a single assets's future Hydropower as a renewable resource

Considering the large number of pumped-storage power plants located in the Alps, the importance of the Alpine region within the European energy system becomes obvious. This storage capacity will most likely be further expanded in the near future and will support the stability of the grid throughout Europe.

An interesting idea for the future of hydropower, proposed by the EU project CH2OICE (www.ch2oice.eu), is the certification of hydropower. This would mean a feasible certification procedure **(«green labelling»)** for hydropower plants to reach the goal of more sustainable hydroelectricity, being renewable as well as environmentally friendly for river ecosystems.

Hydropower production & Directive 2009/28/CE

The Directive 28/2009/CE for the promotion of energy from renewable sources sets a target of a 20% share of energy from renewables for the whole European Union by the year 2020. The increase of the production of renewable energy is an absolute necessity to meet the goal of a reduction in CO2 emissions.

As a consequence, this will probably also lead to enhanced economic growth, since many European companies are currently among the world leaders in research and development of renewable energy technologies. The annual EurObserv'ER report "The State of Renewable Energies in Europe" provides background information on the renewable energy realisation and the renewable energy share in the EU Member States.

The key data for the year 2010 of the European Union countries (EU-27) are the following (EurObserv'ER 2011):

- Renewable energy share of gross final energy consumption: 12.4% in 2010 (11.5% in 2009)
- Renewable energy share in total electricity consumption: 19.8% in 2010 (18.2% in 2009)
- Renewable energy share of gross inland energy consumption: 9.9% in 2010 (9.1% in 2009)

In the table below, the progress of the Alpine EU member countries and the national targets for the year 2020 is shown.

COUNTRY	2009	2010	2020
Austria	30.2%	30.7%	34.0%
Slovenia	19.7%	21.7%	25.0%
France	11.7%	12.4%	23.0%
Germany	9.3%	10.7%	18.0%
Italy	7.7%	8.5%	17.0%

Chapter 1 - Different views of a single assets's future
Hydropower as a renewable resource

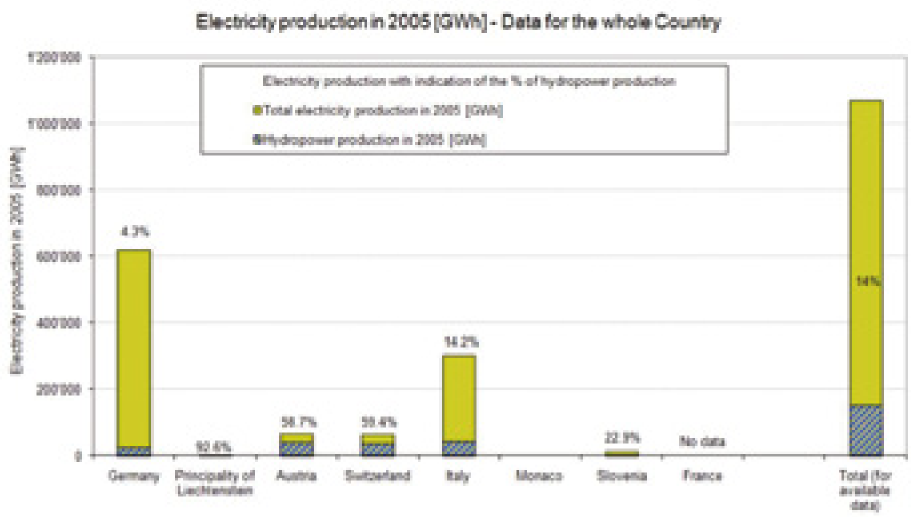
A first map of the residual potential coming from a census of existing HP power plant demands at Alpine Space scale is available as an electronic annex.

Maps of residual HP potential in Alpine Space

Hydropower has many advantages compared to other renewables:

- The high efficiency of up to 90%, which makes hydropower much more efficient than solar energy or wind power;
- Hydropower is independent of sunshine or wind speed, which enables uninterrupted power generation;
- Investments in hydropower are characterized by relatively high initial costs, but followed by long running periods and very low operating costs;
- Hydropower enables a quick response to grid demand fluctuations caused by other renewable sources;
- Since other renewable energies such as solar and wind are not competitive, their development has to be supported through public funding.

In the chart below, the relevance of hydropower for electricity production in the Alpine countries is shown. While the importance in Austria and Switzerland is very high, in Germany hydropower has only a marginal share of overall electricity production.



© Platform Water Management in the Alps 2010

Section 1: The problem to be addressed

Chapter 2: Different views of a single asset's future Alpine rivers - an environment to be protected

The Alps constitute one of the most important biodiversity hotspots at a global level, but as in every complex system, it is also fragile and vulnerable to human impacts.
Running waters have been modified by man across the centuries for several purposes such as fisheries, navigation, irrigation, drainage, drinking water or waste disposal. With the beginning of the 20th century, hydropower became the most important source of electricity generation. The greatest proportion of electric power is generated by only a few large plants, but most of the Alpine rivers are affected by many thousands of small hydropower plants. The Directive 2000/60/EC, with the environmental objective of achieving and/or maintaining a "good" ecological status of water bodies, has created a complex and comprehensive framework for the conservation of surface waters.

From the smallest watercourse to the biggest river, all Alpine rivers and streams host an **extraordinary diversity of habitats and species of flora and fauna**, making the Alps one of the most important **biodiversity hotspots** at a global level.

Alpine freshwaters are highly dynamic systems: thanks to a high amount of solid transport, natural rivers and streams periodically destroy old, and create new, habitats. These dynamic processes create and support optimal ecological conditions for the growth and conservation of all biological communities of Alpine watercourses. But today, only **about 10% of the rivers and streams of the Alps can be considered ecologically intact**: the remaining 90% is frequently polluted, over-engineered and compromised in terms of its flow regime.

▲ Dora di Ferret river - Aosta Valley Region - Italy
© ARPA VdA

Hydropower exploitation and the effect on riverine ecosystems

Unimpaired rivers have the ability to self-support and maintain all of their animal and plant communities in terms of diversity and composition. In ecological terms, we can define all of these complex functions **as the river´s functionality or integrity.**
Hydropower exploitation produces **complex effects** on river ecosystems. The following points give a general overview of these effects on riverine systems.

Dams and weirs (impoundments)

- **General effect:** The damming of a river affects all dimensions of a river ecosystem: the river continuum is disrupted and the natural zonation of habitats is altered; connection to the groundwater can be lost; natural floods are mitigated and the river seldom breaks the banks (lateral and temporal dimensions). Many fish populations are endangered and are unable to maintain stable densities because they have been separated from their preferred spawning grounds (*Poulet 2007, Freeman & Marcinek 2006*).

▲ Leuctrid stonefly
© Leopold Füderer - University of Innsbruck, Austria

Chapter 2: Different views of a single asset's future Alpine rivers - an environment to be protected

- **Impoundment and temperature change:** Impounded river stretches are primarily characterized by decreased flow velocity and increased upstream water volume. Water temperatures of reservoirs and impoundment stretches are cooler in summer and warmer in winter compared to the natural situation, but for residual flow stretches, the opposite pattern is evident. In summary, the temperature differential of several degrees (°C) leads to significant consequences for biological relationships in riverine systems (*Hütte 2000*).
- **Decreasing flow velocity:** The reduced current speed, with only minor surface turbulence, in impoundments and reservoirs diminishes the concentration of atmospheric oxygen in the water. The sedimentation of suspended load is increased and nutrients can accumulate. Reduced water velocity, clear water, increased radiation and nutrient supply favour the growth of aquatic plants and algae, which may even lead to oversaturation of oxygen.
- **River bed colmation:** Changes in river bed conditions and substrate composition are often the result of discharge alternations due to damming (Schälchli 1992). This affects the benthic and the interstitial invertebrate community. The colmation of the substratum is also a major problem for lithophilic fish: colmated gravel banks are unsuitable spawning substrate and therefore endanger the reproduction of fish populations (*Smith 2009*).

▲ Ecdyonurus sp. larva; macrozoobenthos is a good indicator of river health
© Leopold Füderer - University of Innsbruck, Austria

- **River Continuum:** The disruption of the river continuum by dams or weirs is a pressure mainly affecting the fish fauna by preventing up- and downstream migration. Dams fragment habitats and separate fish populations, hence reducing genetic variability.

Hydrological alternation

The natural hydrological regime is altered depending on the hydropower operation: reservoir hydropower plants shift the higher discharges from the summer to the winter months, while run-of-river plants equalize the natural discharge fluctuations of a typical Alpine stream. Only bigger flood events bring in some dynamic processes. The disturbed transport of bedload and sediments into downstream sections reduces the capacity of morphological transformation processes.

▼ Crenobia alpina
© Leopold Füderer - University of Innsbruck, Austria

Discharge alteration is the major physical factor in riverine systems affecting the biotic components and processes (*Forstenlechner et al. 1997, Bunn & Arthington 2002*)

Chapter 2: Different views of a single asset's future
Alpine rivers - an environment to be protected

Residual water stretches and water diversion

The impacts are mainly concentrated in the **water stretches downstream of the withdrawal**. The intensity of the pressure depends on how much water is abstracted, and is measured by the remaining instream flow and the length of the section until the point of water restitution. The discharge is significantly decreased and more or less similar on diurnal and annual scales. Natural floods, bedload transport and riverbed transformations are missing completely or are mitigated. Residual flow stretches are further exposed to higher risks of deterioration of water quality by nutrients, pollutants and toxicants because of the decreased buffer capacity of their smaller water volume.

Hydro peaking / Thermo peaking

Hydro peaking:
Surge waves and rapid drops in water levels are typical effects of the power peaking management of reservoir hydropower plants. Run-of-river plants can also be managed in this way, although with minor amounts of stored water. Thus, the phases of storage can take from only some hours over a few days up to weeks depending on the size of the reservoir. Hydro peaking in general leads to high disturbance and a loss of habitat quality. Surge waves often approach very quickly compared to natural flood events, and aquatic species are unable to adapt, for example by seeking shelter as they would under natural conditions. Catastrophic displacement of fish, eggs and macro invertebrates is often the consequence (Moog 1993, Cereghino 2004). When water levels are returning to normal, some aquatic organisms aren´t able to reach the main flow channel or to find shelter in deeper soil layers and hence may get trapped in pools or stranded on gravel banks. Dry falling of spawning grounds, juveniles and nests are also major problems for fish populations (*Moog 1993, Saltveit et al. 2001, Halleraker 2003*).

Hypolimnic water release:
Increased turbidity of water from high altitude reservoirs or from the hypolimnion affects the temperature regime at the site of return. Rapid fluctuations in temperature may cause stress to fish and must be compensated by dispersal or physiological adaptation.

Turbines

Turbines represent the heart of a hydropower facility, transferring the energy of the running water to the generator. The main impacts of turbines relate to the fish fauna. Fish passing the turbines are exposed to sudden changes of hydrostatic pressure that can cause swim bladder rupture and bubble formation inside tissues (gas bubble disease). The rotor is a mechanical threat that can cause physical injury or mortality, the level of threat depending on turbine type, and the species, age or size of the fish.

Chapter 2: Different views of a single asset's future
Alpine rivers - an environment to be protected

WFD implementation, strategies and policies

In 2000, the European Union established a framework with the objectives of protecting all inland water bodies, groundwater and the accompanying environment, to prevent and reduce pollution, to promote sustainable water usage, to improve aquatic ecosystems and to mitigate the effects of floods and droughts. By 2015, a good ecological and chemical status has to be achieved for all Community waters. The whole process of implementation follows several steps (see table below). For supporting the implementation of the WFD, several guidance papers have been produced within the 'Common Implementation Strategy'.

DEADLINES	OBJECTIVES	ARTICLES WFD
2000	Enforcement	Art. 25
Implementation		
2003	Transposition into national law	Art. 23
2004	Identification of river basin districts and competent authorities	Art. 3
Surveys		
2004	Analysis of river basin district characteristics Examination of pressures and impacts of human activities Economic analysis of water usage	Art. 5
Monitoring		
2006	Register of sites for the intercalibration	Annex V
2006	Monitoring programs for the status of water bodies established Monitoring of the status of surface waters, groundwater and protected areas	Art.8
Involvement of the public		
2006	Publications of time schedule, working program and of the most important issues of water management	Art. 14
2008	Publication of river basin management plan drafts	Art. 13
Management plan and programmes	of measures	
2009	Finalization of management plan and programs of measures First management cycle starts	Art. 13 & 11
2010	Introduction of pricing policies	Art. 9
2012	Implementation of measures	Art. 11
Achievements of objectives and	next management cycles	
2015	Accomplishing environmental objectives First management cycle ends Second river basin management plan & first flood risk management plan	Art. 4 & 13
2021	Second management cycle ends	Art. 4 & 13
2027	Third management cycle ends, extension of time for meeting the objectives	Art. 4 & 13

Chapter 2: Different views of a single asset's future Alpine rivers - an environment to be protected

WFD objectives and assessment

For all European surface water bodies, as directed by Article 4 WFD, the environmental objective is to reach a good ecological and chemical status by 2015 and to prevent deterioration in status class. **Precise and unbiased monitoring** is the key for determining the status of waters and for deciding what measures are needed in the river basin management plans to reach the objective.
The new approach of the WFD is to assess, aside of water quality and chemical status, the ecological integrity of surface waters, referring to biological, hydro-morphological and general physico-chemical quality elements. This means that **different and type-specific ecological characteristics have to be considered.**

A report on status objectives for AS ecoregions and river typologies is available as an electronic annex.

Water Framework Directive status objectives for Alpine Space ecoregions and river typologies

River status monitoring according to the Water Framework Directive

In accordance with the implementation of the European Water Framework Directive (2000/60/EC), the monitoring of aquatic ecosystems and the assessment of their ecological integrity using biotic and abiotic indicators has become a common tool. The indicators are used to check the status of water bodies in a comprehensive way at a river basin scale, and to survey the success of measures applied to reach a good ecological status.

TYPOLOGY	QUALITY ELEMENTS
Biological quality elements	• Phytoplankton • Macrophytes and phytobenthos • Benthic invertebrate fauna • Fish fauna
Hydro morphological quality elements	• Hydrological regime • River continuity • Morphological conditions
Physico-chemical quality elements	• General conditions (nutrient concentration, salinity, pH, oxygen balance, acidity and temperature conditions) • Specific synthetic and non-synthetic pollutants

A technical review describing WFD, Floods and other EU directive implementation is available as an electronic annex

Technical review describing WFD, Floods and other EU directives implementation in Alpine Space

Chapter 2: Different views of a single asset's future
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Abiotic & biotic indicators to evaluate the status of the river ecosystem

To assess the impacts of hydropower management on Alpine river ecosystems, SHARE has developed a **toolbox containing a collection of abiotic and biotic indicators of monitoring standards** used in the Alpine countries following comprehensive scientific bibliographic research.

Useful indicators must respond to the different impacts of HP plants such as banks and soil sheeting or fixation, residual flow, hydro peaking or disruption of the river continuum. Some indicators were further refined and tested in the SHARE Pilot Case Studies, and adjusted as appropriate.

Abiotic & biotic indicators of aquatic ecosystems for the SHARE Pilot Case Studies

In general, an indicator provides information on a distinct set of circumstances. In nature and environmental sciences, indicators are used to measure the health and ecological status of, and the changes to, an ecosystem (mostly anthropogenic), for example in terms of nature conservation.

Abiotic indicators

Abiotic indicators, such as chemical compounds and physical conditions, show the selected indicator components with a precise unit value at the measurement point. Indicators may represent a present condition, or they may comprise long-term measures demonstrating variation in indicator values over time. It is possible to detect very precisely potential indicators such as specific pollutants, toxicants or acidification from point and non-point sources, as well as the profile of water temperature or oxygen concentration.

Biotic indicators

Biotic indicators are biological groups or species reacting to changes in their environment which have consequences for their vital functions, spatial abundance or probability of occurrence. Species' reactions to pressures and changes in environmental conditions are used in the monitoring of ecosystems. Biotic indicators respond to chemical/physical alterations as well as to more comprehensive alterations such as changes in habitat structure or habitat destruction. The sensitivity of an indicator is of particular importance. Biotic indicators are typically less precisely quantified than chemical/physical measures, but they can give more comprehensive information on synergistic effects of environmental impacts (e.g. **fish fauna are highly sensitive to alterations in hydro-morphology due to a loss of habitat or to the disruption of the river continuum**).

Indicators and indices for biological river assessment

This assessment approach uses fish, benthic macro invertebrate communities, and phytobenthos communities to evaluate the ecological status of rivers and streams. Furthermore, riparian vegetation and arthropod communities can also be used for river stretch assessment.

Fish assessment methods

The fish fauna stands out as a potential indicator due to the adaptations of fish species to particular conditions, their consequent sensitivity to environmental change, their specific habitat requirements at different stages of their life cycle, and their longevity, which makes it possible to determine pressures and impacts over periods of time. Most indicators using 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*). Several habitat models have been developed on the requirements of typical species to water depth, current velocity, and substrate (*Schneider et al. 2010, Program CASiMiR-Fish*).

SHARE CASiMiR software to assess habitat conditions along the river channel and bank areas

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Benthic macroinvertebrate 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, their diversity, and their adaptations to specific conditions. In general, a high correlation between indicator values and organic pollution or general degradation can be achieved. However, the use of a multimetric system for general degradation makes it very difficult to make a link to a specific pressure. Possible 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 (feeding groups, littoral or lower river bed colonizers).

Phytobenthos assessment methods

Aquatic plants are important primary producers and grow on organic nutrients. Thus they react mainly to changes in trophic levels unrelated to hydropower production. Other physical factors such as current, light and substratum may, however, favour biomass or a specific species composition.

The irregular response to HP pressure from biological river communities has been considered in the Pilot Case Studies chapter.

MCA indicators used in PCS
Section 3 - Chapter 2

Indicators and indices for physico-chemical assessment

Hydromorphology

This component of river assessment provides a comprehensive approach which includes many indicators, such as river bed dynamics, river bank dynamics, river bed structure, hydrological regime and wet area variation. The importance and fitness of such derived indicators have been considered in the Pilot Case Studies chapter.

MCA indicators used in PCS
Section 3 - Chapter 2

Water quality

The water quality criterion includes general physico-chemical parameters such as temperature, oxygen (O2, BSB5, DOC), pH, conductivity, nitrate, ammoniacal nitrogen, phosphorous, and ortho-phosphate-phosphorous. This approach shows the general water quality and intactness of a fluvial system. Also widely used are saprobes (fungi, bacteria and protozoa) and aquatic plants as indicators of the level of organic water pollution and nutrient load.

A detailed **database of useable indicators (SHARE indicator toolbox)** for river and HP issues has been developed within the SHARE project and is available as an electronic annex.

SHARE indicator toolbox
Map of most vulnerable to HP river typologies
Criteria and indicators to identify vulnerability of Alpine areas and river ecosystems

Section 1: The problem to be addressed

Chapter 3 - Different views of a single asset's future Alpine rivers - different stakeholders & ecosystem services to be considered

There is a large variety of rivers, from mountain creeks to large Piedmont rivers which may be furnished with or influenced by hydro-power equipment. Those rivers support a broad range of eco-systems and are the result of complex and interrelated mechanisms. The whole system is working in dynamic equilibrium because of the natural variability of the driving climatic conditions.
HP production is only one of the Ecosystem services supported by rivers. The resources from the river and from its floodplain have allowed the development of complex and diverse human activities. The expectations of a broad diversity of human communities and of stakeholders have evolved as a consequence of these resources.

The step pool river type - Brunnibach, Uri, CH ►
©Philippe Belleudy – University Joseph Fourier

A diversity of ecosystems

The slope is the driving character of water courses in the mountains, providing the potential for HP systems. The slope is the main factor producing the large diversity of Alpine rivers. In the upstream part of the watershed, the step pool is characteristic of a poor sediment transport (fig. Brunnibach), as debris flow initiated in erodible slopes may dramatically shape the river bed. This material is deposited in the confluence zone and more regularly distributed. Because of the large amount of sediment coming from upstream, the Piedmont river develops the characteristic braided bed (fig.Drac), but the possibility for lateral mobility of the river is often limited in Alpine rivers because of human activities, especially the construction of levees.
There is a direct relationship between water and sediment fluxes from upstream to downstream, and the general profile of the river shows a decreasing slope (and finer bed sediment) downstream. However, rock outcrops may sectorize a river with reaches of relatively gentle slope even in the highest portions of the watershed (fig.Soulcem) in steep un-erodible gorges.
This diversity of river types defines a variety of eco-systems. The same structure, e.g. for HP production, will have different impacts depending on the river type.

Complex and interrelated mechanisms

Understanding river systems is challenging for scientists because they involve a complex series of interconnected processes in different domains, e.g. hydrology, biology (fauna & flora), hydraulics, geomorphology, and geochemistry. The river works naturally from upstream to downstream, and the properties of the downstream reaches are the result of driving parameters which were determined in the upper reaches. Any perturbation at a given point of the watershed will have consequences downstream of this point, even if they are sometimes strongly damped and delayed.

The flow perturbations propagate downstream with a characteristic speed which makes them highly perceptible. In a different way, the transport of bed material by floods is by three orders of magnitude less than the water fluxes themselves, and morphological perturbations need years to develop and to be propagated downstream. The morphological changes and their consequences for the riparian environment, especially the vegetation, follow this rhythm which is far less perceptible than the flood

▼ A braided river – Drac, Fr ©Philippe Belleudy - University Joseph Fourier Grenoble

itself. The variability of the driving factors (flow and sediment upload) and many related effects will build systems in dynamic equilibrium and some interactions may have slow but severe impacts.

Some driving processes are evolving very slowly, or in directions that are not yet clear, rendering a prognosis of river evolution even more hazardous. Land use is a case in point, because the potential impact of transformation of human communities and/or climate change on land use is difficult to predict, therefore consequences for the runoff, and for the sediment supply to the river network by erosion, are very difficult to predict with any degree of precision.

“Natural rivers” and “healthy rivers” are distinct ideas. A natural river is a river whose natural variability is not conditioned or constrained by human actions. A healthy river is a river which has developed a rich variety of species, and whose characteristics are stable. For the people who live along the river, the quality of the rivers is perceived in terms of landscape, recreational potential, economic value, and safety relating to flood threats, etc These are diverse and sometimes contradictory aspects that need to be further developed in the following section.

A wide diversity of human communities and stakeholders.

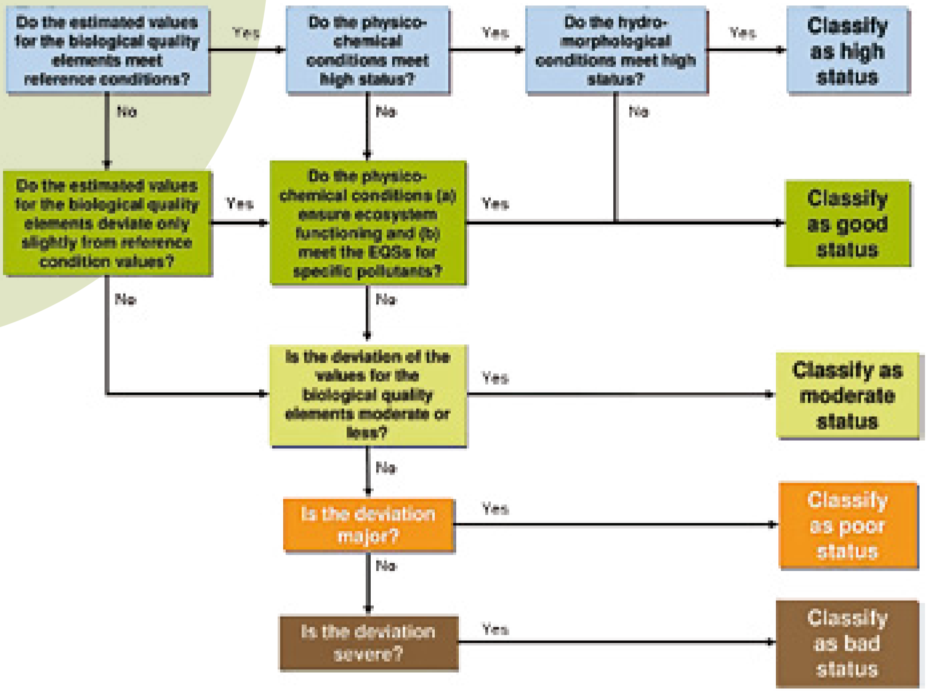
There are many ways to describe the diversity of the demands of the river system and of the needs of stakeholders (ref. RiZeRiLi, 2007). The following gives some examples of these complex interrelations of the stakeholders’ interests:
Generally, the activity in the upstream basins still has some rural and traditional characteristics, compared to the Piedmont region in general which is often more urbanized and has more industrial activities. Key issues, particularly the demand for resources (e.g. land / river protection) and the acceptability of perturbing structures will be dependent on those characteristics.
The sharing of all kinds of resources is affected by conflicts of interest and opposition of the different groups of stakeholders. The river system and its services are one of these resources. With a higher urban concentration and more complex structures, the pressure is especially important in the Piedmont region where the river (water and territory) is coveted at the same time by industry for waste and cooling or HP production, agriculture for water and land reclamation, communications for land reclamation, public services for water, recreational areas and attractive river banks for urban rivers, and NGO’s on behalf of non-speaking species (fauna and flora!). Issues related to risk, such as the demand for expansion areas for flood protection, are conflicting with industrial demand for land and with communication structures (fig. Isère).

As the functioning of the river is at a basin scale, the ecosystem services, and the demand of stakeholders and actors along the river course, must be considered at the same scale, but caring for resources and mediation must be performed at different scales: local (the valley), basin and global.
Some conflicts may arise with demands concerning differing requirements of different stakeholders within their particular territory. For example, the urban riverine population may require a recreational river environment, or the preservation of landscapes upstream to maintain protection for the local farmers’ fields.

• Chapter 3 - Different views of a single asset's future Alpine rivers - different stakeholders & ecosystem services to be considered

Environmental protection of the mountain river may be required by urban populations, sometimes against economic considerations of the energy producer, but also with the fear of a certain deprivation of the local rural stakeholders' territory. Is the recreational and scenic attractiveness of a reservoir created for energy production worth the destruction of pastures and mountain villages? (fig. Roselend, in the previous section). Who will evaluate such a project and with what sort of scale of values?

Immediate impacts are more easily considered than long-term consequences. When assessing the impact of a hydro-power plant on fish habitat, the perturbation caused by hydropeaking or by the variability in water depth will be considered, as well as the eventual scouring of the river bed after a decade of functioning, and the armouring of the river bed will be neglected. In a certain way, the legislation supports such an underestimation. In the WFD, the hydro morphological conditions are assessed only when biological and chemical conditions meet high status; the morphological good status which specifies substrate conditions and connectivity to secondary flow areas does not explicitly mention the necessity for an assessment of the change of such conditions after several years of disturbances to the hydrological regime.



Floodplain in a Piedmont Valley – Isere River Fr
Role of hydro morphological elements in determining Ecological Status in the WFD

Source: UK technical advisory group, cited by Houston and Glasgow, 2008

Chapter 3 - Different views of a single asset's future Alpine rivers - different stakeholders & ecosystem services to be considered

Real impacts are also better considered than potential impacts, in particular, risk issues, i.e. the potential for damage with a low probability of occurrence – "Will it really happen? Will I suffer from it?" - gives the priority in the decision framework to an immediate action for the attention of the riverine populations. This action may even increase the potential for flood risk in the future. This is the case, for example, with dredging in the river bed that temporarily increases the cross-section of the river and its capacity to convey floods, but will contribute to a lack of bed material downstream and a transformation of the river's morphology when repeated after each flood event. In the final political decision, immediate consequences on the electors' life means a decision may be made with little or no consideration of the problems which could be faced by following generations.

Communities themselves are evolving.
Example 1: mountain populations are shifting their interest from an attachment to their traditional activities to a pragmatic adhesion to the industrial or touristic transformations that will accrue some immediate benefits, sometimes with a real long-term improvement to their economy (ref. Roselend dam in Vivier, 1992).
Example 2: farmers of the Piedmont Isere valley (fig. Isère, ref. RiZeRiLi, 2007) are preoccupied with the extension of Grenoble's suburban area, and welcome the flood protection plan that fixes the agricultural land area because it provides an expansion zone for the floods; at the same time they do not accept this "sanctuarization" policy because it restricts the possibilities for development of other activities on those areas in the future.

Last but not least, a territory and its rivers are sometimes organized in a complex administrative scheme (e.g. in France Communes/cantons/départments/EPCI/comités de bassin...). The subsidiarity is difficult to apply because of the multiple interconnected interests.

Basic attitudes

Do not act as a single specialist: The river system is a complex one.
Evaluate the fluxes and assess the seasonal variability. Allow enough room for the natural divagation of the river.
Consider floods and droughts as normal events.
Allow the possibility for sustainable behaviour of the river system within the natural cycle of crisis/relaxation.
Acknowledge the uncertainty in our knowledge of the processes and their evolution.
Take account of processes, even working over a longer time scale.
Take account of human systems. A good decision needs cooperation of everyone along the river.

Section 1: The problem to be addressed

Chapter 4 - Growing conflict of use

The Alps cross the centre of Europe, playing a crucial role in supplying and accumulating water for the continent.
The Alps are widely recognized as the "water towers" or "water castle" of Europe, originating some of the most important European rivers such as the Danube, the Rhine, the Po and the Rhone, carrying out vital ecosystem services and supporting social and economic wellbeing across a wide lowland area.
Integrated water management is focal for the sustainable development of the Alpine Region: there is a high pressure on mountain rivers, generating conflicts of use.
Climate change will increase EU water demand for multiple uses, exacerbating conflicts between different stakeholders.

◄ Natural stretch of Lech river in Germany
©Ianina Kopecki, University of Stuttgart

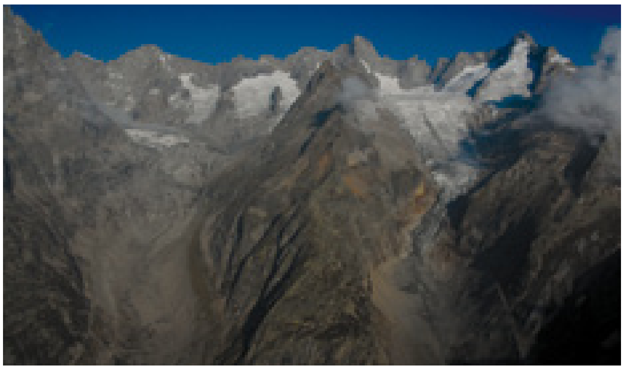
The Alpine region and surrounding areas depend on mountain river water for their development: conflicts of interests often arise between different stakeholders in relation to the use of water in the Alps.
The complex system of water management developed over the last centuries now faces new challenges due to the increasing water use for social and economic needs, and climate change pressures. Therefore, the current system of water management must be suitably and continuously adjusted in order to satisfy different needs in accord with local and EU sets of laws.

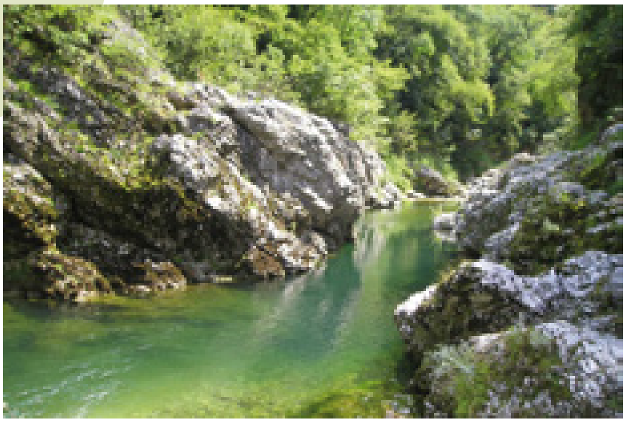
Different views of a single resource's future

The Alpine climate has changed significantly during the last century.
Climate change in the Alps involves complex combinations of short and long-term forces related to weather patterns and amplified by drivers linked to anthropogenic greenhouse gases. Important effects on water systems are already evident: decreases in snow cover, glacier and permafrost cover, temperature increase, severe hydrological alterations and impacts on biological systems.
Estimated changes in precipitation will further alter run-off regimes, with more droughts in summer, floods and landslides in winter and higher inter-annual variability and "more significant changes are expected in the increasing frequency of precipitation extremes than in the magnitude of extremes"
(Source: Beniston et al., 2007).

Pré de Bard Triolet glacier in Aosta Valley (NW Italy). Evident glacial cover reduction from 1992 (above) and 2011(below) involving different water availability patterns ►

© Foundation «Montagna Sicura»(Italy)



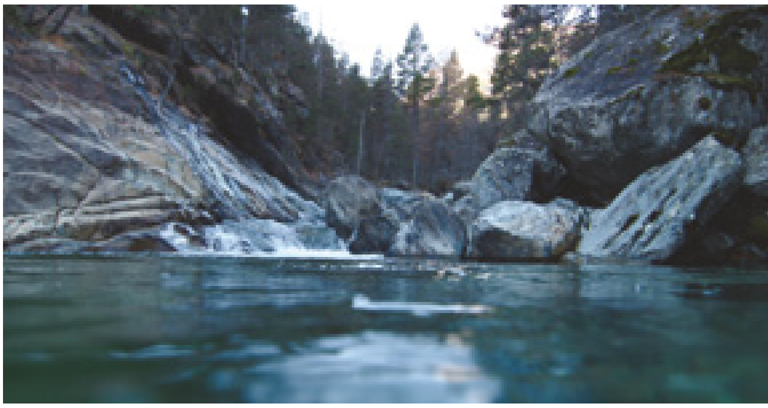


▲ The Astico river upstream of Leda's dam
©Sara Pavan, ARPA Veneto

▲ River Astico at Pria, downstream Pedescala
©Sara Pavan, ARPA Veneto

▲ Flushing of Hydropower plant at Bodendorf
©Florian Asinger, Graz University of Technology

Due to climate modifications, the regime of catchments might change to a constantly reduced water level in summer: this would mean an impact on general water availability, especially in the Southern Alps. As a consequence, water shortage would bring an increased competition for resource use, in particular for agriculture and electricity production. Considering these scenarios, different views of the future of Alpine rivers can be envisaged.



▲ Autumn scene of Chalamy river in North West of Italy
HENCHOZ – Aosta Valley Autonomous region, Direction de la faune, de la flore, de la chasse et de la pêche

On the one hand, many economic sectors such as agriculture, energy production, forestry, tourism and river navigation, as well as millions of European citizens, rely on Alpine rivers to satisfy their needs; but on the other hand, many ecosystems totally depend on Alpine rivers and water availability to maintain freshwater and wetland habitats and biodiversity stock.

Due to the valuable **hydroelectric asset in the Alps**, energy legislation (*Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC*) considers the contribution of hydropower production for the Alpine area to be very important for electricity generation by renewable energy resources in order to reduce emissions of greenhouse gases.

For these reasons, Alpine countries refer to specific national goals for hydropower production, and consequently, increasing attention is given to exploitation of available river stretches, leading to potential conflicts with the conservation of ecosystems and landscapes.

Chapter 4 - Growing conflict of use

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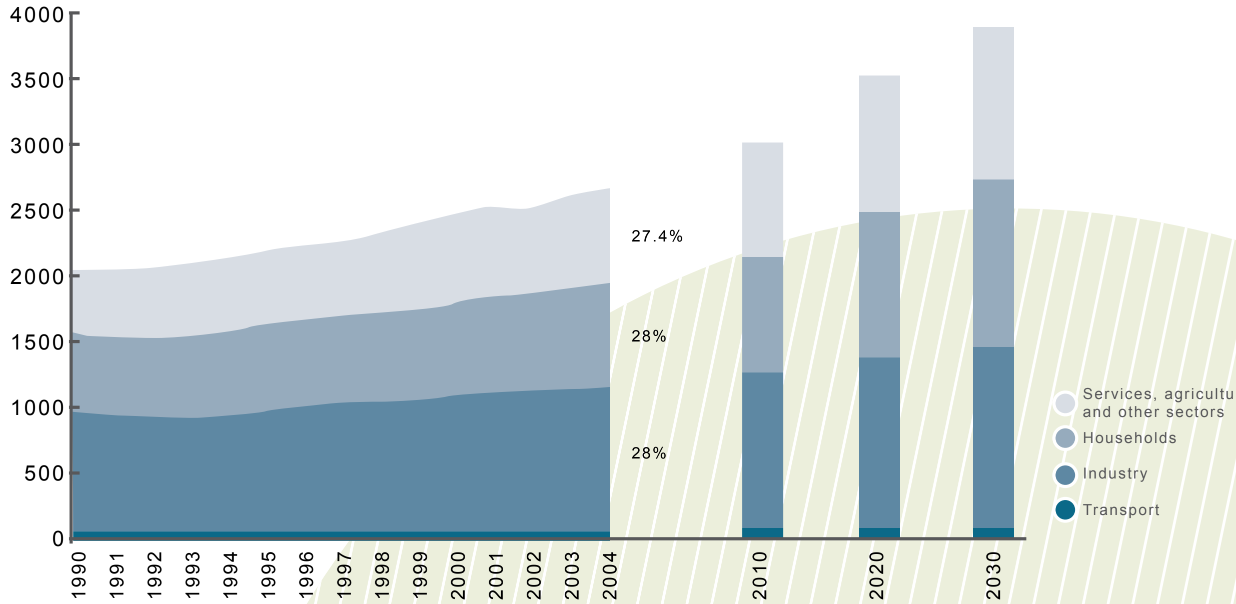
At the present time, the exploitation level of hydropower production in the Alpine area is significant: the **Alpine Convention** Water Platform recently stated that, "hydropower generation can be considered to be the main reason for water abstraction (...).These result in the fact that a significant share of river stretches fails to meet the good ecological status" (*Water and water management issues: Report on the State of the Alps, 2009*).

◄ Still on the river Var, France



Source: © Eurostat (historic data), Primes Energy Model (European Commission, 2006) for projections.

The EU 25 Final electricity consumption is the electricity consumption of the final energy demand sectors: the graph does not include the electricity producers' own use or transmission and distribution losses (*Last upload: 05 Jul 2010*).

Thanks to its variety of habitats, the Alps host **the richest biodiversity areas** in continental Europe and include some of the few isolated and wild areas still existing in Europe. The Alps are one of the most important eco-regions of the world in terms of conserving global biodiversity (*WWF 2004*): almost 30,000 animal species and 13,000 plant species can be found in the Alpine space, and many of these are endemic and included in Habitat and Bird directives.
Alpine rivers and lakes represent a unique environment in the Alps, hosting biological communities that are highly specialized and fragile: e.g. about 80 different fish species live in Alpine water bodies.

Chapter 4 - Growing conflict of use

However, due to a long history of anthropogenic modification and exploitation, many Alpine rivers and streams have been seriously damaged, and about 90% of them have lost their natural state (*WWF, «The Alps: a unique natural heritage» - A common vision for the conservation of their biodiversity - Frankfurt Germany, 2004*). Consequently, the set of laws for river management is openly oriented towards the conservation of the last remaining natural stretches, and towards the restoration of the river sectors impacted by human activities.

◄ Wild autochthonous Brown trout in Le Borne torrent, Haute-Savoie, France

©Erik HENCHOZ – Aosta Valley Autonomous region, Direction de la faune, de la flore, de la chasse et de la pêche

EU directives, contradictory objectives?

On the one hand, the **Directive on Electricity Production from Renewable Energy Sources**[1] obliges EU member states to increase their share of renewable electricity production, in order to reduce greenhouse gas emissions. The aim was to reach a "22.1% indicative share of electricity produced from renewable energy sources in total Community electricity consumption by 2010".

On the other hand, the **Water Framework Directive**[2] (*WFD*) obliges EU member states to reach and maintain a "good" ecological status of water bodies by 2015. The WFD refers to river continuity as a "quality element" to assess the ecological status, and underlines the need for "control on abstraction and impoundment in order to ensure the environmental sustainability of the affected water systems".

For some, the priority is to **protect and restore rivers' ecological status**, which means reducing human activities impacting water bodies. For others, **rivers are a vital source of energy, income and local development**, thanks to the social and economic activities they support.

Alpine territories have a highly strategic interest in developing and maintaining an important hydropower generation capacity, but river conservation and restoration allow rivers to perform not only more evident **ecological services** such as touristic activities, landscape conservation, mountain agriculture and angling, but also the reduction of natural hazards such as floods or landslides: These are key issues for local communities and stakeholders involved.

Decision makers are committed to find a balance between hydropower and river ecosystem needs.

▲ Hybrid of Marbled trout and Brown trout in Chalamy river, Italy ©Erik HENCHOZ – Aosta Valley Autonomous region, Direction de la faune, de la flore, de la chasse et de la pêche

[1] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC

Chapter 4 - Growing conflict of use

Hot questions box

Is it better to protect or to produce? Who will be the beneficiaries of this choice? How will the outcomes be evaluated?
In the case of water shortage, what amount of water would be allocated to hydroelectricity production?
Who cares about rivers? Do healthy rivers have related stakeholders in Alpine communities or not?
Which mechanism will be applied in the case of decreasing water availability (water scarcity and droughts) to solve emerging conflicts among different water users (agriculture, industry, hydroelectricity production, drinking water supply etc.)?

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  Technical review describing WFD, Floods and other EU directives implementation in Alpine Space

- SHARE – WP 5.4 A - *Technical report on criteria and indicators to identify vulnerability of Alp areas and river ecosystems*:
  Map of most vulnerable to HP river typologies

- SHARE – WP 5.4 C - *Mapping of most vulnerable river typologies* - GIS mapping (software & media):
  Criteria and indicators to identify vulnerability of Alpine areas and river ecosystems

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Section 2: SHARE solution, how to ...

a) SHARE solution: balancing river ecosystems and hydropower requirements, supporting the decision, and making transparent and shared objectives.

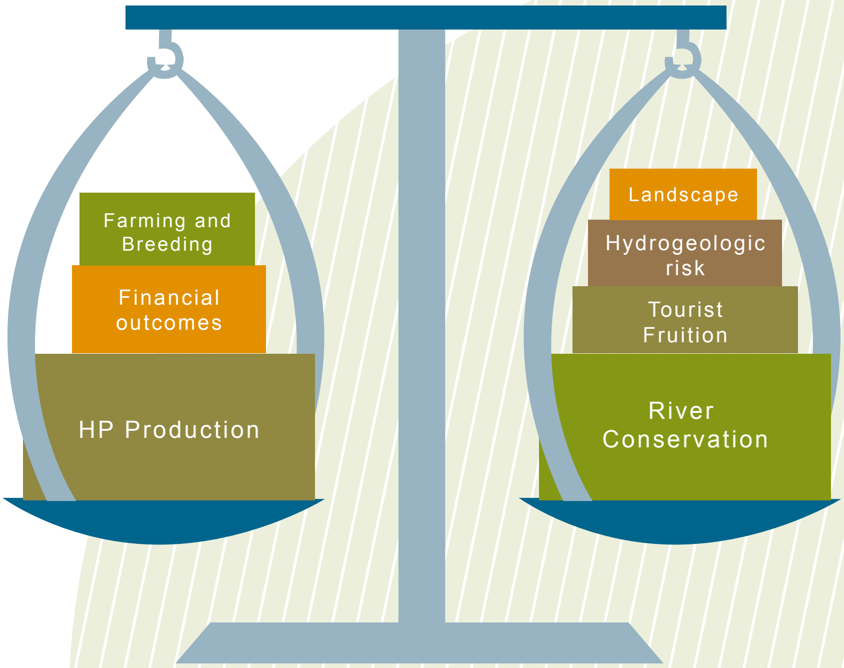
Make the balance

SHARE puts forward concrete means to strike a balance between the needs of hydropower, of public administrators in terms of water bodies' health, and to all stakeholders involved in river and hydropower-related issues.

To reach this balance, SHARE has created a **mathematical decisions support system** (MCA) to consider all actors involved, their interests and points of view, but also the legislative requirements using a clear procedure.

SHARE aims to apply the MCA methodology to the HP plants' decision processes.

This approach is led using an existing informatics tool customized during the project to facilitate the comprehension of the procedure by all stakeholders; it's called **SESAMO software**. It works with projects containing data and structures that feed the decision process. The structure of the project reflects the logical steps of the methodology.



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What are these steps that you need to identify?

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- **WHAT to evaluate**

First, you will need to identify possible management alternatives.

- **HOW to evaluate**

Second, case-specific issues will be clarified in order to select criteria and indicators which are necessary to build the decision tree.

- **WHO is involved or takes part?**

The aim of this MCA methodology is to help all stakeholders to take a common decision regarding their case, and therefore to reach an agreement taking into account as much as possible each point of view and interest. That is why the identification of all the people who may be linked directly or indirectly to the case is important.

- **WHEN can you evaluate?**

A key aspect of the MCA methodology is that this tool can be implemented ex-ante or post-ante.
In other words it can refer to a new project, e.g. a new HP implementation, but it can also be used for a decision taken in the past.

- **WHERE – Perimeter**

Each specific case is unique, regarding the “What, How, Who, When”, but also regarding the “Where”. Indeed, a case can refer to a single HP plant, to a group of plants in a river system or to management of an entire basin.

Section 2: SHARE solution, how to ...

• b) Multi-Criteria Analysis: what is this?

Multi-Criteria Analysis (MCA) appeared in the 1960s as a decision-making tool. It is used to make a comparative assessment of alternatives, on the basis of some evaluation criteria.

The validity of the results is strongly linked to the choice of the criteria, which need to be defined carefully, taking into account all the factors that could affect the problem that is going to be analyzed. The method is designed to help decision-makers integrate the different options, reflecting the opinions of the actors concerned. Participation of the decision-makers in the process is a central part of the approach. The results are usually directed at providing operational advice or recommendations for future activities.

Classical MCA is a rigorous mathematical methodology that allows stakeholders to assign a score to each alternative. This score is a quantification of the performance of the alternative in relation to each criterion and it represents a measure of the global validity of the alternative with reference to the criteria selected to evaluate it.

At the end of the analysis, a vector of the performances will be produced that presents the order of preferences of the alternatives.

The scores allow ranking of alternatives. The alternative that is characterized by the highest score is the best alternative for the problem in question.
The decision process consists of five main steps:

- Selection of alternatives
- Selection of criteria
- Utility function choice
- Weight allocation
- Final ranking

Section 2: SHARE solution, how to ...

Chapter 1 - STEP 1: What to evaluate? Stakeholder identification, problems and alternatives

Who are the stakeholders involved?

Aquatic environments are subject to different interests. Thus, the development and management of water resources without a doubt will raise conflicts between different actors.
In the case of SHARE, the stakeholders of interests are generally as follows: operators of hydroelectric plants, institutional services of water and aquatic systems, fishermen, associations for the defence of nature, territories in charge of management of water resources etc.
It is necessary to audit all opinions relating to the different issues relevant to each of these actors and then to consider several scenarios of implementation, reflecting the ambitions of each. The process must be as thorough as possible in order to achieve a balanced and transparent multi-criteria analysis.

What is an alternative?

Alternatives are possible scenarios of HP plant implementation that can be considered by the stakeholders. In general terms, a project alternative must represent all the possible actions that a designer is able to undertake to influence future events.

All the variables that the designer is not able to control (exogenous variables) are part of the scenario within which the project is placed. For this reason, the scenario represents a possible evolution of the context. It is not dependent on the specific alternative and so it does not depend on the stakeholder's choices.

An alternative is able to have an influence on the indicators that represent the system. In other words, each alternative will produce some modification of certain indicators, but not necessarily all of them.

In order to compare all the different alternatives, it is necessary to introduce the so called "zero alternative", that will allow the stakeholder to compare alternatives that are not perfectly homogeneous with one another. The "zero alternative" represents the value that the indicators of the process would assume in the case that no project, nor management different to the present, will be realized and, by definition, it sets the reference for all indicators.

These alternatives vary according to each local issue, and they should therefore be adapted to each situation encountered. Each holder of interest may present a scenario of implementation of which they are satisfied, allowing it to be analysed, compared and balanced with the scenarios proposed by the other holders of interests within the roundtable discussion.

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Section 2: SHARE solution, how to ...

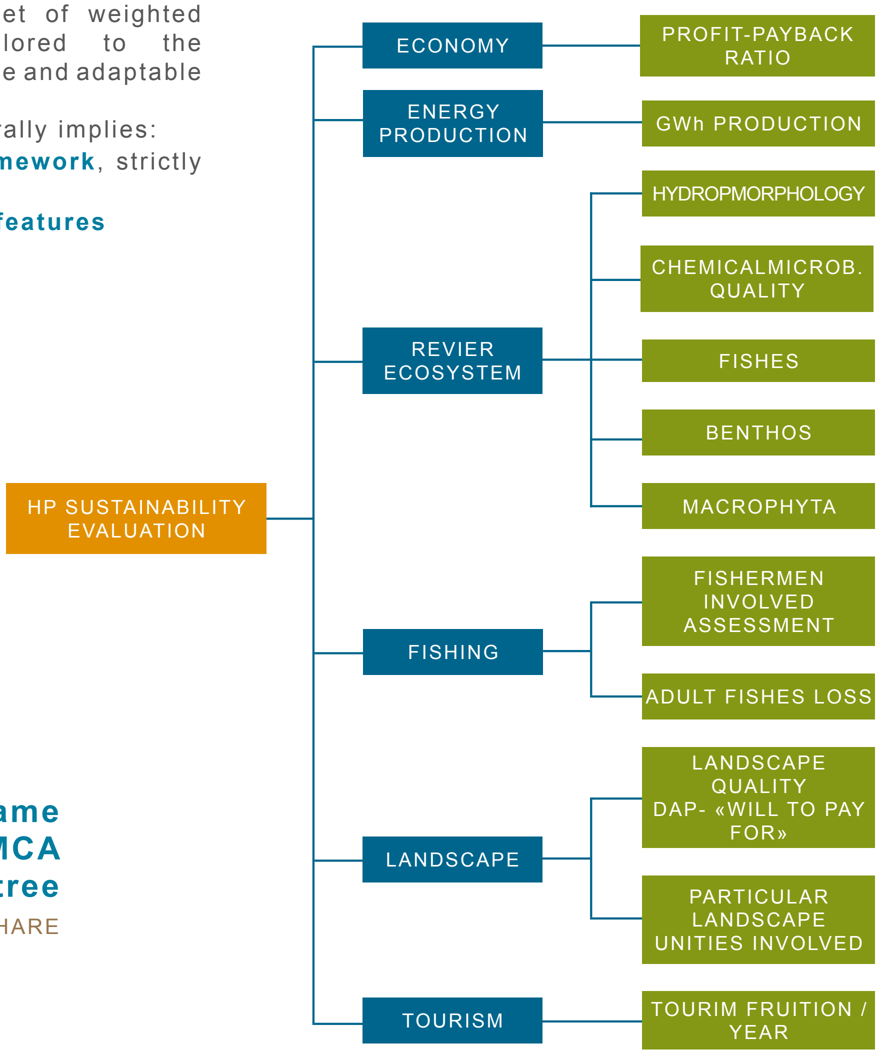
Chapter 2 - STEP 2: How to evaluate? System description: criteria, indicators, the decision tree

Every river management situation can be described using general criteria (such as energy production, economy, river ecosystem, landscape, etc.).
Every criterion has to be detailed by one or more indicators entailing quantitative information about the effects of different management alternatives.
Indicators are a viable way to pass from an amount of "rough data" to "useful information".
Criteria and indicators are branches and leaves of the "decision tree", the framework used by SHARE MCA to fully describe every river situation.
SHARE MCA needs good indicators to give good results.

The SHARE decision tree

The SHARE MCA provides a **decision tree** composed of an interrelated set of weighted **criteria** and **indicators** tailored to the requirements of each specific case and adaptable to every river situation.
SHARE MCA decision tree generally implies:

- a **common decision tree framework**, strictly "stakeholder focused";
- a specific focus on **indicator features & meanings**.



A generic frame of SHARE MCA decision tree
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Criteria

Criteria are standards used for judging something or for making a decision about something to be considered: SHARE criteria are strictly "**stakeholder focused**" meaning that each criterion has at least one stakeholder involved in the decision making process.
The comprehensive set of **SHARE MCA criteria** is specified below:

- **ENERGY PRODUCTION**
- **ECONOMY** (related to HP exploitation)
- **RIVER ECOSYSTEM**
- **TOURISM** (and other river assets)
- **FISHING**
- **LANDSCAPE**
- **OTHER CRITERIA** (drinkable water, factories, agriculture, etc.)

Indicators

Every criterion must have at least one **indicator** meaning "a measure, generally quantitative, that can be used to illustrate and communicate complex phenomena simply, including trends and progress over time" *(EEA, European Environment Agency, 2005)*.

Some indicators could be more "official" being derived from a set of laws, some could be economic (i.e. value in euros), and some others could be derived from expert-based qualitative assessment: all of them are strictly dependent on **data availability** and transparency of meaning. SHARE MCA allows consideration of indicators representing "**hard information**" (such as MegaWatts per hour produced or euros gained by selling energy) and "**soft information**" (such as river status ecological quality classes, fishermen satisfaction levels, etc.) together in the same decision tree.

Generally, every stakeholder chooses their own criteria indicator set to better represent their own interests, according to specific situation requirements.

▶ How to select good indicators for SHARE MCA?

The choice of indicators can be made considering different aspects:

- **Indicator fitness:** every indicator must have a causal relationship with different alternatives of management considered; using non-reactive indicators limits the significance of MCA
- **Compliance with the legislative framework:** when possible, and when significant, it is important to use official indicators required from a local set of laws to strengthen decision making being strictly legally compliant
- **Compliance with stakeholder needs:** indicators have to represent related stakeholders in a clear way; stakeholders must recognise their own interests in indicators
- **Compliance with the investigation:** indicator suitability in framing the investigated topic is essential in order to grant significance to information; the same criteria, evaluated in different contexts, locations, timings, scales, etc. could require different indicators
- **Available datasets:** it may be impossible to acquire data (i.e. for cost reasons, for time reasons, etc.), so indicators identified and implemented with available data must be preferred

Chapter 2 - STEP 2: How to evaluate? System description: criteria, indicators, the decision tree

Water framework Directive (2000-60-CE) assigns a strategic importance to indicators related to biological river community status (diatoms, macrophytes, macrozoobenthos and fishes). Very often in mountain stretches, official WFD-related indicators don't seem to respond as expected to river HP effects and so, it may be possible that no HP upstream - downstream gradient is evident through sampling.
Fish-based indicators can respond very well to HP pressure, but frequently fish populations are heavily affected by uncontrolled restocking by fishermen.

Why this lack of response to HP pressure?

- *Is it due to the official metric choice being more related to other drivers (trophic & nutrient conditions, riverbed modifications, pollutant presence ...)?*
- *Is it due to a low taxonomic level of classification of biota (impossible to adopt the "rivet popping" approach)?*
- *Is it due to the average size & home range of organisms considered being too small (benthos, diatoms)?*
- *Is it due to too short a period of investigations?*
- *Is it due to the adaptation of communities to chronic HP effects?*
- *Is it due to the combination of HP effects and natural mountain constraints?*

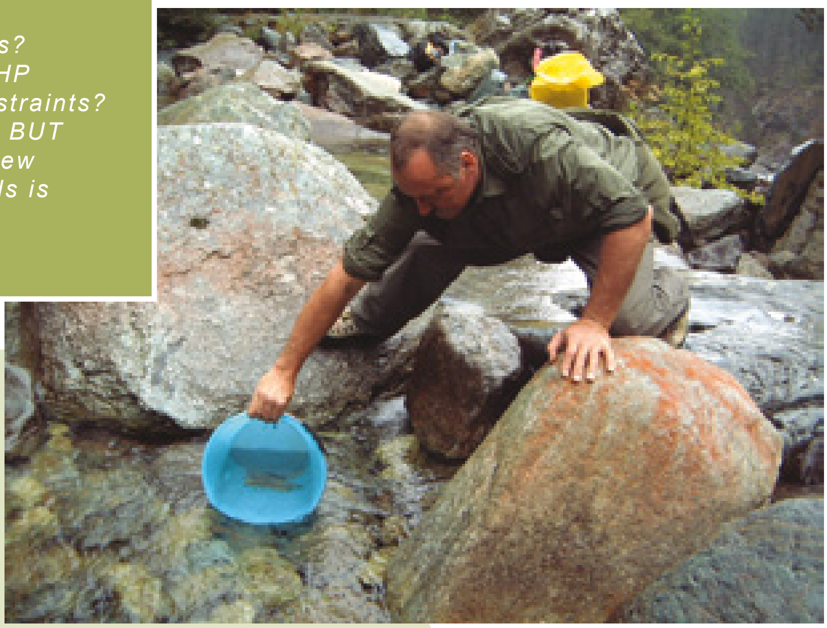
It is an interesting research topic BUT in the meanwhile the amount of new demands and concession renewals is constantly growing!

Indicators must be **real indicators**, meaning that they have to be provided with **full meta information** (such as name, description, aim, measurement unit, methods of elaboration, bibliographic references etc. - *see SHARE indicators tool box*) and should have a corresponding dataset with which they can be elaborated.

Indicator fitness is a focal topic: every alternative must exert a clear effect on indicator value, and the methodology or the model to quantify indicator values corresponding to different alternatives has to be clearly understood.

◄
WFD biological community indicators and SHARE MCA

Fish populations are reactive to HP pressure, but they can be affected by uncontrolled restocking by fishermen
▼



Chapter 2 - STEP 2: How to evaluate? System description: criteria, indicators, the decision tree

Name of the indicator: HP effect on landscape (proxy indicator)

Aim: Approximate assessment of the influence of different HP exploitation alternatives on the Landscape

Classes: 1 – negligible negative impact;
2 – small negative impact;
3 – significant negative impact;
4 – strong negative impact;
5 – extremely strong negative impact;

Utility function: Stepwise decreasing function

Indicators can be implemented **ex ante** (indicator values are predicted / assessed / calculated / forecast) or **ex post** (indicator values come from a direct measure from sampling or monitoring): if indicator implementation is done ex ante, the logic guiding the attribution of indicator values has to be fully declared, especially concerning environmental indicators (i.e. twin basin comparisons, modeling supported by software for specific models, expert based assessment, other kinds of statistical interpolation / derivation, proxy simulation, but not by magic forecasting ...)

◄ An example of proxy indicator for landscape criterion in SHARE MCA

When data to develop indicators are not available or useable for different reasons, or there's no open indicator to describe criteria (such as tourism, landscape, etc), a viable solution is the use of a **proxy indicator**. This indicator typology provides a quantification of the effect of each alternative on the criterion, considering a simplified score based on a limited number of classes (*see the box below*).

Proxy indicators can be considered as the "last resort" to be used with a lot of care and in a very limited way within the decision tree: a weak indicator can give a weak informative contribution.
Be aware: SHARE MCA is not a crystal ball, but a model to optimise information (and indicators) for use in decision making. As for every model "***if you load trash, you will have trash***"...

Various materials for a first start with SHARE MCA are available on the SHARE website here.

What is SHARE?

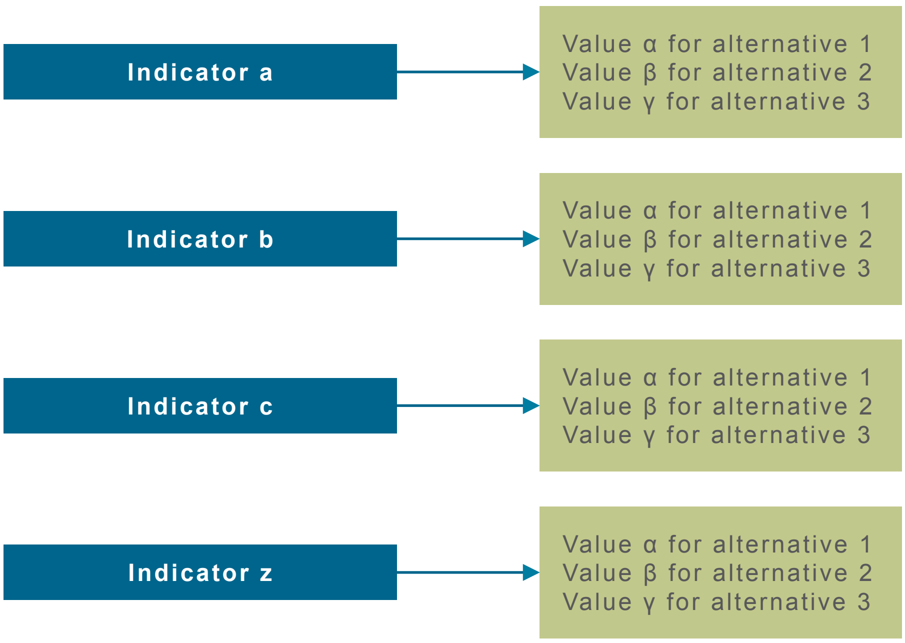
Section 2: SHARE solution, how to ...

Chapter 3 - STEP 3: How to evaluate? Description of how each alternative causes effects on each indicator.

SHARE provides a specific software called SESAMO to support MCA use for river management and hydropower exploitations.
SESAMO is a tool that helps to collect and weight in a neutral way all stakeholders' knowledge and information, even if it concerns opposite views. In order to do this, the user needs to define the alternatives and indicators, and evaluate the effects of each alternative on each indicator: SESAMO won't do this on its own.
This first step is really important and can also be an "icebreaker", a support for all concerned to discuss each interest and point of view. Indeed, the software makes comparable and compatible opposite alternatives, and different propositions. Stakeholders will measure them together and put them on the same level. They have to assess, quantify and estimate the effect of each alternative on each indicator.
Indicators can take many different forms in terms of units, types, measures, etc. Their comparison can be very difficult in some cases.

Description of each alternative's effect on the criteria

Every alternative is detailed by one or more causal factors / pressure indicators (coming also from legislation) describing the alternatives' effect on status indicators. In other words, each causal factor is directly linked to the status indicators modifying their value.



Indicators and related values in SHARE MCA
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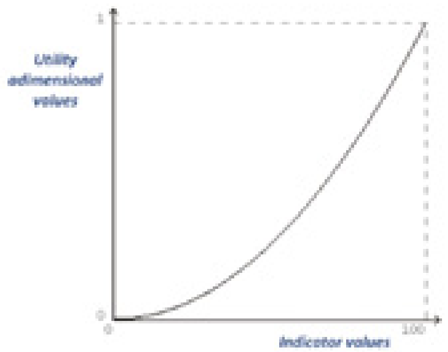
Process of normalization: the Utility Function



A generic Utility Function

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The appropriate methodology to compare these various indicators is the **normalisation**. The normalisation makes the data consistent and operational. It provides relative values of indicators in order to compare them.
The normalisation process transforms the indicators into **adimensional values**, whereby Indicators lose their own dimension and become comparable to each other.

This transformation is done by building a Utility Function, a mathematical function that assigns to each value of the indicator a corresponding indicator with an adimensional value ranging between 0 and 1.

Data normalization isn't just a mathematical step, but it is part of the political phase of the application software SESAMO: **this is a subjective phase, and different utility curves can be applied to the same criterion for different case studies**.

An example with an environmental macrozoobenthos indicator (I.B.E. - Indice Biotico Esteso)

Macrozoobenthos living in rivers and streams can be used to assess the quality of water: in Italy a specific index called I.B.E. – **Indice Biotico Esteso** (Ghetti, 1997), derived from the Extended Biotic Index (Woodiwiss, 1978), has been developed and regularly applied for river health monitoring. I.B.E provides a good example of how indicators can be used in SHARE multi criteria analysis. The result of the IBE is a numeric value that can be converted into 5 levels of biological quality:

INDICATOR	INDICATOR VALUE	DESCRIPTION (NORMALISATION)	NORMALISATION (UT.FUNCTION)
IBE	< 3.5	BAD	0
IBE	3.5 – 5.5	SUBSTANDARD	0.25
IBE	5.5 – 7.5	SUFFICIENT	0.5
IBE	7.5 – 9.5	GOOD	0.75
IBE	> 9.5	HIGH	1

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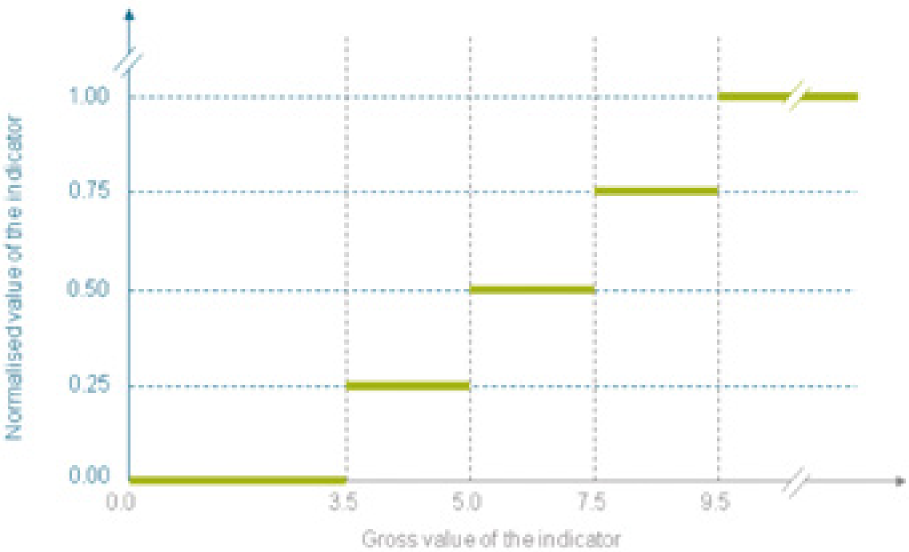
Chapter 3 - STEP 3: How to evaluate? Description of how each alternative causes effects on each indicator.



Basic Utility Function for I.B.E indicator

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An example with the indicator « Annual hydroelectric production »

Another example can be provided using a common energy indicator, the **annual hydroelectric production** expressed as the percentage of expected production in MWh that can be produced from a new HP plant development. Following the HP designer requirements, different levels of satisfaction can be defined: hydroelectric production can theoretically vary from 0 to 100% of expected production, based on installed capacity, the gross head and the flow equipment. In the utility function shown below, the production is considered "high" for HP requirements if exactly corresponding to 100% of expected production, "good" if in the range from 80% to 99% of expected production, and "bad" if less than 80% of expected production.

INDICATOR	INDICATOR VALUE	DESCRIPTION (NORMALISATION)	NORMALISATION (UT.FUNCTION)
Annual hydroelectric production	0 – 79% of expected Production	BAD	0
Annual hydroelectric production	80-99% of expected Production	GOOD	Linear curve from 0.75 to 0.99
Annual hydroelectric production	100% of expected Production	HIGH	1

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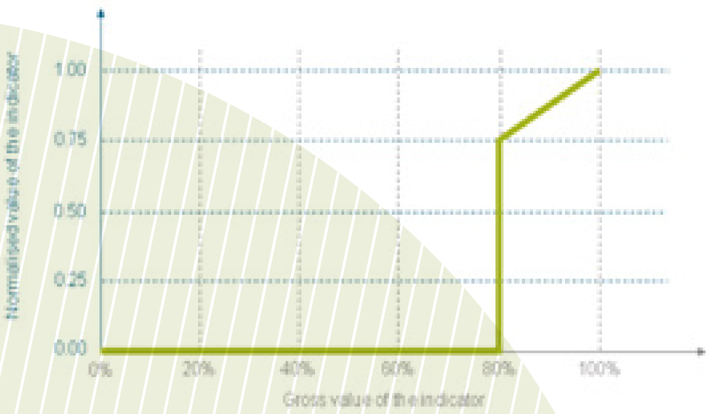
Chapter 3 - STEP 3: How to evaluate? Description of how each alternative causes effects on each indicator.



Annual hydroelectric Utility Function

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Weight allocation

Criteria and indicators are generally characterized by different levels of importance that necessarily must be included in the evaluation. This is obtained by assigning a "**weight**" to each indicator and criterion. The weight assigned indicates its importance in relation to the other indicators/criteria considered. Weights represent the mechanism through which a stakeholder can express their idea of the relative importance among criteria. A coefficient wI, can be associated with each criterion and this coefficient, namely a weight, is used to calculate the overall performance of an alternative.

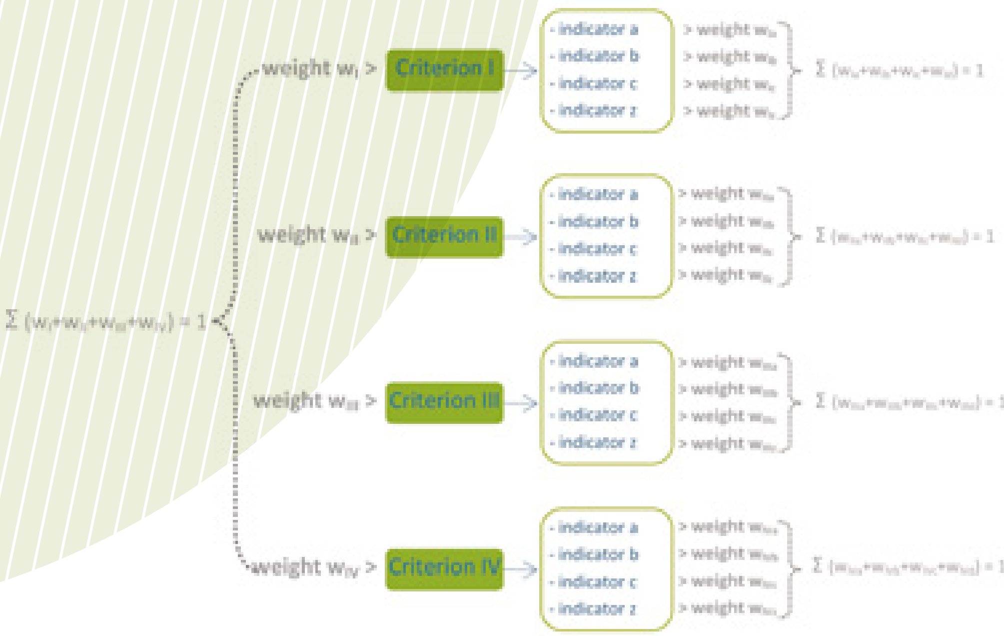
The vector of weights should be stated by the stakeholder, because it should be representative of their structure of preferences. This is neither always simple nor immediate, because the rigorous procedure to obtain the vector of the preferences requires a certain degree of interaction between the MCA technicians and the stakeholder group.

This "weighting" phase is a political phase. It should be conducted with all the stakeholders identified and should be a consensus of all involved.

The methodology is as followed:

- assign a weight to each indicator describing a criterion;
- assign a weight to each criterion

The normalised weights must be equal to "1".



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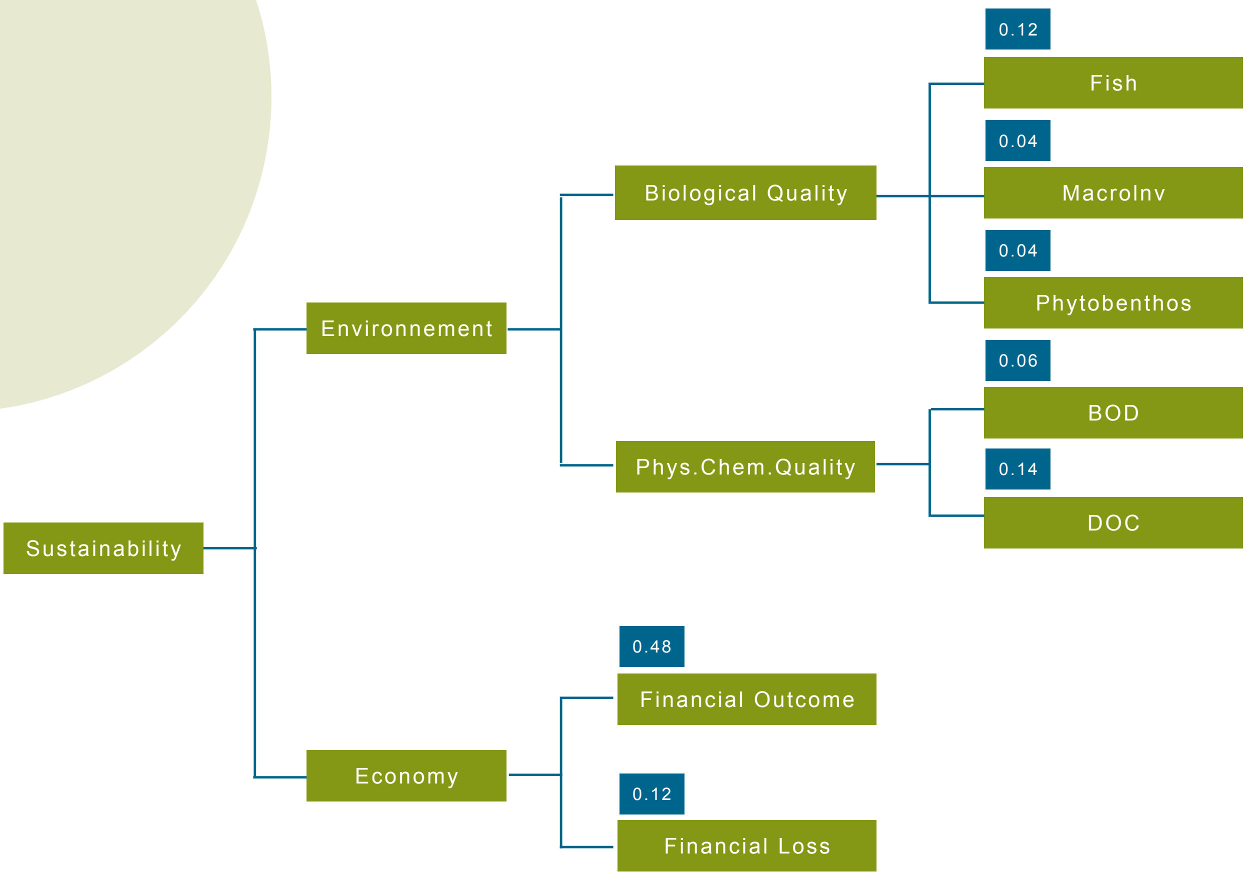
Chapter 3 - STEP 3: How to evaluate? Description of how each alternative causes effects on each indicator.

The rigorous technique for weight allocation (free allocation) consists of assigning a weight to each leaf of the tree, without taking into account the hierarchical structure of the criteria. This procedure is shown in the picture below.



Free weight allocation technique

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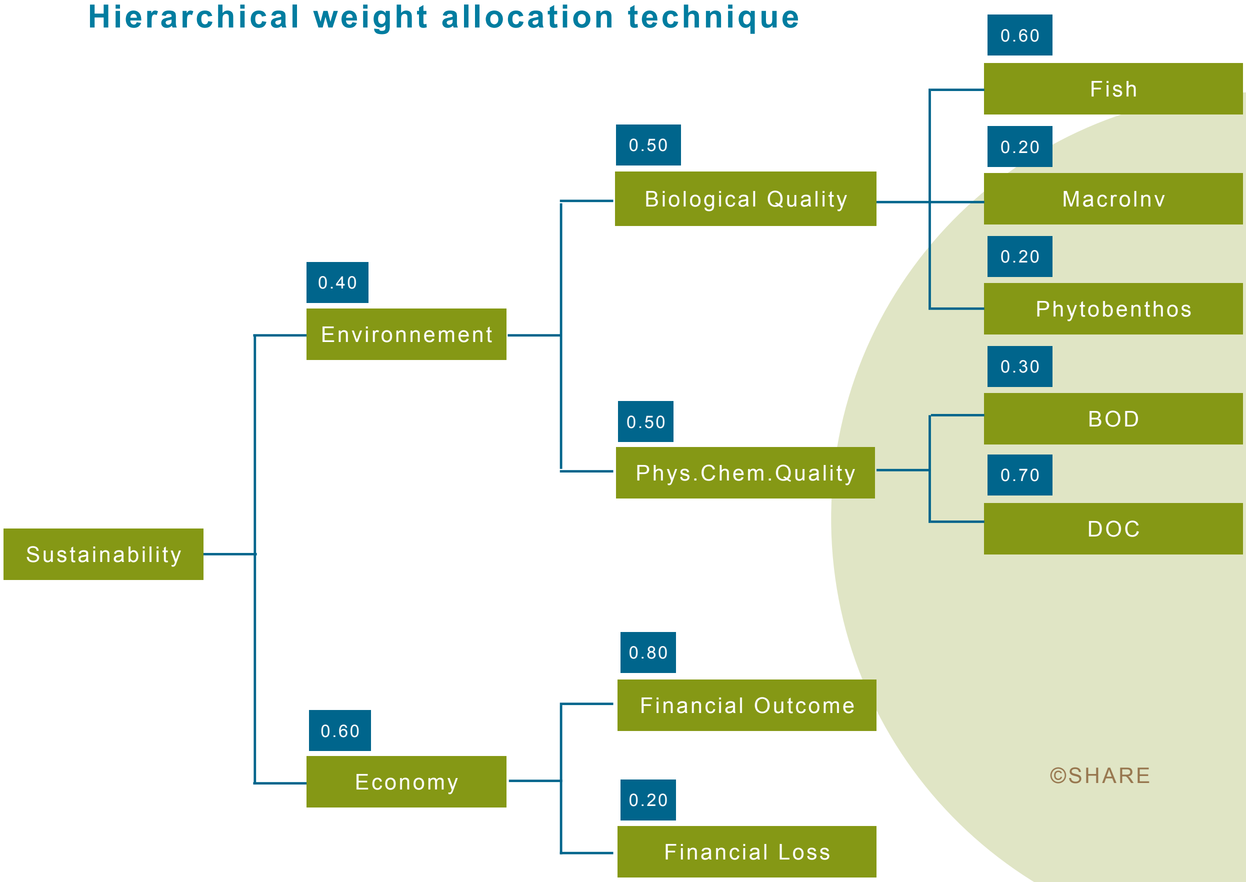
Otherwise, it is possible to assign the coefficients for every group of nodes that are leaves of the same branch, for every level of the tree.
Inside each group, the sum of the coefficients must be equal to 1. This process is called hierarchical allocation of the weights, and an example is shown in the following figure.

Chapter 3 - STEP 3: How to evaluate? Description of how each alternative causes effects on each indicator.

Hierarchical weight allocation technique



The weights associated with each leaf of the hierarchy are calculated as a product of the coefficients assigned from the leaf to the root of the tree.
This kind of allocation has the advantage that the coefficients are assigned to homogeneous elements and so it is possible for different groups of experts to work on the definition of coefficients linked to their own expertise.

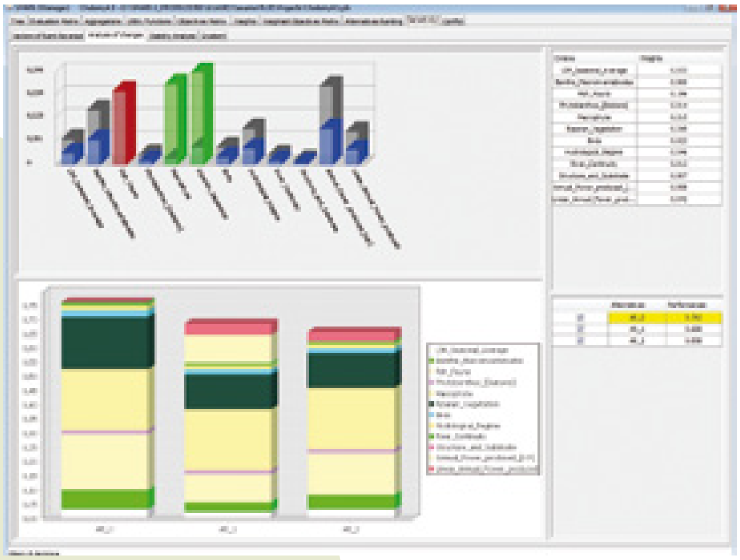
In general terms, the weight coefficient allocation on the leaf can be done by experts of the sectors involved, while further up in the hierarchy, it is necessary that the politicians suggest the values to adopt (e.g. a technician assigns values of the coefficients for Biological Oxygen Demand - BOD and Chemical Oxygen Demand, belonging to "Physical Chemical Quality" criterion while a policy maker defines the coefficients for economy criterion). Actually, it is meaningful to compare elements that are not leaves of the tree, because the relative importance of these objectives must be stated only on a political basis.

Nevertheless, in decisional problems characterized by the presence of a large number of indicators, it is not possible to avoid assigning the weights based on the hierarchy, because this methodology allows simplification of a problem that would otherwise be too complex for the stakeholder.

Chapter 3 - STEP 3: How to evaluate? Description of how each alternative causes effects on each indicator.

Then, for each alternative, the software SESAMO calculates a total, as a function of the indicators (utility function), criteria and weights. The results can be seen below as an example:

▼ SESAMO representation of criteria and weight attribution



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This is the representation of a decision tree, with the first part the different criteria and weight attribution. The second part is a representation of the results with the three alternatives and the weight of each criterion depending on the case. On the right side, for this example, the software indicates that the alternative “zero” has the highest performance rate.

Sensitivity analysis

A decisional process is, by its nature, strongly influenced by the concepts of uncertainty and subjectivity.
Every aspect of the analysis is evaluated in different ways by the different stakeholders, because they focus their attention on different aspects.
Even if MCA is a rigorous procedure from a mathematical point of view, some steps that are necessary to establish the overall performance of an alternative are strongly subjective and, in spite of this, they assume a determinant role.
The weight attribution, for example, represents a phase of the process in which the choices of the stakeholder can significantly influence the final result. Because of the presence of these kinds of actions, it is fundamental to manage techniques that can support the stakeholder in dealing with subjectivity.
On the other hand, it is necessary to provide methods able to deal with the uncertainty of the overall ranking; in particular, **it is fundamental to have the possibility to carry out a sensitivity analysis** of the result, varying those parameters that are intrinsically subjective and uncertain (especially the weights) and assessing how these variations affect the final result.
The sensitivity analysis must be carried out with specific methodologies that vary with the type of uncertainty to be considered, and with the elements affected by the uncertainty (impacts, utility functions and weights).

Chapter 3 - STEP 3: How to evaluate? Description of how each alternative causes effects on each indicator.

The sensitivity analysis is very important in order to understand **how the final ranking of the alternatives can vary** if impacts, utility functions or weights assume values that are not the reference values.
In particular, the sensitivity analysis will focus on the investigation of possible rank reversal (that is, the inversion of the preferential order of the alternatives). Besides, it can be based on the evaluation of the stability of the ranking, or, in other words, on the evaluation of the size of variations in impacts, or in utility functions, or in weights, such that the final ranking does not change.
SESAMO also embeds a **dashboard representation** of alternative performance, criteria and weights to ease SHARE MCA use and aid comprehensio

▼ SHARE SESAMO dashboard representation

Self standing dashboard representation of MCA

How the number of indicators affects Multi Criteria Analysis

Links and Bibliography

Introduction part b

- Girardi P., Botta M., Brambilla C., Laniado E., 2003. Sistema di supporto alle decisioni SESAMO. Software per la valutazione a molti attributi: manuale utente. Rapporto RdS SOSTE/SOSTIENI A3/021039 (www.ricercadisistema.it) (in Italian).

Section 3: Applying SHARE

Chapter 1 - Wrap up: what SHARE does & what SHARE does not do

SHARE provides a viable Multi Criteria Analysis (MCA) methodology to public administrators and policy makers involved in river and hydropower issues to support the decision making process to be implemented in Alpine countries.
SHARE MCA is explained in a user-friendly way by a set of online tutorials available on the project website.
SHARE also provides a toolbox to put into practice MCA, including a specific software (SESAMO), a database of indicators, criteria to identify more vulnerable water bodies, software to define HP residual potential, guidelines to integrate MCA in local rules and a collection of related management laws.
Pay attention: SHARE MCA is a tool to help decision making, but it doesn't take the right decision by itself...

The SHARE toolbox

SHARE provides to public administrators and stakeholders several tools, described below.

SHARE MCA methodology and software

The main tool is the SHARE's software (called SESAMO) to implement the **Multi Criteria Analysis (MCA) approach to assess and compare different alternatives** related to hydropower exploitation and river management.

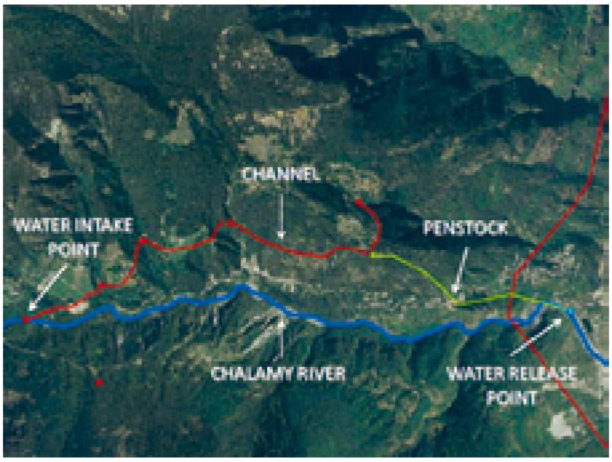
SESAMO software and related handbook

SHARE MCA is applied as "**balance**" for evaluating conflicting river management alternatives defined by different criteria detailed by indicators. For each alternative, a **total performance score/vote** is calculated starting from the assessment of effects of each management alternative on the specific river system. Decision makers are helped to **identify the more sustainable alternative** using an interrelated set of weighted indicators tailored to the requirements of each specific case.

MCA can be applied at different spatial and temporal scales.

- **Spatial scale:**
  - **single HP plant assessment**: MCA can be used to evaluate different alternatives regarding both a single ***new hydropower plant*** building (see also below "Ex ante analysis") or ***existing hydropower plant*** management (see also below "Ex post analysis");
  - **Several HP plants joint assessment**: MCA can be used to evaluate either building of a ***new group of hydropower plants*** in one or more river stretches (see also below "Ex ante analysis") or different management alternatives for an ***existing group of hydropower plants*** concerning one or more river stretches (see also below "Ex post analysis");
  - **Basin scale assessment**: MCA can be used to evaluate different management alternatives considering ***all hydropower plants in a whole basin*** (i.e. focusing mitigation measures such as experimental flushes from existing HP plants on specific river stretches to maximize positive effects at a whole basin scale);

- **Administrative scale assessment (regional level planning)**: MCA can be used to plan and assess different management alternatives concerning ***all hydropower plants in a whole region*** (i.e. defining stretches or basins as favourable, less favourable, non favourable or to be excluded for hydropower exploitation at a whole regional scale).



◄
MCA application
for single HP plant assessment
on the Chalamy river
(Aosta Valley Region – Italy)

©Aerial image of Chalamy river (Aosta Valley Regional Administration, aut. n. 1156 28.08.2007)

- **Temporal scale:**
  - ***Ex ante analysis***: SHARE MCA can be used to evaluate different alternatives of hydropower exploitation before building a new plant or a group of new plants. For example, when the administration holding water rights is asked for a new concession, different alternatives can be assessed using SHARE MCA such as:
    - the rejection of new water withdrawal
    - the approval of new water withdrawal as requested from the project manager
    - the approval of new water withdrawal with additional conditions such as:
      - a different total amount of water withdrawn
      - a different monthly amount of water withdrawn
      - another location of the plant
        - with a different monthly amount of water withdrawn
        - with fixed MIF / with modulated MIF
        - with underground pipes
        - with a specific sediment release control plan and monitoring
      - river restoration and mitigation actions (even located outside the river basin),
      - including prerequisite measures targeted at the mountain communities involved
      - ...

    The alternatives have to be explicitly defined as potential ***options to be evaluated***.
  - ***Ex post analysis***: SHARE MCA can be used to evaluate different management alternatives, either for a single existing plant or group of plants (i.e. for planning experimental flushes spread at basin or regional scales).

More generally, MCA can be used in different phases of HP authorization and strategic planning (regional strategies) as a response to local and national legislative requirements.

A set of online tutorials to aid the comprehension of MCA methodology

SHARE MCA is explained in a user-friendly way by a set of online tutorials available on the project website:

- **4 online seminars**;
- **2 fake news** papers about environmental and hydropower issues;
- **2 short videos** about the problem to be addressed and the SHARE answer.

Chapter 1 - Wrap up: what SHARE does & what SHARE does not do


The Daily Share

FINALLY BY NOW ALL STREAMS WILL BE RENATURED!!

DISMANTLED ALL THE HYDROELECTRIC POWER PLANTS: WATER WILL COME BACK TO THE RIVERS

© SHARE Environment Fake news

The SHARE Fake news paper about environmental issues

SHARE fake news

A review of concrete implementation of MCA methodology: different Pilot Case Studies in 11 Alpine rivers

The MCA methodology has been tested on **11 Pilot Case Studies** on various mountain basins (in the 5 Alpine countries involved) to test and adjust the MCA decision support system.

A selection of images of 11 SHARE Pilot Case Studies

SHARE 11 Pilote Case Studies


©SHARE Pilot Case Studies

A set of indicators & monitoring standards to feed MCA implementation

SHARE provides elaboration of a set of indicators and monitoring standards to end users, derived from project Pilot Case Studies, to facilitate the MCA approach.

SHARE indicator toolbox

SHARE geo-databases to identify applicable laws and competent authorities dealing with river management and hydropower issues in the Alpine region

SHARE provides two geo-databases to facilitate information searches related to legislation, institutions and target individuals dealing with rivers and hydropower in the cooperation area.

SHARE geodatabase

A set of quality standards and guidelines to integrate MCA in local rules

In order to facilitate the use of MCA methodology, short **guidelines for integration of SHARE MCA into national and transnational legislative frameworks** have been elaborated.

SHARE guidelines to integrate MCA in local rules

Chapter 1 - Wrap up: what SHARE does & what SHARE does not do

A review of eco-investments

A review of measures for mitigation and compensation for negative effects of HP plants on Pilot Case Study rivers is currently available.

SHARE eco-investments, mitigations & restoration action

Criteria to characterize Alpine river vulnerability to hydropower

SHARE provides criteria for mapping Alpine river ecosystems' vulnerability to hydropower exploitation, including:

- **a river ecosystems vulnerability profile definition** for each river typology, following the WFD classification;
- **a common definition of criteria and indicators to identify more vulnerable typologies** of Alpine areas in relation to HP management;
- **a definition of river types that are more vulnerable to HP**, and relative **GIS mapping** based on administrative layers.

Criteria and indicators to identify vulnerability of Alp areas and river ecosystems

A review of MIF and natural discharge assessment methods

SHARE provides a review of best **methods to estimate the Minimum Instream Flow (MIF)** and natural discharge commonly used in each Alpine space country.

MIF definition and discharge estimation methods report

Methods and software for HP potential assessment

SHARE provides two different tools:

- **VAPIDRO-ASTE**: a software designed to compute and evaluate the residual potential hydro power energy and to show the best locations for future projects;
- **Smart Mini Hydro**: a user friendly software to assess the economic feasibility of HP plants.

SHARE VAPIDRO-ASTE software for evaluation of the residual hydropower potential

VAPIDRO-ASTE software for evaluation of the residual hydropower potential

© VAPIDRO-ASTE software logo

Chapter 1 - Wrap up: what SHARE does & what SHARE does not do

© Smart Mini Hydro software logo

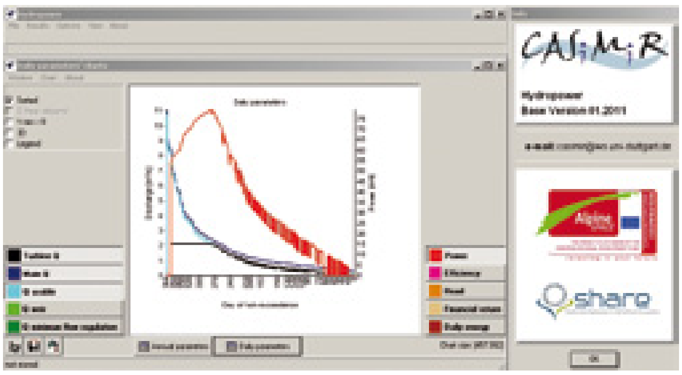
Smart Mini Hydro software to assess economic feasibility of small HP plants

SHARE Smart Mini Hydro software to assess economical feasibility of small HP plants

A software for river habitats simulation model (CASiMiR)

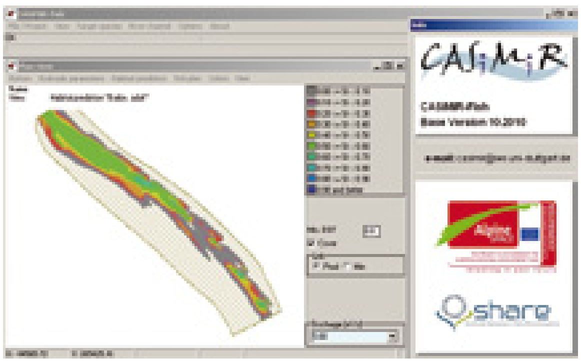
SHARE provides a software for a habitat simulation model, called CASiMiR software, designed to assess the habitat conditions along the river channel and bank areas.

This software is composed of two different modules: CASiMiR-Hydropower and CASiMiR-Fish. CASiMiR-Hydropower helps to assess the economic effects for hydropower production as a result of ecologically adjusted discharges in minimum flow studies. Various plant operation scenarios can be easily simulated and compared using table and chart views of CASiMiR-Hydropower.
CASiMiR-Fish is designed to assess habitat conditions for fish within a river channel and its bank areas. The newest version of CASiMiR-Fish can also be used for assessing habitat quantity and quality for macrozoobenthos species.



The CASiMiR-Hydropower module for evaluation of economic effects for hydropower production.

© CASiMiR-Fish software logo



The CASiMiR-Fish module for evaluation of the habitat conditions along the river channel and bank areas.

SHARE CASiMiR software to assess habitat conditions along the river channel and bank areas

Chapter 1 - Wrap up: what SHARE does & what SHARE does not do

A Permanent Technical Panel of technicians, administrators and policy-makers

SHARE MCA methodology aims to be realistic, unbiased and efficient: for that reason, project tools have been developed with the feedback of a **Permanent Technical Panel** (PTP) created during the project implementation. PTP is an Alpine network linking together people working for public administrations, legal authorities, hydropower companies, environmental and fishing associations, research institutes of river ecology and hydraulic engineering.

SHARE PTP

What SHARE does not do?

SHARE methodology **doesn't provide its own data & information by itself**, but it tries to better use those already existing ("capitalize on local knowledge").

SHARE methodology **doesn't create new knowledge**, but needs good knowledge: the quality of analysis strictly depends on data availability & information quality ("If you load trash, you will have trash").

SHARE methodology **doesn't make everyone satisfied every time**: the best performing management alternative could obviously disappoint some stakeholders ("from a bilateral approach to multilateral approach").

SHARE can hardly ever **be mainstreamed**: it needs transparency and real cooperation among stakeholders ("A black box methodology can be wickedly manipulated or simply fails as every model").

SHARE MCA is a tool to help decision making but it doesn't take the right decision by it self...

Section 3: Applying SHARE

Chapter 2 - Pilot Case Studies: a concrete application of MCA to Alpine rivers

The SHARE MCA approach has been tested in 11 Pilot Case Studies (PCS) concerning both existing or planned HP plants, and significant historical information relating to river ecosystems.
In general, case studies broadly represent common situations of HP
Experimental settings concern specific sets of alternatives, management rules, exploitation settings, temporal scales, indicators and river basin dimensions.
This chapter illustrates experimental settings and facilitates the comprehension of different decision tree models and potential comparative applications.

Project Partners Pilot Case Studies and management alternatives

The SHARE approach has been tested in 11 Pilot Case Studies (PCS).
SHARE Pilot Case Studies SHARE Pilot Case Studies decisional trees

Each PCS has been thoroughly analyzed through the MCA application and described in
SHARE project monographs PCS alternatives full description

The table below provides a short summary description of every PCS with MCA alternative definitions.

▼ PCS short description and MCA alternative definitions

PCS RIVER	PCS GENERAL DESCRIPTION	MCA ALTERNATIVES
CHALAMY	MCA is used to estimate the effects on different concerned criteria of increasing releases of an existing HP plant in a small river, with high natural capital, included in a regional park	**ALTERNATIVE 0**: no MIF released (historical management until 2008) **ALTERNATIVE 1**: 20% of maximum potential MIF released **ALTERNATIVE 2**: 60% of maximum potential MIF released **ALTERNATIVE 3**: 100% of maximum potential MIF released
DORA BALTEA	Dora Baltea is a glacial river with several existing run-off HP plants. MCA is used to understand the effects of increasing water releases on different concerned criteria by 4 HP facilities	**ALTERNATIVE 0**: no MIF released (historical management until 2008) **ALTERNATIVE 1**: 20% of maximum potential MIF released **ALTERNATIVE 2**: 60% of maximum potential MIF released **ALTERNATIVE 3**: 100% of maximum potential MIF released
CHISONE	MCA is used to drive diachronic and spatial analysis of the effects of different HP management in in four river reaches of the Chisone River, interested by the presence of a hydropower plant (Pourrières reservoir and Fenestrelle power station), considering a set of scenarios covering different hydropower exploitation management practices	**ALTERNATIVE 0:** no HP exploitation. This is a hypothetical scenario not including Pourrières reservoir and referred to potential natural conditions from a hydrological and morphological point of view. **ALTERNATIVE 1:** reservoir presence + MIF released + current hydro-peaking. This alternative corresponds to present management of Pourrières reservoir and Fenestrelle HP plant. **ALTERNATIVE 2:** reservoir – no MIF release – current hydro-peaking. This condition corresponds to the 2007-2008 management practices of Pourrières reservoir and Fenestrelle HP plant. **ALTERNATIVE 3:** reservoir – no MIF – no hydro-peaking. This condition corresponds to the 2000-2001 management practices of Pourrières reservoir and Fenestrelle HP plant.

CORDON	MCA is applied to assess different hypotheses of energy production improvement on the upper reach of the Cordon creek which is already equipped with a small HP plant. The underlying basin is very small (6.9 km2). There is also a monitoring station for water and solid discharge that is potentially exploitable for energy production	**ALTERNATIVE 0**: present single plant configuration **ALTERNATIVE 1**: dismantling of existing HP plant intake and construction of a new intake immediately downstream of the monitoring station **ALTERNATIVE 2**: keeping the existing HP plant and building a new power plant with the intake immediately downstream of the monitoring station, and release just upstream of the HP plant (“two small plants in line”)
ASTICO	MCA applied to existing run-of-the-river HP plant with the aim to detect the optimal MIF quantity to release from the considered withdrawal. The plant has a dam creating a small reservoir	**ALTERNATIVE 0:** historical management - no MIF released. **ALTERNATIVE 1:** hydrological MIF release **ALTERNATIVE 2:** increase of the released water up to 150% of the hydrological MIF release **ALTERNATIVE 3:** increase of the released water up to 200% of the hydrological MIF release
KOKRA	MCA is used to assess effects on criteria of different existing HP plants and a new small HP plant. Requested tuning Environmental Flow will be defined from the main area of consideration	**ALTERNATIVE 0:** Current situation **ALTERNATIVES n** (n = 10): different values for residual instream flow from the lowest possible minimum low-flow (Qlow) to the mean annual flow (Qmean) ADDITIONAL ALTERNATIVES (MEASURES) FOR INDICATOR LONGITUDINAL CONTINUUM: - Investor can build a weir on location where there is no impassable sills - ***Measure 0*** - Investor can build a fish pass on one of the impassable sills - number of built fish passes is 1 - ***Measure 1*** - Investor can build fish passes on 2 of the impassable sills - number of built fish passes is 2- ***Measure 2*** - Investor can build fish passes on 3 of the impassable sills - number of built fish passes is 3 - ***Measure 3*** - Investor can build fish passes on 4 of the impassable sills - number of built fish passes is 4 - ***Measure 4***
MUR	Mur PCS tract is interested in a set of concatenated run-off HP plants (4 plants) with flushing management problems. Bodendorf HP plant is the head of this Power plant chain. MCA is used to define better flushing alternatives to optimize effects on all stakeholders involved, in particular in order to reduce the negative ecological impacts of flushing	**ALTERNATIVE 0:** current flushing conditions **ALTERNATIVE 1:** extending the duration of flushing with probably good sediment transport but large ecological impact on downstream ecosystems **ALTERNATIVE 2:** reducing the duration of flooding with longer secondary flushing with clear water, reducing ecological impacts but probably insufficient sediment transport
INN	WFD implementation intends to “preserve” a famous meander impacted by a historical HP plant: MCA is a support to define the best way to manage different stakeholder requirements	**ALTERNATIVE 0**: historical management practices before the hydro-electric facility installation in the meander **ALTERNATIVE 1**: current management practice with Q dot=0.4 m^3/s water discharge released in the meander **ALTERNATIVE 2**: increase till Q dot = 6.0 m^3/s of water discharge released in the meander **ALTERNATIVE 3**: building a fish ladder at the upper side of the main weir requiring a Q dot=13 m^3/s of water discharge released in the meander

Chapter 2 - Pilot Case Studies: a concrete application of MCA to Alpine rivers

ARC-ISERE	Long term effects of old HP production systems are represented in a wide basin: MCA supports a broad spatial and temporal scale ex-post analysis	**ALTERNATIVE 1:** no HP installed in the upstream basin. **ALTERNATIVE 2:** presence of important storage dams in the upper portion of the basin **ALTERNATIVE 3:** Downstream dams and "STEPs", interbasin transfers **ALTERNATIVE 4:** present state of the river: all hydroelectric equipments
VAR	A set of sills originally built to moderate the effects of floods, is equipped with micro-hydropower plants. Upstream, due to the small dams, silts deposited tend to limit water exchange between the aquifer and the river. Thus some old existing hydraulic works would be threatened in cases of flooding and may collapse, increasing the hydrogeological risk. These sills will be lowered in the goal that the river returns to its natural functioning and flood transports sediments unhindered. Three stations on the sill 8th, 9th and 10th must be removed	**ALTERNATIVE 0:** maintenance of sills equipped with power plants (current case and not maintainable) **ALTERNATIVE 1:** removal of all sills and power plants (desired solution by the objectives of SAGE) – except n° 16 **ALTERNATIVE 2:** development of new power plants technology: airbag sill on the total width of the river (solution studied by the operator) **ALTERNATIVE 3:** development of new power plant technology: airbag sill on a partial width of the river (solution studied by the operator)
LECH	The river reach is heavily affected by hydropeaking with strong negative effects on flora and fauna (especially fish and macroinvertebrates fauna). The upstream HP plant controls the daily discharges which range between a basis discharge (Q min of 10 m³/s in winter, 20 m³/s in summer) and a maximum power plant turbine discharge (Q max of 160 m³/s) usually inducing flow peaks two times a day. Alternative hydropeaking schemes are set, aiming for a reduction of negative effects by increasing the basis discharge, reducing the maximum discharge and optimizing daily discharge variation	**ALTERNATIVE 1:** historical situation **ALTERNATIVE 2:** status quo: Q max = 160 m³/s, Q min = 10/20 m³/s (winter/summer), Q change not specified **ALTERNATIVE 3:** new agreement on hydropeaking: Q max = 135 m³/s, Q min = 25/40 m³/s (winter/summer), Q change = max 50 m³/s / 30 min **ALTERNATIVE 4:** new agreement on hydropeaking and renaturation **ALTERNATIVE 5:** IWS proposal on hydropeaking and renaturation **ALTERNATIVE 6:** IWS proposal on hydropeaking

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PCS decisional trees, monographs and extended alternative descriptions are available in annexes to the present report.

SHARE Pilot Case Studies alternatives full description

As detailed above, MCA has been applied to different sizes and typologies of HP plant facilities as summarised in the table below.

Chapter 2 - Pilot Case Studies: a concrete application of MCA to Alpine rivers

Table 3.2.2: Alternatives considered in the different PCS's

PILOT CASE STUDY	EX ANTE / EX POST	HP POWER (MW)
Dora Baltea	4 existing plants	Champagne II 27.0 MW Saint-Clair 31.0 MW Hone I 18.5 MW Bard 3.2 MW
Chalamy	1 existing plant	Champdepraz 2.3 MW
Chisone	1 existing plant	Pourrières 17.0 MW
Cordon	1 existing plant + 1 planned plant	0.19 MW
Astico	1 existing plant	Bessè 2.88 MW
Sava (Kokra)	1 planned plant	1.0 MW
Mur	4 existing plants	Bodendorf 7.0 MW St. Georgen 6.0 MW Murau 4.4 MW Untzmarkt 4.6 MW
Inn	1 existing plant	Kirchbichl 24.0 MW
Arc-Isère	big existing plants system	2520.0 MW
Var	8 existing plants	Sill 10: 1.778 MW Charles Abert: 3.366 MW La Mariée: 1.739 MW Selves: 2.515 MW La Manda: 2.030 MW Les Cappans: 2.367 MW La Courbe: 2.377 MW St Sauveur: 2.469 MW
Lech	1 existing plant	Dessau 10.3 MW

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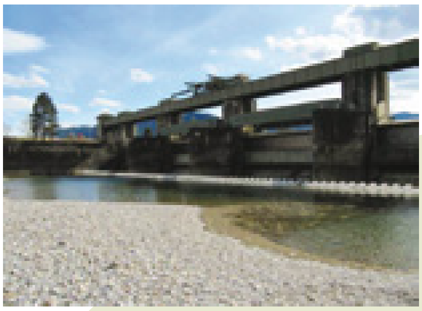
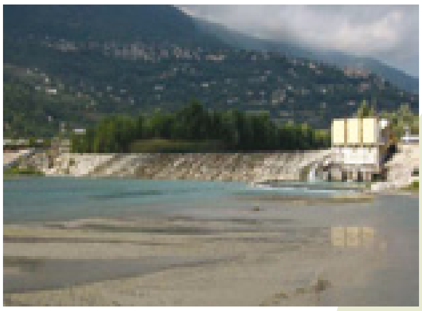
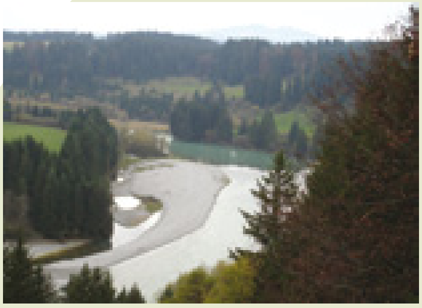
Chapter 2 - Pilot Case Studies: a concrete application of MCA to Alpine rivers







From up-left ▶

LP - CHALAMY
© ARPAVDA
LP - DORA BALTEA (Montjovet)
© S. Venturini
PP1 – CHISONE
© REGIONE PIEMONTE
PP2 – CORDON
© ARPAV
PP2 – ASTICO
© ARPAV
PP4&PP5 – KOKRA
© E-ZAVOD; UL
PP6 – MUR
© TUG
PP7 – INN
© UNI-INNSBRUCK
PP9 – ARC-ISERE
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PP11 – LECH
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Chapter 2 - Pilot Case Studies: a concrete application of MCA to Alpine rivers

MCA indicators used in PCS

SHARE MCA implies the compulsory use of indicators referred to common criteria: PCS decisional trees hold the same basic structure of criteria, but different sets of indicators: typology and number of indicators, whose value variation is at the basis of multicriteria analysis, depend on the single Pilot Case Study characteristics and the chosen alternatives.

HP Energy & Economic indicators

Such criteria, provided with specific indicators related to HP production (energy) and economic aspects (investments, benefits), evaluate how each alternative affects the performance of the hydroelectric plants in the geographic areas of each PCS (Tab. 3.2.5). Those effects will depend on the type of each plant and hydrological characteristics of each river basin.

River conservation indicators

Almost all PCS have considered common sub-criteria (Tab. 3.2.6) such as:

- Biological components
- Physico-Chemical components
- Hydromorphological components

Biological indicators have often been extracted from datasets collected following legislative requirements, even if quite frequently in mountain stretches, the official metrics (related to diatoms, macrophytes and macrozoobenthos) seem to respond more to trophic status than to river HP effects: in other words, in some PCS no evident HP upstream - downstream gradient has been evident during sampling and data elaboration. Fishes seem to be the more reactive biological component in relation to HP pressure, even if they are often heavily affected by uncontrolled restocking by fishermen, whose effects can be difficult to distinguish from those arising from HP pressure.

Different possible hypotheses can be proposed to explain the irregular response of biological river communities, such as:

- the official metric chosen is commonly more related to other drivers (e.g. trophic & nutrient conditions, riverbed modifications, pollutants presence);
- the taxonomic level of classification of biota is too generic (e.g. using family level rather than species level) and doesn't allow the adoption of a rivet popping approach;
- the average size and home range of the organisms considered (e.g. benthos, diatoms) are too small to be related to the effects of HP presence in the river;
- the period of investigation is too short to allow detection of HP effects on river communities;
- the adaptation of communities to chronic HP effects may hide the impacts of HP;
- the combination of HP effects and natural mountain constraints can make it difficult to separate HP effects from global conditions of river reach.

The above mentioned hypotheses outline very interesting research topics, but cannot really be fully treated in a cooperation project, not least because in the meanwhile management problems due to new demands and concession renovations are constantly growing.

Hydromorphological indicators (as residual discharge, wet area variation, longitudinal continuity, morphological river bed variations, etc.) are generally considered only in some PCS, above all where new HP plants are planned along a natural river reach. The natural discharge and **hydro morphological elements are reactive to HP pressure**, but considered in the assessment of the status of water bodies only for those of "high ecological status" (WFD, All. V, tab 1.2.1).

From PCS experience, hydro morphological indicators could hold strategic information to assess HP effects on hydro systems, directly related to WFD river status. In particular, high hydro morphological diversity seems to be closely linked to a **high number of ecosystem** services supported (J. H. Thorp et al. "Linking Ecosystem Services Rehabilitation and River Hydro geomorphology", 2010).

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At the same time, their value is generally positively related to the value of other mountain WFD communities ("**umbrella indicators**") and their spatial scale closely fits the scale of HP exploitation and planning. For instance, they have been used at a single HP plant level (Lech, Dora Baltea, Mur, Chalamy) referring to metrics such as:

- Wet Area (Volume) variation weighted at a meso - habitat scale
- Depth variation weighted at a meso - habitat scale
- Weighted usable area (WUA) for biota accommodation
- MESOHABSIM (Parasiewicz et al. 2007) metrics
- CASiMiR Computer Aided Simulation Model for Instream Flow Requirement (Noack et al. 2010) metrics
- IFIM Instream Flow Incremental Methodolgy (Bovee et al. 1998) metrics

Hydromorphological methods have also been used for wider (basin) scale applications, mainly linked to riparian vegetation status and ecological functionality (IFF - Indice di Funzionalità Fluviale (Siligardi et al., 2007) in Dora Baltea and Chalamy rivers): at this scale, hydromorphological indicators are useable as representations of the natural capital and annexed ecosystems services exposed to HP pressure.

River Functionality Index report

MCA indicators considered in SHARE Pilot Case Studies ►

PCS	ENERGY INDICATORS	ECONOMY INDICATORS	RIVER CONSERVATION INDICATORS	TOURISM INDICATORS	LANDSCAPE INDICATORS	OTHER
CHALAMY	Annual Energy produced Linear Annual Energy produced	Administration level (regional level) Producer level (financial outcomes)	Physico-chemical parameters EPT FISH Hydromorphology	Tourism (and other river fruition) Fishing (Fisherman score, Weighable usable area – IFIM – for adult sizes)	Landscape scenery value (Tyrol)	
DORA BALTEA	Annual Energy produced Linear Annual Energy produced	Administration level (regional level) Producer level (financial outcomes)	Physico-chemical parameters EPT FISH Hydromorphology	Tourism (and other river fruition) Fishing (Fisherman score, Weighable usable area – IFIM – for adult sizes)	Landscape scenery value (Tyrol)	
CHISONE	Global Production Local production	Costs Proceeds	River ecosystem - Hydrology (flow variation, hydrological integrity, hydropeaking) - Morphology (riverbed substratum, banks, morphological integrity) - Aquatic environment (Fish, macrophytes, macrobenthos) - Riparian environment (riparian habitats, riparian communities) - River corridor functionality index – IFF Global environment - CO2 offset	Fruition - Residual flow reach (fishing, tourism) - Reach downstream of water release (fishing, tourism)		
ASTICO	Local (annual en produced, discharge en coefficient) Global (National En Improvement, National RES En Improvement)	Producer level (financial outcomes)	River ecosystem (fish, macrobenthos, macrophytes) Global environment (CO2 offset)	Fishing	Landforms	
CORDON	Local (annual en produced, linear annual en produced, installed power, discharge en coefficient) Global (National En Improvement, National RES En Improvement)	Producer economy (financial outcomes, specific	River ecosystem (fish, macrobenthos) Global environment (CO2 offset)	Fishing	Landforms Artificial buildings	

PCS	ENERGY INDICATORS	ECONOMY INDICATORS	RIVER CONSERVATION INDICATORS	TOURISM INDICATORS	LANDSCAPE INDICATORS	OTHER
KOKRA	RSE hydro-energy (annual production)		Biological quality (fish, phytobenthos) Hydromorphological quality (river long continuum, river transversal continuum) Chemical and physico-chemical quality (temperature)			
MUR	Annual en production	Energy production lack (duration of flushing, energy price per kWh, power installed) Flushing efficiency (volume original, sediment output, volume before flushing)	Abiotic indicators (bedload transport, change of grain size distrib, suspended sediment conc peak, suspended sediment concentration average) biotic indicators (substrate conditions, juvenile fish conditions, adult fish conditions)			
INN	Energy production (annual en production GWh per year rough estimation)		Biological quality (macroinvertebrates hydraulic habitat suitability, fish hydraulic habitat suitability index) Hydromorphological quality & connectivity for fish (discharge requirements for fish, river connectivity fish ladder/bypass)		Landscape aesthetical value	
ARC-ISERE	Local (discharge en coefficient) Global (energy renewable directive, national en improvement)	Benefit HP producer Local economy	Local - Physical&chemical Local - Biological (composition and abundance of flora aquatique, benthic fauna, fish fauna) Local - Hydromorphological parameters (flow regime, river transv continuity, river long continuity, morphological condition - depth&width variation, structure&substrate of river bed, structure of riparian zone) Global - CO_2 offset	Fishing Rowing and rafting	Landforms flora fauna Infrastructures	Other stakeholders - water abstraction (irrigation, industry and drinking) - waste water discharge dilution (urban and pluvial and industrial) Flood risk - maintenance cost for flood control structures - new flood control structures

PCS	ENERGY INDICATORS	ECONOMY INDICATORS	RIVER CONSERVATION INDICATORS	TOURISM INDICATORS	LANDSCAPE INDICATORS	OTHER
VAR	Energy production (annual energy produced, production regards local consumption, production regards local hydropower production)	Economy related HP exploitation (financial outcomes producer level, economy regional level)	Hydromorphology (solid transport continuity, river changes) Fish continuity Terrestrial and aquatic biodiversity	Tourism linked to HP plant visits		Drinkable water intake upstream Security of the river bed (exceptional events as a hundred-year flood, hydraulic works management costs)
LECH	Total daily energy production Peak daily energy production	Total daily profit Annual renaturation expenditures for spawning grounds renaturation	Hydromorphology Biological quality (fish, macrozooinvertebrates)	Local sport fishery Recreation		

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River assets, Landscape & other stakeholders Criteria and Indicators

Additional indicators related to River assets, Landscape and other stakeholders' water uses have been used in different PCS with a low frequency as shown in the tables below.

▼ Presence of indicators regarding River assets, Landscape and other uses of different stakeholders

Competing uses

PILOT CASE STUDY	IRRIGATION	FACTORIES	POLLUTANT DILUTION	DRINKING WATER
Chalamy	NO	NO	NO	NO
Dora Baltea	NO	NO	NO	NO
Chisone	NO	NO	NO	NO
Astico	NO	NO	NO	NO
Rio Cordon	NO	NO	NO	NO
Kokra	NO	NO	NO	NO
Mur	NO	NO	NO	NO
Inn	NO	NO	NO	NO
Arc-Isère	**YES**	**YES**	NO	**YES**
Var	NO	NO	NO	**YES**
Lech	NO	NO	NO	NO

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▼ River assets, Risk and Landscape

PILOT CASE STUDY	TOURISM	FISHING	CANOEING AND WATER SPORTS	RISK MANAGEMENT	LANDSCAPE
Chalamy	**YES**	**YES**	NO	NO	**YES**
Dora Baltea	**YES**	**YES**	NO	NO	**YES**
Chisone	**YES**	**YES**	NO	NO	NO
Astico	NO	**YES**	NO	NO	**YES**
Rio Cordon	NO	**YES**	NO	NO	**YES**
Kokra	**YES**	**YES**	NO	NO	NO
Mur	**YES**	**YES**	NO	**YES**	NO
Inn	NO	NO	NO	NO	**YES**
Arc-Isère	**YES**	**YES**	**YES**	**YES**	**YES**
Var	**YES**	NO	NO	**YES**	NO
Lech	**YES**	**YES**	NO	NO	NO

A detailed **database of useable indicators (SHARE indicator toolbox)** for river and HP issues has been developed within the SHARE project and is available as an electronic annex.

SHARE indicator toolbox

Section 3: Applying SHARE

Chapter 3: SHARE quality standards and guidelines to integrate MCA in law

A guidebook for policy-makers has been produced to help decision-makers take transparent and well informed decisions where hydropower is involved, thanks to the SHARE MCA methodology and the implementing software

Dealing with complexity is certainly the main challenge for policy makers.

Taking a decision for a local or a regional authority presents a challenge in considering the point of view of many citizens, and the interests of many users or actors, which are sometimes contradictory. This is a serious responsibility: taking a wrong decision could cause lasting damage (i.e. for generations), or destabilize definitively any capacity to satisfy the general interests of those involved. However, things have moved forward over the last decade: the knowledge of actors has increased, in tandem with the regulatory framework.

We are no longer in a period when development of Alpine regions is driven by monopolies; decision makers have to aim for sustainable development. This dominant concept can also be considered as a school of open-mindedness and balanced decision making: **how can the short-term need of development be balanced with the long-term necessity of social regulations and environmental preservation?**

The integration of sustainable development into policy making could then be considered as a renewable resource for democracy, and hence could support the core democratic concept of consensus, "commune values" or general interest. In a political and operational context, sustainable development, sometimes considered as politically correct, has become a strategic topic because of the "transversality" it implies; however, it remains difficult to integrate into decision making due to the sectored approaches used by administrations and institutions. It is also difficult to translate decisions into actions whilst maintaining a balanced position. An authority has to deal with the power of experts. **Transparency has become absolutely necessary for political decisions and public actions.**

In some ways, the legal framework can also give paradoxical, or even schizophrenic, orientations. That is the case between the EU Water Framework Directive and the EU Energy-Climate package: is it possible to respect both the "good quality of water resources" and the objectives of 20% of renewable energy in 2020 considering Alpine hydropower potential?

The Alpine challenge

The Alpine economy has been strongly influenced by its capacity to make an asset out of a permanent natural handicap, i.e. slope, climate or other natural elements such as water in its various forms (ice, snow and liquid). The abundance of water (precipitation) in the Alps combined with the slope provides a factor of risk, but it has been used to reduce manpower and progressively to supply the energy needs of all of Europe. Hydropower has certainly been one of the main structural forms of energy production for Alpine valleys; the installation of many **electro-intensive industries (EII** such as carbon, aluminium, etc.) in Alpine valleys during the XIXth and XXth centuries is the direct consequence of the proximity of hydropower plans. At the turn of the XXIth century, EII are in such global competition that it is hard to maintain them in Europe, but **hydropower remains a strategic sector** as it is the main renewable component of energy sources. Hydropower could then be considered as a strategic sector, as it is in Austria and Switzerland, because, even if it is not low-cost energy, it is flexible and performs well. It should be noted that the total power output of the Alpine hydropower stations is more than 45,800 MW.

Alpine regions are giving the highest attention to the **natural capital** they have in heritage. Therefore, the double question of the good quality of water resources and the good level of renewable energy production is of vital importance in the Alpine area. The ecosystem services are now also considered as part of its economic value[3], thus recognizing that the Alps have the necessary assets to be a leading region regarding green growth.

[3] The Economics of Ecosystems and Biodiversity (TEEB) study is a major international initiative to draw attention to the global economic benefits of biodiversity, to highlight the growing costs of biodiversity loss and ecosystem degradation, and to draw together expertise from the fields of science, economics and policy to enable practical actions to move forward. www.teebweb.org

Another key factor is the importance reached by the issue of adaptation to **climate change**. The Alps is forecast to be subject to temperature increases up to twice the rate of that in the lowlands. The impact on the economy, environment and natural risks could therefore be profound. Even though the solution is global, many Alpine actors and municipalities have developed climate plans which have instigated some crucial energy policies. The Action plan for climate of the Alpine Convention could be considered as an emblematic initiative from ministerial actors. During the preparatory discussion before the ministers' decision at the Alpine conference in Evian, certain exchanges between some administrators of the European Commission DG Environment and some civil servants of the Alpine ministers were particularly strong regarding the conflict between a strict consideration of what is a "good level of water quality" and the necessity of support for micro and Pico-hydropower plans to adapt to climate change. At this European level, such a controversial debate between actors sharing common challenges and values is symbolic of the complex context within which policy makers should decide whether and how to develop micro-hydroelectricity in the Alps.
The risk is that the important potential of renewable energies in the Alps will appear impossible to realize, or too expensive to mobilize, because of the political complexity in deciding what is good or bad, even if the **real choice is generally between the lesser of two evils**.

River ecosystems versus hydropower? Environment versus adaptation to climate change?

During the period of SHARE, the Alpine Convention and the Alpine national states set up a "Water platform" presided over by Switzerland, following the report on the State of the Alps dedicated to water issues. The "water platform" has recently worked on Common guidelines for the use of small-scale hydropower in the Alpine region - Alpine Signals Focus 1 - 2011.

The SHARE project has been a core component of this work and these common guidelines provide an important element to consider the importance of the issue, but also to study how to implement the SHARE MCA in law.

The growing concept of territorial cohesion in EU affairs could help us to consider the challenging elements that have to be integrated with particular attention, but at which levels of governance (or government) and at what scale? We have to consider that the EU Water Framework Directive is one of the major legal frameworks to propose a Regional Environmental Governance.

www.reg-observatory.org

The creation of management structures organized at the scale of rivers and basins is certainly a major progression for the territorial approach in EU policies outside CAP and Cohesion policies. In this context, SHARE MCA appears as a modern and scientific way to aggregate different criteria to inform decision making, which fits well with the history of the Alpine cultural landscape[4] defined by the interaction between social, cultural, environmental and economic driving forces in the Alpine territory.

Considering this favorable Alpine "compost", SHARE MCA appears as a perfect tool to integrate complex data and to manage multipart systems. Rather than ignoring a particular dimension or giving too much weight to a single issue, the SHARE MCA supports a balanced integration of every interest. SHARE MCA helps to objectify a decision, avoiding non-transparent political assessments made with overly technical standpoints.

In many cases, new hydropower projects face a pros-or-cons ex-post evaluation. There are costs for such a process: Ecological costs if a plan destroys or degrades some ecosystems, economic costs if a proposed plan is abandoned. **In the case of the SHARE MCA process being officially integrated in a shared ex-ante evaluation, only sustainable projects would be proposed**. A political analysis and decision would still be possible regarding the weight given to the various indicators linked to the priorities.

[4] See Werner Bätzing, Die Alpen, Geschichte und Zukunft einer Kulturlandschaft, Munich, 1991

Chapter 3: SHARE quality standards and guidelines to integrate MCA in law

During the meeting undertaken with various experts, stakeholders and decision makers, the SHARE MCA process was received positively, giving real opportunities to organize better partnerships and multilevel governance. This is absolutely necessary for mountain territories such as Alpine regions to adapt policies to the specific challenges or "regions with natural or geographic permanent handicaps". Regional environmental governance is a key challenge for the sustainable development of mountain regions.

Pertinent scales of actions: where and when to integrate the SHARE MCA procedure?

The integration of SHARE MCA into legislation, plans or programs should be analysed with respect to the need for integration, the degree of integration, and the identification of interfaces for possible integration. Territorial cohesion appears at this stage to be a key element in identifying the pertinent scale for defining **"interfaces" between powers (authorities, civil society, users, etc.) and politics**, considering both efficiency and equity.

The need of SHARE MCA integration into the legal framework

The need for the integration of SHARE MCA into the legal process is directly linked to the wide range and diversity of impacts associated with HP production. Classically perceived as a conflict between economic interests and ecological impacts, the range of real or potential interrelations is very complex, including competing economic (fisheries, but also tourism and agriculture) and environmental interests, such as renewable energy production and the good ecological status of river bodies, expressed by the respective European directives RESe and Water Framework Directive (WFD).
The potential benefits of a tool helping to support decision makers in understanding the complexity of interactions between HP and other activities linked to the use of water resources in a river stretch are however linked to questions of transparency, sensitivity and completeness.
The issue of **transparency** refers to the fact that all steps of the MCA-tool have to be understandable and retraceable by the decision makers, controlling bodies, other stakeholders, and the general public.
Sensitivity means that the tool used cannot only handle the architecture of the river system and the different impacts triggered by the different alternative solutions of HP production, but also a shift of priorities.
Completeness refers not only to the integration of all aspects relevant for decision making, including the scoping (i.e. a clear and concise identification of the aspects for each case), but also to the integration of their interactions.
In the context of the SHARE project, the usability of the proposed SHARE MCA approach is being assessed in the national Permanent Technical Panels (national PTP), integrating the stakeholders with interests linked to HP decisions.

The degree of SHARE MCA integration

Some evaluation and decision making methods have been directly integrated into the legal set of laws: Thus the evaluation of alternatives has been integrated into the spatial impact assessment of different countries as a compulsory step[5].

SHARE guidelines to integrate MCA in local rules

[5] E.g. Germany §15 ROG; http://bundesrecht.juris.de/rog_2008/__15.html

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Taking a similar approach, SHARE MCA could be integrated into the decision making process for HP decisions as a **compulsory tool**. Direct integration in the legal process requires a respective decision of the responsible legislative body, thus the different procedures of lawmaking and amendments have to be considered for each involved public authority and country.

The identification of interfaces (intermediary / partnership bodies)

The integration of the SHARE MCA procedure into legislation may be more efficiently focussed on interfaces at the pertinent scale of governance (river or local, basin or regional, national or European). These interfaces could be defined as governance bodies at the crossroads of strategic planning and operational actions that could foster a partnership mediation (dialogue). This soft-law dimension is absolutely crucial within the strict legal framework set by the EU WFD to integrate the territorial dimension of river basins (interregional or inter-municipal), but also for the broader-scale energy plans that are set up at regional or local level.

Besides a compulsory legal integration of SHARE MCA into the legislative procedures, the identification of common existing interfaces between these procedures and MCA would help to clarify the concrete benefits of the SHARE MCA approach, or at least some of its relevant elements on a technical and pragmatic level.
These types of interface can refer to:

- the scoping of the impact on resources and activities;
- overall or specific goals and objectives;
- territorial and political priorities;
- the identification of stakeholders and their level of involvement in the decision making process.

Legal and Administration competencies

There is a **variety of legal and administrative competencies concerning water management** of the different territorial partners involved in the SHARE project, and more broadly in the wider Alpine Space. One of the characteristics of water management is that administrational territories and water basins do not always correspond. Additionally, the different types of integration of water management bodies have to be seen in the respective administrational and legal context.

In contrast to other policy fields (e.g. cohesion or agricultural policy), **water management is no direct issue of EU decisions**. The EU level is, however, involved in water management by the setting of EU-directives, headed by the Water Framework Directive (2000/60/CE WFD)[6], that have to be implemented into national laws of the member states.
In **France** and **Slovenia**, the legislative competencies are exclusively concentrated at the national level. All laws, guidelines or directives, as for example the French environmental code[7], are set up by the national authorities.
Since 1992, the large river basin level is covered by the SDAGE - “Schéma d’aménagement et de gestion des eaux”. Currently seven SDAGE cover the European French territory, although only one of them, the SDAGE for Rhône and Mediterranean[8], covers the territory of the Alps.

These types of water management plan contribute directly to the implementation of WFD (2000/60/CE). Similar plans or programs at comparable levels can be found in Austria – the national water management plan (Nationaler Gewässerbewirtschaftungsplan)[9]; in **Germany** – the management plan (Bewirtschaftungsplan) drafted by the State of Bavaria for the Danube river[10] and the plan covering the German Alpine territory; or, in **Italy** the plan covering the Po water basin (Piano di Gestione del Distretto idrografico del Po)[11].

Integration of Multi Criteria Analysis in Plans and Programs

Plans and Programs are drafted by water management bodies in order to ensure a sustainable use of water resources. In all Alpine states participating in the SHARE project, they

[6] For more information on the Water Framework Directive : http://ec.europa.eu/environment/water/water-framework/index_en.html
[7] For an English version of the French Environmental Code: http://195.83.177.9/code/liste.phtml?lang=uk&c=40
[8] www.rhone-mediterranee.eaufrance.fr/gestion/dce/sdage2009.php
[9] http://wisa.lebensministerium.at/article/archive/29368
[10] www.lfu.bayern.de/wasser/wrrl/bewirtschaftungsplaene/index.htm
[11] www.adbpo.it/on-multi/ADBPO/Home/articolo1080.html

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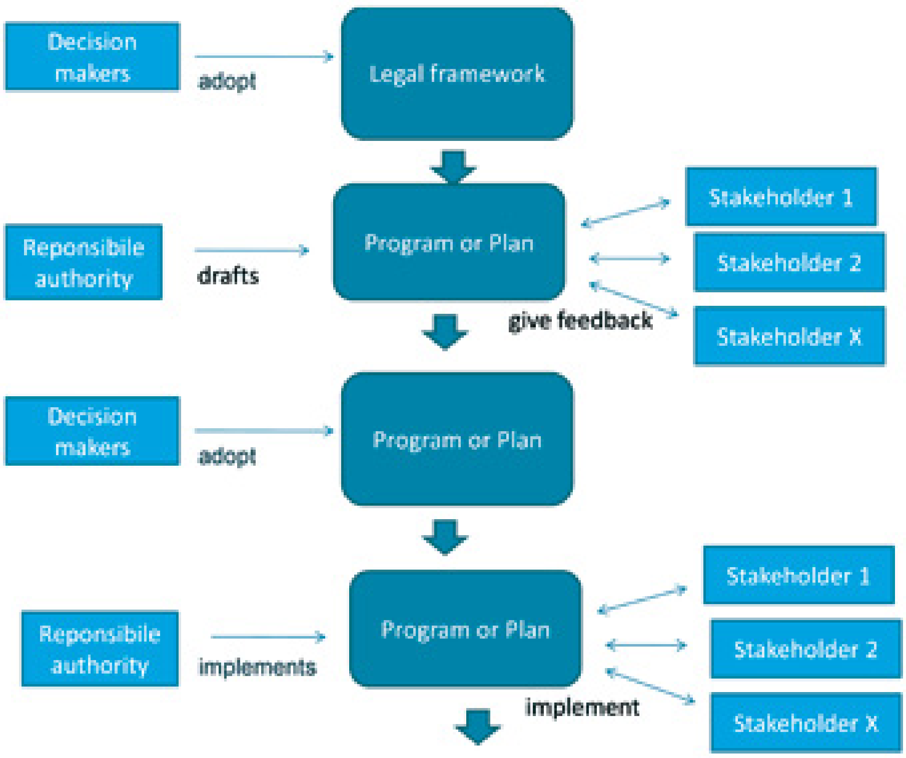
are usually set up at least on two levels - a larger basin and a sub-basin level - and involve, in addition to the public authorities, decision makers and different stakeholders.
The newest generation of water management plans and programs is usually directly linked to the WFD.

It appears that **plans and programs are strategic tools set up for a period of 10-15 years** integrating all activities and interests relevant to water management in the respective area. If relevant, HP production is either addressed explicitly or in a transversal way.
During the different phases of their thematic relevance, water management tools and programs offer different interfaces for direct or indirect integration of the SHARE MCA approach:
Drafting phase: Scoping of relevant interests and activities; scoping of political priorities set out by decision makers; integration of stakeholders;
Adoption: Direct integration of decision makers and political responsibilities;
Implementation: Deployment of goals and objectives.



Flow model of the different phases of the process for the drafting, adoption and implementation of plans and programs

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▼ Rhône-Mediterranean 2010 is covering the territory of the French Alps
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11,000 water courses exceeding 2 kms and 1,000 kms of shoreline

There are abundant water resources in the Rhone-Mediterranean basin:

- Large number of surface flows (44% of the national total)
- Exceptionally high density of water bodies (Lakes Léman, Annecy and Le Bourget, etc.)
- Large wetland coverage (surface area over 7,000 Km^2),
- 400 catalogued aquifer systems,
- Glaciers (15.5 billion m^3 of stored water), etc.

Example: Identifying interfaces for the integration of SHARE MCA into a program in France: The “Schéma d’aménagement et de gestion des eaux” for the Rhône – Mediterranean water basin, covering the territory of the French Alps[12]

The SDAGE is a planning tool for the orientation of integrated water management in large river basins based on the French law 03/01/1992 and 30/12/2006 on water and hydrographic environments and the Water Framework Directive.
The SDAGE for the Rhône – Mediterranean river basin, covering the whole of the French Alps, has been put into practice in 2010. In contrast to the previous version from 1996, hydro power is mentioned as a transversal activity, linked to orientations of physical restoration of the natural environment (OF 6) and water balance (OF7).

With reference to the different orientations, the SDAGE develops more concrete “dispositions” and “measures”. These dispositions and measures indicate action fields, goals and stakeholders for future decisions which could be rebuilt in an SHARE MCA approach.
For **example**, the disposition 6A13 from the current SDAGE refers to the “improvement or development of the coordinated management of constructions at the scale of a river basin”, thus identifying an action field: Management dispositions are supposed to be “improved”, not one by one, but in a “coordinated” way. It also offers a scale: a watershed basin.

In order to fill the SHARE MCA criteria, it make sense to summarize, if not all planning dispositions referring to HP, at least a set of thematically connected dispositions and measures.

[12] www.rhone-mediterranee.eaufrance.fr/gestion/dce/sdage2009.php

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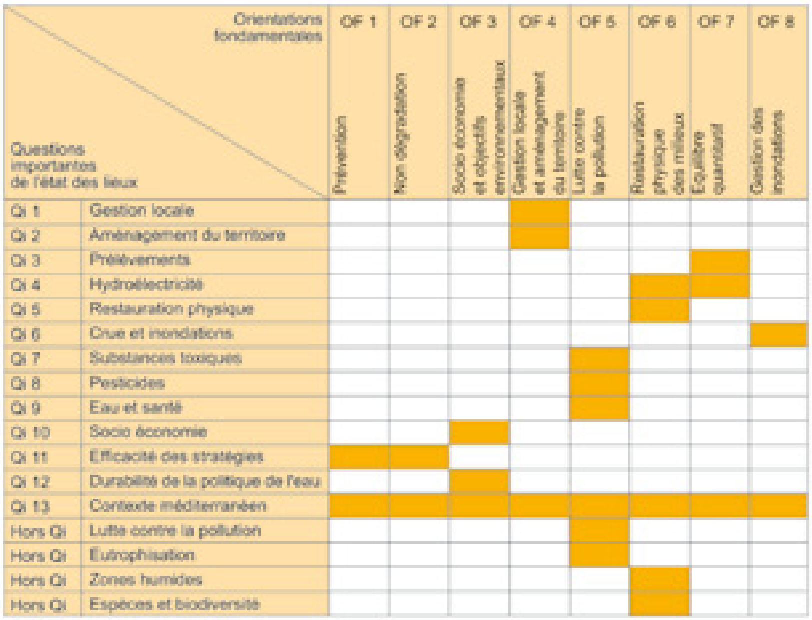

In the SDAGE 2010 Hydroelectricity is addressed as a transversal question

Issued from the pdf www.share-alpinerivers.eu/tools-and-resources/online-handbook-links/publi%20SDAGE.pdf/view p.50

The SDAGE offers a grid for governance by creating a "Riverbasin Committee", and respective territorial sub-structures for governance and participation. Furthermore, the SDAGE also offers a tool for participation and integration of stakeholders.
In an analogous way, planning and program documents are set up at lower levels. In France the SAGE (Schéma d'aménagement et de gestion des eaux) is established for more limited territories.

MCA for project evaluation

Project evaluation is a more classical field of the application of SHARE MCA characterized by the initiative of a project proponent. The proponent addresses the responsible authority with a request for permission or allowance. The authority scopes the field of investigation, informs the stakeholders and other authorities, and organizes, if relevant, public hearings and finally takes the decision.

Usually, decision makers are not directly involved. However, the decisions taken by the public authority have to be in line with laws, directives, programs and plans, adopted by the decision makers.

A new project has to be validated by the competent authorities and therefore its impacts on the different aspects of water management have to be assessed. Due to the project focus, **the framework of the subject for the assessment is less strategic and more feasible.**

An apparent contradiction of project evaluation arises in the fixing of the best moment for an overall multi criteria analysis: The outlines of the project have to be clear enough in order to determine its impact on the resources and on the different users, but still "fuzzy" enough to allow an appropriate adaptation to the constraints of each particular case. A possible answer to this contradiction could be an evaluation in three phases:
Phase I: project ideas assessment - by project applicant;
Phase II: project orientation: preliminary assessment; first legal scoping;
Phase III: orientation for the legal procedures – by public authorities, participation of stakeholders
Good legal interfaces for the integration of SHARE MCA into the project evaluation should follow the steps of the respective procedures that consider a variety of different aspects and offer the possibility of wider participation, as in Environmental Impact Assessment (EIA) and in Strategic Environmental Impact Assessment (SEA)[13].

[13] For more information on the European EIA guideline http://ec.europa.eu/environment/eia/home.htm

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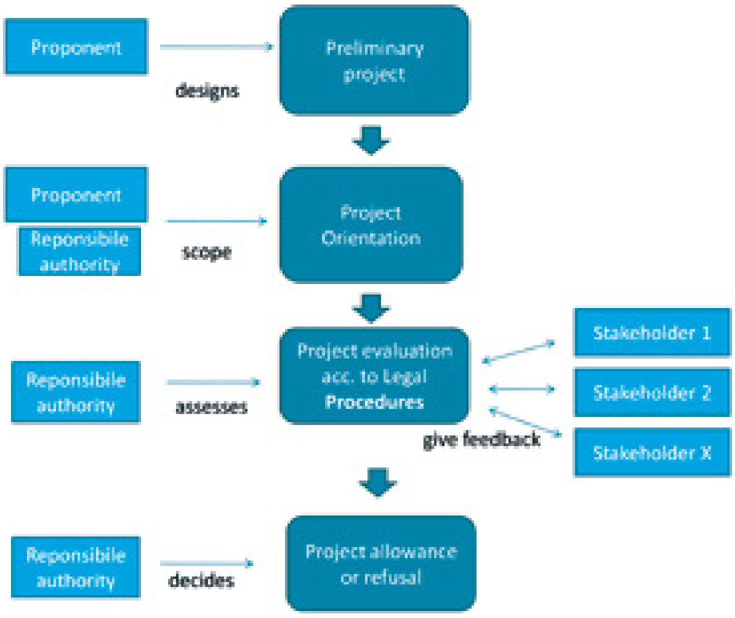

The main steps of a project evaluation procedure

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Contract and agreements among stakeholders and between public authorities and stakeholders

HP management is characterized by a growing relevance of **contracts among public authorities and relevant stakeholders**. Usually on the initiative of the responsible public authorities, stakeholders representing relevant interests of river resources agree on HP issues in the form of a contract. The advantage for all sides is that HP issues can be addressed in a focused manner, while still involving a range of relevant interests.
As the potential range of topics of such **HP focused water management agreements** is large, the use of the SHARE MCA approach is recommended.
Fixing of criteria which can guide the authorities in their relevant decisions is one interface. It is based on the fact that the agreement for criteria is the most sensitive issue for the discussion of HP decisions. If it is possible to shift the set-up of relevant criteria from a case-by-case discussion to a more structured setting, the transparency of HP decisions would be increased.
Another possibility is the integration of SHARE MCA into **plans and contracts** as a pilot tool. This is an option, if stakeholders representing different interests have already initiated a discussion about a set of scenarios on the future of hydropower in a definite context. As different as these measures are in terms of precision, timeline or feasibility, SHARE MCA for a pilot case or territory could be one of the alternatives This is particularly true as these agreements prove on the one hand the potential of negotiation on HP issues, confirmed by the successful agreement signed by the different stakeholders, and on the other hand that this type of agreement usually requires implementation, monitoring and renegotiation.

Some examples can be quoted:

Example 1: criteria for hydropower in Tyrol (March 2011)

Tyrol government report

Tyrol has extended its long experience of stakeholder dialogue to the field of hydropower. The scope of the agreement is the criteria. Fixed in a fairly detailed set, the criteria are very operational and can be implemented at all phases of the project planning process, as well as for programs and plans.

Kriterium	Indikator	Modellierbar[26]	Bedeutung	Bewertung		
				Punkte	Intervalldefinition	
Technisch-wirtschaftliche Aspekte Bewertung der zur technischen Nutzbarmachung eines Wasserkraftpotenzials erforderlichen monetären Aufwendungen (ökonomische Effizienz) als Investitionskosten bezogen auf das Jahresarbeitsvermögen	Investitionskosten bezogen auf Jahresarbeitsvermögen € / (kWh/a)	Ja	***	0	$e_{TW} > 2,2$	
				1	$2,2 \geq e_{TW} > 1,85$	
				2	$1,85 \geq e_{TW} > 1,5$	
				3	$1,5 \geq e_{TW} > 1,15$	
				4	$1,15 \geq e_{TW} > 0,8$	
				5	$e_{TW} \leq 0,8$	
Effizienz der Energieproduktion Bewertung der für die Stromerzeugung beanspruchten Gewässerabschnitte (technische Effizienz) als Verhältnis des Jahresarbeitsvermögens und der Länge der in Anspruch genommenen Gewässerstrecke (km)	(GWh/a) / km	Ja	***	0	$e_{Eff} < 1,25$	
				1	$1,25 \leq e_{Eff} < 2,0$	
				2	$2,0 \leq e_{Eff} < 4,0$	
				3	$4,0 \leq e_{Eff} < 8,0$	
				4	$8,0 \leq e_{Eff} < 12,5$	
				5	$e_{Eff} \geq 12,5$	
Beitrag zur Versorgungssicherheit					Projektbewertung	Begleitende Potenzialstudie
Speicheroption/Systemstabilität Bewertung der Möglichkeit einer Anpassung der Stromerzeugung an die jeweilige Nachfrage durch die zeitliche Entkopplung von natürlichem Wasserangebot und Abarbeitung anhand des Verhältnisses zwischen Speichervolumen und jährlicher Zuflussmenge (sog. Speicherkennzahl λ) multipliziert mit der nutzbaren Fallhöhe.	$[(m^3/a) / (m^3/a)] * m$	Ja	***	0	$e_{Sp} = 0$	$e_{Sp} = 0$
				1	$0 < e_{Sp} < 1$	$0 < e_{Sp} < 25$
				2	$1 \leq e_{Sp} < 10$	$25 \leq e_{Sp} < 100$
				3	$10 \leq e_{Sp} < 100$	$100 \leq e_{Sp} < 200$
				4	$100 \leq e_{Sp} < 200$	$200 \leq e_{Sp} < 400$
				5	$e_{Sp} \geq 200$	$e_{Sp} \geq 400$

Detailed set of criteria from the Tyrolean agreement on criteria for the evaluation of HP projects

The criteria is set up by a group of administration experts, and discussed, amended and validated by stakeholders of the different interest groups (hydro-energy, fishing, environmental NGOs) and finally adopted by the decision makers (regional government and parliament).
The set of criteria even integrates a non-compulsory proposal for weighting:

1. Energy production: 25%
2. Nature conservation: 23%
3. Hydroecology: 22%
4. Water management: 18%
5. Spatial Planning: 12%

Example 2: Convention for sustainable hydropower in France

The convention was set up on the initiative of the French Ministry of Environment, Equipment and Sustainable Development, in the context of the Grenelle national environment round table agreements [14].

Le Grenelle de l'environnement report on hydroelectricity

This national agreement was signed by the main involved organisations and companies: Association des Maires de France, Association Nationale des Elus de Montagne, Union Française de l'Electricité, France Hydro électricité, EAF, EDF, GDF Suez, Compagnie Nationale du Rhône, Syndicat des énergies renouvelables, WWF, Fondation Nicolas Hulot, ANPER-TOS, SOS Loire Vivante – ERN France, NASF, UICN France, Comité National de la Pêche Professionnelle en Eau Douce, Comité de liaison des énergies renouvelables.
The "convention" covers different topics, that range from the general agreement on the importance of hydropower as a source for renewable energy, to goals for HP-energy contributions to national energy production, and very specific topics such as the decommissioning of particular plants.
For the moment, no particular attention is drawn to the Alpine territory, so this possibility has to be assessed with reference to the large range of agreements possible under this convention, and to a probable future update.

[14] More information on the French Grenelle procedure : http://www.legrenelle-environnement.fr/-Version-anglaise-.html?rubrique33

Chapter 3: SHARE quality standards and guidelines to integrate MCA in law

- **Examples for agreements on goals and measures are:**
  - Ruling of biological minimum flow
  - Preservation of continuity of amphibian communities
  - A plan for the eel population
  - A goal of an annual increase in hydroenergy production of 3TWh until 2020
  - Promotion of mediation initiatives
  - Research into environmental integration of HP plants
  - Promotion of small installations (below 12 MW)
  - Decommissioning (not in the Alps)

With respect to the importance of the Alps within this subject, SHARE MCA could here offer some very specific interfaces in order to implement the convention:

- Provision of a support tool to identify the potential of the contribution of the Alpine territories to the annual 3Twh increase until 2020, while preserving the ecological continuity
- Identification of the potential for small HP production
- Assessment of an optimization of the impact of new and existing plants on river ecology

This conventional and soft law approach gives the opportunity for regional level decisions, as was the case, for example, in Corsica which held a regional convention between mountain municipalities and EDF, and in the large plan of Poutès (in Haute-Loire France).

- Report of the state of the Alps Alpine convention
- EEA technical report vulnerability water scarcity
- Alp water scarce and other Alpine Space projects on water reports
- CIPRA reports
- ESHA reports
- BUWAL reports
- EEA Megatrends
- DG ENV + DG ENERGY reports
- Directive 2009/28/CE

Section 3: Applying SHARE

Chapter 4: A new kind of water governance

The SHARE MCA can support a real economic valuation of ecosystem services considering river resources available in mountain regions How to take decisions and assess different interests of environment conservation, climate change adaptation and economic growth? How to transform permanent handicaps into assets? How to create wealth in a sustainable economic model? There are some of the major challenges that mountain regions have to face in balancing a rich but fragile environment, a specific socio-cultural model and some economic capacities to transform additional costs into added value and quality.

Studies and analyses have demonstrated that the **homogenous territorial dimension** is an appropriate framework to organize governance. If administrative borders cannot follow geographic and cultural delimitation, it is absolutely crucial for mountain territories to develop a balanced model as close as possible to the local level. We have identified that, regarding the integration of the SHARE MCA procedure into legislation, it is more efficient to **focus on interfaces (soft law governance bodies) at the pertinent scale of governance** (river or local, basin or regional, national or European).

Regional environmental governance

SHARE analysis is based on the efficiency of a territorial – regional, human and environmental-approach to public policies. This framework could be linked to the EU objective of territorial cohesion, but also to the WFD; it has a place in many national policies that adopt a territorial approach, or are considered at a multiregional level (massif, basin, etc.) or local level. The challenge is to consider how people living in the same kind of environment could develop a similar cultural and political framework to organize, plan and manage specific organizations, specific problems or specific assets.
The work of specialist scientists is also a key element in making progress regarding the sustainable efficiency of public policies.

This **territorial model of governance** is much more efficient if its aim is to avoid conflicts and to reach a consensus.
However, water and mountain management in Europe is facing great difficulties in terms of understanding who is doing what in these politics of scale, and of interacting levels. These levels of politics reflect in turn the interests of particular communities, which can be found both in a region and in an interest group. The fact is that the internal market and the wider access to information have created interdependences at European levels, in addition to traditional interdependencies at smaller geographic scales in mountains. The question of mutual recognition is therefore highly relevant if the European Union and mountain ranges such as the Alps want to find together new ways to answer old challenges (water use in mountains) in a changing context (climate change, energy supply).
The growing concept of multilevel governance supported by the Committee of the Regions is certainly useful for understanding issues and helping them to progress. The only problem is that the "pyramidal" analysis of subsidiarity (municipalities-regions – states – EU) neglects the local scale that could create pertinent interfaces for a new governance. However, could approaches at the scale of basin governance be politically efficient enough to definitively face the challenge?

Mountain water governance & river basin governance: how to organize partnership with territorial coherence

Water is definitively a strategic issue for the Alps: a great resource (recreation, drink, energy, irrigation, industries, etc.), a great creator of natural risks and a great producer of conflicts between mountain actors, but also between mountain actors and metropolised lowland actors. We have considered that SHARE MCA applied to water and hydropower management is a good tool to bring together various actors in a shared analysis. SHARE MCA is also an interesting tool to use because it helps to deal with complex operative questions and to make decisions! It is an interesting way to support political action rather than **to develop another technocratic body where the "old" form of government should be marginalized**.

On the contrary, SHARE MCA **gives back to the policy makers and authorities a capacity to decide with a framed support of technical services**.
MCA and the SHARE project provide an interesting way to give back to the political authorities a core role in such a strategic decision process as the assessment of new (micro) hydropower installations in the Alps.

Economic valuation of ecosystem services

The issue of assessment of new **micro hydropower installations** in the Alps linked to adaptation to climate change and green growth won't be sustainable if ecosystem services aren't respected.
We know with the TEEB study the importance of the challenge of economic valuation of services. **How to identify the real price of a public good such as fresh water?** If we consider the various laws regarding compensation, organization and taxes relating to energy production from high altitude hydropower plants, energy appears as one of the major ways for mountain regions (including, but not exclusively, the Alps) to benefit economically from the natural water resource. The informal and historic way of compensation could also be considered as a first step towards a more complex compensation system.

The TEEB study[17] and the work done by many European and international actors –in particular DG Env of the European Commission or UNEP- is absolutely relevant to mountain regions, which are great producers of ecosystem services.

The Economics of Ecosystems and Biodiversity (TEEB) study is a major international initiative to draw attention to the global economic benefits of biodiversity, to highlight the growing costs of biodiversity loss and ecosystem degradation, and to draw together expertise from the fields of science, economics and policy to enable practical actions to move forward.
As part of good governance, decision-making that affects people and uses public funds needs to be objective, balanced and transparent. Access to the right information at the right time is fundamental to coherent policy trade-offs. A better understanding, and quantitative measurement, of biodiversity and ecosystem values to support integrated policy assessments are core parts of the long-term solution . At regional and local level, **ecosystem services** could also be included in policy.

TEEB for Policy Makers

The balanced model that SHARE MCA is proposing creates a great opportunity to consider both the sensitivity of biodiversity but also the importance of the economic value of products. It provides the possibility to really imagine a **sustainable model of development for mountain regions**, linking ecosystem services and production of hydropower with a higher transparency.
SHARE proposals could also be an efficient way to organize, with the support of MCA, a system of compensation mobilized by the eco-certification of electricity (**green certificates or labels**). The market of hydroelectricity would give a price for a production that could be identified through the SHARE MCA to a certain level of quality of river ecosystem. In this way, we would have equivalence between an ecological service and economic value.

Rewarding benefits through payments and markets: Payments for ecosystem services (PES schemes) can be local (e.g. water provisioning) up to global (e.g. REDD-Plus proposals for Reduced Emissions from Deforestation and Degradation, as well as forestation, reforestation, and effective conservation – if designed and implemented properly). Product certification, green public procurement, standards, labelling and voluntary actions provide additional options for greening the supply chain and reducing impacts on natural capital.

Reforming environmentally harmful subsidies:

[17] www.teebweb.org

Chapter 4: A new kind of water governance

Global subsidies amount to almost US$ 1 trillion per year for agriculture, fisheries, energy, transport and other sectors combined. Up to a third of these are subsidies supporting the production and consumption of fossil fuels. Reforming subsidies that are inefficient, outdated or harmful makes double sense during a time of economic and ecological crisis.
Addressing losses through regulation and pricing: many threats to biodiversity and ecosystem services can be tackled through robust regulatory frameworks that establish environmental standards and liability regimes. These are already tried and tested and can perform even better when linked to pricing and compensation mechanisms based on the 'polluter pays' and 'full cost recovery' principles, altering the status quo which often leaves society to pay the price.

Just remuneration of hydropower regarding its impact on river ecosystems

The real cost of hydropower should also take into account the value of ecosystems. The various elements in discussion regarding concession and public procurement of hydropower installation need to consider this value.
SHARE MCA gives the opportunity for sharing a sustainable model of development, and for organizing new regional environmental governance, which can both address the objectives of EU 2020 regarding green growth.

Evaluation sequence building on scientific information

Source: Stephen White, own representation, TEEB

The link between renewable energy and ecosystem services made with SHARE MCA stimulates the better organization of the new model of the green economy that the Alps could propose to Europe. Therefore, Water and Energy should be topics to be developed in a European **macroregional strategy for the Alps.**

share

Sustainable Hydropower in Alpine Rivers Ecosystems

European project SHARE

Merging scientific tools,
local specificities
and operational requirements

Get involved in SHARE Network

registering online!

Members are involved in and benefit from SHARE at several levels: specific access to SHARE results, feedback on both approach and tools developed by SHARE.

www.share-alpinerivers.eu

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Products list

ANNEXES AVAILABLE ON THE ONLINE VERSION
Alps water scarce and other Alpine Space projects on water reports
BUWAL reports
CIPRA reports
Criteria and indicators to identify vulnerability of Alpine areas and river ecosystems
DG ENV + DG ENERGY reports
Directive 2009/28/EC
EEA Megatrends
EEA technical report vulnerability water scarcity
ESHA reports
How the number of indicators affects Multi Criteria Analysis
Le Grenelle de l'environnement report on hydroelectricity
Map of most vulnerable river typologies to HP
Maps of residual HP potential in Alpine Space
MCA indicators used in PCS Section 3 – Chapter 2
MIF definition and discharge estimation methods report
Reg Observatory
Report of the state of the Alps Alpine convention
River Functionality Index report
Self standing dashboard representation of MCA
SESAMO software and related handbook
SHARE 11 Pilot Case Studies
SHARE CASiMiR software to assess habitat conditions along the river channel and bank areas
SHARE eco-investments. mitigations & restoration action
SHARE fake news
SHARE geodatabases
SHARE guidelines to integrate MCA in local rules
SHARE indicator toolbox
SHARE Pilot Case Studies
SHARE Pilot Case Studies alternatives full description
SHARE Pilot Case Studies decisional trees
SHARE Pilot Case Studies monographs
SHARE PTP
SHARE Smart Mini Hydro software to assess economical feasibility of small HP plants
SHARE VAPIDRO-ASTE software for evaluation of the residual hydropower potential
Technical review describing WFD, Floods and other EU directives' implementation in Alpine Space
TEEB for Policy Makers
Tyrol government report
Water Framework Directive status objectives for AS ecoregions and river typologies
What is SHARE?

Glossary

Alpine Convention (the)
The convention states that in the Alps, “hydropower generation can be considered to be the main reason for water abstraction (...). This results in the fact that a significant share of river stretches fails to meet the good ecological status”. - From Water and water management issues: Report on the State of the Alps, 2009 -

Biodiversity
Also called biological diversity, biodiversity is the variety of life found in a given place on Earth or, often, the total variety of life on Earth. A common measure of biodiversity, called species richness, is the count of species in an area. - From the Encyclopædia Britannica -

Directive on Electricity Production from Renewable Energy Sources
This directive obliges EU member states to increase the share of renewable electricity production in order to reduce greenhouse gas emissions. The aim was to reach a “22,1% indicative share of electricity produced from renewable energy sources in total Community electricity consumption by 2010”.

Hydropower
In the Alps, hydropower (or HP) is the most important renewable energy source: this traditional form of energy generates more than 90% of electricity production.

MCA Methodology (the)
A method to assess and compare different management alternatives of hydropower plants and rivers. It will help decision makers to weight and balance all river-related issues, in order to take transparent and well informed decisions where hydropower is involved.

Water Framework Directive
The WFD refers to river continuity as a “quality element” to assess ecological status, and underlines the need for “control on abstraction and impoundment in order to ensure the environmental sustainability of the affected water systems”. It obliges EU member states to reach and maintain a “good” ecological status of water bodies by 2015.

Acronyms

ARPA	Regional Agency for Environment
MCA	Multicriteria Approach
PCS	Pilot Case Studies
PP	Project Partners
PTP	Permanent Technical Panel
SHARE	Sustainable Hydropower in Alpine River Ecosystems
WFD	Water Framework Directive

Financial Partners

SHARE is a running project in line with the European Territorial Cooperation Alpine Space programme 2007-2013.
SHARE has been approved and co funded by the European Regional Development fund.

The Alpine Space Programme

The Alpine Space Programme is the EU transnational cooperation programme for the Alps. Partners from the seven Alpine countries work together to promote regional development in a sustainable way. During the period 2007-2013, the programme is investing €130 million in impact-oriented projects. These focus on competitiveness and attractiveness, accessibility and connectivity, environment and risk prevention.

www.alpine-space.eu

The European Regional Development Fund

The ERDF aims to strengthen economic and social cohesion in the European Union by correcting imbalances between its regions. In short, the ERDF finances:

- Direct aid to investments in companies (in particular SMEs) to create sustainable jobs;
- Infrastructures linked notably to research and innovation, telecommunications, environment, energy and transport;
- Financial instruments (capital risk funds, local development funds, etc.) to support regional and local development and to foster cooperation between towns and regions;
- Technical assistance measures.

The ERDF can intervene in the three objectives of regional policy:

- Convergence
- Regional Competitiveness and Employment
- European Territorial Cooperation

The ERDF also gives particular attention to specific territorial characteristics. ERDF action is designed to reduce economic, environmental and social problems in towns. Naturally disadvantaged areas geographically speaking (remote, mountainous or sparsely populated areas) benefit from special treatment. Lastly, isolated areas also benefit from specific assistance from the ERDF to address possible disadvantages due to their remoteness.

http://ec.europa.eu/regional_policy/thefunds/regional/index_en.cfm

GERES contribution to the SHARE project is supported by GDF-SUEZ Foundation

www.gdfsuez.com/fr/groupe/fondation-gdf-suez/fondation-d-entreprise-gdfsuez

www.share-alpinerivers.eu

Why a SHARE handbook?

This report is a slim hypertext conceived as a tool to support sustainable river and hydropower management undertaken by local administrators, public and private consultants and other river stakeholders.

Our intention is to guide the reader in a simple way through the SHARE methodological approach, and the different tools and resources developed and tested during the SHARE cooperation project.

Enjoy it!