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WATER AND WATER MANAGEMENT ISSUES
Report on the State of the Alps

ALPINE CONVENTION
Alpine Signals - Special Edition 2

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Magnificent aquamarine waters of the Soča River source, Slovenia.

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The present report has been approved by the X[th] Alpine Conference, held in Evian (France) on 12 March 2009. It has been drafted by the Permanent Secretariat of the Alpine Convention in conjunction with an ad-hoc expert group jointly chaired by Austria and Germany, in coordination with the French Presidency of the Alpine Convention.

Stakeholders from the science world and relevant NGOs have also contributed to the report.

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CASE STUDIES

FIGURES

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NATIONAL CONTRIBUTIONS

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ABBREVIATIONS

AC	Alpine Convention
APAT	L'Agenzia per la protezione dell'ambiente e per i servizi tecnici (Agency for Environmental Protection and Technical Services) - Italy
ARPA	Agenzia regionale per la protezione ambientale (Regional agency for the protection of the Environment) - Italy
ATO	Ambito Territoriale Ottimale (Optimal territorial space)
CIPRA	International Commission for the Protection of the Alps
CIS	Common Implementation Strategy of the European Water Framework directive
DPSIR	Drivers-Pressures-State-Impact-Response (Framework)
EAF	Ecologically Acceptable Flow
EEA	European Environmental Agency
EPDRB	Environmental Program Danube River Basin
ESDS	European sustainable Development Strategy
ET	Evapotranspiration
FOEN	Federal Office for the Environment
GAR	Greater Alpine Region
GCMs	General Circulation Models
GCOS	Global Climate Observation System
HD	Habitats Directive
IRKA	Internationale Regierungskommission Alpenrhein (Alpine Rhine International Government Commission)
IRR	Internationale Rheinregulierung (Rhine international regulation)
ISCAR	International Scientific Committee on Research in the Alps
IWRM	Integrated Water Resources Management
MAP	Multiannual Work Programme of the Alpine Conference
NADUF	National (Swiss) River Monitoring and Survey Programme
NAQUA	National (Swiss) Groundwater Quality Monitoring Network
OcCC:	Organe consultatif sur les changements climatiques (Advisory Body on Climate Change) - Switzerland
OECD	Organisation for Economic Co-operation and Development
ÖPUL	Österreichisches Programm einer umweltgerechten Landwirtschaft (Austrian Agri-Environmental Programme)
PAI	Piani di Assetto idrogeologico (Hydro-geological Structure Plans)
PLANALP	Platform Natural Hazards of the Alpine Convention
PPP	Public Private Partnership
RBA	River Basin Agency
SOIA	System for Observation and Information on the Alps
UN-ECE	United Nations Economic Commission for Europe
UWWTP	Urban Waste Water Treatment Plants
WDMP	Water Development and Management Plan
WFD	Water Framework Directive
WGMS	World Glacier Monitoring Service
WLC	Water Local Committee
WRG	Wasserrechtsgesetz (Austrian Water Act)
WWTP	Waste Water Treatment Plants

PREFACE

Integrated water management is one of the main issues for the sustainable development of the Alpine Region. Furthermore, surrounding areas also depend on the water from the Alpine Region for their development. Conflicts of interests therefore arise in relation to the use of water in the Alps. A sophisticated system of water management has been developed over many hundreds of years but this now faces new challenges due to both the increasing use of water and climate change. The current system of water management therefore needs to be duly and continuously adjusted to the prevailing conditions.

Water is inherently a crucial topic for the Alpine Convention, with the main objective of preserving or re-establishing healthy water systems, in particular by keeping lakes and rivers free of pollution, by applying natural hydraulic engineering techniques and by using water power, which serves the interests of both the indigenous population and the environment alike.

This second report on the State of the Alps has therefore been produced to promote discussions on "Water and Water Management Issues". It describes the integral understanding of "water management", the state of waters in the Alpine space, the relevance of the Alpine space for water supply to surrounding areas, as well as the challenges for future water management issues. Important examples include the design of new installations as well as the upgrade of existing ones for the production, transport and distribution of hydroelectricity in order to make optimal overall use of the existing infrastructure system in the Alpine region, taking into account the need for environmental protection. It is also important to develop strategies on how to deal with water scarcity and droughts in the different regions of the Alps.

This new report is the only existing overview document which includes such a rich background of information on the state of waters in the Alpine space.

The full report is available in English on the website of the Alpine Convention (www.alpconv.org) and the summaries in 5 languages (it, fr, de, sl, en) are available in paper version and on the website. The report is published in a special edition series of the "Alpine Signals" and represents a crucial component of the System for the Observation and Information on the Alps (SOIA).

The Permanent Secretariat of the Alpine Convention wishes to thank all the experts and representatives of the Contracting Parties for their valuable contributions. Special thanks go to the Presidency and the members of the ad-hoc expert group, who also hosted the meetings at which this report was discussed and drafted.

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A INTRODUCTION

The Alpine Convention and Water Policy

The Alpine Convention is a multilateral framework treaty signed in 1991 by the eight states of the Alpine arc as well as by the European Community. Its main objectives are the sustainable development of the Alpine territory and the safeguarding of the interests of the people living within it, embracing the environmental, social and economic dimensions in the broadest sense. In order to achieve its objectives, the Framework Convention has been equipped with a large number of thematic protocols over the years.

Water is listed among the twelve themes in relation to which the Contracting Parties are supposed to take measures and coordinate their policies (Article 2 of the Framework Convention). The Alpine Convention aims at preserving and re-establishing healthy water systems, especially keeping waters clean and protecting the natural environment. This is to be accomplished by balancing the local population's interests with environmental needs. Water is considered to be a crucial element for different uses such as hydroelectricity production, irrigation or drinking water as well as in biotopes, especially in forests, for environmental regeneration and diversity and in natural and cultural landscape features. This is why aspects of water protection are to be found in the protocols on Energy, Nature Conservation and Landscape Protection, Soil Protection, Tourism, Spatial Planning and Sustainable Development, Mountain Agriculture, Mountain Forests and Transport. A specific protocol on water is not in place.

Moreover, since the Convention was signed in 1991, further relevant issues have appeared, such as changes in water availability and natural hazards, particularly in relation to climate change, growing demand for water and its conflicting uses, spatial-development-related requirements. In addition to the changes in the natural framework, the legal framework and paradigm of water management has also changed. Today, water management aims to be practiced at the level of river basins.

The discussions on the need for a separate protocol on water have been quite controversial, in particular at the meetings of the Permanent Committee of the Alpine Convention held in the years 2003 and 2004. In these meetings the Permanent Committee explored the possibility of establishing a Water Protocol based on a draft of the International Commission on the Protection of the Alps (CIPRA International). Although the view was expressed that important topics related to water in the Alps are covered by existing regulations, especially those contained in the EU Water Framework Directive (WFD) and its daughter directives, the importance of a specific Alpine water dimension was also acknowledged. It was therefore decided to include water as a topic in the Multi-annual Working Programme of the Alpine Conference (MAP) for the years 2005-2010.

In the Multi-annual Working Programme of the Alpine Conference, water resources are mentioned as one of the most important priorities. The state of water and waters in the Alps is observed in the framework of the system for the observation of and information on the Alps (SOIA), which is one of MAP's six operational priorities. SOIA aims at contributing to Alpine policy development by providing data and information. Indicators have been set up to monitor the fulfilment of the objectives set out in the Alpine Convention and its protocols – also for water. The Reports on the State of the Alps - a crucial tool for observation and information on the state of the Alps - are published regularly by the Alpine Conference. After the first Report, focusing on Transport and Mobility in the Alps, the Alpine Conference at Alpbach in November 2006 chose water as the topic for the Second Report on the State of the Alps.

Procedurally it was decided that the Permanent Secretariat should submit this Report to the Alpine Conference in coordination with the presidency of the Alpine Conference, accompanied by an ad-hoc expert group under Austrian-German Presidency, the Focal Points of the Contracting Parties for consultation purposes on the one hand and the most important stakeholders of science, observers and interested NGO´s on the other. The basis for this Report are case studies, highlighting specific aspects, and national contributions on already available information submitted by the members of the Expert Group and Focal Points. As regards its content, the report focuses on the most important water management issues. By analysing the existing legislative instruments in the water sector, it provides the basis for recommendations on the measures necessary to address those issues.

Furthermore, the Alpine Conference highlighted the need to continue the dialogue started at the conference "The Water Balance of the Alps" held in Innsbruck in 2006, in particular by a second conference in Munich in 2008 involving all relevant stakeholders. This second conference took place on 30th October 2008. Three weeks prior to this conference, the draft Report on the State of the Alps "Water" was put on the web to allow for an in-depth discussion at the conference. In general, the findings of the draft report were well received and supported. The following proposals were made to address additional issues:

- to make reference to the CIPRA input with regard to the results of its 1992 river survey and to its proposal for a potential Water Protocol
- to focus more specifically on the socio-economic aspects put forward by the Swiss Centre for Mountain Regions in order to launch a debate on the right price for water resources in the Alpine area
- to consider the need for enhanced long-term monitoring in the high Alpine regions as proposed by ISCAR
- to highlight the importance of forests as a protection against natural hazards
- to point out that water management strategies should be ecosystem-based, with a long-term perspective at catchment scale as proposed by WWF Italy
- to enhance co-operation between the water management sector and the scientific community in order to avoid potential knowledge gaps, as proposed by ISCAR
- to quantify in more detail the share of small and micro-hydropower plants in overall energy production

The only issue of major disagreement was the potential added value of a water protocol. Experts from the water administrations of all Alpine countries and the European Commission unanimously held the view that, due to the broad range of existing regulations already in place, there would be no added value in a new legal instrument; CIPRA International strongly disagreed. Against this background, the idea of setting up a platform for water management in the framework of the Alpine Convention has arisen as a potential way forward. Abstracts, presentations and findings of the conference were published by the conference organisers.

All these findings as well as further issues addressed by the organisations “Deutscher Alpenverein” and “Verein zum Schutz der Bergwelt” in their written comments (elaboration of guidelines on hydropower generation and residual water, enhanced involvement of the research sector, need to address adaptation to effects of climate change in River Basin Management Plans, impacts of new water sports activities) were taken into account more specifically in the Report.

Structure and Key Issues of the Report on the State of the Alps “Water”

The general description of water management and the description of the Alpine water resources including the driving forces for water management are elaborated in chapter B.1. The Report on the State of the Alps “Water” compiles and presents harmonised data on the state of waters in the Alps, the quality of waters (chapter B.2.2), the quantitative aspect of waters (chapter B.2.3), the hydromorphology (chapter B.2.4) of surface waters, and the social and economic aspects of Apine waters (chapter B.3), protection against natural hazards (chapter C), water in the context of climate change (chapter D), and it also provides an overview on regulations concerning waters in the member countries to the Alpine Convention (chapter F). The identification of major water management issues and the main challenges of water management are the outcome of the Report.
More specifically, the Report compiles information from the Alpine countries on monitoring programmes, the chemical quality of water (point sources, diffuse sources and the chemical status of surface water and groundwater in the Alps), water abstraction, residual water and hydro-peaking, droughts and water scarcity, reservoirs and regulated lakes as well as on river morphology and continuity. Finally, it summarises information on property rights and provisions for access to water in the different countries, charges regarding the use of water, different management systems for water supply (public or private), hydropower generation in the Alps and water management for conflict solving.

Mountain-specific issues of water identified in and covered by this Report are the production of artificial snow, upstream-downstream relations, ice and permafrost.

Each chapter starts with an introduction presenting general information on the topic dealt with in the chapter and any respective information concerning the entire Alpine range. Furthermore, each chapter offers conclusions when relevant, in addition to national contributions and key studies to deepen the insight into a specific issue.

This provides the Parties to the Alpine Convention with a basis for reflection on the further development of specific requirements for sustainable water management in the Alps in order to attain the goals referred to in the Framework Convention, the protocols and the Multiannual Working Programme of the Alpine Conference.

B STATUS OF WATERS IN THE ALPS

B.1 GENERAL DESCRIPTION

B.1.1 WATER MANAGEMENT – AN INTEGRATED APPROACH

Water resources management covers all human activities relating to the use of water, protection of water and protection against the hazards of water. Integrated water resources management attempts to harmonise these three main objectives.

The term water resources management has often been understood to mean only one aspect: the economical use of water. However, the approach of pursuing particular interests independently of other objectives is now past history, because, the more demands that are made on a watercourse, the more conflicts of interest arise.

From use to management

The impacts on all domains of water resources management must be considered when planning measures. A variety of solutions which address the requirements of the different sectors should be sought. So, where water was once "used", it must now be "managed". Accordingly, the focus is no longer purely on the element water, but on the watercourse and the watershed as a whole.
The planning of measures must also take into account the fact that the impacts of interventions are not only local, but also affect conditions further downstream. This also includes interactions between surface waters and groundwater. Integrated management therefore concerns not only the immediate environs of the intervention on the watercourse, but the whole river basin area. Activities connected with spatial planning or agriculture and forestry must also be considered.

Monitoring the hydrological cycle and reacting

The natural basis for water resources management is the water balance, the temporal and spatial variation of the water resources. In order to provide a basis for decisions regarding water use, relevant monitoring of the hydrological cycle is absolutely essential. In this respect, water resources management also has a future-oriented role to play: it must react in good time to changes in the natural water availability - for example due to climate change - and make adjustments.
The above considerations mean essentially an integration in scope (going beyond the individual sectors of water resources management), an integration in time (adopting a long-term planning perspective) and an integration in space (with the watershed as the spatial reference for planning and decision-making): This approach is generally known as Integrated Water Resources Management (IWRM) (see also figure 1 sketching the IWRM approach).

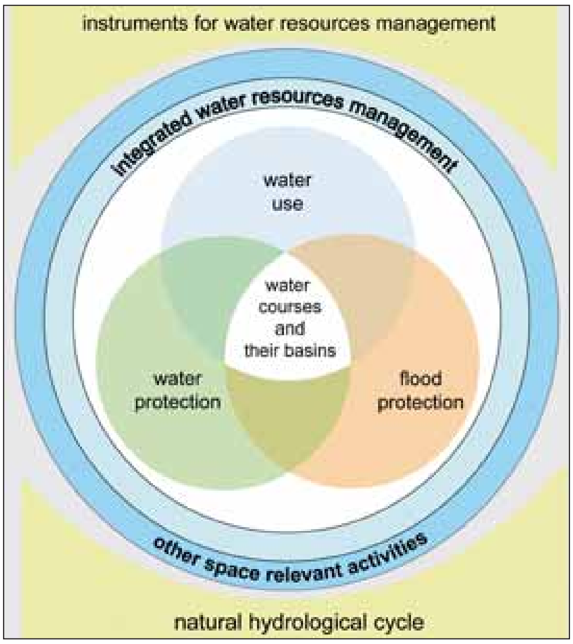

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Fig. B1-1: Schematic of Integrated Water Resources Management

B.1.2 DESCRIPTION OF THE ALPINE WATER RESOURCES

The Alpine water resources take many different forms, and they all have a particular role to play in the Alpine water cycle and its surroundings. The Alpine water resources comprise rivers, lakes, wetlands, groundwater bodies, glaciers and precipitations while the evaporation and outflow of water to the surrounding areas represent output fluxes from the Alpine area's water balance.
Glaciers, soil, artificial and natural lakes are very important for the storage of water. The amount of water in rivers depends on the climate, the rainfall, depending on the season, and on the basic geological conditions. In areas characterised by Atlantic climate, the river discharge is much higher than in those characterised by continental weather. The density and pattern of the surface water network depend primarily on the geological subsoil. In karst regions, the density of surface waters is low despite high precipitation. The outflow of water runs underground and the water often reappears

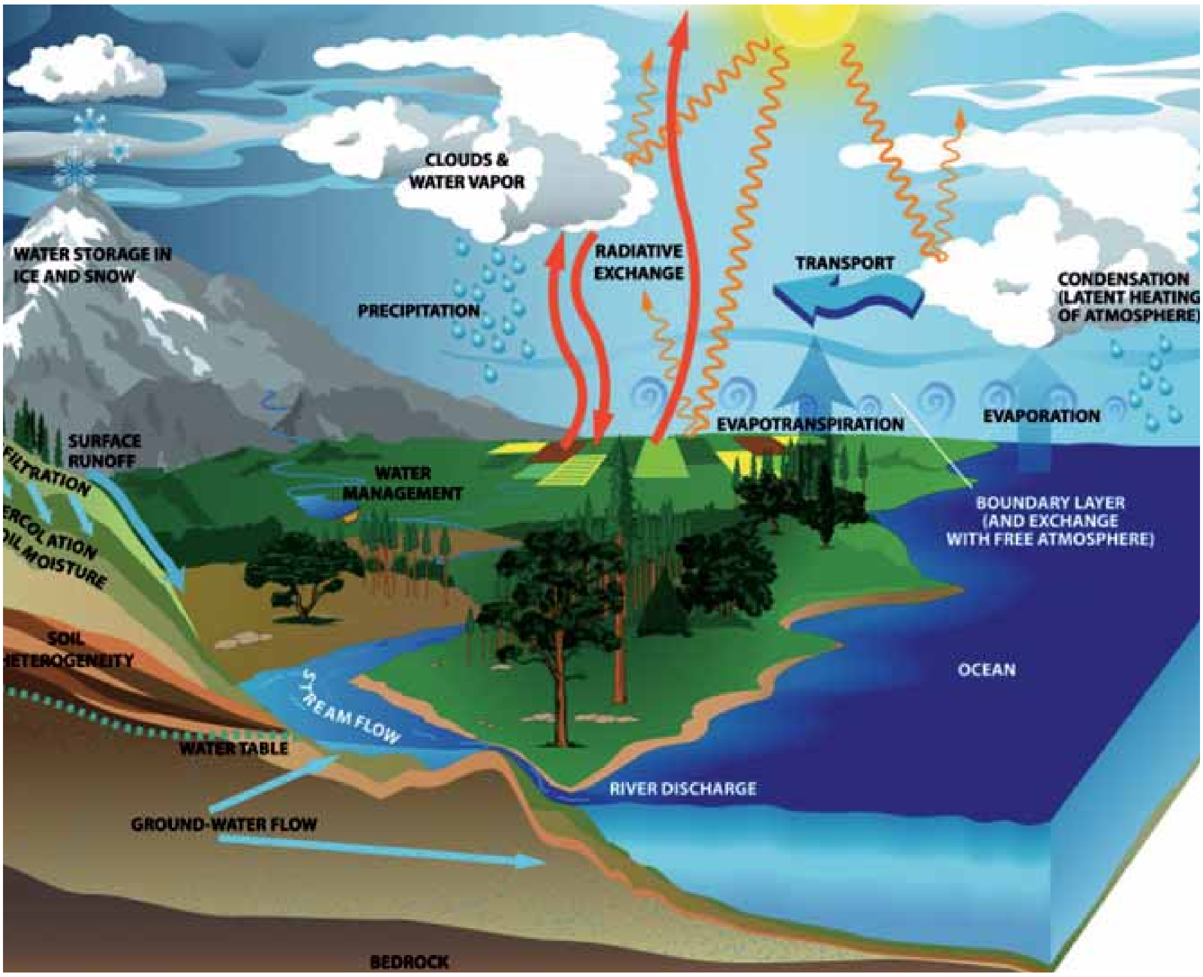


Fig. B1-2: Water cycle
Source: http://www.usgcrp.gov/usgcrp/default.php

at the bottom of valleys at a great distance from the place of the rainfall.
The influence of precipitation on the water cycle and phenomena such as erosion depend primarily on the land cover. In this respect, forests influence the run-off and retention of water intensively. The lakes in the Alpine space and especially the lakes located on the borders of the Alps are able, to a certain extent, to balance the outflow, and they are important for the retention of sediments. Examples of lakes with balancing functions on the borders of the Alps are Lake Constance, Lake Léman, as well as Lake Chiemsee or Lake Traunsee.

In the Alps, rivers and lakes are highly interlinked and they all flow into the 6 main Alpine river basins (Rhine, Rhone, Po, Danube and Adige). The most important river basins fed by Alpine river systems are the catchments and river basins of the Rhine, Rhone Po and Danube. The wetlands of high importance are described in the 92/43/EC Fauna-Flora-Habitat-Directive (FFH) and the Natura 2000 net.

Rivers, lakes and groundwater bodies often cover surfaces involving different countries and administrative levels. Therefore, upstream-downstream relations are important for river management. Along different rivers, international commissions whose primary goal is the common management of the river, its shores and adjacent land were therefore established many years ago. One example is the European Commission of the Danube, dating back to the 1856 Treaty of Paris and comprising representatives from each of the riparian countries, which is responsible for the administration of the Danube River.
The surface occupied, the hydromorphology, the structure of rivers and lakes and the water quality have been modified significantly over the past two centuries by human activities. For more information see chapter B.1.4 Driving Forces for Water Management.

Four climatic sub-regions in the Greater Alpine Region (GAR)

In order to characterise the climatic conditions of the Alps we need to differentiate between sub-regions since hydrometeorological conditions are quite different in the different parts of the Alps. To that end, the database HISTALP is used. The database on historical instrumental climatological surface time series of the Greater Alpine Region (HISTALP) consists of monthly homogenised records which take into account the five main climatic elements: cloudiness, sunshine, precipitation, temperature and air pressure of the past 140 years. The database allows conclusions to be drawn on the complex Alpine topography and its bordering regions. Due to its location at the intersection of four principle climate regimes, the GAR climate is additionally influenced by vertical factors.

The following points show the most significant climatic trends concerning the GAR:

- In the 19th century temperature increased from -0,5 to 0,8 °C while in the 20th century it increased from 1,0 to 1,4 °C
- Air pressure increased from 0,9 to 1,3 hPa in the 20th century and vapour pressure rose from 0,4 to 0,9 hPa
- The years from 1950 to 2000 witnessed a decrease in relative humidity from 1,8% to 10,4%.

Another remarkable event is the sharp U-turn of autumn-precipitation trends in the 1970s, which shifted from a persistently decreasing tendency to a sudden increase (from 23% up to 35% in the last 25 years, significantly so in the NE and for the low-elevation mean). GAR winters have become dryer over the last 25 years, significantly so in the SW and for the low elevation mean (-27%). Recent trends in winter precipitation have been accompanied by respective trends in sunshine (significant increase in all sub-regions from 17% to 29%), cloudiness (a slight decrease from 3,1% to 7,4%) and relative humidity (significant decrease for all low-elevation sub-regions, strongest in the SE with -4,8%) [1].

According to the analysis of precipitation, temperature, sunshine, cloudiness and air pressure changes carried out from the very start of the observation and documentation activities (the most extensive data set on air pressure and temperature dating back to 1760; precipitation records date back to 1800, those on cloudiness date back to the 1840s and the ones on sunshine date back to the 1880s), the GAR cannot be clearly distinguished from its surroundings. However, it is possible to distinguish the following four climatic sub-regions: the Northwest (NW), the Northeast (NE), the Southeast (SE) and the Southwest (SW).

Most climatic elements can be subdivided into four horizontal sub-regions of approximately similar size [2].

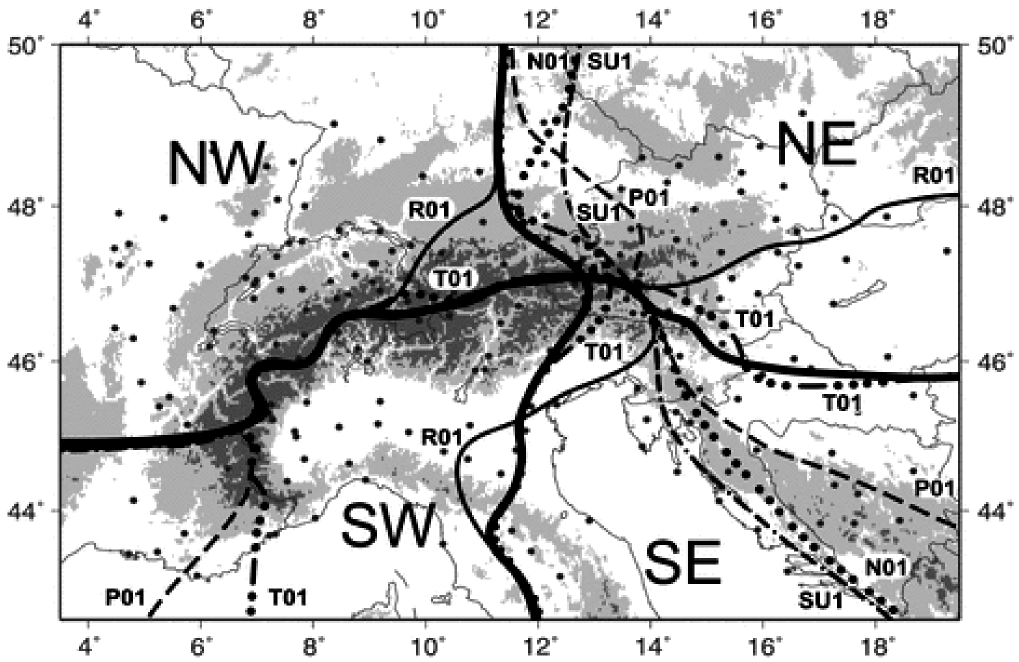


Fig. B1-3: The HISTALP Region: **Points***: stations.*
Thin lines: *element-specific sub-regions Northwest, Southwest, Southeast for P01 air pressure, T01 air temperature, R01 precipitation, SU1 sunshine, N01 cloudiness.*
Bold lines: *intra-elemental comparisons based on equal sub-regions for each climatic element.*

[1] HISTALP – Historical Instrumental Climatological surface time series of the Greater Alpine Region, Ingeborg Auer, Reinhard Böhm, etc. 2006, Royal Meteorological Society
HISTALP Project, http://www.zamg.ac.at/forschung/klimatologie/klimawandel/histalp/
[2] FORALPS dataset: Application on the question of regional climate change, Ingeborg Auer, Reinhard Böhm, Anita Jurkovic, Eva Korus, Central Institute for Meteorology and Geodynamics, Vienna, Austria (ZAMG)

The Central Alpine chain, from the La Grave-Les Ecrins group in the West to the Hohe Tauern group in the East, is the most clearly distinguishable climate border existing in the GAR, where all the five elements register the same value. A second continental-scale climate border could be anticipated between (western) oceanic influences of the Atlantic and (eastern) continental features of the Eurasian continent. Surprisingly, the climate transitions turned out to be rather uniform and abrupt for the different climatic elements, although there are no additional topographic forces pushing through mountain chains in this area. They generally follow the 12 degree eastern meridian in the northern part of the GAR[3].

The characteristics of the different sub-regions affect water resources availability and water management. Precipitation rates show the most significant regional and seasonal differences, for instance in the 20th century the NW region witnessed a 9% increase in precipitation rates, whereas the SE region registered a 9% decrease. A similar increase in sky coverage took place in the Northwestern sub-region of the GAR due to the increase in precipitation over the last 140 years. Similarly, the continuing dryness in the SE was preceded by a decrease in cloudiness over the last 140 years[4]. In the 20th century, relative humidity in the eastern GAR decreased 7 times as much as in the western GAR.

In the future, the climatic features of these four sub-regions are destined to become even more distinct under the impact climate change.

Climate Change and Water Resources

During the five years from 1995–2000, the World Glacier Monitoring Service (WGMS) measured a decrease in size of 103 out of 110 glaciers analysed in Switzerland, 95 out of 99 glaciers in Austria, all 69 glaciers in Italy and all 6 glaciers analysed inFrance.

The glaciers play an important role in the river run-off mainly during springtime and summertime. Due to climate change, their interaction with the river water regime will be significantly altered in the coming years.

With the change in climate, snow cover, the film of snow and firn on glaciers are becoming factors of crucial importance for the speed and intensity of the melting of glaciers and, consequently, also for river discharge. Therefore and also in general, snow fall is to be considered as a significant parameter for the Alpine water cycle, for water availability and the distribution of water resources. Snow reacts immediately to temperature and precipitation. Hence, parameters like snow-cover duration and snow depth in different altitude zones are good indicators of climatic changes. The winter of 2007 demonstrated, in particular, the impact of temperature increase on snow cover.

A thorough analysis of future climate change and its influence on water resources and their management in the Alps is described in chapter D of this Report.

Hydrological Regime and Run-off

The hydrological regime of the Alps has a crucial influence on the European water balance, especially as the Alps are located in the centre of Europe. The run-off of the main Alpine rivers to the surrounding regions is illustrated and explained in detail in the following chapter: B 1.3 "The Alps – Water Tower of Europe".

Literature:

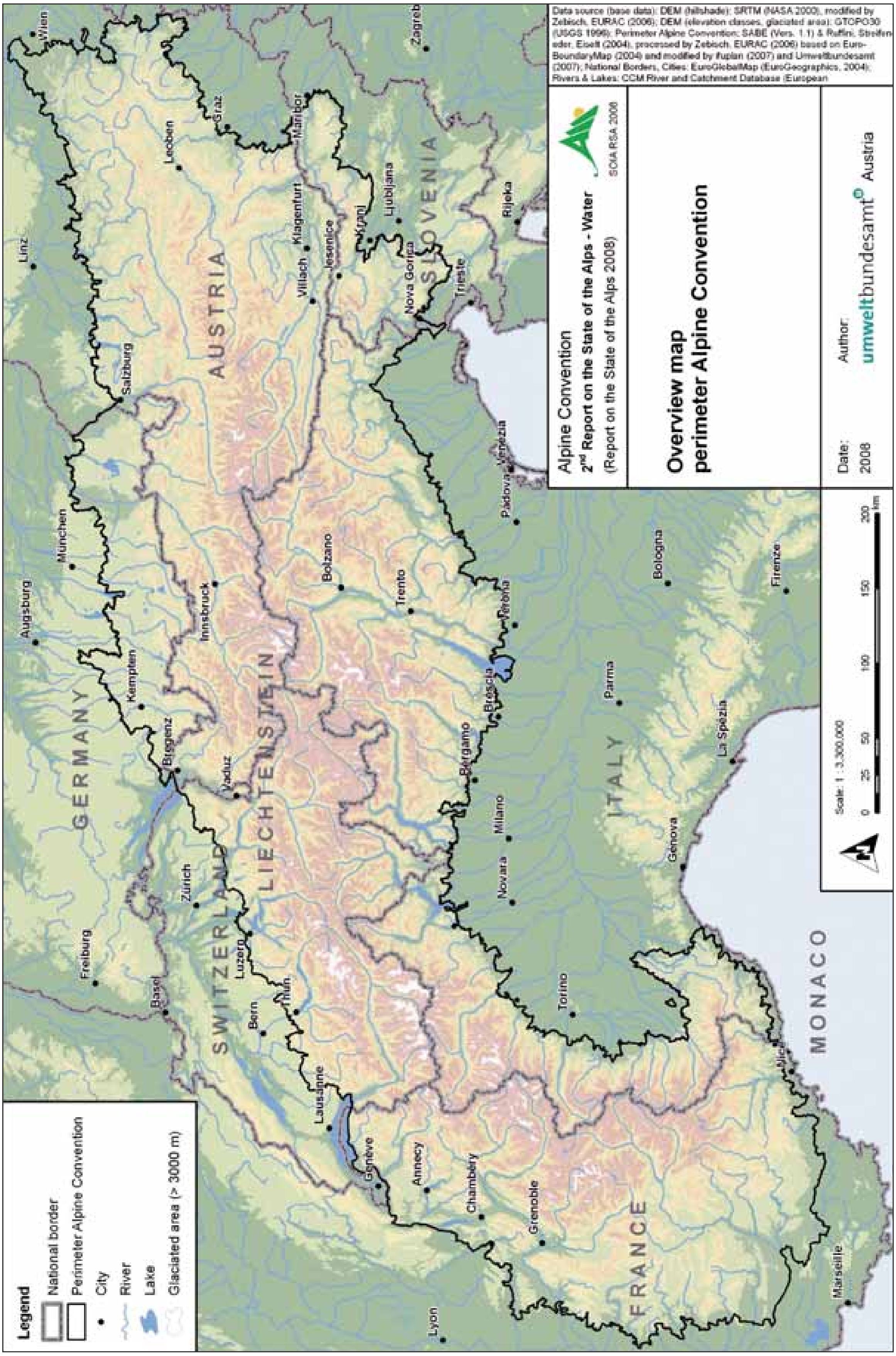
Landscape - History of Switzerland and its neighbouring area; The last 30 million years of history of the Earth, of Climate and Vegetation , René Hantke; 1991; Zürich

HISTALP – historical instrumental climatological surface time series of the Greater Alpine Region, Ingeborg Auer, Reinhard Böhm, etc. 2006, Royal Meteorological Society

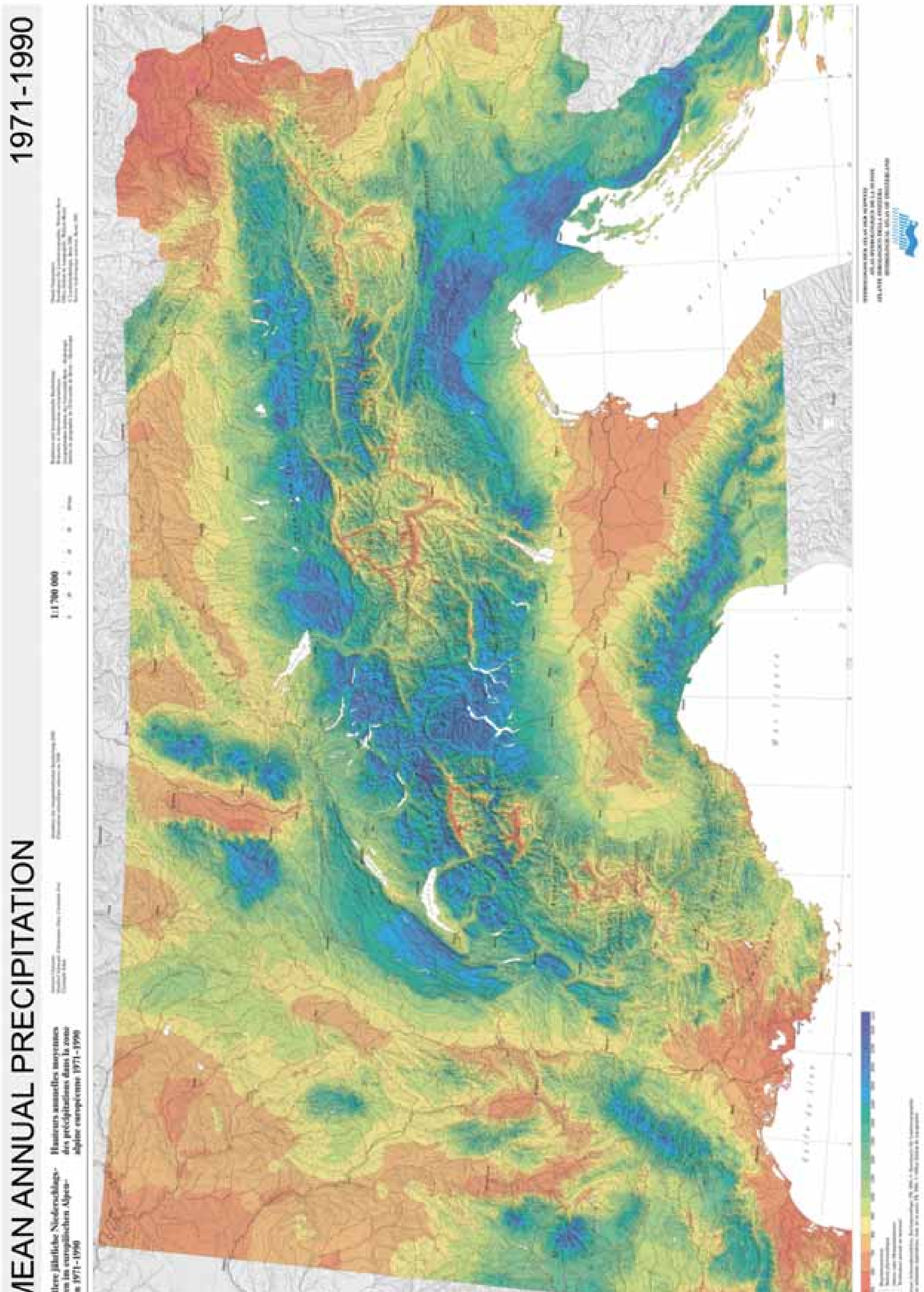
FORALPS dataset: Application on the question of regional climate change, Ingeborg Auer, Reinhard Böhm, Anita Jurkovic, Eva Korus, Central Institute for Meteorology and Geodynamics, Vienna, Austria (ZAMG)

[3] HISTALP – historical instrumental climatological surface time series of the Greater Alpine Region, Ingeborg Auer, Reinhard Böhm, etc. 2006, Royal Meteorological Society

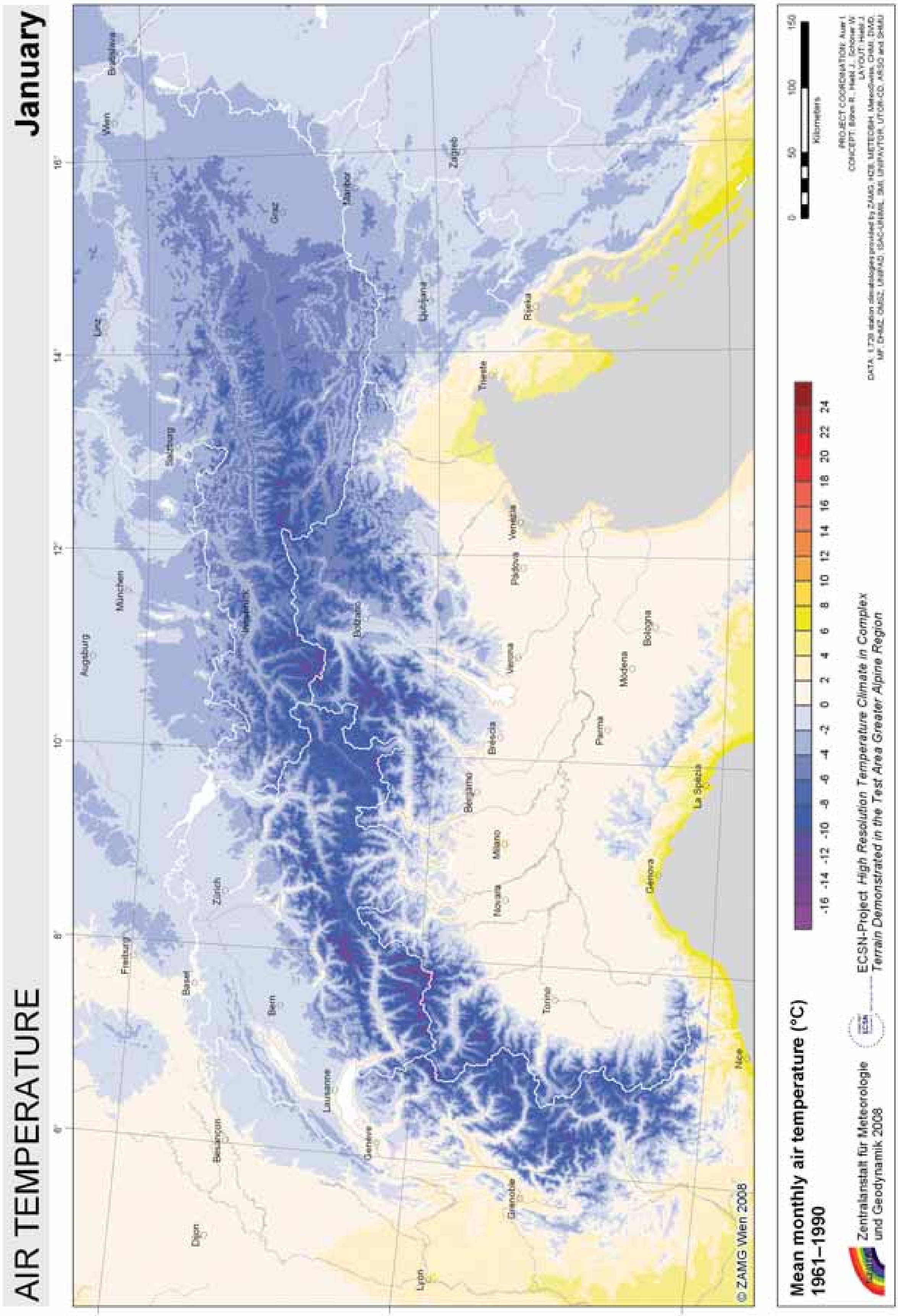
[4] HISTALP – historical instrumental climatological surface time series of the Greater Alpine Region, Ingeborg Auer, Reinhard Böhm, etc. 2006, Royal Meteorological Society



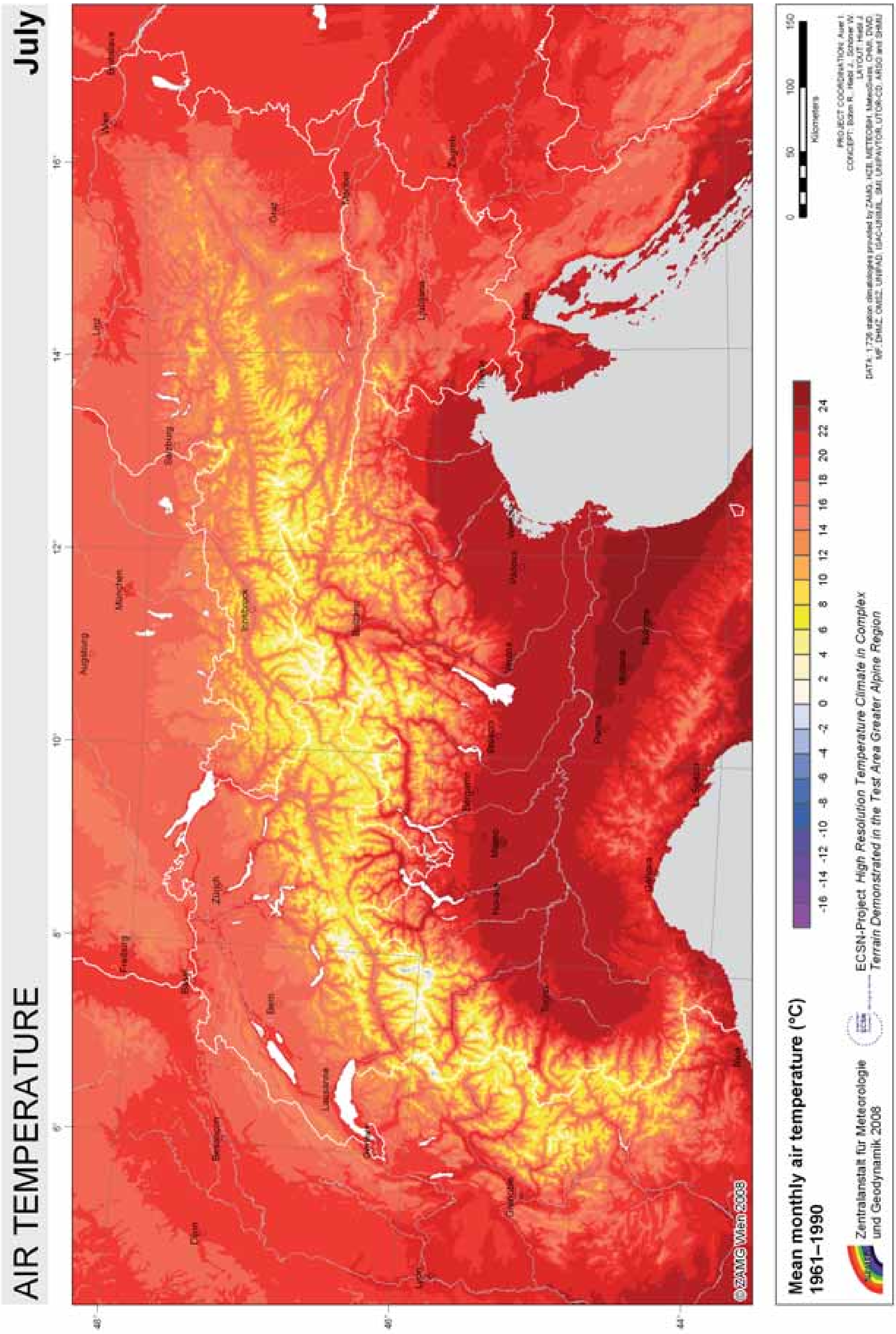
Map 1: Overview Alpine Perimeter



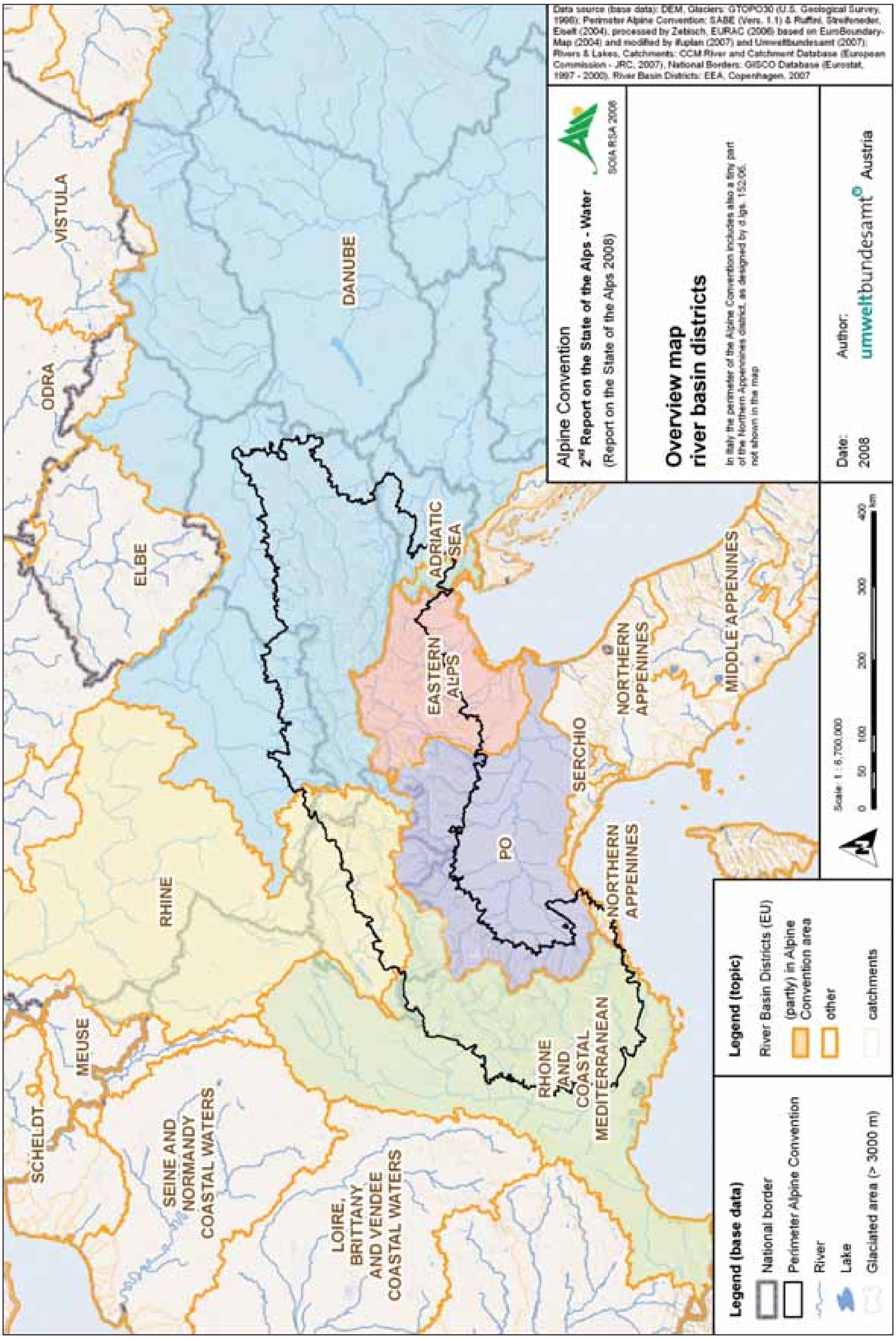
Map 2: Precipitation



Map 3: Average Air Temperature in January



Map 4: Average Air Temperature in July



Map 5: Overview river basins on European scale: The area of the Alps in Europe is very small and supplies a disproportionate amount of water. In Italy the perimeter of the Alpine Convention includes also a tiny part of the Northern Apennines district, as designed by d.lgs. 152/06, not shown in Map 5

B.1.3 THE ALPS - 'WATER TOWER OF EUROPE'

The Alps are widely known as the "water tower" or "water castle" of Europe.

The abundance of water is due to
- the uplift and subsequent cooling of air which then turns into rain,
- the low rate of net radiation,
- lower temperatures and
- frequent snow cover and
- shorter vegetation periods

which altogether result in lower evaporation and higher annual run-off. Especially in spring and summer the lowlands of the Danube, Rhine, Rhone and Po profit from the Alpine run-off. In summertime the Alps supply a disproportionate amount of water - from 35% (Danube) up to 80% (Po) - of the overall discharge in the different catchments[5] (the figures in Tab. B1-1 represent the percentages on a yearly basis and are thus lower).

	Canton Uri	Switzer-land	Europe
Precipitation [mm]	2.088	1.458	780
Evaporation [mm]	382	469	510
Change of stocking [mm]	- 5	- 2	0
Run-off [mm]	1.711	991	270

Tab.B1-1: "Average yearly water balance 1961 – 1990"[6]

Rhine

The Rhine, up to Mainz, relies heavily on the Alpine hydrological regime. Only downstream from Mainz does the oceanic influence become gradually predominant. Especially during summertime, the Alps contribute significantly to the total discharge of the river. In June, for example, the Alpine contribution to the total discharge in Rees is on average 52%, although it accounts for only 15% of the space of the feeding area.

Rhone

While the shift between the summer and the winter influence on the discharge of the Rhine is gradual and takes place along the course below Mainz, for the Rhone the change occurs at the mouth of the Saône and, unlike the Rhine, it is sudden. The table below shows that the average contribution of the Alps to the total discharge of the Rhone is 41%.

[5] Hydrological Atlas Switzerland, The Hydrological Significance of the European Alps, Daniel Viviroli, Rolf Weingartner, Institute of Geography of the University of Berne, Berne

[6] Hydrological Atlas Switzerland, The Hydrological Significance of the European Alps, Daniel Viviroli, Rolf Weingartner, Institute of Geography of the University of Berne, Berne

Po

The discharge of the Po is influenced by the complex interaction between the climate of the Alps, the Apennines and the Mediterranean. Major rivers in the Alpine space (Dora Baltea, Ticino, Adda, Oglio and Mincio) limit considerably the late summer minimum discharge of the Po and they generally balance its discharge regime.
The average contribution of the Alps to the discharge of the River Po represents more than half of the overall figure (53%), whereas in summertime this figure can rise to 80%.

Danube

The Danube's Alpine river character originates from the Alpine tributaries Iller, Lech, Isar, Inns (Passau-Ilzstadt).
Further downstream the inflow of the Drava into the Danube accentuates this feature and leads to an overproportional influence of the Alpine resources on the discharge of the Danube, as shown in the table "Contribution of the Alps to the total discharge".[7]

Water Towers under Climate Change Conditions

According to temperature measurements during last century, the warming in the Alps exceeded 1,5 °C, which is more than twice the global warming average.

As a consequence, the key environmental pressures such as changes in temperature (affecting snow cover, snow pack and biodiversity), changes in precipitation patterns (possibly with extreme weather events such as droughts and floods) and changes in wind regimes might have a severe impact on the water balance of the Alps and the surrounding areas[8].
The regime of catchments might change to a constantly reduced water level in summer, which has an impact on water quantity as well as on the temperature of surface waters.
The discharge from mountain-dominated territories in terms of timing, volume and variability will influence run-off characteristics in the lowlands as well[9].
In this respect, the EEA study on vulnerability and adaptation to climate change in Europe mentions the effects of the climatic shift on water balance with regard to navigation in the surrounding lowlands[10].

A more detailed analysis of climate change aspects is outlined in chapter D of this Report.

[7] Hydrological Atlas Switzerland, The Hydrological Significance of the European Alps, Daniel Viviroli, Rolf Weingartner, Institute of Geography of the University of Berne, Berne

[8] „How will the Alps respond to climate change?", Lučka Kajfež-Bogataj, University of Ljubljana, IPCC WG2 Vice chair

[9] IPCC, 2001

[10] Vulnerability and adaptation to climate change in Europe, EEA Technical Report, No7/2005, European Environment Agency

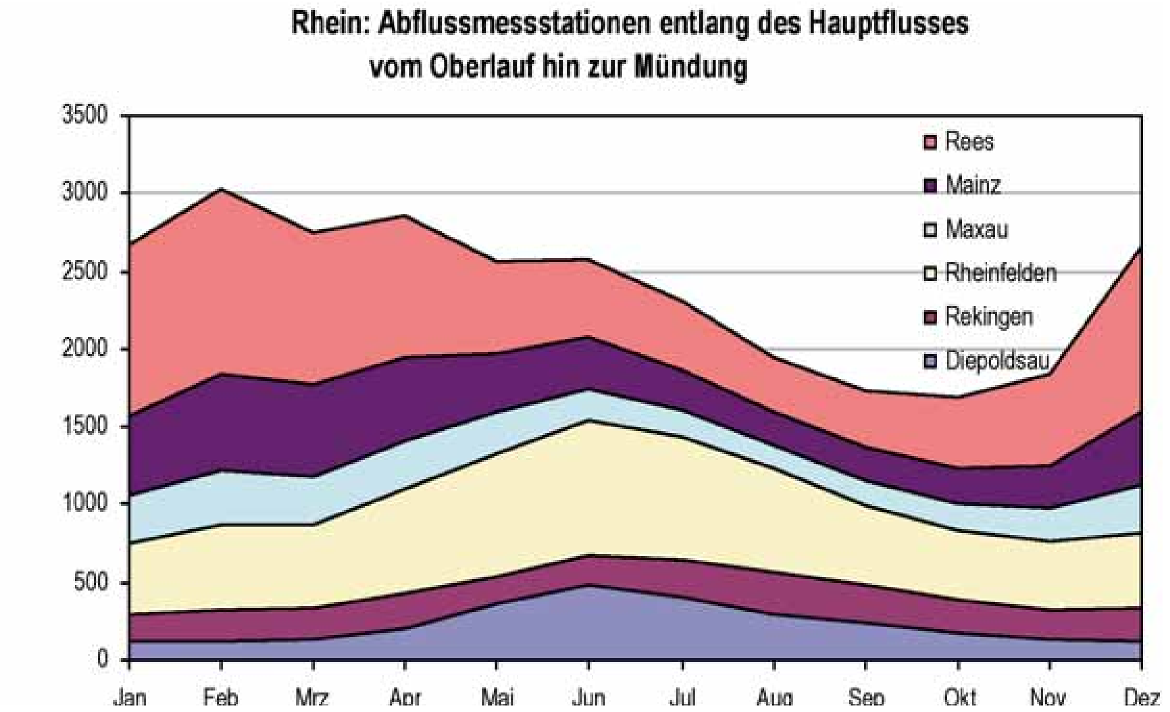


Fig. B1-4: Flow measuring stations along the main river from the upper part to the river mouth (Source of the diagram: Hydrological Atlas Switzerland[11])

The importance of the water-supplying Alps for the European centres in the lowlands surrounding the Alps

Chapter B.1.4. describes in detail the driving forces of water management in the Alpine region. When facing the current and future challenges of water management it is necessary, apart from following the development in the Alpine region, also to consider the importance of the water supply from this region for the development of the surrounding areas.

Increased water use and changing requirements for water supply and management in the lowlands surrounding the Alps is, inter alia, the result of ever increasing urbanisation and economic growth, which affects land use, water use and water balance in general. At the same time, the risk of economic losses in tourism, hydropower production and agriculture rises.

The urbanisation of major valleys and areas close to European centres such as Marseilles, Milan, Munich, Ljubljana, Zurich and other cities depend partly and directly on the availability of Alpine water.

Water from the Rhine-fed Lake Constance, for example, is piped over 200 km to the north[12] for household usage[13].

Reaction to such changes requires coordination within the basin (bilateral and, wherever necessary, multilateral) across geographical and institutional borders in order to cope with increasing water distribution conflicts. The Alpine lakes may possibly acquire increasing importance for water management, including the requirements of the lowlands - firstly for flood control and secondly, to a certain extent, the Alpine lakes serve also as multifunctional tools in the regulation of the water balance.

River	Average contribution of the Alps to the total discharge [%]	Area of Alpine space [%]	Overproportionality of the Alpine space
Rhine	34	15	2,3
Rhone	41	23	1,8
Po	53	35	1,5
Danube	26	10	2,6

Tab. B1-2: "Contribution of the Alps to the total discharge"

[11] Hydrological Atlas Switzerland, The Hydrological Significance of the European Alps, Daniel Viviroli, Rolf Weingartner, Institute of Geography of the University of Berne, Berne

[12] The hydrological significance of mountains – from regional to global scale, Daniel Viviroli and Rolf Weingartner, Department of Geography, University of Berne, 2004

[13] The hydrological significance of mountains – from regional to global scale, Daniel Viviroli and Rolf Weingartner, Department of Geography, University of Berne, 2004

Conclusions of the chapter The Alps - Water Tower of Europe

- The Alps supply a disproportionate amount of water from 35% (Danube) up to 80% in peak times (Po) of the overall discharge in the different catchments. The significant contribution of the Alps to the total discharge of the 4 main Alpine river basins always needs to be taken into consideration when dealing with water management issues.
- The Alps play a specific role in temporary important periods of water scarcity.
- Due to climate changes, the regime of catchments might change to a constantly reduced water level in summer, which has an impact on water quantity as well as on the temperature of surface waters. As a consequence, it is likely that the need for water, in particular for agricultural purposes and for electricity production, will meet with increased competition from the needs of river-water ecosystems.

Literature:

Hydrological Atlas Switzerland, The Hydrological Significance of the European Alps, Daniel Viviroli, Rolf Weingartner, Institute of Geography of the University of Berne, Berne

„How will the Alps respond to climate change?", Lučka Kajfež-Bogataj, University of Ljubljana, IPCC WG2 Vice chair
IPCC, 2001

Vulnerability and adaptation to climate change in Europe, EEA Technical Report, No7/2005, European Environment Agency

B.1.4 DRIVING FORCES FOR WATER MANAGEMENT

Anthropogenic socio-economic activities causing pressures on the environment are often referred to as "Driving Forces", having a fundamental impact on water management in a wide range of aspects. One of the main objectives of a modern water policy is to ensure sustainable development through consideration of this variety of factors, influencing the status of water resources.

Apart from human needs and related activities, which are regarded as the main factor for the consideration as a "Driving Force", the spatial framework for these activities is of major importance as well. Due to the special character of the mountainous area with its steep landscape in most cases, only a small share of the region is suitable for year-round settlement at all, concentrating at the bottom of valleys. This fact amplifies human impacts on Alpine waters in a variety of aspects, which are very characteristic for this European region in many ways.

Furthermore, economic development and water management are closely linked with each other. One aspect is that access to a sufficient quantity of water in adequate quality is the fundamental pre-condition for economic activities. Additionally, economic development and an increased standard of living often cause a rise in per capita consumption of goods, services and energy with related impacts on water resources as well. Some of the indicated aspects – the main driving forces for water management in the Alpine space - will be highlighted in greater detail on the following pages.

The "Drivers-Pressures-State-Impact-Response-Framework" (DPSIR-Framework[14]) represents a way of organising information and reporting on the state of the environment, whereas the various factors are connected with each other through a causal chain. More information on the DPSIR-Framework can be extracted from Fig. B1-5. "Pressures" and "Impacts" will be addressed in detail in chapter B.2.

The DPSIR Framework

DPSIR is a general framework for organising information and reporting about state of the environment covering Driving forces, Pressures, State of the environment, Impacts and Responses. The idea of the framework was, however, originally derived from social studies and only then widely applied internationally, in particular for organising systems of indicators in the context of environment and, later, sustainable development.

Population and settlements in the alps

The present delimitation of the Alpine Convention area comprises about 190.000 km^2. In 2004 around 14 million people were living in this area. During the 1990s the population increased in the Alpine Convention area by 7,8% as indicated in table Tab. B1-3.
However, the demographic process is not homogeneously spread across the Alpine region. Growth is especially observed in the central Alpine area. The Provinces of Oberbayern, Salzburg, Tyrol, Vorarlberg, Alto Adige, Trentino, the majority of Cantons in the western parts of Switzerland and Liechtenstein have all recorded an increase in population.

In sharp contrast to the overall situation, a cluster of municipalities along the Italian Alpine sector which includes the area from Liguria to Lago di Garda is facing a steady decrease in population. Also several municipalities in the Provinces of Belluno and Udine have recorded a decline in population. The same tendency is

[14] For further information see: The DPSIR Framework. (2002). In UNEP/GRID-Arendal Maps and Graphics Library. Retrieved 16:17, August 27, 2008 from http://maps.grida.no/go/graphic/the_dpsir_framework.

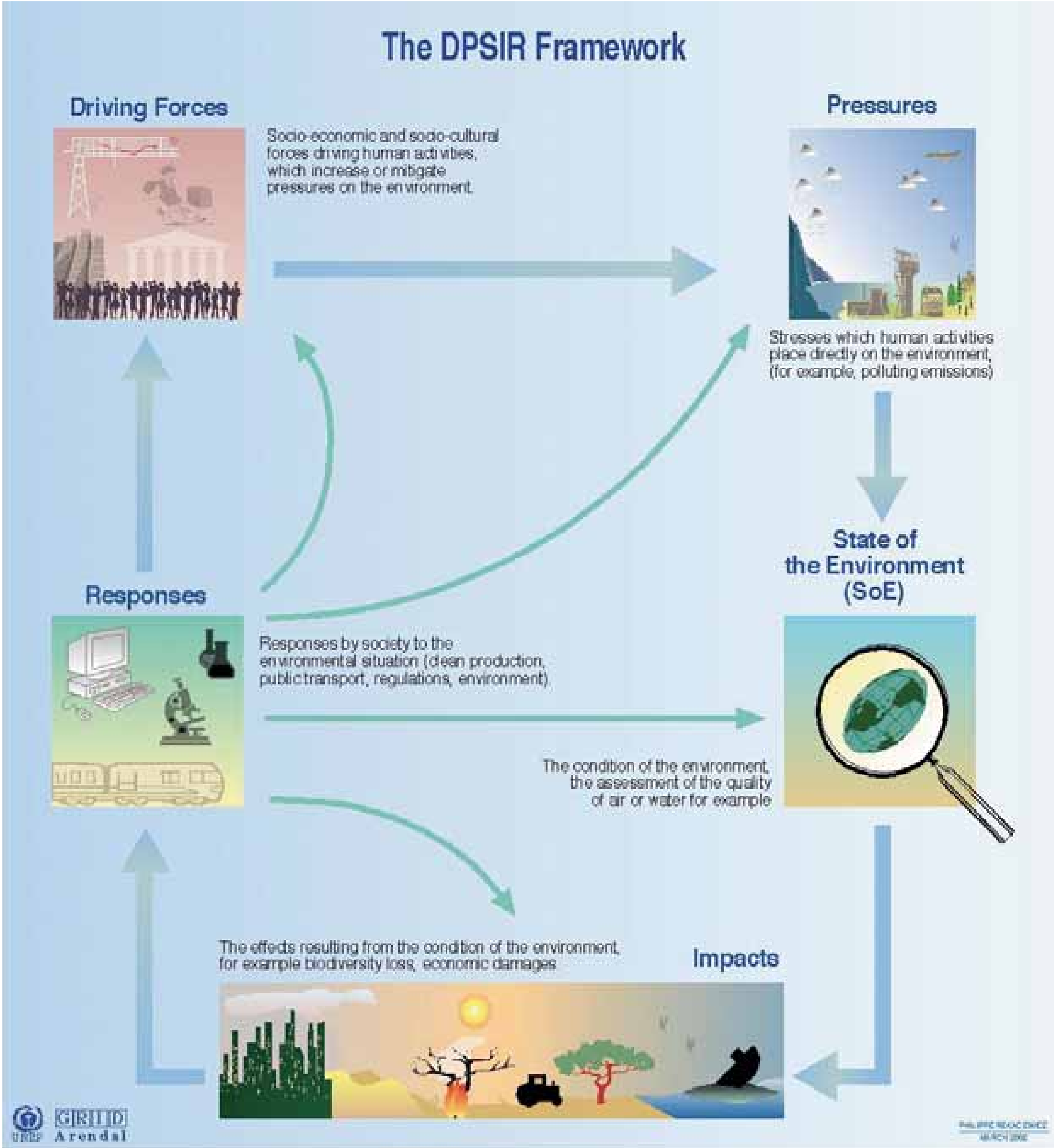


Fig. B1-5: The DPSIR-Framework

observed in the Slovenian Alpine region and in Austria throughout eastern Styria and in the southern parts of Lower Austria too. Even in the Swiss Cantons of Uri, Bern and in the northern part of Ticino the population has decreased.

Population growth for the Alpine perimeter was not only going on throughout the 1990s. In fact, today the Population in the Alpine Convention area is twice as high as it was at the end of the 19th century.
This development resulted in an increased population density, which is a basic indicator in evaluating the human pressures on space and in distinguishing between rural and urban areas. Throughout the whole Alpine Convention area the average density is 73 people per km^2.
Compared to the national values (e.g. Germany: 231.1 inh./km^2, Italy: 197.1 inh./km^2), the Alps are one of the less populated regions in Europe.
Tab. B1- 4 lists inhabitants and population density of a number of Alpine regions.
Map 6 gives an overview of the population density on the basis of municipalities for the whole Alpine arc.

However, topography plays a key role in analysing population density patterns in mountainous regions. Many parts of the Alps must be considered as unsuit-

Country	Area [km²]	Municipalities	Inhabitants[15]	Change in inhabitants[16] [%]	Population density [inhabitants/km²]
1	2	3	4	5	6
Austria	54.620	1.148	3.255.201	+4,8	60
France	40.804	1.749	2.453.605	+9,2	60
Germany	11.0723[17]	285[17]	1.473.881	+15,7	133
Italy	51.184	1.756	4.210.256	+5,7	82
Liechtenstein	160	11	34.600	+13,2	229
Monaco	2	1	32.020	+6,8	16.010
Slovenia	7.864	60	661.135	+1,2	84
Switzerland	24.862	944	1.827.754	+13,1	74
Alps	**190.568**	**5.954**	**13.948.452**	**+7,8**	**73**

Tab. B1-3: Population change and density in the Alpine Convention area during the 1990s[18]

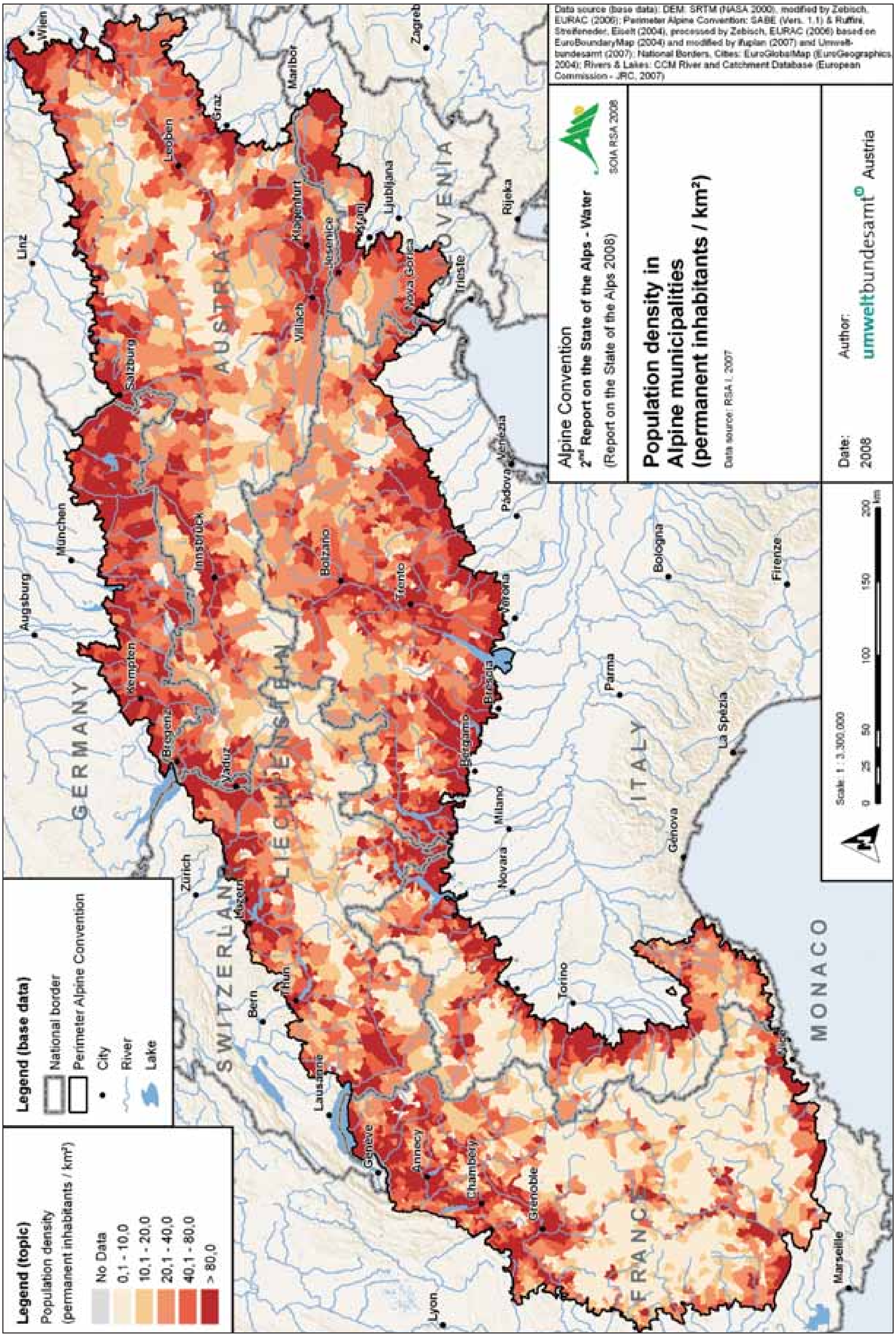
Region	Inhabitants (2005)	Area [km²]	Population density [inhabitants/km²]	Area of permanent settlement [km²]	Population density [inhabitants/km²]
1	2	3	2/3	4	2/4
Tirol	692.281	12.648	54,7	1.542	449,0
Vorarlberg	363.237	2.601	139,7	621	583,0
Salzburg[19]	524.400	7.154	73,3	1.540	340.5
Styria[19]	1.183.303	16.392	72,2	4.948	239,1
Germany – Area of the Alpine Convention	1.473,881	11.072	133,1	5.650	260,9
Autonomous Province of Bolzano/Bozen	477.067	7.400	64,5	612	779,5
Switzerland – Area of the Alpine Convention	1.827.754	24.862	73,5	3.475	525,8

Tab. B1- 4: Inhabitants and population density in some Alpine regions[20]

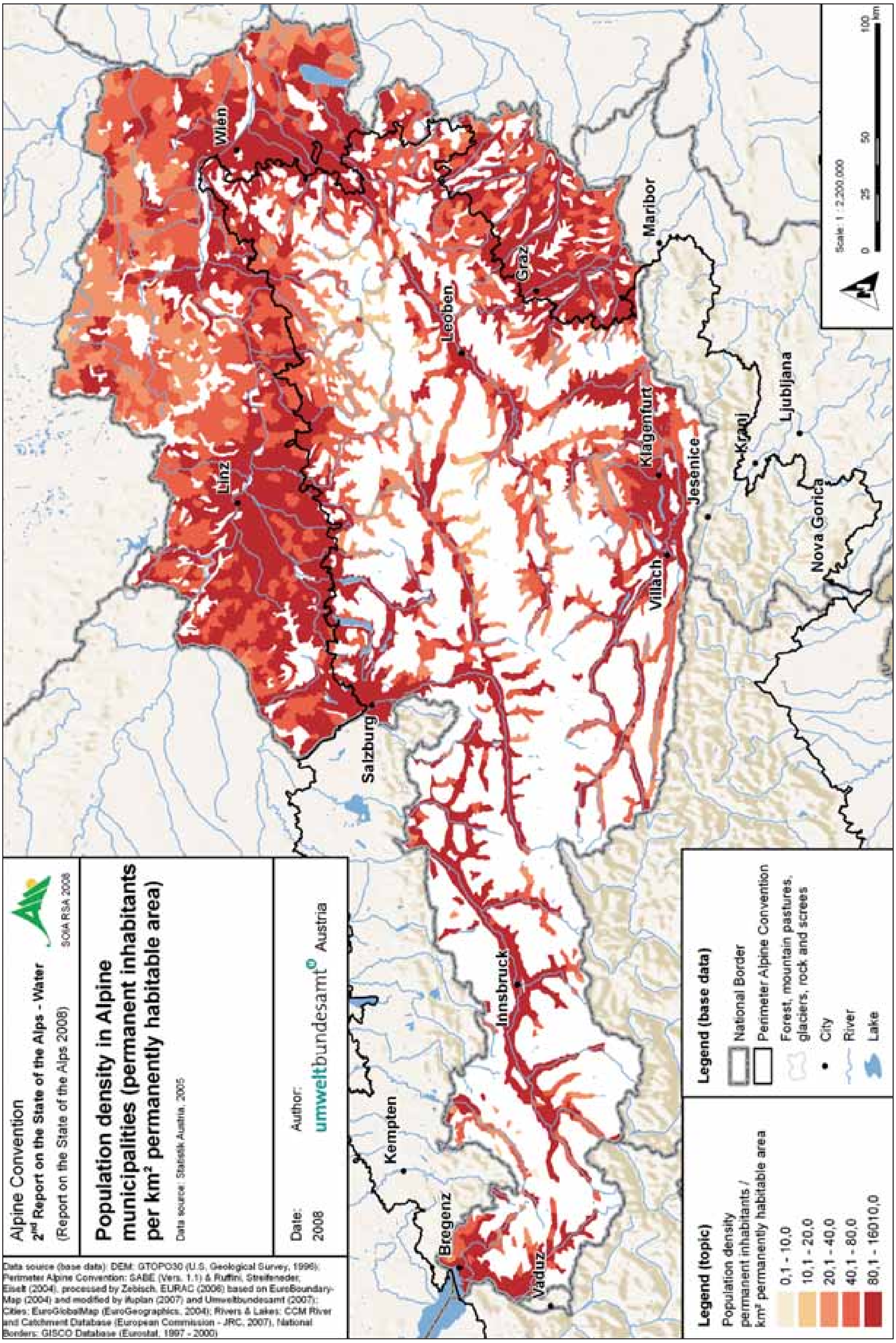
able for human settlements. To give a more realistic and comparable picture of the population density, the area of permanent settlement, as the most appropriate indicator, should be taken into account. If the areas of permanent settlements are the basis of the calculation, this results in higher values for the population density of Alpine regions as displayed in Map 7, in the case of Austria for example.

© Urša Gale
Photo B1-1: Space for settlements and infrastructure is concentrated at the bottom of Alpine valleys. (Motorway between Munich and Ljubljana, regional and local roads and the reservoir of the Moste hydropower station). Slovenian Alps, Lipce, Karawanken.

[15] Date of survey: AT: 2005, DE, IT, LI, SI and CH: 2004, MC: 2000, FR: 1999.
[16] Due to data availability the reference year varies between 1987 and 2001: MC: 1990/2000, AT: 1991/2001, FR: 1990/1999, DE: 1987/2000, IT: 1990/2000, LI: 1990/2000, SI: 1991/2000, CH: 1990/2000.
[17] Not included 10 municipality-free areas.
[18] Sources: AT (UBA), FR (IFEN), DE (LfStaD), IT (ISTAT), LI (AVW), SI (Statistical Office of the Republic of Slovenia), CH (FSO).
[19] Belongs partly to the AC area
[20] Source: Salzburg (Amt der Salzburger Landesregierung 2004), Vorarlberg (BMVIT 2005), Styria (Amt der Steirischen Landesregierung 2001), Tirol (Amt der Tiroler Landesregierung 2004), Bolzano/Bozen (Autonome Provinz Bozen-Südtirol 2004), DE (LfStaD 2004), CH (FSO 1985).



Map 6: Population density in Alpine municipalities



Map 7: Population density in Austria

As can be seen, population density reaches high values, similar to those in densely populated urban centres, within the narrow valleys and small basins of the Alpine area. Human activities are also related to the discharge of chemical and organic substances from industrial facilities but also urban wastewater treatment plants, causing pressures on the quality of water. Additionally, infrastructure projects like roads and railways also add to a shortage of space for aquatic ecosystems in these areas. The effect is that once naturally braided Alpine river systems were regulated due to the need of protecting human settlements and infrastructure from flooding, resulting in an increase of space suitable for settlements on the one hand, but in a loss of ecological diversity on the other. This trade-off, carried on for centuries, is one of the main reasons for significant changes in the character of today's Alpine rivers and hence one of the most significant driving forces for water management in the Alps.

Land use and agriculture

One of the characteristics of the Alpine perimeter is the rough climatic conditions. Suitable areas for agricultural activities are therefore mainly located at the bottom of narrow valleys, which offer favoured climatic conditions compared to areas situated at higher altitudes. Hence, arable land or intensively used grassland is mainly located in these limited plain areas, which were subject to human efforts for securing the food supply for the resident population. Flood protection schemes in combination with drainage were the technical approaches for the expansion of limited areas for agricultural activities. Wetlands and related space for rivers were claimed mainly from the 19th century on until the second half of the 20th century for conversion into suitable areas for agriculture.

These measures can be seen as one important reason for the change in land use within the Alpine perimeter into a situation known nowadays. According to an assessment of land use in the Alps from the year 2000[21], about 18% of the Alpine area is used for agriculture, mainly concentrated in valleys and the low mountain ranges. An additional 18% is used as grassland, including Alpine pastures. Hence, agriculture is a significant form of land use within the Alpine perimeter, which has left its marks on the mountainous landscape and has also changed the character of Alpine river systems.

However, although agricultural activities certainly have a significant impact on rivers through the conversion of wetlands into agricultural land, the effects as a driver on the chemical quality of water are rather limited. This circumstance is mainly caused by the fact that Alpine agriculture is carried out in minor intensity, compared to regions outside of the Alpine perimeter, with related less intensive application of chemical fertilizers or pesticides.

© Kdo Luftaufklärung / BMLV
Photo B1-2: Intensive agriculture by the Drava River, Austria.

[21] Corine Land Use Europe, 2000:
Download from http://dataservice.eea.eu.int/dataservice/ on 23.06.2005

Regarding the quantity of water, due to high values of precipitation, the classification of the Alpine space as "water rich" and, compared to other European regions, the relatively small share of land used for agriculture, irrigation is only infrequently exercised. Nevertheless, although irrigation is not a major driver for the use of water for the whole Alpine arc, in some cases (like in Alto Adige or the Valais for instance) it can become of increased significance locally, causing pressures on the availability of water for other users or for ecology.

Tourism

The Alps are - caused by the attractiveness of the landscape - a popular destination for countless tourists. With the development of mechanical support for ascension using ski-lifts, especially winter tourism has experienced an unexpected rise in recent decades. Over 60 million holiday guests, another 60 million day tourists and about 370 million tourist nights spent make the Alps the largest holiday region in Central Europe[22]. Regarding the whole of Europe, only the Mediterranean region is a more favoured tourist destination[23]. These numbers indicate a certain significance of tourism as a driving force for Alpine water management.

Tourism can be considered as a key industry for many Alpine areas. About 10% of the Alpine municipalities feature a "touristic monostructure"[22]. Based on good natural and infrastructural conditions (i.e. concerning sufficient snow cover), tourism here dominates the whole local or regional economy. The majority of tourist nights spent are counted during the summer period. Nevertheless, winter tourism is economically more important in many places due to the higher spending by winter tourists.

Tourism intensity, as displayed in Map 8, is defined as the number of tourist beds per resident population. Municipalities with a tourism intensity higher than 1 are regarded as tourism centres. About 9% of Alpine municipalities exceed this value. In other words, these municipalities offer more tourist beds than they have resident population. Another 8% of municipalities show tourism intensities between 0,5 and 1 tourist beds per inhabitant[24].

Tourism may impact water management as a driver in several ways. This important economic sector increases the total average population living within the Alpine area. One related aspect is that the total demand for freshwater is increasing correspondingly on the one hand, causing a rise in wastewater which affects the quality of Alpine river systems on the other. Since overnight stays are not distributed equally throughout the whole year, water supply and wastewater infrastructure have to be adapted to high-season peaks, which occur mainly throughout a couple of weeks during the summer and winter period, causing increased investment costs apart from the practical challenges in the management of the systems. A special sticking point in this respect is the occurrence of high population densities and the occurrence of high amounts of wastewater during the winter period, while concurrently the rivers are in the low-flow period.

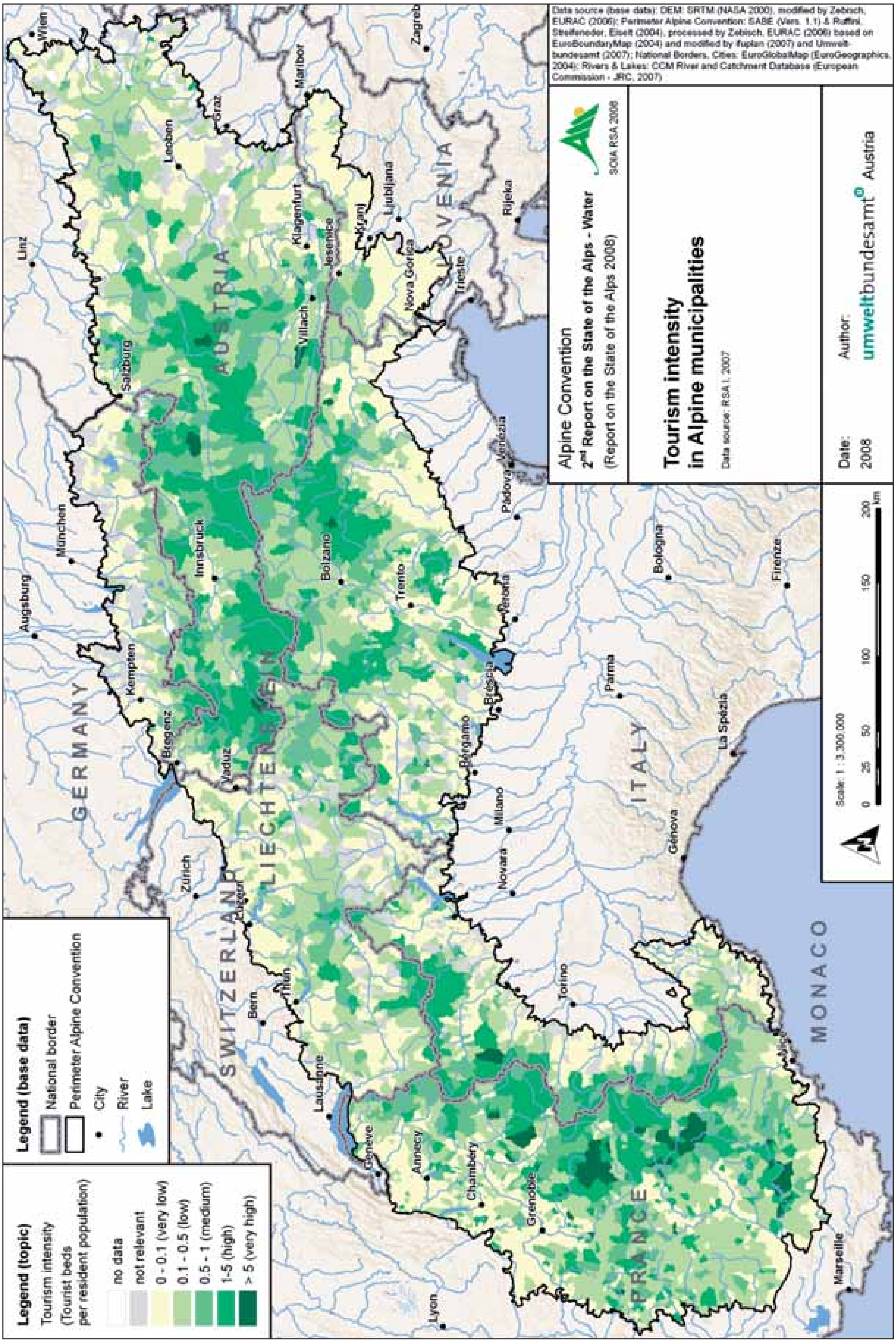
Since tourism is linked with the need for the provision of commercial facilities like hotels, shops or parking lots, this branch also contributes to increased pressures on spatial planning and traffic. One related aspect, which has already been mentioned, is the challenge of protecting settlements and tourism infrastructure from natural disasters like floods, resulting in a classical conflict between the objectives of economic development and the protection of nature.

Furthermore, one facet of winter tourism in relation to Alpine water resources, which has become very prominent and increasingly important for the tourism industry in recent years, is artificial snow production in connection with climate change. Since the guarantee of snow-covered slopes for winter tourism is a pre-condition for securing the economic income of ski resorts, technical equipment has steadily risen in number, leading to increased abstractions of water from rivers in the Alpine area.

However, the development of newer schemes for artificial snow production has increased the efficiency in terms of energy and water consumption as is also described in chapter "B.2.3.1". One aspect is the construction of ponds for the storage of water, which contributes towards a reduction of pressures on rivers during the low-flow period in winter time. But still, an overall extension of facilities may lead to increased pressures on water resources and make an appraisal based on every individual case necessary. In the event that scenarios for climate change in the Alpine area become apparent, further pressures on Alpine water resources due to winter tourism are foreseeable. Another facet of tourism is new water sport activities such as canyoning or rafting, with their impact on flora and fauna as put forward by the organisation "Deutscher Alpenverein".

However, tourism also contributes towards triggering positive developments for water management, removing existing pressures from Alpine waters. The cross-reference which should be addressed here is the protection of lakes, which started in the 1960s. The construction of ring sewer systems around lakes and the removal of phosphates from urban wastewater was certainly

[22] Bätzing, W. (2003): Die Alpen – Geschichte und Zukunft einer europäischen Kulturlandschaft. C. H. Beck, München.
[23] EEA – European Environment Agency (2003): Europe's Environment – The Third Assessment. Copenhagen.
[24] Alpine Convention (2007): Report on the state of the Alps - Transport and mobility in the Alps. Innsbruck.



Map 8: Tourism intensity in Alpine municipalities

pushed by summer tourism. The results can be seen in the achievement of the restoration of excellent water quality in the majority of Alpine lakes.

Energy demand

Natural resources like fossil oil or coal are scarce in the Alpine space compared to other regions in Europe. The use of the energetic potential of water has therefore been of vital interest to the population for meeting energy needs and is therefore an important driver for Alpine water management. For centuries water has been used for the operation of flour mills or saw mills – technologies, which were introduced as a substitute for human manual labour. The technological progress during the 20th century substituted old technologies and established hydropower plants for electricity production instead.

The reason for the attractiveness of hydropower generation in the Alps can be found in the perfect preconditions therefore. Steep slopes in combination with high precipitation are the basis for lucrative facilities and make hydropower generation a significant economic factor for Alpine countries. Apart from run-of-river power stations, which cover a share of the base load of electricity demand, Alpine storage and pumped-storage power stations are flexible to provide extra electricity at peak times of demand.

© A. Kryžanowski
Photo B1-3: Energy demand: small hydropower station built during Napoleonic wars as dam for flushing timber and recently refurbished as small hydropower station. Kanomeljske klavže dam near Idrija, Slovenia

The long-lasting tradition in the use of the energetic potential of water caused considerable impacts on and changes to the natural environment of the Alpine space. As such a change, the interruption of the river continuity has to be mentioned, where dams from hydropower stations cut off river stretches and prevent aquatic life like fish from migrating, which is necessary for reproduction in certain life cycles. One apparently negative impact of hydropower plants on aquatic ecology is the reduction of river run-off or, in some cases, the complete absence of water in river stretches downstream from diverted run-of-river power stations. With the reduced transport of sediments, which are trapped in dams, the dynamic balance is disturbed, causing increased erosion of the river bed with corresponding impacts on morphological processes and lost biotopes, apart from falling levels of the groundwater table.

The above-mentioned different aspects of hydropower generation and energy production aim at highlighting the significance of energy demand as a driver for Alpine water management. Since the majority of river stretches and water resources, economically worthy of being used for hydropower generation, were already developed in the last decades, the remaining stretches, which are still largely in their natural condition, are rising in value since they have become increasingly unique in the Alpine space. This is probably one of the reasons why plans for new projects are heavily discussed, raising public emotion.

Current developments in the energy market with increasing prices coupled with growing demand for electricity further stimulate the quest for new facilities. Additionally, the current strategy of increasing the share of renewable energy like hydropower in the context of climate change is further fuelling the debate.

Environmental protection and nature conservation

Environmental protection and nature conservation have increasingly became a driving force for water management since the general public has become sensitive and alerted to environmental issues. This development found its way into an active civil society as well as into public institutions and the political process, culminating in laws which aim at the sustainable use of the environment or at the conservation of nature. This process could be observed to an ever greater extent in the last quarter of the 20th century, with a number of new environmental laws and policies coming into force.

Formally, a distinction has to be made between “environmental protection" and "nature conservation", as these two terms are frequently confused since they are very similar. While "environmental protection" is rather based on the point of view of protecting the environment with the aim of protecting human living conditions, "nature conservation" means the preservation of nature in a condition which is as unaffected by anthropogenic influences as possible. Based on these definitions, "Natura 2000" sites for instance should be considered to be legislation for nature conservation rather than environmental protection, while the EU Nitrates Directive, aiming at the reduction of water pollution with nitrates from agricultural sources, can be considered to be the latter.

Important types of protected areas in EU countries

The incentives for protecting certain areas follow different considerations in order to reach a set of objectives. The main types of protected areas (as listed in Annex IV of the EU Water Framework Directive[25]) can be summarised as follows:

i) Areas designated for the abstraction of water intended for human consumption
ii) Bodies of water designated as recreational waters, including areas designated as bathing waters
iii) Nutrient-sensitive areas
iv) Areas designated for the protection of habitats or species where the maintenance or improvement of the status of water is an important factor in their protection

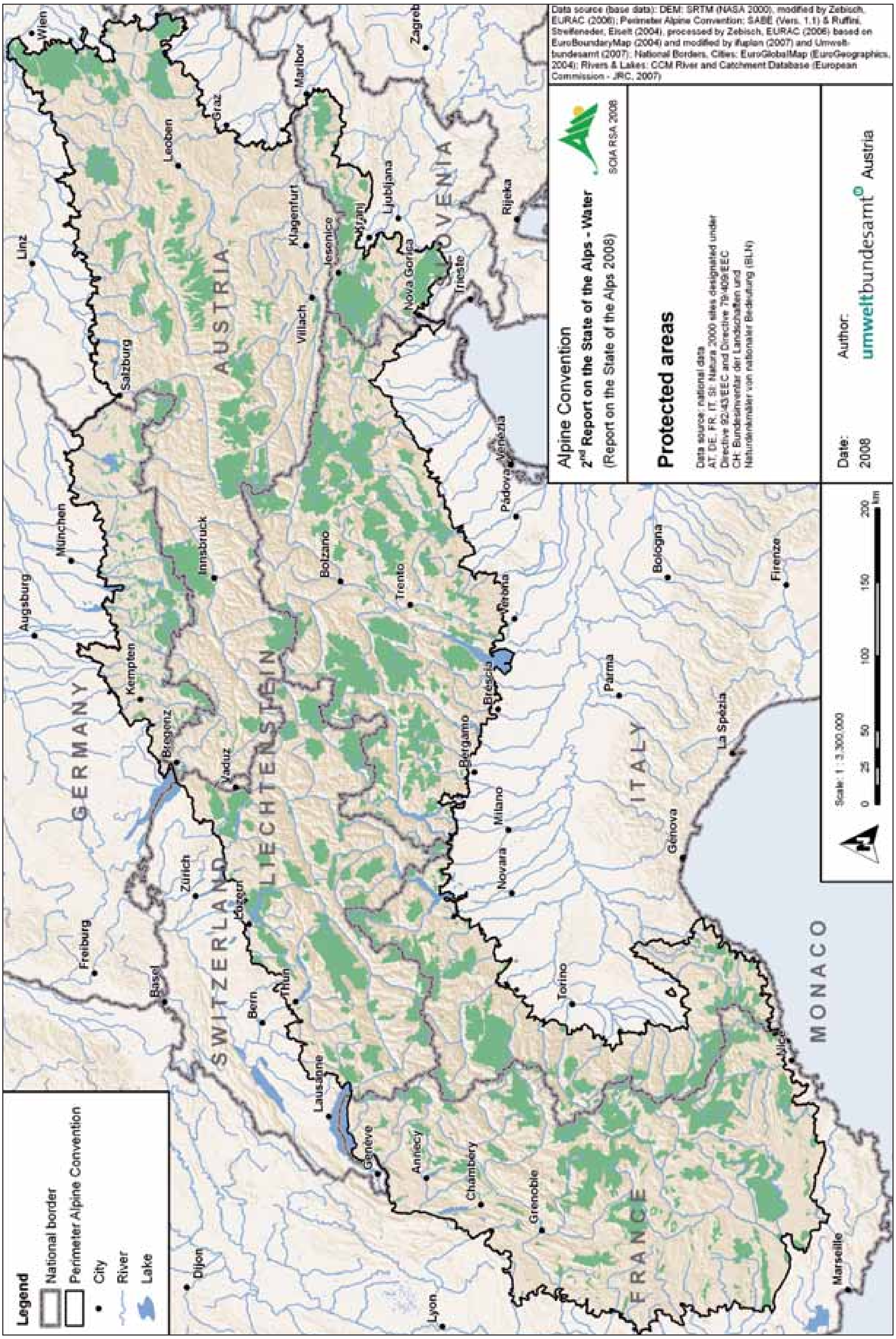
i) In areas designated for the abstraction of water for human consumption, the protection of water from alterations which can cause negative impacts on human health is intended. This is carried out by the responsible public authority with special regulations on the management or use of certain pieces of land and waters or bans and constraints on the construction of certain facilities for instance. Apart from protecting waters which are already used for water supply, regulations also aim at protecting waters which may possibly be used for future water supply schemes.

ii) Regarding recreational waters, in principle waters which are in use for human regeneration and relaxation can be considered as such. Recreational waters may include areas which are used for leisure activities like bathing or boating for instance. A part of these areas may also be covered by areas designated as "Natura 2000 sites". The aim of protecting waters for recreational activities is to meet certain water quality parameters in order to assure the protection of human health. This should be guaranteed through compliance with threshold values for microbiological, physical or chemical parameters in order to protected human beings from infections.

iii) An element for the protection of waters from pollution with nutrients like nitrates or phosphates is the designation of nutrient-sensitive areas. Such areas might already be affected by high nutrient concentrations for groundwater or, for surface waters if found to be eutrophic or which may become eutrophic in the near future if action is not taken. By designating nutrient-sensitive areas, the geographical framework is established for implementing adequate measures in order to reduce nutrient concentrations and protect waters from eutrophication. Thus, such measures can become legally binding not only within sensitive areas, but also in regions which discharge into such areas. Measures can contain more stringent provisions for the discharge of wastewater in the case of point sources like urban wastewater treatment plants or special legal requirements on farming practices in the case of diffuse sources of pollution. For EU countries, the legal framework regarding the protection of waters from nutrient pollution is mainly governed by two directives – the Urban Wastewater Treatment Directive and the Nitrates Directive.

iv) Maintenance and improvement of the status of water is an important factor for the protection of certain habitats or different species. The designation of protected areas is a contribution towards achieving this aim. The most prominent types of protected areas for EU Member States are designated areas according to the EU Habitats Directive and the EU Birds Directive. The main aim of the EU Habitats Directive is, on one the hand, to promote the maintenance of biodiversity by requiring EU Member States to take measures to maintain or restore natural habitats and wild species at a favourable conservation status, introducing strict protection for those habitats and species of European importance. The EU Birds Directive on the other hand provides a framework for the conservation and management of, and human interaction with, wild birds in Europe. These two Directives form the basis of the so-called "Natura 2000" network, which has been set up in order to protect the most seriously threatened habitats and species across Europe (see Map 9 "Protected Areas in the Alpine Space"). Apart from the European-wide ecological network Natura 2000, the existence of additional protected areas, like Ramsar Sites or National Parks within EU countries but also within Switzerland, should be highlighted.

[25] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, ABl 2000 L 327/1, Water Framework Directive, WFD



Map 9: Protected areas in the Alpine space

Protected areas in Switzerland

In Switzerland there are several instruments available for nature and landscape conservation as well. The competences and duties for these matters are within the responsibility of the Confederation.

It can issue inventories of objects of national importance (habitats, landscapes, natural heritages) and contribute financially to nature conservation activities. There are different types of inventories with different levels of protection. The Cantons are in charge of the implementation of the inventories.

The following Swiss inventories can be mentioned as being water-related:

- The federal inventory of landscape and natural monuments of national importance (the so-called BLN-inventory)
- The habitat inventory

Regarding the latter one, in order to protect the habitats for flaura & fauna, the legal basis for habitat inventories was established in 1987. The Confederation, acting in accordance with the Cantons, designates habitats of national importance and lays down the protection level, which is then compulsory. At present, inventories for high moors and transition moors, fens, alluvial zones and breeding areas for amphibians are in force.

Downstream needs

The Alpine arc plays a primary role for the river basins to which it belongs; the water which is discharged and stored in the Alps often represents the major contribution to the whole water balance of a river basin. Downstream necessities are therefore a key driving force for the management of Alpine water.
Downstream needs are related to the economic sectors which use and depend on water, such as agriculture, tourism, industry, energy and transport, but also to the environment and the necessity of maintaining biodiversity, water quality, diminishing risk of forest fires and soil impoverishment.
In general, the satisfaction of those needs is naturally guaranteed, but under particular conditions such as droughts, the availability given by the natural water balance is not sufficient for all needs – therefore, it sometimes becomes necessary to extract more water from those parts of the "regulated" water tower. In such cases, only a coordinated management of the Alpine lakes and artificial reservoirs can help to mitigate the problem.
Therefore, coordinated watershed balance management has been tested already along several river catchments under different conditions and with satisfactory results. Those experiences have shown that only an integrated and sound management of the basin's water balance, including stored Alpine water, is effective in the prevention and mitigation of the impacts of water shortages.

© A. Bianchini
Photo B1-4: Up- and downstream, Mt Paganella with Lakes Garda and Cavedine In the background, Italy.

Climate change

In the long run, climate change has always been and will increasingly become a driver for water management in the Alpine space. Changes in the water balance have escaped the notice of the population in recent decades, although adaptation to the changing circumstances has been made constantly, for instance during the small ice age from 1350 to 1880 in the form of decisions regarding adequate areas for human settlements. These activities were, to a certain degree, restricted by a lack of technological potential in the field of hydraulic engineering. Floods in particular limited the possibilities for humans to develop settlement areas at the bottom of Alpine valleys. Technological adaptation to the climatic conditions, more precisely to extreme events and natural hazards, was one of the starting points for the development of settlements, agriculture and economic activities.

Since these days the challenge has always been to manage the abundance of water (in the form of floods) as well as the demand for water (drinking-water supply but also droughts) in the seasonal interplay. Beside the seasonal changes, the overlaying large-scale climatic variations in temperature and precipitation also made it necessary for humans to adapt to those changes in environmental conditions. The history of the development of settlement areas in the Alps illustrates those processes and helps us to understand the dynamic conditions with which people had to cope.

Since public discussions on climate change have arrived at a point where it is generally agreed upon and accepted that we have to expect drastic and comparably rapid man-made changes in the upcoming decades and centuries, the focus has now shifted towards estimations on what the related impacts on our living environment will look like. The model-based calculated predictions, which consequently look different depending on the Alpine region observed, will be discussed in greater detail in chapter "D. Climate Change".

However, there is no doubt that climate change will present new challenges to water management not only in Alpine countries but also in the rest of the world. Both mitigation measures and also the ability to adapt to the expected changes will be necessary in order to avoid any negative impacts on human living conditions and on our environment. A combination of technical solutions, foresighted planning and water management, which has to be understood in as broad a form as possible, are key for counteracting climate change as a driver, which certainly increases the pressures on and challenges to Alpine water management.

B.2 PRESSURES AND IMPACTS

The ecological conditions of rivers and streams are usually characterised by different biological indicators. The habitat conditions can be described by the following three abiotic influencing factors:

a) water quality

b) water quantity and

c) river morphology and continuity.

As indicated in Fig. B2-1, impacts from different kinds of pressure can be identified through these factors.

Alpine rivers are extremely dynamic ecosystems. Their ecological condition strongly depends on the longitudinal, lateral and vertical connectivity and on the natural variations of the hydrological cycle.

These are important pre-conditions for the existence, reproduction and well-being of the type-specific biocenosis, characteristic of Alpine rivers including, for instance, typical fish (e.g. greylings or trout), amphibians or macroinvertibrates (e.g. stone flies).

A preliminary section on monitoring networks now follows; this chapter is structured according to the concept which is depicted in Fig. B2-1.

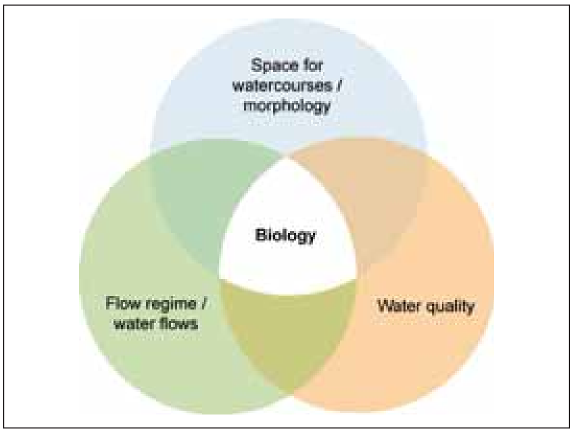


Fig. B2-1: The ecological status as interplay of the abiotic influencing factors and biological conditions.

© BMLFUW
Photo B2-1: Greylings are a typical species which can be found in Alpine rivers.

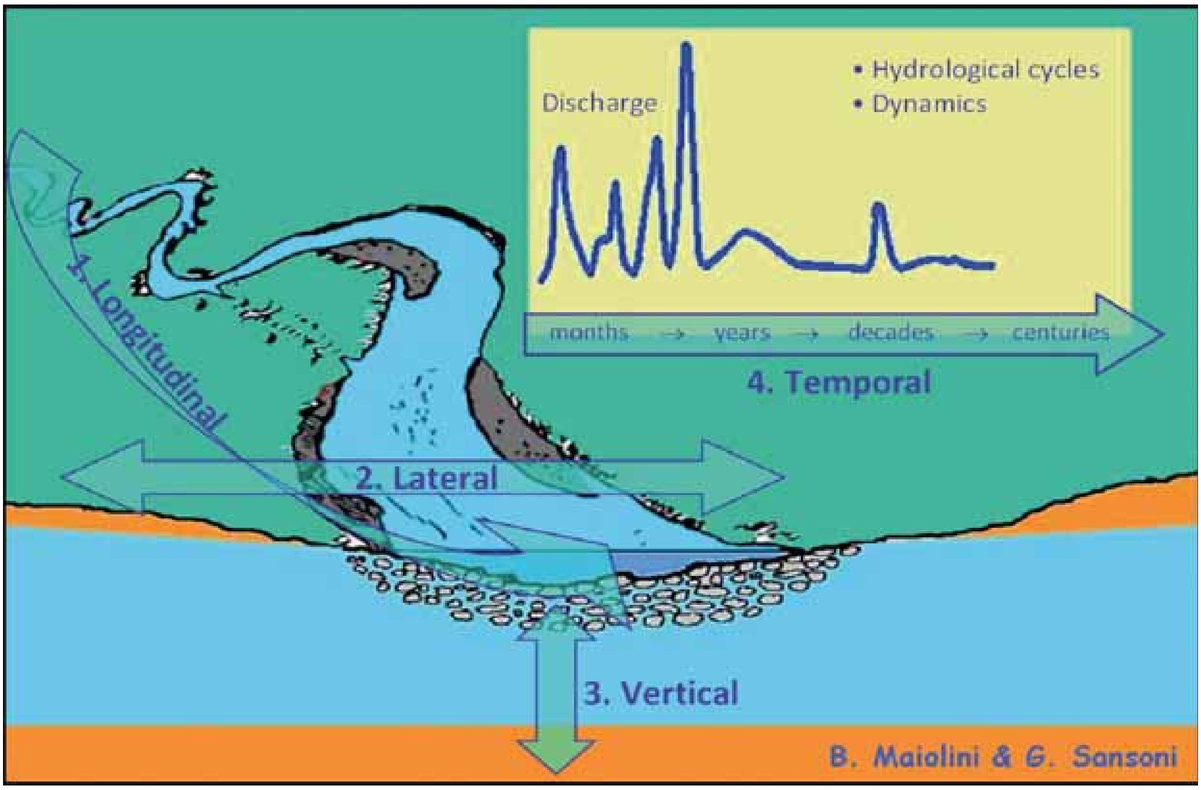


Fig. B2-2: The 4 dimensions of river ecosystem – longitudinal, lateral and vertical connectivity; temporal dynamics

© BMLFUW

Photo B2-2: The existence of stone flies is a typical indicator of high water quality. In their larva life-cycle, their habitat is in the interstitial space of gravel in the river bed.

B.2.1 MONITORING PROGRAMMES

Monitoring programmes are a fundamental tool in the management of water resources since the measurement of quality and quantity parameters provides a sound basis to enable target-oriented planning and the control of success and the performance of tailor-made measures and programmes in the course of water management.

Since the water cycle in our environment is a very complex system with a number of influencing factors having an impact on the status of waters, monitoring networks aim at giving consideration to this fact by covering a wide range of attributes with a broad set of parameters. This set of parameters is measured periodically on a nation-wide scale within the whole a Apine perimeter. Apart from the present status, the evaluation of tendencies is of major interest as well since the early detection of unfavourable developments provides an advantage in counteracting such trends in due course. Reliable long-term data series are the basis to that end.

The assessment of existing pressures which potentially influence the status of waters is a prerequisite for the design of monitoring programmes and the selection of sites in order to support policy decisions. In line with a risk-based approach, the density of monitoring as well as the number of parameters may differ, depending on whether there is a risk of failing to achieve environmental objectives.

Apart from the necessity of monitoring programmes for administrative purposes, monitoring is also a crucial instrument for the research activities of the scientific community. In this respect, the programmes are, in general, designed more specifically and oriented towards special research interests.

"With respect to observation systems for climate change, reference is given to WMO's GCOS (Global Climate Observation System) to ensure the availability of global observations for climate (http://www.wmo.int/pages/prog/gcos/index.php)

GCOS intends to be a long-term, user-driven operational system capable of providing the comprehensive observations required for:
- Monitoring the climate system,
- Detecting and attributing climate change,
- Assessing impacts of, and supporting adaptation to, climate variability and change,
- Application to national economic development,
- Research to improve understanding, modelling and prediction of the climate system.

GCOS addresses the total climate system, including physical, chemical and biological properties, as well as atmospheric, oceanic, terrestrial, hydrologic, and cryospheric components."

Water quality

Appropriate programmes for monitoring water quality and the assessment of the status of waters have been in place in all countries within the Alpine perimeter. Since 2007 all programmes for monitoring water quality in EU member states have been based on the provisions of the EU Water Framework Directive[26] (for more details please see Directive 2000/60/EC article 8 and Annex V) and have to be revised every 6 years.

The conceptual approach of a monitoring cycle of 6 years comprises in EU member states

a) for surface waters

- a surveillance monitoring with the objective of supplementing and validating the assessment of impacts, to design future monitoring programmes, to assess long-term changes in natural conditions as well as in those resulting from widespread anthropogenic activities; surveillance monitoring is carried out for each monitoring site for a period of at least one year and includes all parameters indicative of all biological quality elements (e.g. fish), of all hydromorphological quality elements (e.g. river continuity), of all general physical – chemical quality elements (e.g. nutrients), of all other pollutants discharged in significant quantities (e.g. heavy metals) and of priority-list pollutants (e.g. atrazine);

[26] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, ABl 2000 L 327/1, Water Framework Directive, WFD

- an operational monitoring with the objective of establishing the status of waters identified as being at risk of failing to meet their environmental objectives and of assessing any changes in the status of such waters resulting from the programme of measures; parameters of operational monitoring have to be tailored to the on-site situation and have to be indicative of the pressures to which the waters are subject;

- an investigative monitoring, in particular where the reasons for any failure to achieve environmental objectives is unknown, or to ascertain the magnitude and impacts of accidental pollution.

b) for groundwaters

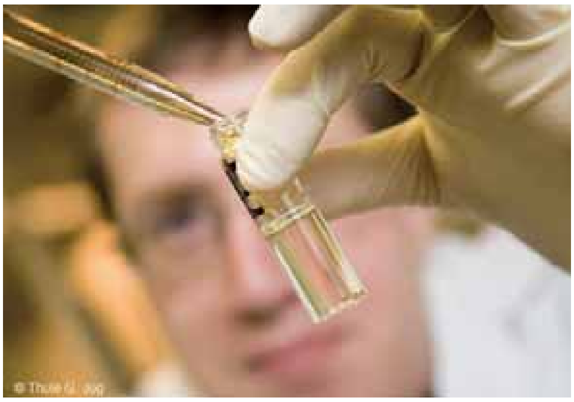
- a surveillance monitoring in order to supplement and validate the assessment of impacts and to provide information for use in the assessment of long term trends (both as a result of changes in natural conditions and through anthropogenic activities); core parameters to be monitored at an appropriate frequency are oxygen content, pH value, conductivity, nitrate and ammonium;

- an operational monitoring with the objective of establishing the status of groundwaters considered of being at risk of failing to achieve environmental objectives and to establish the presence of any long-term anthropogenically induced upward trend in the concentration of any pollutant, respectively.

In order to be able to guarantee the highest quality standards of the monitoring programmes, different elements of quality assurance are in place. They include inspections by accredited laboratories before and while they are entrusted with analysing samples as well as the compulsory participation in inter-laboratory comparisons. More details will be set out in a forthcoming Commission Directive laying down, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, technical specifications for chemical analysis and monitoring of the water status.
The approach outlined above for monitoring water quality is in place in all EU member states.

Switzerland has monitoring systems in place, providing a similar level of information. At a national level[27], the monitoring networks on water level and run-off, the network NADUF for the continuous monitoring of the water quality of watercourses, on water temperature, on sediment transport and the groundwater monitoring network NAQUA with its modules on quality, quantity and isotopes are to be mentioned.
As to methods to assess impacts, reference is made to the so-called "Modular Stepwise Procedure", a framework and standardised set of methods to assess the ecological status of rivers in Switzerland[28].

Map 10 and Map 11 provide an insight into the monitoring networks for water quality in place at national level. Findings and results of monitoring are dealt with in more detail in the forthcoming chapters.



© Thule G. Jug
Photo B2-3 and B2-4: Modern methods for the analysis of water quality are in use and applied by accredited laboratories.

Water quantity

Monitoring of "water quantity" enjoys a long-lasting tradition in monitoring programmes for the assessment of the water cycle in the Alps. In order to be able to draw conclusions on water quantity aspects, a comprehensive monitoring network, including gauging stations for measurements of precipitation, snow depths, water levels of lakes and groundwater as well as the discharge of rivers, is the pre-condition. Having a set of reliable long-term monitoring data for water quantity is a central necessity for projects, programmes and management questions in the field of key water management issues like flood protection, hydropower generation, forecast models in respect to climate change but also for the provision of public water supply.

[27] More information on http://www.bafu.admin.ch/hydrologie/01831/index.html?lang=en

[28] More information on www.modul-stufen-konzept.ch

Map 12 and Map 13 give an overview of the network of gauging stations within the Alpine perimeter for the assessment of discharges of rivers and the water levels of lakes as well as for assessing the water levels of groundwater.

© N. Trišič
Photo B2-5: Groundwater monitoring station, source of the Kamniška Bistrica River, Kamnik-Savinja Alps, Slovenia

© Amt der Tiroler Landesregierung
Photo B2-6: Gauging station for measuring the quantity of spring water

Conclusions

Substantial efforts have been made within the states of the Alpine Convention in order to capture the picture of the status of Alpine waters. Biological quality elements, hydromorphological quality elements, general physical-chemical quality elements and other pollutants like priority list substances, for instance, but also the water quantity of surface waters are monitored periodically and strategically aligned with possible pressures occurring within the catchments of Alpine river systems. As the underlying maps indicate, an adequate coverage of monitoring sites for administrative purposes is in place.

Since monitoring networks have had to be established according to the provisions of the EU Water Framework Directive since 2006[29], the collection of additional data on biological and hydromorphological quality elements is currently underway.
A revision of the monitoring network takes place in a six-year-cycle – the period to which the river basin management plans apply for EU countries.

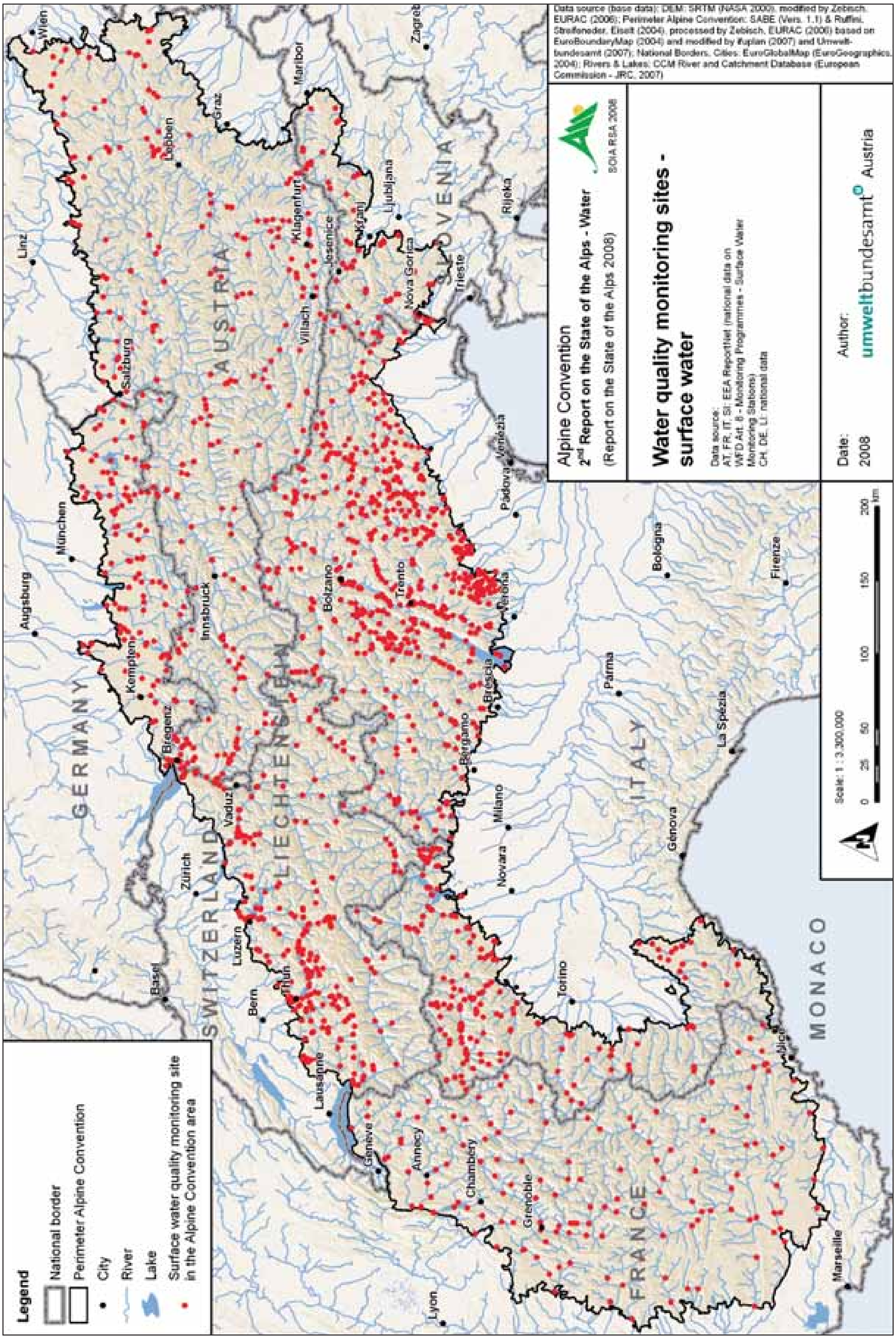
Regarding groundwater, the list of measured parameters naturally differs from surface waters due to the absence of biological and hydromorphological quality elements.

Therefore, the Alpine monitoring network, which was recently reorganised and updated with the implementation of the EU Water Framework Directive in EU Member States and also in Switzerland, is considered to be prepared for future challenges with the provision of continuous and area-wide data series on Alpine waters.

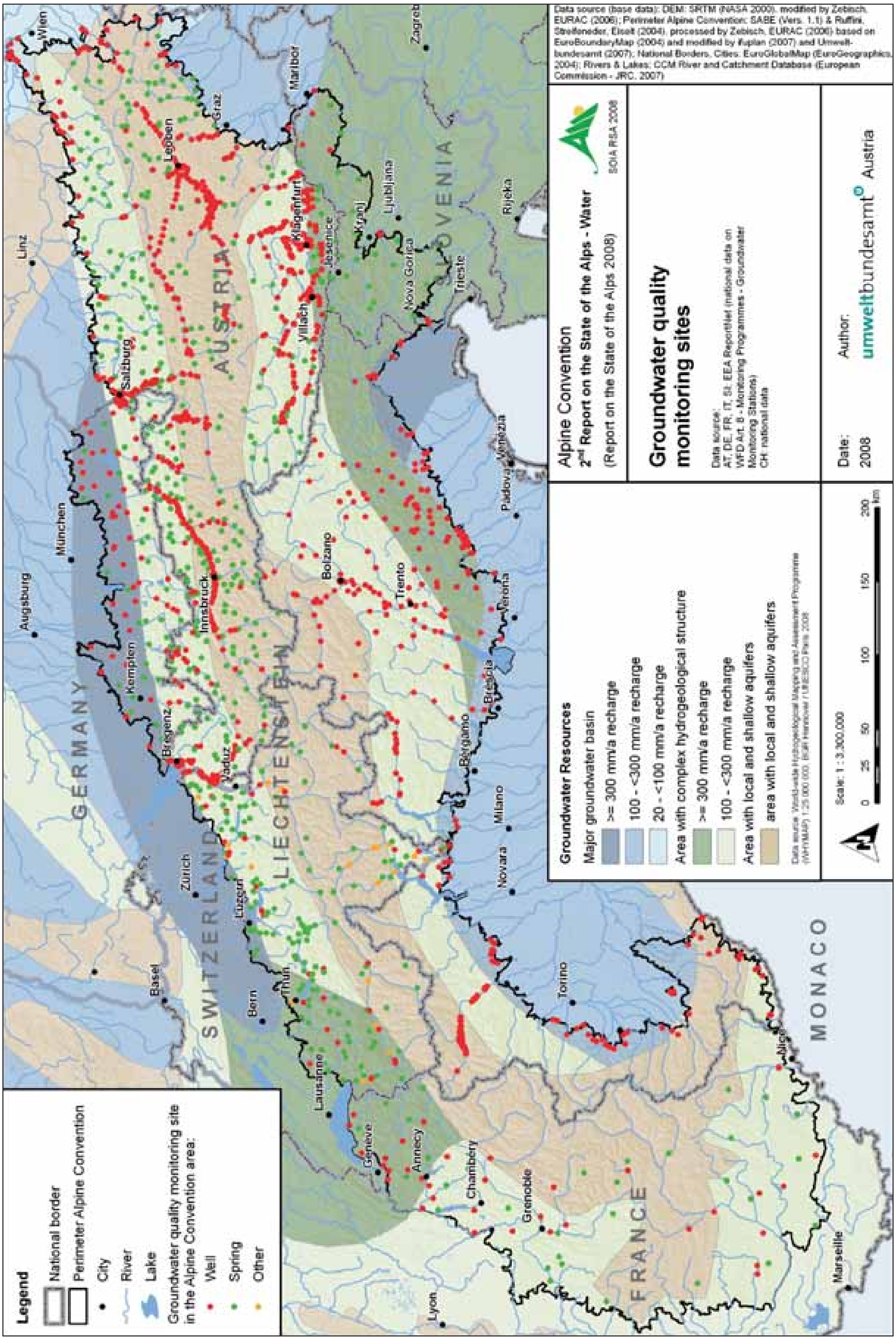
However, a question that still needs further assessment is the adequate coverage of higher Alpine regions within the national monitoring programmes. Long-term data series for waters in such areas in particular could provide valuable information for further research activities.

This applies especially to ongoing research on climate change where gathering additional data would provide an enhanced basis for scientific projects.

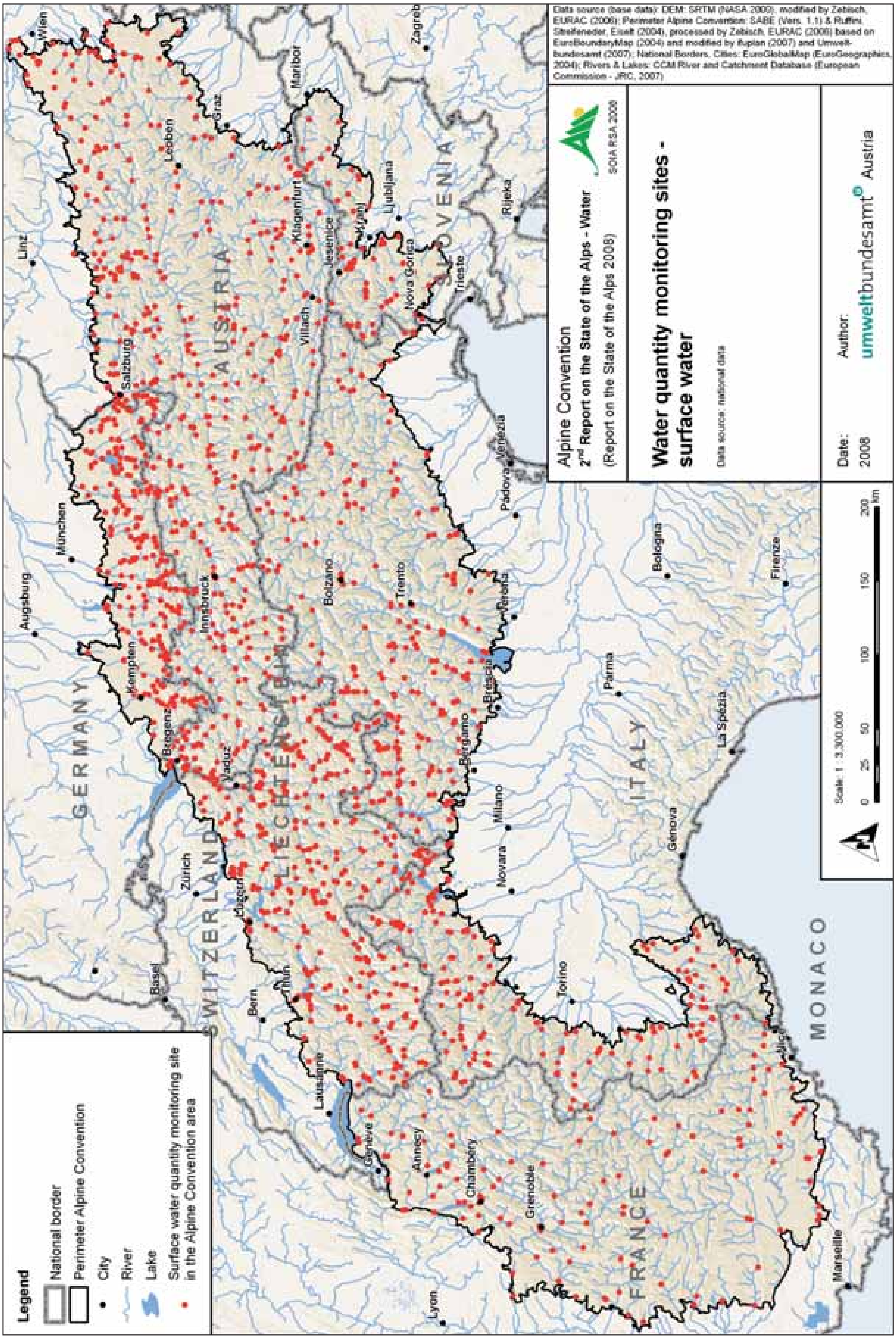
[29] See Article 8 and Annex V of the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, ABl 2000 L 327/1, Water Framework Directive, WFD



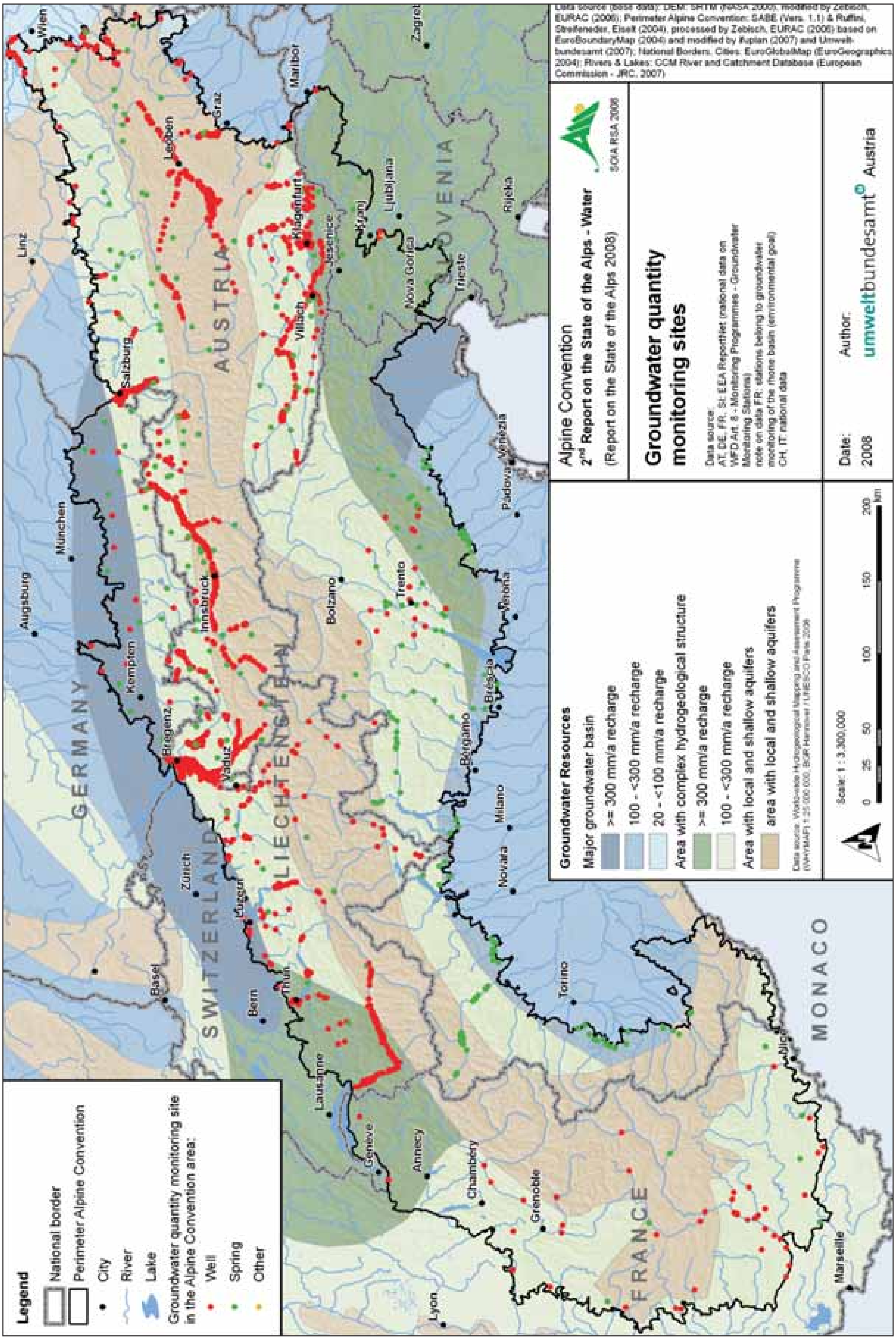
Map 10: Surface water quality monitoring sites in the Alpine area



Map 11: Groundwater quality monitoring sites



Map 12: Surface water quantity monitoring sites



Map 13: Groundwater quantity monitoring sites

B.2.2 CHEMICAL QUALITY OF WATER

The chemical quality of water is the cumulative result of a broad range of different types of pressures. Depending on the source of chemical ingredients or pollutants in Alpine waters, a distinction can be made between point sources and diffuse sources of pollution.

Point source pollution mainly originates from human settlements and from direct discharges from industries. However, in regions with a low connection rate to urban wastewater treatment plants, scattered human settlements can also be characterized as a form of diffuse pollution, whereas the most prominent form is diffuse pollution from agricultural sources. Apart from farming, natural background emissions and atmospheric depositions also contribute to the observed concentrations of chemical substances in Alpine waters.

In the following chapters, pressures on the chemical quality of waters from point source and diffuse source pollution will be addressed separately. Afterwards, the chapter on the chemical status will give an impression of the situation and impacts originating from chemical pressures on waters in the Alps.

B.2.2.1 POINT SOURCES OF POLLUTION

A point source of pollution is a single identifiable localized source of water pollution, which can cause pressures on waters through the emission of chemical substances, organic substances or nutrients.

Point source pollution mainly comes from wastewater, discharged from pipes at industrial facilities, urban wastewater treatment plants or mining activities into rivers, streams, lakes or, in infrequent cases, into groundwater. Sources of wastewater may additionally include stormwater and groundwater, which gets into sewer systems through inflow and infiltration, as well as commercial operations which discharge wastewater from individual cesspits into urban wastewater treatment plants.

Point sources of pollution can – especially if the wastewater is untreated or only partially treated – contain organic and inorganic substances, which have the potential of causing negative alterations to the aquatic environment or to be hazardous to both humans and other life-forms. Furthermore, they may lower the amount of dissolved oxygen in the receiving stream, since oxygen is required and used by microorganisms in the consumption of organic substances.

Since point source pollution mainly originates from settlements and industrial facilities, urbanisation of the valleys and basins puts increased pressure on Alpine waters. Additionally, growing activities in tourism can be regarded as another reason for pressure on the aquatic environment. This fact is becoming apparent especially during the peak winter season when Alpine rivers are in the low-flow period and therefore concentrations of chemical substances are increased due to low dilution.

During the 20th century, the first wastewater treatment systems were constructed at sites where wastewater was previously discharged untreated directly into rivers and lakes. Since these practices caused substantial alterations in the quality of Alpine waters, in the 1970s efforts were increased to treat wastewater by constructing urban wastewater treatment plants.

Nowadays, all Alpine countries make every effort to treat wastewater from settlements and industrial facilities. For EU countries, the EU Urban Wastewater Treatment Directive is binding, setting the framework for the treatment of wastewater from urban settlements. Comparable legislative instruments for the discharge of wastewater from the industry are in place. The same applies to Switzerland, Liechtenstein and Monaco.

Map 14 provides an overview of urban wastewater treatment plants in place within the Alpine perimeter. In the map, WWTP are classified according to the level of treatment (3 classes: primary, secondary or more stringent treatment). Typically, wastewater treatment involves these three stages. Primary treatment separates solids from the wastewater stream.

Then, in the second phase of treatment, the dissolved biological matter is progressively converted into a solid mass which can be removed from the water by using water-borne microorganisms. The third and final phase, which allows raising of the effluent quality of wastewater again before it is discharged into the receiving environment (like rivers, streams, lakes or even groundwater), includes continuing processes for purification such as nutrient removal or disinfection. In practice, various options exist:

They range from activated sludge plants incorporating all these three stages to wastewater treatment plants with three separate stages. The EU Urban Wastewater Treatment Directive requires at least treatment up to the secondary stage (with some exceptions) for facilities greater than a population equivalent of 2.000. If the wastewater is discharged into a sensitive receiving area, the third stage (nutrient removal) needs to be in place in most cases at plant sizes above levels specified in the Directive.

As can be inferred from Map 14, a high number of urban wastewater treatment plants are in place within the Alpine range as a result of consequent investments in recent decades in all countries. Most facilities are already equipped with technologies for tertiary treatment.

Since the implementation of the EU Urban Wastewater Treatment Directive is currently underway, additional upgrading of facilities with currently lower treatment standards can be expected in the near future.
More information on the national situation regarding point sources of pollution within the Alpine share of each country will be addressed individually in the national contributions at the end of the chapter in order to give an overview of the situation within the Alpine perimeter.

© Rita Newman
Photo B2-7: Major investments in wastewater treatment plants in recent years have significantly improved water quality of Alpine rivers and lakes.

© Agence de l'Eau Rhône – Mediterranée et Corse
Photo B2-8: Example of intensive tourism industry in the French Alps

Conclusions

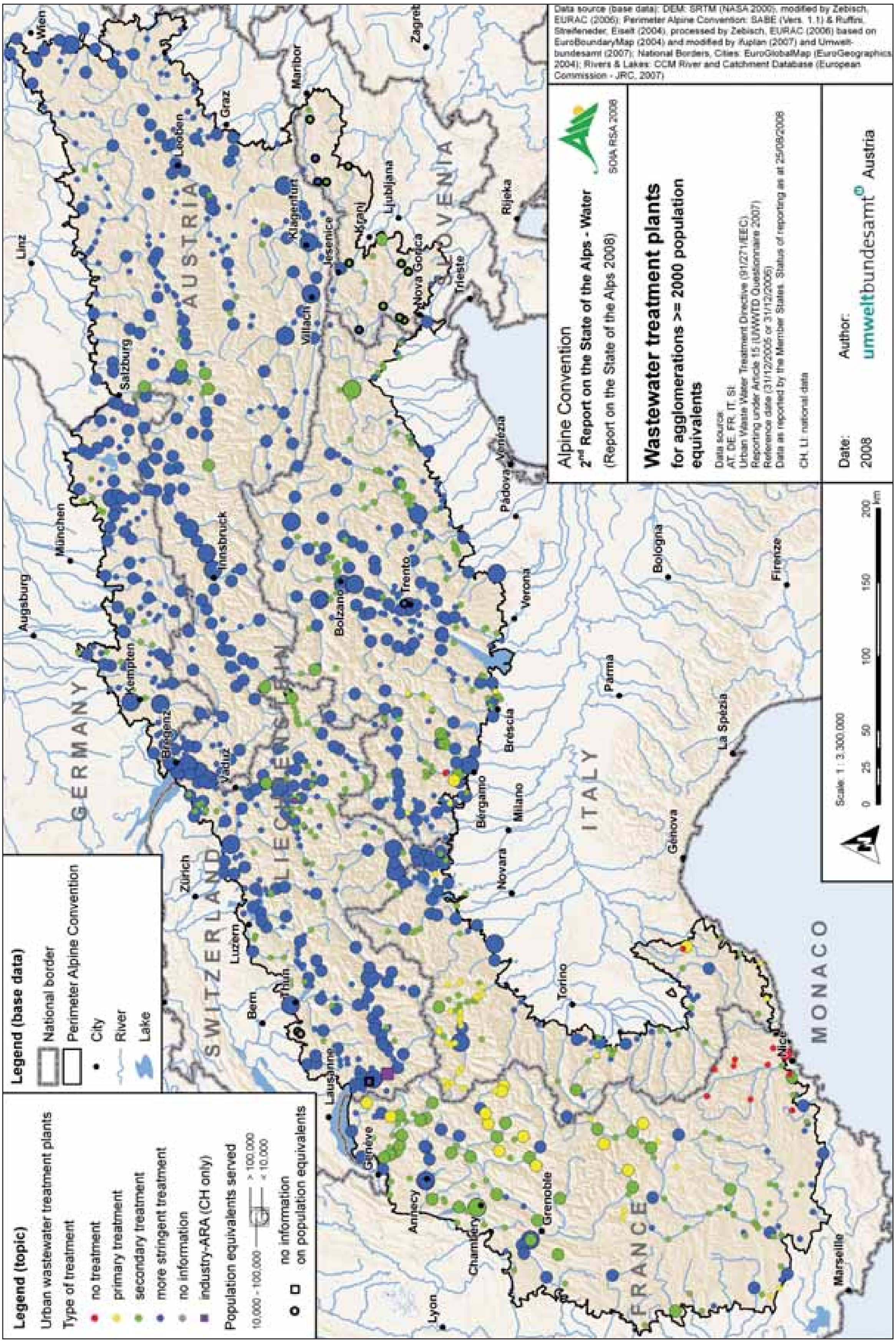
The necessity of treating wastewater from point sources before it is discharged into the environment is generally accepted and agreed upon within the states of the Alpine Convention. This understanding also culminated in a binding legal framework, which sets targets and standards in order to improve and maintain the chemical quality of Alpine waters.

Therefore, considerable expenditure in urban wastewater treatment have been undertaken in recent decades, leading to the present situation where facilities are mostly in place or under construction for the main settlement areas with a population equivalent greater than 2.000, with related high connection rates of the population to centralised systems throughout the whole Alpine perimeter. A connection rate of the population to centralised systems of 100% is not the aim and would not be an adequate solution, considering the percentage of scattered settlements and thus economic viability.

The respective figures for the connection rate to decentralised systems within the Alpine space therefore tend to be higher compared to the figures of areas beyond the mountainous area due to the dispersed settlement structure prevailing in the Alps, which makes connection to centralised sewer systems more expensive. The alternative of treating wastewater from the remaining small share of settlements, which are not connected to centralised systems, with adequate decentralised facilities is considered to be an acceptable solution.

However, one challenge for wastewater treatment which remains is assuring adequate effectiveness of purification in areas with an intensive tourism industry, especially during the winter period. Low temperatures diminish the performance of facilities during the natural low-flow periods of Alpine rivers. Higher concentrations can therefore be observed during such times compared to the rest of the year.

As regards direct discharges from industry, legislation and permission systems are in place which also specify targets and standards regarding the treatment of these industrial discharges. Companies are therefore obliged to invest in treatment facilities in order to meet environmental targets set by responsible public authorities. However, toxic substances could still be a concern.



Map 14: Wastewater treatment plants for agglomerations >=2000 Population Equivalents

National Contributions Regarding Information on Point Sources of Pollution

Austria

In the last decades, increased efforts were made in Austria in order to reduce pollution by urban wastewater – one of the most significant point sources of water pollution. The most commonly used technical approach for water protection in this respect is urban wastewater treatment plants. The number of plants has increased steadily over the last years from 1.362 plants greater than a population equivalent of 50 (p.e.) in 1999 to the current number of more than 1500 facilities in the entire country. The capacity of all facilities together amounts to more then 20 million p.e.

This high number of urban wastewater treatment plants leads to a connection rate to the public sewage network of about 89% nowadays, which is a constant improvement on the low figure of 3% in 1968. Wastewater of the remaining 11% of the Austrian population is processed either in individual sewage treatment works smaller than 50 p.e., cesspits (followed by agricultural application or transport to urban wastewater treatment plants) or other appropriate treatment methods. A connection rate of 100% to public sewage networks is not realistic due to the scattered settlement structure, but the employment of decentralized treatment technologies (like reed beds) would provide an alternative.
Regarding the degree of purification, 94% of the total urban wastewater load is subject to tertiary treatment (after primary mechanical and secondary biological treatment), resulting in a further reduction of pressures on the chemical quality of Austrian waters. The effect of the application of these technologies is an average reduction in the discharge (for the whole country) of 77% for nitrates, 88% for phosphates, 91% of COD and 98% of BOD5 (COD and BOD5 are indicators for the organic pollution of wastewater).

Austria spent amounts between 945 million euros in 2001 and 641 million euros in 2005 in the urban wastewater treatment sector. In the last years, approximately 78% of financial resources were used for the rehabilitation and extension of sewer systems. The remaining 22% reflect expenditure on new plants or the extension and adaptation of already existing sewage treatment works. In future, additional investment costs of more than 5 billion euros are estimated to be required until 2015 according to the Austrian Report on Article 5 of the EU Water Framework Directive.
Regarding the industrial sector, related wastewater is mostly treated together with urban wastewater in urban wastewater treatment plants. However, big industrial complexes in particular are equipped with treatment facilities of their own, discharging directly into freshwater bodies after treatment (so-called ‘direct discharges’). About 150 such facilities exist in the whole country at present (water relevant IPPC facilities plus others). In total, industrial direct discharges account for about 1.000 million m^3 per year of treated wastewater released into Austrian freshwaters (about the same amount as for urban wastewater treatment plants greater than 2.000 p.e.). The conditions for the discharge of both – urban wastewater treatment plants and direct dischargers – are subject to stringent regulations, ensuring the removal of pollutants to a high extent. The level of performance of treatment is regularly inspected by the responsible public authority.

France

The French perimeter of the Alpine Convention includes a permanent population close to 2,2 million, which tourism can doubled. Within the 1 750 municipalities of this perimeter:

- less than 10% of the permanent population living in 558 municipalities (32%) with a total population of 200 000 inhabitants, (up to 400.000 inh. including seasonal consumers) do not have a public system and therefore rely on individual sanitation systems ;
- ~90% of the population lives in the remaining 1.192 communes and is connected to a public sewage treatment plant, some of these plants being common to several municipalities. The 1.042 existing plants have a total capacity of more than 4,4 million p.e., as the design takes strong seasonal population fluctuations (which can even double) into account.

Capacity size (range in population equivalent)	Number of w.w. plants	Total design capacity range
Below 500	596	135.575
> 500 to ≤ 1.000	135	122.900
> 1.000 to ≤ 5.000	197	451.190
> 5.000 to ≤ 10.000	32	231.900
> 1.000 to ≤ 100.000	78	2.289.700
> 100.000	4	1.170.000
Total	**1.042**	**4.401.265**
Private individual (one household)	(estimated 80.000)	(estimated 400.000)

Tab. B2-1: The number and design capacity of the public wastewater treatment plants can be broken down as shown above

Biological treatment, including nitrification, is the common configuration. The treatment plants in ski resorts have to satisfy several specific requirements like: complete covering of the treatment units, landscape integration, compact building, adaptation to strong and rapid flow with load variations and to low sewage temperature, etc. In particular, the nitrification during the tourist peaks has been the subject of applied pilot and full-scale research, which came up with recommendations for appropriate design and operation.

The basins of the large Alpine lakes (Léman, Annecy, le Bourget) are faced with nutrient removal requirements. The Annecy and Bourget lakes are protected by coastal collecting sewers and by complete transfer of the treated effluent out of the lakes' watershed. The treatment plants on Lac Léman, which have direct discharges to the lake, are equipped for nutrient removal. Sludge treatment and disposal is often realised by way of incineration because of the limited possibilities for agricultural recycling (due to climate, agricultural surface). However, composting and solar drying are upcoming alternatives.

In the rural areas, treatment by macrophyte filters is becoming common. They prove to be a successful alternative for conventional plants, even up to altitudes of 1 000m.

In 2008, most treatment works with capacities above 15.000 p.e. comply with the European and national standards, the latter being in some cases more stringent. Full compliance with both standards will be reached when the upgrading of 9 plants with a total future capacity of 770.000 ip.e., currently underway, is achieved. In the capacity range of 2.000 to 15.000 ip.e., priority is given to the completion of 11 units with biological treatment (totalling a capacity of 100.000 p.e.) which are still lacking in appropriate capacity.

Industrial effluents are mostly connected to the urban sewers. However, about 200 large industrial plants existing in the Alpine perimeter rely on their own sewage treatment plants:

- 121 metallurgical industries, from machining to plating, including aluminium smelting,
- 15 large chemistry transformation plants (some ranked Seveso),
- 43 pulp mill and wood industries
- and moreover, 27 trade storages can also be listed.

All of them largely comply with discharge regulations. The pollution reduction ratio for all of these industries is estimated to be close to 93% (an approximate figure based on the raw and net pollution levy calculation for organic and toxic waste; note that effluent can even sometimes be discharged into a public sewer network).

Germany

Close to 1,3 million people live in the Bavarian part of the territory covered by the Alpine Convention. About 90,1% of these people are connected to public sewage treatment plants. From 1963 to the present day, a total of 278 municipal sewage treatment plants have been constructed by the municipalities responsible for sewage disposal. Altogether, the design capacity of these plants totals a population of approx. 3,3 million p.e. (population equivalent). The number and design capacity can be broken down as follows:

Size range	Number	Total design capacity in EW
1 (> 100.000 EW)	4	970.000
2 (> 10.000 to ≤ 100.000 EW)	55	1.980.075
3 (> 5.000 to ≤ 10.000 EW)	20	147.750
4 (> 1.000 to ≤ 5.000 EW)	73	207.740
5 (≤ 1.000 EW)	126	31.999
Total	**278**	**3.337.564**

Tab. B2-2: Between 1973 and 2007 alone, Euro 4,6 billion was invested in the purification of sewage by the municipalities in the German (Bavarian) part of the Alpine region. To this end, the municipalities received close to Euro 1,3 billion in subsidies from the State of Bavaria.

Under §7a of the German Federal Water Resources Act, sewage must be treated in accordance with the state of the art. These requirements are defined in Appendix 1 to the German Wastewater Ordinance, which generally stipulates mechanical-biological purification as the minimum for all sewage treatment plants. Plants with design capacities of more than 5.000 p.e. must also ensure nitrification of wastewater. For design capacities above 10.000 p.e. the nutrients nitrogen and phosphorous must be eliminated. The statutory required values for the effluent concentrations meet the parameters of the European Council Directive 91/271/EEC of May 1991 concerning urban wastewater treatment.
The sewage of around 150.000 inhabitants is currently treated in individual private plants (packaged treatment plants). Since 2002, they have also been subject to the above requirements. These packaged

treatment plants, which in the past were frequently equipped only with a mechanical treatment stage, are being upgraded with biological stages (with financial support from the State of Bavaria).

In the Bavarian part of the regions covered by the Alpine Convention, there are altogether 120 direct discharges of industrial wastewater. For the most part, this is wastewater from dairy processing, manufacture of beverages, meat processing, production of non-metallic minerals, manufacture of paper and cardboard, metalworking and processing, treatment of water for cooling systems and steam generation as well as wastewater containing mineral oil. State-of-the-art treatment is also stipulated for these types of wastewater, as defined in the individual Appendices to the German Wastewater Act.

The development of the public and private sewage disposal plants largely complies with the statutory requirements. With the exception of individual private plants, there is currently no need for further action.

Italy

The following data[30] relate to urban wastewater treatment plants in the Alpine area and concern 378 treatment plants serving 346 urban areas (territorial units to which the data relates) with over 2.000 "Abitanti Equivalent" (AE, or "population equivalent p.e.").
The total amount of biodegradable material for the urban areas (load generated) is equal to 8.054.469 p.e., of which around 94% is collected (7.599.048 p.e.).
Of the 378 treatment plants in the area in question, 245 are equipped with advanced treatment facilities that are advanced beyond secondary or biological treatment, while 13 plants have only primary treatment; one single plant is equipped only with preliminary treatment.

Of the 245 plants that have the more advanced secondary treatment, 66 have specific treatment for the removal of phosphorous, 48 are equipped with specific treatment for the removal of nitrogen, 72 are equipped with specific treatments for the removal of both (nitrogen and phosphorous), and 59 plants have "other types of treatment" in addition to secondary or biological treatment.
The total load on arrival at the aforesaid plant is equivalent to 5.384.959 p.e., which corresponds to the total organic load treated at the treatment plants (67% of the total load of the urban areas throughout the territory concerned).
No information is available on the situation in rural areas. Nor is any information available regarding investment in treatment plants.
With regard to Italian legislation, the "urban wastewaters" can consist of a mixture of domestic and industrial wastewater. The industrial component, however, has to be subjected to a specific treatment that is capable of eliminating substances originating from specific production cycles and must consequently comply with emission values and limits. With regard to the discharge of dangerous substances, the figures for the monitoring of inland waters[31] relate only to 9 regions (Basilicata, Emilia Romagna, Lazio, Liguria, Lombardy, Piedmont, Tuscany, Umbria and Veneto), for a total of 123 waterways and 227 monitoring stations.
It should be stated that northern Italy has the largest concentration of industrial plants whose discharge can contain dangerous substances as set out in List I of Directive 76/464/EC. As far as central and southern Italy are concerned, the industrial plants are fewer in number and are mainly situated in the coastal areas. In some regions, such as for example Valle d'Aosta, there are no industrial processes containing any of the 99 substances.
In 3.790 checks carried out across the national territory, it was found that the following families or groups of dangerous substances were present: pesticides (36%); metals (30%); volatile organic compounds (28%); IPA, halophenol and semi-volatile organic compounds (2%). Some of the substances mentioned above originate from diffuse sources of pollution (e.g. pesticides used in agriculture).
The maximum values of emission were laid down by Italian legislation in 2003[32]. In the majority of checks carried out, the values of the aforementioned dangerous substances were found to be within legal limits (in 84% of cases there was compliance for metals, in 90% of cases for volatile organic compounds, in 72% of cases for IPA). Nevertheless, in the absence of a complete and up-to-date national framework regarding industrial waste, in terms of quality and quantity, it is not possible to formulate complete evaluations or reach conclusions in relation to which substances (from the aforesaid types of discharge) are released into the water environment and to what extent.

[30] figures transmitted to the APAT by the Regions and Autonomous Provinces of Trento and Bolzano in compliance with article 15 (4) of Directive 91/271/EC.

[31] figures from APAT "monitoring of substances in List I of Directive 76/464/EC", 2000-2002.

[32] Decreto 6 novembre 2003, n. 367 - Regolamento concernente la fissazione di standard di qualità nell'ambiente acquatico per le sostanze pericolose, ai sensi dell'art.3, comma 4, del Decreto legislativo 11 maggio 1999, n.152

Slovenia

In the Alpine region of Slovenia we have 53 Urban WastewWater Treatment Plants (UWWTP) that provide annual emission reports (this report is obligatory for UWWTPs with a design capacity above 50 p.e. – population equivalent).

The level of treatment, the total sum of design capacity and the total quantities of treated wastewater for the year 2006 were as follows:

- primary treatment (1 UWWTP, 300 p.e., 1.160 m^3/year)
- secondary treatment (44 UWWTPs, 144.275 p.e., 5.513.429 m^3/year)
  - tertiary treatment (8 UWWTPs, 142.723 p.e., 5.864.083 m^3/year)

The total nutrient elimination, due to UWWTPs, for the year 2006 was as follows:

- COD – 6.867 tonnes/year
- tot P – 44 tonnes/year
- tot N -199 tonnes/year

Urban regions: In the Alpine region there are 50 agglomerations larger than 2.000 p.e.. Only 17 of them do not have UWWTPs yet, but will be equipped with UWWTPs by the end of 2015 at the latest.
In rural areas appropriate WWTP is required as well, in principle by way of mechanical treatment or small biological WWTPs. Investments in UWWTPs, and development of UWWTPs in the past have been in accordance with the UWW Collecting and Treatment Operational Programme.
In the Alpine region of Slovenia we have 87 direct discharges from industry that provide annual emission reports (such reports are obligatory for industrial facilities above 50 p.e. OR above 4.000 m^3/year of WW OR above 15 m^3/day of WW OR potential release of dangerous substances).

Industrial facilities are located in major urban areas and, as a rule, their wastewaters are collected and treated at UWWTPs. All the facilities are licensed and monitored according to national legislation. Industrial facilities have to provide wastewater treatment levels which meet the limits imposed by national legislation.
Industrial facilities cannot operate without the required permits and the monitoring of wastewater.
Large animal farms that are important point sources of pollution in some other parts of Slovenia are not present in the Alpine area. Other agriculture and food-processing related facilities (e.g. dairies, wine cellars, cheese dairies) fall into the category of industrial plants and are connected to UWWTPs.

In the Alpine area of Slovenia there are three major abandoned mines in which mercury (Idrija), uranium (Žirovski vrh) and zinc and lead (Mežica) were mined. Apart from these three mines abandoned in the 20th century, there is an unspecified number of small mines in the Alps which were abandoned earlier during the Middle Ages or in the Industrial Age.
One specific case is the recently abandoned zinc and lead mine in Cave del Predil (Germ. Raibl, Slov. Rabelj) in Italy. Groundwater from the mine is pumped into a tunnel crossing the Italian-Slovenian border and released into a small surface water recipient in Slovenia, which is a tributary of the River Soča. It is unusual that three specific features are found together:

- groundwater from dewatering low levels of the mine is pumped into a tunnel and released into a surface water recipient in the valley on the other side of the mountain ridge,
- water is artificially transferred into another major basin (from the Black Sea Basin into the Adriatic Sea Basin),
- water is artificially transferred from one country to another (from Italy to Slovenia).

Point sources of pollution in the Alps are unevenly distributed. They are mainly concentrated at urban agglomerations and industrial facilities in the valleys or in the outskirts of the Alps.

Urban wastewater and industrial pollution sources are well monitored and under control. The majority of urban agglomerations and industrial facilities are already connected to UWWTPs. The rest of them will be taken care of according to the national plan of meeting the WFD requirements by 2015.

Small point sources of pollution in dispersed settlements in rural areas are taken cared of on a case-to–case basis as is appropriate by way of small mechanical or biological WWTPs.

Abandoned mining facilities do not have any operational monitoring. They are monitored indirectly by a national network for water quality ambient pollution monitoring.

Switzerland

Wastewater treatment in Switzerland is of a high standard. The development of collection and treatment infrastructure created the conditions for the recovery of the country's water bodies. The total costs of installing this infrastructure (sewer systems, treatment works, stormwater tanks, etc.) were in the region of 40-50 billion Swiss francs; replacing it would cost approx. 80-100 billion Swiss francs. Current challenges include the establishment of sustainable wastewater management and ongoing optimisation of the treatment system.
The Federal Water Conservation Act calls for the establishment of public sewer systems and central wastewater treatment works. Switzerland's wastewater management infrastructure - comprising some 900 treatment plants and 40.000-50.000 km of public sewers with 97% of the Swiss population being served by connections to wastewater treatment works by 2005 - is now practically complete.

Emissions from industrial sites are subject to authorisation, which has to comply with the standards set out in the Federal Water Conservation Ordinance.

Information on the pollution of surface waters with nitrates
Nitrate is deemed to be an indicator of impacts from domestic wastewater from urban areas, from agriculture and, to a minor extent also from industry. The measured concentrations in Switzerland, however, are considered to cause no impairment to the fauna and flora of surface waters. Furthermore, the intensity of human impacts in the Alpine basins is in general quite low. In the Alpine space wastewater from 94% of the population is treated in central purification plants. That means that, apart from locally and temporarily very limited events, as e.g. accidents in the handling of fertilizers in farms, no considerable concentrations of nitrate are expected. As a consequence, monitoring of Alpine water bodies is quite sparse compared to the watercourses in the densely populated Swiss plains (the so-called Mittelland). The 90% percentile of the measurements from the last years located in the Swiss Alpine area is mostly below 1,5 mg/l nitrate-N (the legal requirement being 5,6 mg/l N, i.e. approximately 25 mg/l nitrate, for running water bodies that provide the basis for the supply of drinking water). At most, somewhat higher concentrations of nutrients are observed during X-mas holidays downstream of major winter ski resorts. In general, however, nitrate is not an environmental concern for surface waters in the Swiss Alpine area

B.2.2.2 DIFFUSE SOURCES OF POLLUTION

Diffuse sources of pollution are defined as pollution arising largely from land-use activities that are dispersed and therefore do not have one clearly identifiable source. They can be the result of numerous small contributions that are sometimes individually minor but collectively significant for the chemical quality of water.

Diffuse pollution can cause pressures on waters through the emission of chemical substances, organic substances or nutrients, which originate from current and past land-use activities in agricultural but also urban environments. Diffuse pollution may also include emissions from forestry and atmospheric deposition. Some diffuse pollutants of watercourses are not pollutants at all unless transported from the land into the watercourse, with soil or nutrients being the most obvious example.

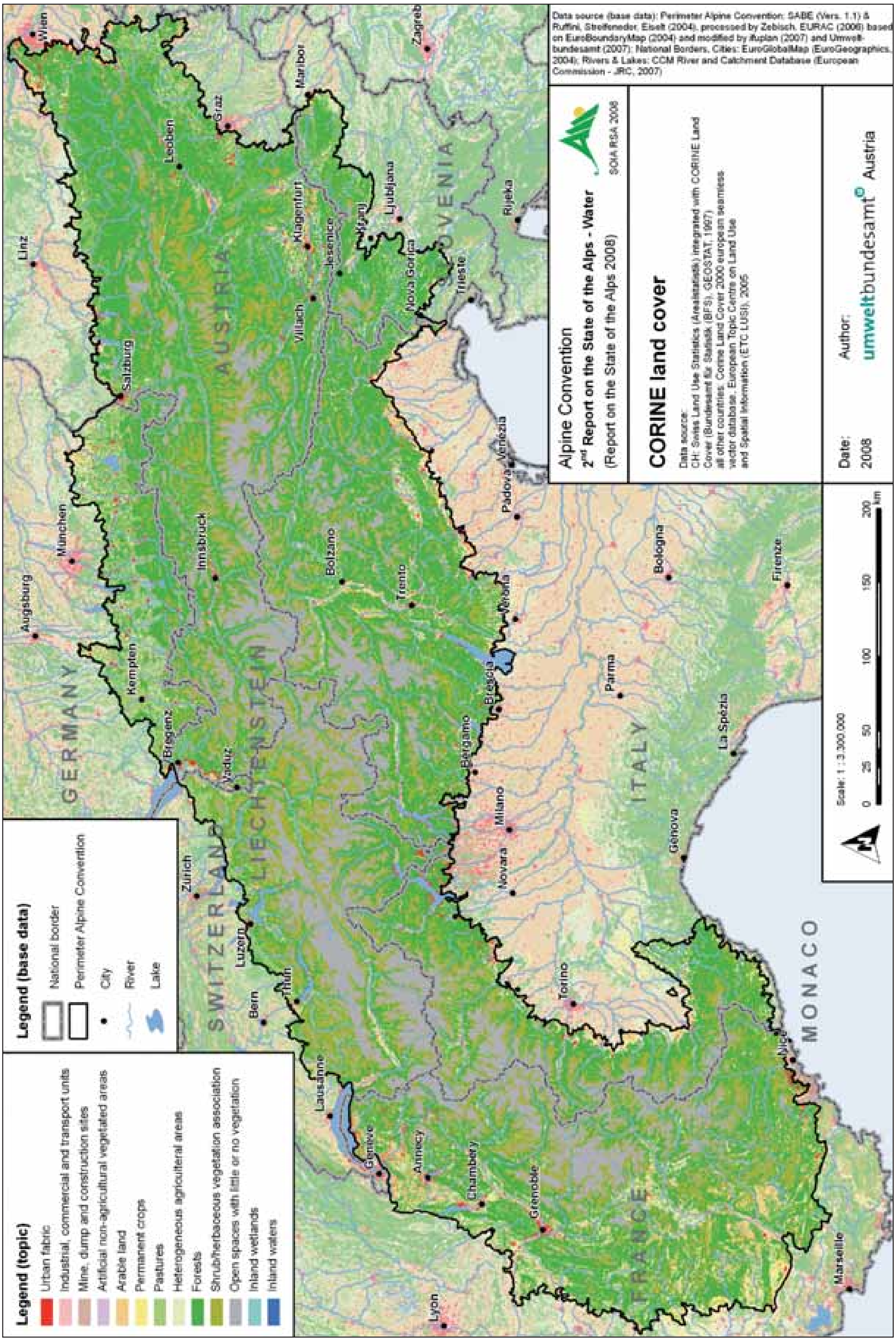
Typical cases for diffuse pollution are sheet run-off from fields, seepage of nutrients from soils into groundwater or field drains. Since diffuse pollution is closely linked to land use, sources are in many cases agricultural activities like the application of mineral or organic fertiliser on farmland, livestock stocking rates on pasture land or the application of plant-protection products on arable land, orchards and vineyards. Therefore, threats to waters resulting from diffuse pollution can be estimated to some degree by using information on land-use activities.

Map 15 displays Alpine land cover and land use. The area within the Alpine perimeter is largely characterised by forests, grassland and open spaces with little or no vegetation at higher altitudes. Arable land is concentrated in the lowlands outside of the Alps. Therefore, the most typical source of diffuse pollution – intensive agricultural activities – is largely missing on a large scale and concentrated along some valleys and on the outskirts of the Alpine perimeter.

The extent of diffuse pollution of waters depends on various factors. For nutrients from agriculture, for instance, these factors may include type and intensity of land use, precipitation, loss of nutrients to the atmosphere, soil erosion, soil composition or the hydrogeological situation.

The case study from Bavaria at the end of the chapter provides an example of a groundwater body which is affected by high nitrate concentrations due to diffuse pollution from agricultural sources.

There is no single solution for tackling diffuse pollution. Some of the most commonly used approaches are 'Best Management Practices' in agriculture, which rely on a range of measures. They may include changes in behav-



Map 15: CORINE land cover

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Photo B2-9: Cattle grazing on high altitude pasture lands at M. Sciliar's feet as a form of traditional agriculture in the Alpine area

iour and housekeeping, source control or site control to reduce and alleviate diffuse pollution impacts. Practical examples of this are limitations on land application of fertilisers, periods when the land application of fertilisers is prohibited, crop rotation, awareness-raising among farmers with the aim of changing behaviour or, in some cases, the ban on the application of certain plant-protection products.

Reducing diffuse pollution is not always within the sphere of influence of a single state. Regarding diffuse pollution with nitrogen from atmospheric deposition, meteorological conditions can contribute considerably towards increased nitrate concentrations in Alpine waters. The source of origin of nitrogen in such cases can be agricultural activities (in the case of NH_x ambient pollution) or incineration processes and traffic (in the case of NO_y ambient pollution), which can also be located outside the national borders of the respective state, finding its pathway across longer distances through the atmosphere and followed by transport via precipitation to the Alpine water system.

However, one example of an effective policy instrument which aims at reducing diffuse pollution from agricultural sources is the EU Nitrates Directive 91/676/EEC[33], which sets the framework for related measures in order to tackle diffuse pollution in EU member states. But programmes for the promotion of environmentally friendly agriculture, which are offered to farmers on a voluntary basis, also contribute towards the reduction of diffuse pollution by way of financial incentives for changes in behaviour and land use.

The national situations regarding diffuse sources of pollution within the Alpine share of each country will be addressed individually at the end of the chapter in order to give an overview of the situation within the Alpine perimeter.

[33] Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (91/676/EEC), EU Nitrates Directive

Conclusions

Since diffuse pollution is closely connected to land use, one of the main potential sources of diffuse pollution is agriculture. However, compared to lowland areas, the Alpine space is lacking in comparative advantages in the production of agricultural goods. Steep slopes, comparably poor soils, high altitudes and rough climatic conditions hinder intensified forms of agricultural production. This is especially the case for farming activities on arable land. Agricultural land use is therefore often carried out in form of extensive cattle grazing and dairy farming on pastures, leading, in combination with high precipitation rates, to related low concentrations of nutrients or pesticides in Alpine freshwater systems. Hence, diffuse pollution from agricultural sources is generally considered to be a minor problem for the chemical quality of Alpine water resources but can occur at a local level.

With regard to other forms of diffuse pollution, concentrations often reflect the natural background concentration, in case of heavy metals for instance. In case higher concentrations occur, they mostly indicate point source pollution from mining activities or industrial facilities.

Case Study from Germany (Bavaria)

Groundwater body in Bavaria at risk caused by high nitrates concentrations

A clear pressure on a groundwater appears in aquifer Inn IIIA2 on the northern border of the Bavarian Alpine region with nitrate values of 35 - 50 mg/l. The nitrate problem has been systematically monitored and analysed for about 12 years.

In 2004, in the framework of the Art. 5 analysis of the EU Water Framework Directive on the river basin characteristics, the groundwater body was estimated to be "at risk of failing to reach the good groundwater status". However, only approx. 30 percent of this aquifer lies in the landscape of the Alpine region.
The pressures on groundwater increase by the same magnitude as the intensity of the agricultural use increases and the precipitation decreases. 57 percent of the surface is used agriculturally.

The groundwater body belongs to the group of porous aquifers. It begins behind the most recent moraine belt of the last ice age and consists of moraine material in the southern part with stored glacial gravel and sand. In its middle section the aquifer is mainly composed of gravel and grit from high glacial terraces with a loess cover, the south is dominated by low-terrace grit.

The deeper aquifer of the tertiary layers of fine sand, sand and sandy gravel is protected relatively well, because the nitrates remain in the quarternary aquifer close to the surface.

Currently, the agricultural authorities and the water authorities are preparing a programme of measures under the Water Framework Directive in order to reduce the nitrate concentrations in the groundwater body Inn IIIA2.

The agricultural authorities are aware of the fact that restrictions on current farming practice will possibly be necessary. The aim is to achieve enhancements of the groundwater status by advising the farmers accordingly. In some cases the groundwater quality has already been successfully ameliorated for water-supply purposes. However, due to the persistent high pressure on the groundwater body short-term success is not to be expected.

The nitrate problem will continued to be observed in the future. In any case, the nitrate pollution must be reduced by active measures in a step-by-step approach.

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Photo B2-10: Well in Grabenstätt (aquifer Inn IIIA2)

National Contributions Regarding Information on Diffuse Sources of Pollution

Austria

Land cover within the Alpine perimeter of Austria is mainly characterised by a combination of forests and grassland. As the Alpine region is largely lacking in suitable areas for growing crops, livestock farming in connection with grassland is the predominant form of agriculture. These circumstances result in rather extensive agricultural activities in the mountainous region of Austria.

In figures, 32.700 km^2 (of which 14.100 km^2 are arable land and 17.900 km^2 are grassland) out of the total Austrian area of 84.000 km^2 is used for agriculture – about the same amount as for forestry (33.100 km^2). Crop farming is mainly concentrated in the north and east, outside of the Alpine perimeter. Within the Alpine region, arable land amounts to less than 1% of the area. Thus, most agricultural land in the Austrian Alps is per manent grassland – including a high share of Alpine meadows (7.300 km^2).

The risk of pollution due to nutrients from diffuse sources is low in grassland areas given the high share of extensive grassland. Thus, the rather extensive form of agriculture, as practiced in the Alps leads, in connection with dilution (from high precipitation of up to 3.500 mm/year), to comparably low concentrations of nitrates in Alpine waters. Nevertheless, even low concentrations multiplied by high runoff may result in considerable loads of nutrients, transported in rivers to the receiving seas.
As regards the quantification of concentrations, surface waters show average values below 10 mg/l and in many cases even below 2 mg/l for NO_3, concentrations which are similarly indicated for groundwater. Hence, nitrates in Alpine waters do not come close to the national threshold value of 50 mg/l NO_3 for drinking water purposes. A fact which also means that nearly all Austrian drinking water can be consumed without any prior removal of pollutants.

With the aim of keeping nutrient concentrations low, Austria is applying its Nitrates Action Programme throughout its entire territory. The stringent provisions of the Nitrates Action Programme, which is based on the EU Nitrates Directive (91/676/EEC), contribute to maintaining the present favourable situation. Additionally, financial incentives, which are provided on the basis of the Austrian Agri-Environmental Programme "ÖPUL" and promote environmentally friendly agriculture, support the achievement of this aim.

Regarding pesticides, due to the domination of livestock farming on permanent grassland in Alpine Austria and the comparably low share of arable land, pesticides are no real issue for the quality of water. The only pesticide found to a larger extent in this area is atrazine. Less than 0,5% out of over 900 monitoring sites for water quality in the Alpine region show levels of atrazine and its metabolites above the national threshold value for drinking water of 0,1 mg/l – concentrations, have constantly decreased since 1995 when atrazine was completely forbidden in all of Austria. The remaining low and still falling levels can be explained by the retention capacity of groundwater bodies.

As regards micro-pollutants, an issue recognized only recently, Austria is currently in the process of estimating the dimension of this matter as well as identifying possible measures regarding the issue. Different studies on the occurrence and impact of hormones, tensides and pharmaceutical products have been commissioned and the topic has also been addressed in workshops of international river basin commissions. This is why, the need for measures regarding micro-pollutants is still being evaluated.

France

The monitoring stations for water survey (on groundwater and surface water) confirm few problems with regard to diffuse pollution which are encountered in the French Alps. Among the 5.000 km of watercourses (with sufficient data available, out of 12.500 km) within the Alpine Convention perimeter, 21% are in an unsatisfactory state due to metal concentrations (mostly from natural sources), 25% are unsatisfactory because of organic micro-pollutants (besides pesticides) and 7% because of pesticides, 8% are unsatisfactory because of nitrate concentrations. These results do not reflect the overall situation where the good water status is mostly met. Like in other neighbouring countries, an explanation for these satisfactory results can be the land use, mainly extensive grazing of pastures, with a dominance of dairy farming and extensive grazing. Litte fertiliser is being used, the nitrate discharges are quite low. Besides those natural areas, some limited areas such as orchards and vineyards call for vigilance, especially as regards pesticides.

According to the Drinking Water Directive of May 21st, 2001 the nitrate pollution from nitrates in the French area of the Alpine Convention (A.C.) is quite a minor problem. Considering the whole perimeter of the Rhone river basin in 2005, only 0,3% (22) out of 12.000 independent public water supply systems delivered water with a nitrate concentration exceeding 50 mg/l (less than 0,18% of the flow delivered). Within this same area (much larger than A.C.) 84,4% of the water systems delivered water with a concentration lower than 10 mg/l, and 95,5% lower than 25mg/l. This data collected by controls performed by the health department, gives an overview of wells and springs used as drinking water resources. A comparison with data from 1999 shows a slow trend towards lower levels, as in 2005 spots exceeding 25mg/l fell by 23%.

Quality is also satisfactory with regard to pesticides. For the whole Rhone river basin only 3,7% of the supply systems showed at least one analysis with a concentration exceeding 0,1micro.g/l for one pesticide, but only 0,11% of them exceeded this level in more than 20% of the analyses (~7 000 inhab.). Very few alerts were observed in the Alpine areas (in orchards and in vineyards as already mentioned). Several national regulations asking for a reduction in the use of pesticides should improve the situation even further.

The modernisation of cattle sheds (with funding by both the State and the River Basin Agency) is reducing existing direct discharges (the main pollutants being phosphorus, ammonia and suspended solids). Manure spreading is also controlled according to specific schemes and schedules; it can also be traced. Last (but not least!) a matter of growing concern which cannot be ignored is cattle strolling in the beds of small streams; the influence on the quality of water cannot be neglected, especially when this occurs in the upper reach of the stream.

Germany

To assess the groundwater pollution from nitrates the limit specified in the Drinking Water Directive of May 21, 2001 or the quality standard according to the EC Water Framework Directive of 50 mg/l nitrate is applied. The nitrate pollution in the groundwater of the Bavarian Alpine region is comparatively low; on average the nitrate concentration in this area is in the order of 10 mg/l. 94% of the monitoring stations, including wells and springs used for water supply give nitrate concentrations of < 25 mg/l, at a 90% percentile of approx. 20 mg/l nitrate. Merely some 6 % of the observed monitoring stations showed nitrate values of between 25 and 40 mg/l. The limit of 50 mg/l nitrate is practically never exceeded. The nitrate concentrations in the groundwater are therefore predominantly within the range of the naturally occurring load or are to be considered as low.
This is a result of the relatively high mean annual rainfall of > 1300 mm as well as the extensive grazing of pastures in this area, with a dominance of dairy farming (cattle) and the extensive grazing of steep slopes. Areas with a high density of livestock and a high N-input give rise to high nitrogen losses, but these do not cause problems due to the high annual rainfall. With regard to land use, other forms of farming or livestock other than cattle only play a subordinate role. In the northern part of the Alp foreland agricultural farming (mostly maize and crops) can account for up to 30% of farming. There is again no sign of large-scale nitrite problems in this area.

The use of mineral fertiliser is comparatively low due to pasture grazing; the amount of organic fertiliser depends on the intensity of the livestock farming, however, it is mostly below 170 kg/hectare and year. Precise figures on fertiliser use are, however, not available. It is to be assumed that the share of ecologically farmed land in the Alpine region is above the Bavarian average.Altogether the growth rates have been in the range of approx. 4% to 7% per annum. Details of the land used are not available. To limit the nitrate input the code of good practice pursuant to the Fertiliser Directive must be observed (including the implementation of the EU Nitrate Directive). Support programmes are available to further reduce the nitrogen input into the soil and thus into the groundwater.

Nitrate concentrations in surface waters are low. This is due to the comparatively low input through the "groundwater" as the main pollution pathway, and also due to the high water yield of the rivers, which dilutes pollution. The existing data show that the applied quality norm of 50 mg/l for the chemical status, as specified in the EU Water Framework Directive, is by no means reached. It is planned to verify the result of the inventory with regard to the estimated nutrient load through sampling, based on a survey of the ecological status using the relevant biological quality components.

Italy

In Italy the use of nitrates has been regulated since 1980, laying down the classic limits of 25 mg/l as the guideline and 50 mg/l as the maximum admissible concentration in water for human consumption. The guideline of 25mg NO_3/l for water used for human consumption has been specified by the Nitrates Directive (91/676/EEC).
Currently, according to the provisions of Legislative Decree no.31/01 – Implementation of Directive 98/83/EC regarding the quality of water destined for human consumption, the presence of nitrates such as NO_3 in water destined for human consumption must not exceed the limit of 50 mg/l. Furthermore, the national legislation establishes that the presence of nitrates (or their possible presence) in a concentration exceeding

50 mg/l (expressed as NO_3) in fresh surface water, in particular water used for producing drinking water, and in groundwater, represents one of the criteria for identifying the so-called "vulnerable areas".

At a national level[34], in 82% of the monitoring stations the average concentration in groundwater was less than 40 mg/l and in only 12% of all cases did it exceed the maximum value of 50 mg/l. As far as surface waters are concerned[34], almost all of the concentration values are less than 25 mg/l and only in one case (out of 1.248 monitoring stations) did it exceed the threshold of 50 mg/l.

For the Alpine area, the monitoring results for surface waters and groundwater carried out during the period 2001-2002 confirm the national figures. The average concentration values in surface waters and groundwater are at fairly low levels, almost always below 25 mg/l. Also with regard to maximum concentration values, the limit of 50mg/l was exceeded in only 5% of the monitoring points.

In 2006, the quantities of fertilisers on the market in Italy exceeded 5 million tons, of which around 3 million were mineral fertilisers with 60% being single component fertilisers (nitrogen based) and 40% composite fertilisers; organic and organic-mineral fertilisers totalled around 600.000 tons and soil conditioners around one and a half million tons. In 2006, in comparison with 2005, there was a reduction of 1.5% in the quantity of fertilisers introduced onto the market, while between 1998 and 2006 there was an increase of 12% in the number of products introduced onto the market.

In relation to pesticides introduced onto the market, there was an increase of 1,5% between 2004 and 2005. Between 1997 and 2005, on the other hand, there was a fall of 6,4%. In the latest report on pesticides in waterways[35], the substances mainly to be found over the past thirty years have been herbicides (such as atrazine, simazine, terbutylazine and its metabolites), with concentrations often in excess of the limit of 0.1 µg/l established for drinking water. Contamination by such substances is widespread throughout northern Italy, where their use has been particularly intensive, but it is also to be found in central and southern Italy. The seasonal nature of the phenomenon in surface waters leads to an increase in the levels of concentration during the period when the substances are used and during periods of rainfall.

At national level[36], in the period 1997-2004, the contents of the active ingredients diminished overall by 0,6%, varying according to the categories of pesticides. In terms of distribution of pesticides, it should be pointed out that, with regard to their impact on human health and on the environment, there has been a consistent fall in the distribution of toxic and highly toxic products. At the same time, since 1999, there has been an increase in the distribution of organic pesticide products whose use, however, it still limited in comparison with other classes of pesticides.

In terms of national legislation, particular importance is placed on the monitoring of the quality of waterways, as it is the necessary condition for identifying the measures to be adopted in order to control pollution. At national level, the basic planning instrument for defining action strategies in relation to water is the Water Protection Plan, which is drafted and implemented by the Regions which have to comply with the contents of the provisions laid down by the River Authority. The approval of this document by the regions, as well as providing the first full description of river areas and the classification of the environmental state of surface waters and groundwater, enables an up-to-date understanding of the state of the resource, to define the environmental objectives and measures necessary for achieving them, as well as to define the programme for investigating the effectiveness of measures carried out.

At present[37], Water Protection Plans have been adopted by the regions of Liguria, Veneto, Lazio, Campania, Puglia, and by the Autonomous Province of Bolzano; the Water Protection Plans have been approved in the regions of Valle D'Aosta, Piedmont, Lombardy, Emilia Romagna, Tuscany, Sardinia and the Autonomous Province of Trento.

In relation to the measures aimed at restricting pollution produced by agricultural nitrates, with the implementation in 1999 of EEC Directive 91/676 an initial series of "areas vulnerable to agricultural nitrates" was identified in Italy, to be reviewed or carried out every four years. The legislation, in order to protect areas vulnerable to nitrates, provides for the introduction of one or more Agricultural Codes of Good Practices, to be applied at the farmers' own discretion, and other protection measures.

Another measure for controlling widespread pollution is the identification of "areas vulnerable to pesticides", which are portions of the territorial area where it is necessary to limit or prevent the use of authorised pesticides, even temporarily, in order to protect water resources from the possibility of contamination. For the purposes of protection, those zones that can be considered as being vulnerable to pesticides are those of significant natural interest and for the protection of useful organisms, and specially listed natural areas[38].

[34] figures transmitted to the APAT by the Regions and Autonomous Provinces of Trento and Bolzano in compliance with Ministerial Decree of 18 September 2002, no. 198 – monitoring carried out during 2001/2002

[35] Figures from APAT, "National Control Plan on the environmental effects of pesticides. Pesticide residues in water". Annual Report 2005

[36] Figures from APAT, Annual environmental statistics 2005-2006

[37] figures from APAT "Tematiche in Primo Piano" Annual Environmental Statistics 2007

[38] Article 5, Law 6 December 1991, no. 394(d).

Slovenia

The Alpine region covers 33,4% of the territory of Slovenia. With the exception of the River Drava all other springs, creeks and rivers are headwaters. Due to sparse population, non-intensive land use and other human activities in general, low pollution of surface waters and groundwater in the Alpine region is expected compared with the rest of the Slovene territory. This area is also naturally protected because most of the mountainous region is covered by forests. Considering the water monitoring results it can be stated that surface waters and groundwater in the Slovene Alpine region are high quality water resources. The Alpine region itself is not uniform. In mountainous area the activities are mainly organic farming, pasture and tourism while in the foothills the pressures are higher compared with high mountainous areas. This is also confirmed by the results of national water quality monitoring. The quality of surface waters and groundwater is monitored via the national water quality monitoring programmes and assessed according to national environmental legislation, the Decree on the Chemical Status of Surface Waters, OJ RS 11/2002 and the Decree on Groundwater Quality Standards, OJ RS 100/2005.

Nutrients

In surface waters and groundwater three types of inorganic nitrogen are analysed, ammonium, nitrites and nitrates. In surface waters and in groundwater the predominant type is nitrates. The Slovene threshold value for nitrates in groundwater is 50 mg NO_3/l while in surface waters it is 25 mg NO_3/l. In surface waters total inorganic phosphorus as well as phosphates are monitored while in groundwater monitoring is limited to phosphates. The national threshold value for phosphates in groundwater is 0,2 mg PO_4/l, no limit has been specified for total phosphorus or phosphates value in surface waters.
Nitrate concentrations in all Alpine rivers in the period from 2000 to 2006 were below 8 mg NO_3/l, mostly lower than 3 mg NO_3/l. In the same period, phosphates were, with very few exceptions, < 0,1 mg PO_4/l.

Lakes are much more sensitive to the input of nutrients than rivers. Both of Slovenia's two natural lakes with a surface area > 0,5km^2, are located in the Alpine region. Lake Bled and Lake Bohinj are both of glacial origin but their hydrology, morphology and lake catchment characteristics are completely different. This is also the reason for their different trophic condition. According to the OECD criteria (Eutrophication of waters, Monitoring, Assesment and Control, Anon, OECD Paris,1982) Lake Bohinj is still an oligotrophic lake with an average phosphorus concentration of 4 µg P/l over the last five years. Lake Bled ranked among eutrophic lakes in the 1970s. The average phosphorus concentration during the period 1979 -1980 was 75 µg P/l. After installation of a depth siphon outlet in 1980/81 and after regulation of the local sewer system in 1982-1985, a sharp decline in nutrient concentration was observed. In the last five years the average phosphorus concentration in Lake Bled has been 13 µg P/l and the average nitrogen concentration has been 299 µg N/l, which is a decrease by about 83% for phosphorus and 36% for nitrogen. Lake Bled has again joined the ranks of the mesotrophic lakes.

Monitoring results from 2000 to 2006 indicate that nitrate and phosphate concentrations in groundwater depend both on the aquifer type as well as on the pressures in the catchment area. Nitrates in the mountainous area aquifers are below 3 mg NO_3/l, while in the foothill aquifers the nitrate concentrations are higher but do not exceed 8 mg NO_3/l, their average value being 5,5 mg NO_3/l. This is explained partly by different aquifer types and their background concentrations as well as by different pressures. Similarly, phosphate concentrations in the groundwater of high mountains are lower than 0,05 mg PO_4/l, their average value being 0,015 mg PO_4/l while in the foothills the concentrations are up to 0,1 mg PO_4/l, their average value being at 0,03 mg PO_4/l.

Pesticides

An annual amount of 1.000 tons of pesticides is used in Slovenia, a minor portion of it being applied in the Alpine region. In surface waters and groundwater about 100 different pesticides and some of their relevant metabolites have been analysed. The standard for individual pesticide or its relevant metabolite is 0,1 µg/l. Monitoring results for the period from 2000 to 2006 provide evidence of almost no pollution of waters by pesticides. In rivers, pesticide concentrations were mostly below the limit of detection (LOD). The only exception was very low concentration of diuron (0,03 µg/l) close to LOD in the small river Nadiža in 2005. In the groundwater of the Alpine region all the pesticides analysed from 2000 to 2006 were lower than the LOD of the analytical method.

Heavy metals

Metals and metalloids in lower concentrations reflect the natural background of an aquifer or catchment while higher concentrations indicate point source pollution due to specific human activity, mostly mining, industry or waste disposal. In the Slovene Alpine region there was a mercury mine in Idrija as well as a lead and zinc mine in Mežica together with metal-processing facilities. Both mines and facilities were closed a few years ago but the impact of these activities can still be evidenced in the rivers Meža, Mislinja and partly Drava as well as in the rivers Idrijca and Soča. In surface waters the national threshold values for mercury and cadmium are 1 µg/l, for copper 5 µg/l, for chromium, nickel and lead 10 µg/l and for zinc 100 µg/l. For groundwater the only threshold value is set for chromium (30 µg/l). Groundwater is the main drinking water resource in Slovenia, so its quality is often compared with the drinking water standards (Rules on Drinking Water, OJ RS 19/2004) whose levels are for mercury 1 µg/l, for cadmium 5 µg/l, for lead 10 µg/l and for nickel 20 µg/l. In the period from 2000 to 2006, heavy metal concentrations above the national threshold values were recorded from time to time in the rivers Drava (nickel), Meža (nickel and chromium) and Soča (copper, nickel and zinc). The impact of the lead and zinc mine in Mežica as well as mercury mine in Idrija on water quality can be better evidenced by the river sediment. From the results of the river sediment analysis it can be concluded that pollution of the rivers Drava (zinc, lead), Meža (zinc, cadmium, chromium, nickel and lead), Soča and Idrijca (mercury) has declined but the presence of the metals in their sediment is still evident.

Metal concentrations in Alpine groundwater were lower in the period from 2000 to 2006 than standards for drinking water and threshold values for groundwater. The average values for metal concentrations at all sampling sites of the Alpine region reflected the aquifers' background (copper 0,8 µg/l, zinc 6,0 µg/l, cadmium 0,03 µg/l, chromium 0,3 µg/l, nickel 0,5 µg/l, lead 0,3 µg/l and mercury 0,05 µg/l). The Slovene government has issued the following operational programmes to reduce environmental pollution:

- Operational programme for the reduction of surface water pollution caused by priority sub stances and other dangerous substances, Government of the Republic of Slovenia, 27/05/2004
- Operational programme for urban wastewater collection and treatment, Government of the Republic of Slovenia, Decision No. 352-08/ 2001-2
- Operational programme for the reduction of mercury emissions from the dispersed sources in Slovenia, Government of the Republic of Slovenia, 26/02/2004

Switzerland

Information on the pollution of groundwater with nitrates

The Alpine regions of Switzerland profit from being headwater catchments, thus not being influenced by upstream inflows into their groundwater and surface waters. Moreover, the intensity of agricultural activities is quite low in the Alpine area so that, in general, nitrates in the groundwater do not constitute a problem. High nitrate concentrations are normally correlated to intense agriculture. Due to topographic and climatic reasons, however, agriculture in the Alpine regions takes place only to a limited, local extent.

It does, therefore, not come as a surprise that all analysed measuring stations of the Swiss national monitoring network at 1.000 m above sea level show nitrate concentrations lower than 10 mg/l.

The average value of the stations located in mountain pastures for the years 2002/03 is even less than 2.5 mg/l, the average for the whole agricultural mountain zone being around 5mg/l. Somewhat higher nitrate concentrations were found in the lower parts of the Swiss perimeter of the Alpine Convention, e.g. in the agricultural regions of the Cantons Grisons and Valais. The national legal requirements for groundwater set at a maximum of 25 mg/l were, however, also exceeded in these regions but only in few exceptional cases.

Phosphorus

From the 1950s, watercourses - like lakes - were subject to excessive nutrient inputs. In recent decades, improvements in wastewater treatment and a ban on phosphates in detergents have led to a substantial decrease in phosphorus concentrations in lakes, which can also be observed in the watercourses below the lakes. This trend is exemplified by phosphorus loads in the Rhine at Basle: a sharp decline in phosphorus concentrations was seen before 1990, with continuous reductions thereafter. Between 1990 and 2003, a decrease of about 35% was observed. As the Rhine drains about two-thirds of the total area of Switzerland, trends in phosphorus loads at Basle are representative of a large part of the country.

Pesticides

Farmers use pesticides to control weeds, fungal diseases, and insect pests of crops. These agrochemicals can also enter water bodies. In Switzerland, some 400 active ingredients are registered which are constituents of more than 1.000 products on the market. In Switzerland, around 1.500-2.000 tons of such agents are applied. In small- and medium-size watercourses pesticide concentrations may occasionally exceed the legal threshold of 0,1 microgram per litre. Also, at some of the groundwater quality monitoring sites traces of pesticides have been detected in areas of intense agricultural activities.. For some of the agents, analytical detection of very low concentration is still not possible.

To prevent the contamination of water bodies by pesticides, the use of these products is subject to certain prohibitions and regulations, e.g. in groundwater protection zones. As to regulations regarding pesticides in surface waters, their use is prohibited on a 3-metre-wide strip of land alongside surface waters, hedgerows, copses and forest margins. Pesticides are also not to be used on storage sites, roofs and terraces, and on or alongside roads, paths and squares (herbicide-free maintenance).

Sewage sludge

Sewage sludge is no longer to be used as a fertiliser in agriculture. In 2003, the Federal Council decided that the use of sewage sludge as a fertiliser in agriculture is to be phased out by 2008 at the latest. Although sludge contains plant nutrients such as phosphorus and nitrogen, it also harbours a wide variety of pollutants and pathogens from industry and households. In future, sewage sludge is to be incinerated, shifting the problem from the domain of water protection/agriculture to that of waste management.

Heavy metals

Heavy metals accumulating in the sediments and suspended solids of watercourses may have adverse impacts on aquatic organisms. Concentrations of heavy metals were investigated in a sediment contamination study over the period 1999/2000. They were found to have decreased substantially since 1986/1990.

Micro-pollutants

As a result of the excellent wastewater treatment infrastructure, the state of Swiss water bodies has improved significantly over the last few decades. The release of organic trace elements via wastewater treatment works, however, continues to be a challenge to water protection. One example is endocrine disruptors, hormonally active substances that are currently being investigated within the context of the National Research Programme NFP 50. Only in a small number of cases are data available that make it possible to assess the environmental impact of these substances. Apart from the issue of detectability, the difficulty lies in the fact that effects on the environment may be caused not only by a single agent but by metabolites and mixtures of substances. Possible measures include technical procedures for the elimination of micro-pollutants from wastewater that are already known. The use of advanced technical procedures in communal wastewater treatment works would significantly reduce the release of micro-pollutants into watercourses. Micro-pollutants are the subject of several research projects, among them the so-called "MicroPoll strategy" project that was launched by the Federal Office for the Environment in 2006. The aim of this project is to compile bases for decisions and to develop a strategy for reducing the release of micro-pollutants from wastewater treatment works into watercourses.

The case study from Bavaria provides an example of a groundwater body which is affected by high nitrate concentrations due to diffuse pollution from agricultural sources.

B.2.2.3 CHEMICAL STATUS OF SURFACE WATERS AND GROUNDWATER IN THE ALPS

It is generally known that access to clean water for drinking and sanitary purposes is a precondition for human health and well-being. Clean unpolluted water is also essential for our ecosystems. Plants and animals in lakes and rivers react to changes in their environment caused by alterations in chemical water quality. Changes in the composition of species in organism groups like phytoplankton, algae, macrophytes, bottom-dwelling animals and fish can be caused by such developments. They can also act as an indicator for changes in water quality caused by eutrophication, organic pollution or hazardous substances.

Almost all human activities can and do impact adversely on water. Water quality is influenced by and is a cumulative result of both point source and diffuse pollution, which have already been addressed in the previous chapters . Diffuse pollution from farming and point source pollution from sewage treatment and industrial discharge are principal sources. For agriculture, the key pollutants include nutrients (e.g. nitrates, nitrites, ammonia, and phosphates), pesticides (e.g. atrazine, simazine and its metabolites), sediment and faecal microbes. Oxygen-consuming substances and hazardous chemicals tend to be associated with point source discharges.

One significant threat to water bodies is an excessive concentration of nitrates and phosphates, which can cause adverse effects by promoting eutrophication. This is a process of pollution that occurs when surface waters become over-rich in plant nutrients, which can result from the discharge of wastewater from human settlements, industrial facilities or agricultural activities. As a consequence, it becomes overgrown with algae and other aquatic plants. The plants die and decompose, thus depriving the water of oxygen (anoxemia) and rendering lakes, rivers or streams lifeless in extreme cases or diminishing the variety of plant and animal species. In waters high in nutrients and with sufficient sunlight, algal slimes can cover stream beds, plants can choke channels and blooms of plankton can turn the water a murky-green colour. Further consequences may also be oxygen depletion, the introduction of toxins or other compounds produced by plants, reduced water clarity and the dying of fish. Last but not least, excessive nutrient levels can be detrimental to human health. While phosphates are considered to be the limiting factor for eutrophication of inland waters, nitrogen is the driver for eutrophication in the receiving seas.

In order to prevent Alpine waters from the above-mentioned scenarios or to improve the situation, considerable investments have been carried out in the last decades in sewage treatment technologies to tackle point source pollution. In addition, efforts have also been made to reduce diffuse pollution with nutrients. These activities have led to the situation we are faced with today.
Map 16 provides an insight into the current situation regarding nutrient concentrations (i.e. nitrates) in Alpine rivers and the trophic status of lakes.

© BMFLUW
Photo B2-11: Algae blooms are an obvious sign of eutrophication caused by an excessive supply of nutrients due to water pollution.

Regarding rivers and lakes, the growth of algae and eutrophication is driven by phosphates. The state of lakes is expressed in the map by different classes of the "trophic status", ranging from "oligotrophic" to "hypertrophic". "Oligotrophic" means that the respective lake shows very low levels of nutrients, which reflects the typical natural conditions of inner-Alpine lakes. The situation looks different for lakes situated along the outskirts of the Alpine perimeter. The trophic status there can reach levels up to classifications between "mesotrophic" and, sometimes, "eutrophic", hence higher concentrations of nutrients and a related higher productivity can be observed – an indicator for environmental impacts due to agricultural activities and discharges from human settlements.
However, higher nutrient concentrations do not necessarily mean that the lake is polluted, since the categorisation based on the trophic status is a value-free scale and lakes in lowland areas show higher nutrient concentrations in general. A much more telling indicator for negative environmental impacts due to anthropogenic influences is the deviation from the natural category (reference condition) of the lake. Tab. B2-7 in chapter "B.2.3.3 Reservoirs and Regulated Lakes" gives an additional overview of the condition of Alpine lakes with an area greater than 10km^2. The case study on Lake Piburg in the Tyrolean Oetztal valley at the end of the chapter also gives an example of an inner-Alpine lake which used to show strong signs of eutrophication – an exceptional situation which could be improved due to restoration measures in the catchment.

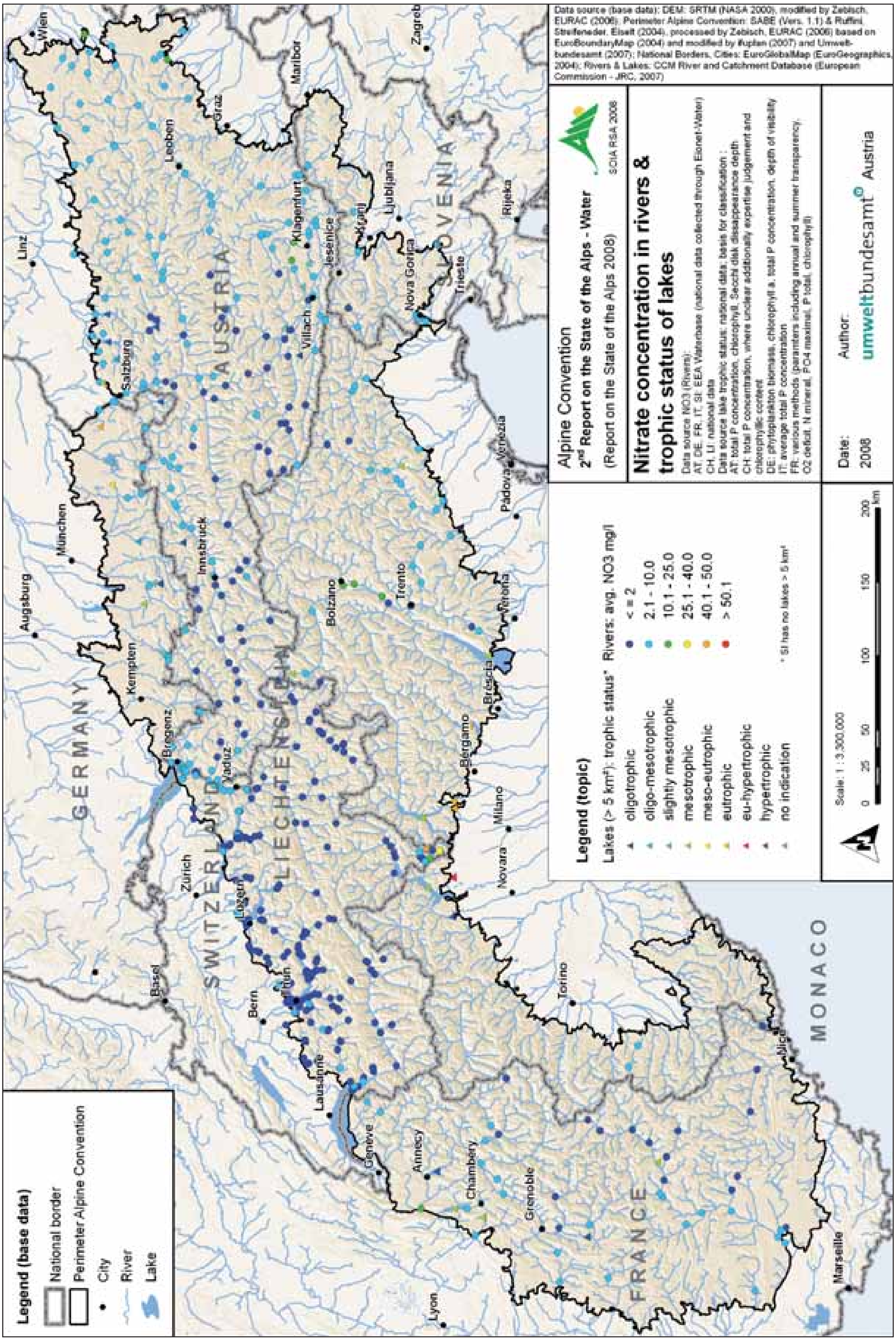
In the case of Alpine rivers, nutrient concentrations are largely very low as shown in Map 16, with values less than 10 mg/l and in many cases even less than 2 mg/l for nitrates (NO_3). Only in very few cases, the values reach levels up to 25 mg/l – a number which still can be considered as unproblematic to human health, since the threshold value for nitrates in drinking water is specified at 50 mg/l in most of the Alpine states.

With respect to nitrates in Alpine groundwater, Map 17 gives an overview of the concentrations as measured by the national monitoring networks.

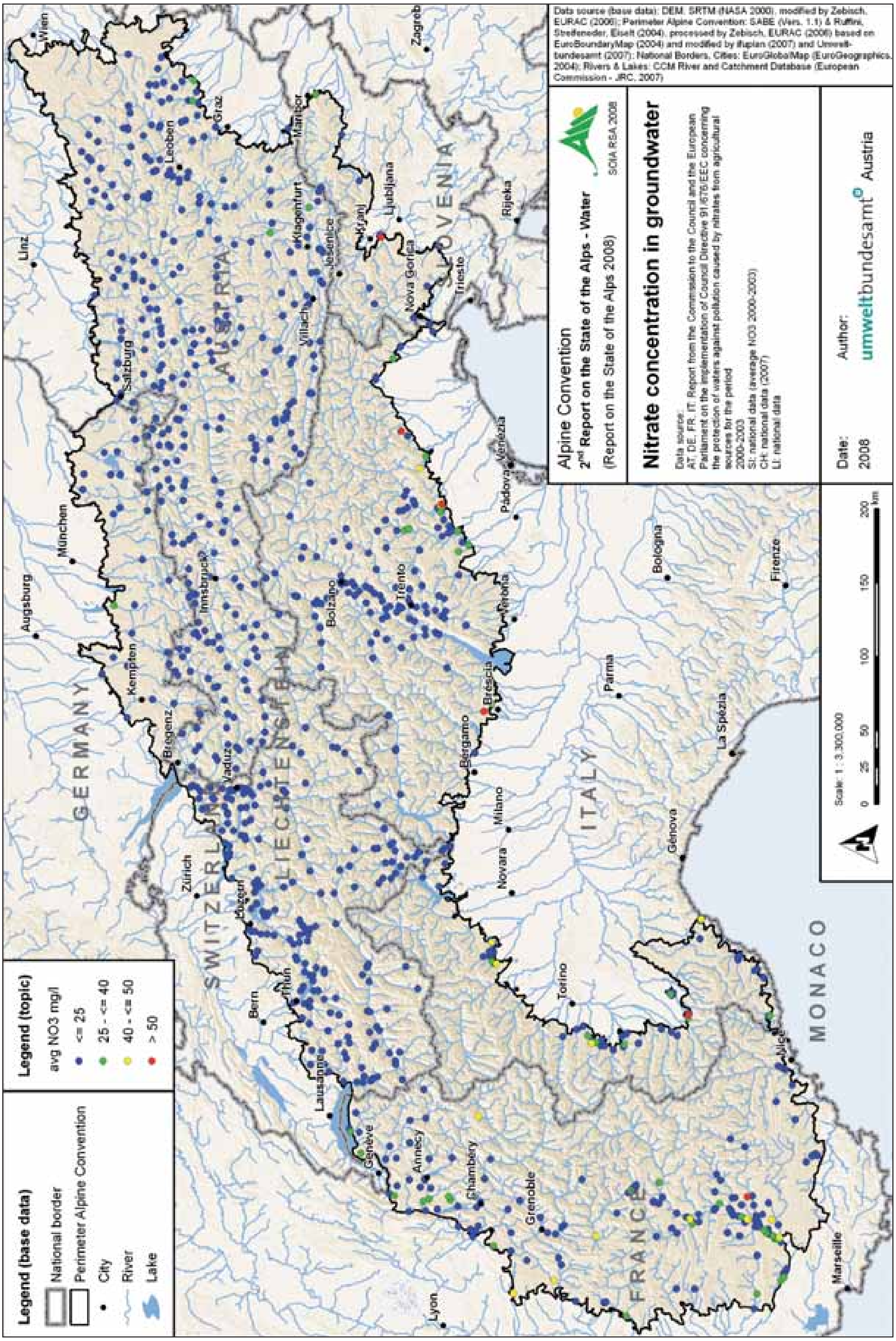
The map shows a similar situation to the nitrate concentrations in Alpine surface waters. Due to the absence of intensive agricultural activities as the potential main source of nutrients in combination with high precipitation rates, the inner-Alpine area shows low concentrations of nitrates in groundwater below 25 mg/l NO_3. Increased concentrations between 25 and 40 mg/l, and only in very few cases, more than 40 mg/l can occur in the lower regions and outskirts of the Alpine arc, where the pre-conditions for agricultural activities are more favourable. An example of an impacted groundwater body in Bavaria caused by agriculture with increased nitrate concentrations was given in the previous chapter. However, due to the absence of main pressures potentially impacting the quality of groundwater bodies, nutrient pollution is therefore generally considered to be a minor problem for groundwater in the Alpine area.

In the case of pesticides, the topic is closely connected with diffuse nutrient pollution since pesticides are also applied onto agricultural land, i.e. on arable land but also in orchards and vineyards. Pesticides used in agriculture can be transported to surface waters as well as to groundwater and threaten both wildlife and human health. Again, impacts on the chemical quality of Alpine waters due to the pollution with pesticides, either of surface waters or groundwater, cannot be considered as a major issue for Alpine water management since concentrations are mostly minor and often below the limit of detection (LOD). This is the case for the major part of the Alpine area, only in a few cases, such as in areas with intensive agriculture (e.g vineyards), can the concentrations exceed the limit set for drinking water of 0,1 µg/l.

Regarding heavy metals and priority substances, such emissions to the natural environment are unevenly distributed and therefore regarded as point source pollution. Discharges appear mainly in urban agglomerations and industrial facilities in valleys or on the outskirts of the Alpine perimeter. The great majority of urban agglomerations and industrial facilities are already connected to either urban wastewater treatment plants or, in the case of direct dischargers, have to comply with special conditions imposed regarding the concentrations and composition of the effluent. The concentrations of such substances in Alpine waters are therefore largely below the threshold values determined by national legislation.



Map 16: Nitrate concentrations in Alpine rivers and the trophic status of lakes



Map 17: Nitrates in Alpine groundwater bodies

Case Study from Austria

Eutrophication of Lake Piburg
Lake Piburg: an indicator of changes in land use, tourism and climate

Lake Piburg, situated in the Oetztal valley (Austria), is a small pre-Alpine lake of 24,6 m in depth which has been studied since 1966 when it showed strong signs of eutrophication (indicated by a massive oxygen deficiency in water layers deeper than 12 m) due to increasing use of the lake for recreational activities (bathing) and intense agricultural land use (maize and potato cultivation) on nearby meadows.

Today, Lake Piburg which became a natural monument in 1928 and part of the protected zone in 1982, is an oligo-mesotrophic (i.e. nutrient-poor) lake. As shown in Fig. B2-3, lands under cultivation does not account for more than 5% of the catchment area (60% forest, 35% Alpine plants and rocks). The most important morphometric and hydrographic characteristics of the lake are shown in Tab. B2-3.

The eutrophication process, i.e. the input of nutrients, especially phosphorus, evidenced itself in the increase of primary production and strong hypolimnetic (= deep water) oxygen depletion. As Lake Piburg does not mix completely in autumn – especially if the mixing phase is short and the formation of ice occurs in the first days of December – reduced substances such as dissolved iron (Fe^{2+}), hydrogen sulphide (H_2S), ammonium (NH_4^+) and methane (CH_4) accumulate in the deep water, i.e. the hypolimnion. As the dissolved oxygen is not only consumed in summer but also in winter under the ice, the mixing phase (in autumn and spring) can cause critical situations because the reduced substances are able to consume the oxygen dissolved in the water. During the winter 1969/70, the loss of dissolved oxygen reached a threatening level (almost the whole lake became anoxic), endangering the lives of a large number of fish and other animals.

For the restoration of the lake, an Olszewski tube was permanently installed in 1970 at a depth of 24 m to remove the oxygen-depleted and phosphorus-rich hypolimnetic water. After the installation of this deepwater withdrawal tube, oxygen saturation increased significantly. In addition, restoration measures in the catchment led to a reduction in nutrient concentrations, but it took nearly 30 years to decrease phosphorous concentrations to the present-day average level of 8 µg l^{-1}.The hypolimnion (13,5-24,6 m) usually has the greatest concentrations because it becomes partially anoxic and accumulates phosphorus released from the sediment. Enormous changes and differences between the water layers could be observed in the period 1975-1982. The concentrations of phosphorus in hypolimnion and metalimniom (7,5-13,5 m) during the period 1982-1992 were reduced by half, while the epilimnion (0-7,5 m) remained relatively constant between 5 and 10 µg l^{-1}. From 1992 to 1997, all water layers had similar concentrations which decreased to ~6 µg l^{-1}. From 1998 on, the concentration started to increase again and became more pronounced in deep water.

The hypolimnetic oxygen saturation deteriorated during the 1980s and again during the 1990s due to progressively reduced discharge of the tube. Today, the tube appears to have become occluded and should be replaced.

In 1982, the new public bathing amenities ushered in a sustainable improvement in limnological conditions because, thanks to the installation of toilets and showers, nutrient input decreased. Since then, however, tourists have been increasingly attracted to the place and on bright summer days several thousand people may be found on the lake shore.

Air temperature trends have demonstrated an increase of approximately 2°C (Fig. B2-4) since the beginning of the 20th century and of ~1°C since 1980, which is twice the global average. Water temperatures also demonstrate this warming process.

During the period 1972-1981, the temperatures of the epilimnetic layer were between 16° and 18°C (a tolerable regime for salmonids), in the period 1982-1991 between 18° and 20°C, and in 1992-2001 between 18° and 21°C. Since 2002 the summer temperatures of the epilimniom have always exceeded 20°C, with the maximum value of 22°C being reached in August 2003. In 2003 the surface temperature of the lake (at a depth of 1 m) reached 25°C, which is absolutely unsuitable for char and trout. Due to high oxygen consumption in deeper water layers, caused by the decreasing discharge of hypolimnetic water via the Olszweski tube, the cool hypolimnion lost its ability to be a potential habitat for salmonids. These changes are evident if we compare the year 1972 (a cold year), with 2000 (the warmest year) regarding annual averages of air temperatures) and 2003 (the year with the highest water temperature).

The correlation between air and lake temperatures, i.e. the average monthly air temperature compared to the temperature of the epilimniom, shows that in spring and at the beginning of summer the water heats up slowly, while at the end of summer and in autumn it is much warmer compared to the atmosphere. Due to ice formation in December, the lake is isolated from the atmosphere and keeps the surface temperature between 2°C and 4°C until the ice melts.

In the one hand, the summer epilimnetic temperatures increased up to 5-6°C between 1972-2006 (while the yearly average increased up to 2,7°C), while the summer air temperature rose by up to ~2°C. On the other hand, the average lake temperature increased only slightly compared to the yearly average air temperature. This phenomenon is caused by the fact that the winter air temperatures have a slight effect on the lake temperature and that deep layers are thermally buffered.

Furthermore, since the 1960s ice formation has occurred 0,41 days later every year, and ice melt has occurred on average half a day earlier per year. In the period 1965-1984, the ice usually formed in the first week of December and melted by the end of March. From 1993, the formation of the ice took place one or two weeks later or in January. Therefore, the period of winter stagnation has become much shorter, i.e. almost by one day per year, but the longer duration of the autumn mixing phase in November and December tends to increase the oxygen saturation before the lake surface starts freezing. The oxygen saturation in the hypolimnion, i.e. below a depth of 13,5 m, has decreased continuously since the beginning of 1990 (with the exception of 2003).
Lake Piburg has changed remarkably in the last two decades: it has become more productive and warmer and the stagnation phase, the mixing phase and the freezing period have shifted. Some of the consequences of these changes are predictable and need to be studied in the following years.

- Oxygen reduction will further increase in the deep water layers of the lake during summer time. At the same time the saturation during the autumn mixing phase may increase.
- Increase in the trophic situation (primary production and respiration) will lead to a higher sensitivity of the lake to nutrient input (tourism, land use…).
- Changes in the composition of planktonic species (bacteria, algae, zooplankton) will occur and sensitive species such as brown trout and arctic char will disappear.

Long-term monitoring suggests that the lake will face new challenges related to climate warming and anthropogenic pressure.

Parameter	Value	Unit
Latitude	45°11'30"N	
Longitude	10°53'00"E	
Altitude	913	m
Catchment basin area	2,65	km^2
Lake area	0,134	km^2
A':A (catchment to lake surface)	19,8	
Maximum length	800	m
Maximum width	265	m
Volume	1,835	10^6 m^3
Maximum depth	24,6	m
Average depth	13,7	m
Length of the shore	1,9	km
Development of the shore	1,5	
Retention time	2	years

Tab. B2-3: Morphometric and hydrographic parameter of Lake Piburg

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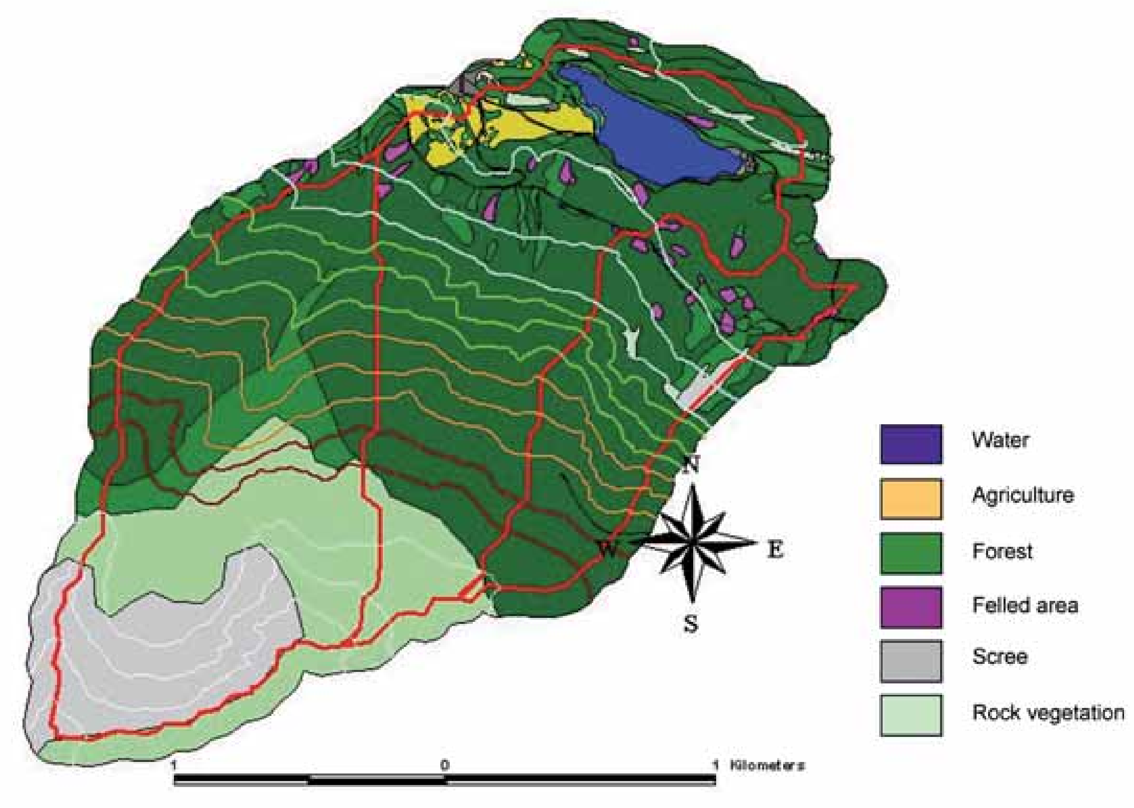


Fig. B2-3: Catchment of Lake Piburg

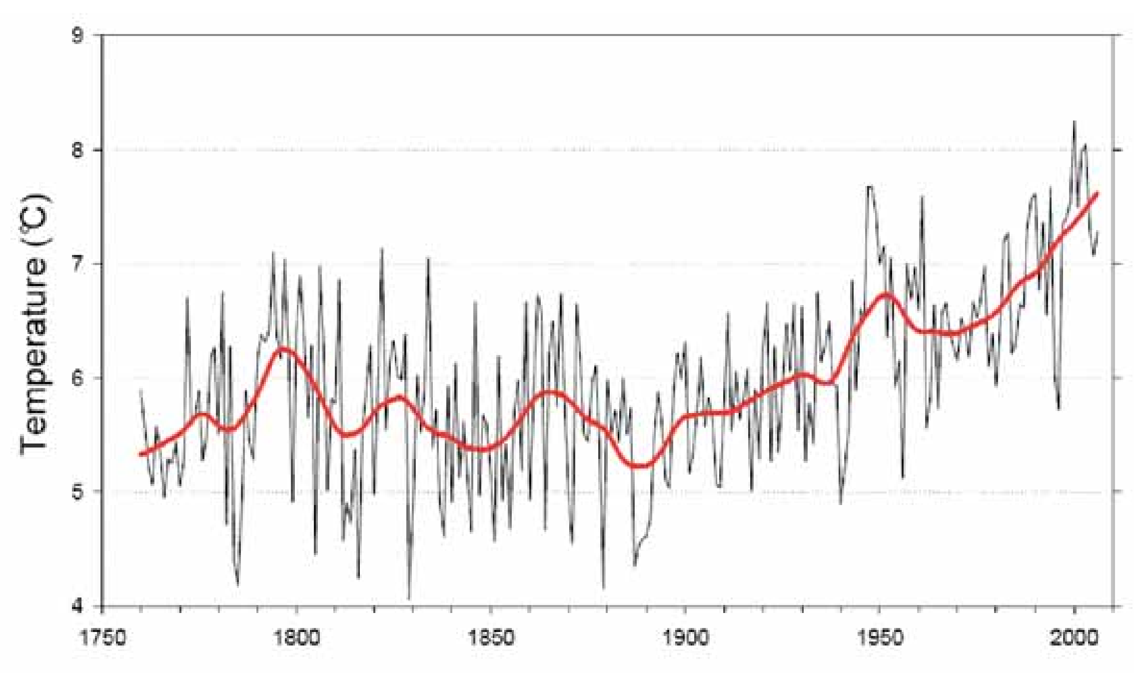


Fig. B2-4: Air temperature of Lake Piburg. Medium annual (black) and trend (LOESS 0.1, 1, red). Data source: Reinhard Böhm, ZAMG Vienna

B.2.3 WATER QUANTITY

B.2.3.1 WATER ABSTRACTION, RESIDUAL WATER AND HYDRO-PEAKING

This chapter deals mainly with environmental aspects regarding the flow regime of Alpine rivers. As shown in photo on the next page water quantity constitutes one of the influencing factors determining the ecological status. The most prominent phenomena regarding alterations of the flow regime in Alpine regions are, on the one hand, too little residual water as a consequence of which minimum standards for the "ecological flow" in river stretches are not achieved due to water abstraction, and, on the other hand, "hydro-peaking" caused by a sudden discharge of water. Both play an important role in restoring and maintaining ecological conditions in the aquatic environment.

The two elements are linked to the abstraction of water from rivers and its discharge back into rivers, causing anthropogenic alterations to the natural flow regime. A case study on the abstraction of water due to hydropower generation on the 'Upper Isar' in Bavaria aims at providing a practical insight into the situation which a number of Alpine rivers have to face. The Article 5 Analysis Report of the EU-WFD showed for the Alpine regions that the main deficits and risks of not reaching the good ecological status are related to hydromorphological issues.

Ecological Flow

The term "ecological flow" refers to the water remaining in watercourses downstream of water abstraction sites irrespective of the reason for the abstraction. These flows are necessary to preserve the various functions fulfilled by rivers and streams, e.g. providing habitats for plants and wildlife, forming a landscape element, feeding aquifers or decomposing and diluting pollutants. The concept includes not only the minimum or base flow needed, but also the variation of flow over time: in magnitude, frequency, duration, timing and water level distance from groundwater tables near the stream.
Water abstraction occurs when water is drawn off from a watercourse, utilised and then returned to the same watercourse or to a different one at a different point or is allowed to seep away. In the case of agricultural irrigation, the water may also get lost into the atmosphere through evapotranspiration. Water abstractions can be differentiated according to their purpose such as for instance:

- Hydropower generation
- Agricultural irrigation
- Cooling, cleaning and water for the production process of industrial plants and commercial facilities
- Drinking water abstraction
- Abstractions for technical snow production (please refer to the description following the conclusion of this chapter)
- Water abstraction from hot springs for spas

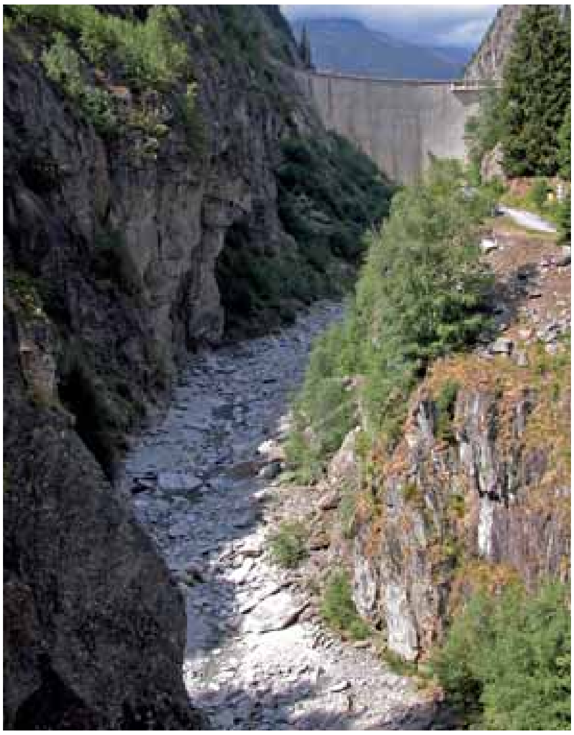
Since sufficient ecological flow is a fundamental element to fulfil the requirements regarding qualitative and quantitative maintenance of the diversity of species and their habitats, the EU Water Framework Directive also takes this fact into consideration to tackle negative impacts on the environment which are considered to be significant in the Alpine area (a detailed description is provided in the national contributions at the end of the chapter). The discharge of rivers is therefore considered in the assessment of the status of water bodies since achieving the "good ecological status" is the aim for all waters within the European Union. Swiss legislation, too, considers the requirements for appropriate ecological flow levels when granting concessions for the abstraction of water, as do EU member states. Today, newly granted concessions take the ecological flow requirements into consideration and may also include specifications on fluctuations in water levels: This approach is geared to restoring near-natural flow dynamics in impacted river flows(please refer to the case study on the River Spöl in chapter B.3.4). With regard to existing installations, different strategies with different deadlines have been adopted with the aim of providing sufficient residual water for rivers in the Alpine area which are already impacted, too.

A practical consequence of fulfilling ecological flow requirements is that less water can be abstracted for traditional anthropogenic water uses, such as hydropower generation for instance, resulting in an economic loss incurred by the respective facilities. However, a fundamental principle of sustainable development is to respect a pattern of resource use that aims at serving human needs while preserving the natural environment. Current and ongoing discussions on the practical implementation of the EU Water Framework Directive or comparable legislation is often still fraught with difficulty although agreement has largely been reached on the fundamental principle of sustainable development, which is unchallenged.

Hydro-Peaking

Hydro-peaking (or surges) is a phenomenon which occurs in line with operations of storage and pumpedstorage hydropower stations, resulting in artificial flow and low-flow phases on a daily basis. The case study on the River Alpenrhein in chapter B.2.4 shows a hydro-peaking hydrograph, illustrating man-made changes to the flow regime of the river.

Storage and pumped-storage hydropower stations con-



© Sandra Crameri
Photo B2-12: Insufficient residual water in rivers is one of the reasons for failing to meet the ecological requirements in a significant portion of Alpine river stretches. River Massa after the "Gebidem" dam, Canton of Valais, Switzerland.

tribute towards the stabilisation of the electricity grid by providing energy at peak-times of electricity demand, however, hydro-peaking also impacts aquatic ecosystems in various ways: water levels, flow velocity and watercourse width are all altered by these man-made events. As a result, organisms may be flushed away surges and adversely affected by the drying-up of areas close to the banks during artificial low-flow periods. Engineered watercourse stretches increase the impact of hydro-peaking on aquatic ecosystems. Even for watercourses without engineered structures, the morphology (e.g. bank slope) plays a role: it determines whether organisms can retreat from the spate and whether they are left stranded above the low-water mark when the flow recedes.

Hydro-peaking occurs mostly in medium-sized Alpine river systems, where the hydropower stations which are related to reservoirs are located. Small rivers are rarely impacted by hydro-peaking, nor can drastic effects be detected in big rivers. Regarding the latter, the reason for this is a reduced quantitative share of water in the river impacted by hydro-peaking. Another explanation is the buffer effect of lakes in the foothills of the Alps.

A Swiss study on trends in hydro-peaking[39] revealed that, in recent years, at some locations, an increase in hydro-peaking phenomena like peak-flow or peak-frequency could be detected. This is in most cases due to an enlargement of the turbine capacity and changes in the mode of operation.

Hydro-peaking can also cause rapid changes in the temperature of affected river systems. In summer, the water in rivers is cooled down after the discharge of relatively cold water from the reservoirs. The opposite effect can be observed in the winter period, when the discharge of comparatively warm water from the reservoirs raises the temperature in rivers.

To reduce the impacts of hydro-peaking, various mitigation measures are possible, such as:

- discharging the artificial flow peaks into a retention reservoir with controlled discharge of the water into the watercourse
- reducing the fluctuations between the two flow regimes (e.g. by increasing the minimum amount of water discharged from the power plant)
- smoothing the transition between flood and low-water phases (e.g. by more gradual start-up / shut-down of turbines)
- "diverting" the flow peaks (e.g. through flooding of alluvial zones)

However, due to the fact that mitigation measures are often accompanied by considerable changes in the management practices of hydropower stations or by related expenses for the construction of retention reservoirs, hydro-peaking is considered to be a pressure to be tackled in a step-by-step approach in order to reduce the impacts on ecology and to fulfil the requirements of environmental legislation in the coming years. Decisions on the best options and appropriate measures in order to fulfil legal requirements to restore and maintaining the ecological status of rivers have to be taken on a case-by-case basis.

(See also the case study on the River Alpenrhein in chapter B.2.4 where hydro-peaking is a concern).

The national contributions at the end of the chapter illustrate the situation regarding ecological flow and hydro-peaking in the Alpine portion of each country.

[39] Pfaundler M., Keusen M. 2007: Veränderungen von Schwall-Sunk. Hydrologische Datenanalyse zur Charakterisierung von Schwall-Sunk Phänomenen in der Schweiz. Umwelt-Wissen Nr. 0712. Bundesamt für Umwelt, Bern. 110 p

Conclusions

A number of different purposes are the reason for abstracting water from Alpine river systems. Apart from the share of water which is used in some regions for industrial purposes, agricultural irrigation or technical snow production, hydropower generation can be considered to be the main reason for water abstraction in order to meet existing energy needs. This results in the fact that a significant share of river stretches fails to meet the good ecological status due to their failure to meet ecological flow requirements.

Hydro-peaking puts additional pressure on aquatic life-forms in regions where storage and pumped-storage power stations provide energy at times of increased electricity demand. In Alpine regions in particular, too little residual flow downstream of abstraction sites together with hydro-peaking is – beside morphological deficits – recognised as a major challenge to water management for achieving the objectives of the existing legal framework.

Since permission to construct new facilities already takes into account the need to realise environmental objectives as well, additional measures are required to reduce the negative impacts of existing facilities on the ecology of freshwater. A step-by-step approach is considered to be an appropriate procedure for the necessary investments in the modernisation of such facilities. The aim of using water while simultaneously meeting environmental objectives is underpinned by existing legal requirements in the Alpine states where both the EU Water Framework Directive and the legal system in Switzerland are considered to be a strong instrument in support of solving any conflicts of interests between the different stakeholders.

Special Alpine Issue: Water Abstraction For Artificial Snowmaking

The following paragraphs focus on artificial snowmaking in terms of issues relevant to water resources management; they do not treat questions related to energy, transport, ethics, etc.

The considerations given here are largely based on two studies on the topic of technical snowmaking which focus in particular on the development of the winter-tourism industry, taking into account the expected developments under changing climatic conditions. The 'Swiss Federal Institute for Snow and Avalanche Research' in Davos, Switzerland, investigated 'Climate change and winter tourism: economic and ecological effects of technical snowmaking', based on three case studies in Swiss mountain resorts (Davos, Scuol and Braunwald) in 2007[40]. This study is hereafter referred to as the "Swiss Study". The second study, undertaken at the 'University of Innsbruck', Austria, in 2007 ("Austrian Study"), investigated the water balance between available water resources and existing water demands based on two case studies in Austria (Kitzbühl and Upper Ötztal valley)[41].

Reliable snow conditions are a crucial economic prerequisite for the skiing industry. The lack of snow due to low precipitation or high temperatures is an immense challenge to winter-sport destinations and especially to mountain railway companies. Artificial snow production is considered by some stakeholders to be the key adaptation strategy to rising temperatures, to enhanced economic competition and to the increasing expectations of winter tourists.

The increase in technical snowmaking facilities in the Alps in recent years has been significant. In Austria, the total skiable terrain equipped with snowmaking facilities increased from 20% in 1991 to 50% in 2007; Switzerland experienced an increase from 1,5% (1990) to 18% (2006). In Germany as well as in the French and Italian Alps, the increase was 30% or more, reaching around 11,5%, 15,5% and 40% by 2004, respectively[42]. Of the total skiable area in the Alps, the area with snowmaking facilities amounted to 25% in 2004. This growth is expected to continue in the near future, as considerable investments are currently being undertaken.

Water requirements for snowmaking can be substantial at a local level, using a considerable share of the annual water abstraction. For example in Davos and Scuol,

[40] Teich M, Lardelli C, Bebi P, Gallati D, Kytzia S, Pohl M, Pütz M, Rixen C, 2007. Klimawandel und Wintertourismus: Ökonomische und ökologische Auswirkungen von technischer Beschneiung. Eidg. Forschungsanstalt für Wald, Schnee und Landschaft WSL, Birmensdorf. 169p.
[41] Vanham D, De Toffol S, Fleischhacker E, Rauch W, 2007. Water demand for snowmaking under climate change conditions in an alpine environment. Conference Proceedings: "Managing Alpine Future", Innsbruck.
[42] OECD, 2007: Climate Change in the European Alps – Adapting winter tourism and natural hazards management (comparison of figures based on various sources).

snowmaking accounts for 22% and 36% of the annual water abstraction, respectively. Water for artificial snowmaking may be extracted from different origins, such as streams, lakes, springs, groundwater and public drinking water infrastructure. In France, around 25% of the total snowmaking facilities are connected to the drinking water supply system. In contrast, none of the mountain resorts covered by the Swiss and Austrian Studies use water from the drinking water supply network. In an Alpine environment, the winter season is a critical period regarding water resources management, because water availability is low and water demand high, especially in areas with an intensive winter-tourism industry. In such areas, artificial snowmaking can lead to conflicts with other water demands (e.g. drinking water supply). Especially in areas where snowmaking stations are connected to the drinking supply network, this can cause temporary water shortages, as figures from a French case study (see below) illustrate. As a measure, storage ponds have been built to store water during water-abundant periods (e.g. summer and autumn) in order to secure the necessary water supply for artificial snow production during water-scarce periods (winter).

© BAFU
Photo B2-13: Artificial snowmaking

However, from the point of view of the regional and Alpine-wide water resource balance , artificial snowmaking is not a significant issue. This is illustrated by the following figures: Only 0,6% of the total annual water abstraction within the French A.C. perimeter is used for snowmaking, while e.g. 43% is used for drinking and domestic supply and 37% for agriculture (irrigation) (see national contribution "France" below). In Switzerland, the amount of water used for snowmaking corresponds to 0,2 – 05% of the annual drinking water consumption. Considering the total estimated amount of water used for snowmaking in the entire Alpine region, this would correspond to only 1,5 – 4% of Swiss water consumption. Water used for artificial snowmaking is released with a temporal shift but does not represent a water loss, since it remains within the local catchment.

Artificial snow production can have ecological impacts on vegetation, soil, animals and aquatic ecosystems. Impacts differ largely between regions, elevation etc. For impacts on vegetation it can be concluded that

1) artificial snow can protect vegetation and soil from mechanical disturbance, however, mechanical damage on ski tracks, in general, is high,
2) artificial snow can protect vegetation and soil from frost that occurs on ski runs with natural snow cover only,
3) the late snowmelt due to artificial snow can alter the composition of vegetation,
4) the input of ions and water through artificial snow is not problematic where meadows and pastures are fertilised by agriculture anyway, but should be avoided on nutrient-poor vegetation such as fens and low-nutrient meadows, and
5) species diversity and productivity are decreased on both types of ski tracks (with and without artificial snow).

An overview study based on an analysis of available literature and long-term investigations illustrates the range of possible ecological impacts and risks associated with artificial snowmaking[43]. The study concludes that both positive impacts (e.g. on vegetation and soil) as well as negative impacts (e.g. shorter vegetation period, erosion, etc.) of artificial snowmaking have previously been overestimated. The exception are ecologically sensitive areas, in which the importance of prior environmental impact assessments, planning and respective regulatory frameworks is underlined, in order to avoid serious ecological impacts such as the impact of ponds on wetlands (see also below). Certain aspects still require further (long-term) investigation. Chemical additives are used to increase the freezing point for snowmaking. A representative study in Switzerland[44] found that currently additives are practically only used for ski races and also there only in exceptional cases. For normal tourist ski tracks, additives are hardly ever used. It is assumed that most of these additives reach the soil, or in case of frozen soils, the surface waters. Critical impacts can be expected on nutrient-poor grasslands and protected areas, where the increased input of nitrogen leads to a shift in species composition and a subsequent loss in biodiversity. However, further investigation and long-term studies are required to better understand the ecological consequences of the use of snow additives prior to drawing definitive conclusions. As an example of a first preventive step in Switzerland, official recommendations have been issued to the race organisers on application modes and restrictions[45].

[43] Pröbstl, U, 2006. Kunstschnee und Umwelt – Entwicklungen und Auswirkungen der technischen Beschneiung. Haupt Verlag, Bern.
[44] Schwörer C, Rhyner H, Rixen C, Schneebeli M, Iten B, 2007. Chemische Pistenpräparation – Grundlagenbericht. [published online November 2007] Available from http://www.slf.ch/schnee-lawinen/grundlagenbericht/chemschneepraeparation.pdf. Eidg. Institut für Schnee- und Lawinenforschung SLF, Davos. 69p.
[45] BAFU, 2007. The Use of Snow Hardeners – Fact sheet. Available from: http://www.umwelt-schweiz.ch/uv-0731-e. Federal Office for the Environment, Bern.

Winter tourism is a primary economic factor in mountain regions, generating 26% of the aggregate income in communities such as Davos. Calculations indicate that in winters with poor snow cover, artificial snowmaking could prevent losses of up to 10% of the aggregate income of Davos. On the other hand, the cost of snowmaking is substantial. According to an estimateby the Association of Austrian Cableways, one cubic meter of artificial snow costs between one to five Euros. Investment costs for Switzerland are estimated at 650.000 Euro per km of snow track, plus yearly operational costs of up to 50.000 Euro per km. This represents 8,5% – 17% of the yearly turnover of the ski-area operators[46].

Given the changing climatic conditions, the trend towards extensive snow production is expected to continue and increase. Regional climate scenarios predict a rise in winter temperatures for the Alpine space. The snow cover at lower elevations has already significantly decreased; and in higher regions, a decrease in average snow depth has been observed. These developments are expected to lead to growing interests of skiing resorts and tourism centres in developing facilities for artificial snowmaking in the future.

[46] CIPRA, 2004. Künstliche Beschneiung im Alpenraum – Ein Hintergrundbericht. alpMedia Hintergrundbericht. Available from: http://www.cipra.org/de/alpmedia/publikationen/2709. CIPRA International, Schaan. 18p.

Conclusions

Artificial snowmaking may represent an important adaptation strategy to enhance winter tourism in view of the changing climatic conditions. In regions like Davos, where winter tourism generates up to 30% of the regional income, the loss potential with no artificial snow production would be significant. Tourist surveys indicate that reliable snow conditions are important in the choice of a holiday destination. Snowmaking facilities can thus be considered to be an insurance benefit for the local economy. However, considering a continued rise in temperatures, snowmaking may cease to be economically attractive. In the long run, an investment in alternative offers may have to be considered for the tourist industry.

On a local basis, temporal water stress due to snowmaking can occur. Artificial snowmaking may give rise to user conflicts between mountain railways (operators of snowmaking facilities), households and other water demand stakeholders. The storage of water in ponds can contribute towards mitigating such effects. However, such infrastructure entails further construction works in fragile environments and therefore due consideration has to be given to environmental concerns during the licensing process (see below). An additional step towards solving water scarcity problems can be a regional water resources management plan, which contributes towards balancing the interests of different water users.

In view of the potentially negative ecological effects, every new snowmaking facility needs to be evaluated as early as in the planning process for its impact on the environment. Legal obligations in order to meet ecological flow conditions, the protocols "tourism", "soil protection" and "mountain forests" of the Alpine Convention, as well as standards in terms of nature conservation sites are important (e.g. in Austria, standards for snowmaking facilities have been issued[47]). Artificial snowmaking should be prevented especially in ecologically sensitive and endangered habitats. Currently, environmental regulations related to this issue differ not only from country to country but even within countries.

In order to optimise the process of balancing conflicting interests related to artificial snow-making, all relevant stakeholder groups, i.e. mountain railway companies, communities, tourism organisations and nature conservation agencies, need to collaborate and exchange their views and positions in the planning process in order to accommodate and consider possible upcoming problems as early as possible.

In conclusion, artificial snowmaking may be a relevant factor for water resource management at a local level. However, if considering the water cycle at a regional scale, or even for the entire Alpine region, the water volumes used for artificial snowmaking are insignificant. Besides, the water extracted for snowmaking remains within the regional hydrological system.

[47] ÖWAV, 2007. Beschneiungsanlagen. ÖWAV-Regelblatt 210 (2. Auflage). Wasser Abfall Regelwerk, Österreichischer Wasser- und Abfallwirtschaftsverband, Wien. 32p.

Case Study from Germany (Upper Isar, Bavaria)

Abstraction of water due to hydropower generation and its impact on the ecology

Ever since 1923, a large part of the River Isar has been diverted to Lake Walchensee at the weir in Krün to generate hydropower. The diversion structure via the Obernach canal has a capacity of up to 25 m^3/s; however, since 1990 approx.100 million m^3/yr remain in the river as residual water flow: during the summer month 4,8 m^3/s, in the winter months 3 m^3/s. As a result of this diversion to Lake Walchensee, the bed load transport capacity of the River Isar is disturbed: as two thirds of the run-off is diverted to Lake Walchensee the long-term bed load transport capacity in the River Isar has dropped, on average, by approximately half (from 40.000 m^3/yr to 20.000 m^3/yr).

The bed load balance of the River Isar between Krün and the Sylvenstein reservoir has been disturbed for decades, this being first and foremost due to the water diversion to Lake Walchensee at the weir in Krün. In this stretch of the Isar bed load deposit and erosion dominate, especially downstream of Wallgau (river km 247,5 to 243,0). The flood events of 2005 confirmed these erosion tendencies. It is therefore necessary to remove the bed load as needed in order to protect parts of the villages of Krün and Wallgau from flooding.

In spite of the dysfunctions caused by the abstraction to Lake Walchensee at Krün and the intrusion on the bed load balance (river regulation Mittenwald), the Isar riverine landscape between Wallgau and the Sylvenstein reservoir is of outstanding importance in terms of nature conservation. Characteristic features of this fluvial topography are morphodynamic processes that occur in high run-off periods, such as shifting of the river course and of the gravel banks (torrent landscape). The gravel banks serve as a habitat for highly specialised species. To enable the shift of the gravel banks, certain flow dynamics are required. The area in question is a registered Natura 2000 site and also constitutes part of the nature conservation area "Karwendel und Karwendelvorgebirge" and is thus under strict protection.
The river engineering measures that are necessary for flood control in Krün and Wallgau and the nature conservation requirements are not in tune with each other. It is therefore necessary to look for solutions which improve flood control without impairing the protection targets of the Natura 2000 areas and which maintain the status of the protected habitat types. A change in the minimum residual flow has a detrimental impact on the management of the Sylvenstein reservoir.
A general conflict of interests exists regarding the Upper Isar, each of which is significant when considered individually: flood control for the villages, nature conservation and a balanced river morphology as well as the generation of renewable energy from hydropower, which does not create CO2 emissions. It is not always possible to reconcile these interests without conflict. Intense discussions between all parties involved are required in order to reach viable solutions and a compromise.

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Photo B2-14: Isar at Wallgau upstream of the weir in Krün (administrative district of Garmisch-Partenkirchen)

Case Study from France

Artificial snow production against other water uses in the French Alps

Artificial snow production, developed over the past 40 years, has recently appeared to be a concern as most of the Alpine ski resorts rely on this equipment to guarantee their budget. The dramatic development has raised a controversy about its possible side effects on water and about its sustainability.

Irregular snowfall in recent years coincides with growing investments undertaken by ski resort managers. As the activity requires more equipment, the investors want an activity guaranteed by way of artificial snow. First installed at the lower resort which was confronted with frequent poor snow cover, the tendency in past years has been to equip every resort. This trend has been a concern to the Rhone River Basin Agency because of conflicts users even if no water shortage has been occured for drinking water supply. Therefore several studies were launched on this topic in 2001 and 2008. This paper gives a synthesis of the findings plus a few considerations on recent developments.

A few figures for the French Alps

Data was collected from 121 ski resorts (out of 160) in the French Alps in 2001. At that time:

- 85% of the resorts were equipped with artifical snow production facilities;
- most of the equipment was installed below 2.000 m.
  - 16% below 1.500 m
  - 64% from 1.500 m up to 2.000 m
  - 20% above 2.000 m
- within these resorts, 15% (average) of the surface was served by an average of 2,7 snow gun/ha;
- 1m³ of water is needed to produce 2m³ of snow;
- the average water requirement for this purpose was: 3.300m³/ha/yr.

Following some water shortage incidents in the public drinking water service, the study focused on the water resources required for snow production. The following conclusions were drawn:

– only 25% of snow production facilities in the resorts were connected to the public service network (using drinking water) for snow production (for 28 resorts consumption reached 1,6 Mm³/yr); in most resorts the situation was not satisfactory as conflicts occurred.
– another 25% relied on torrents : (for 29 resorts the abstraction reached 1,6 Mm³/yr);
– 50% of the resorts relied on small dams built especially for this purpose (for 57 resorts = 3,4 Mm³/yr).

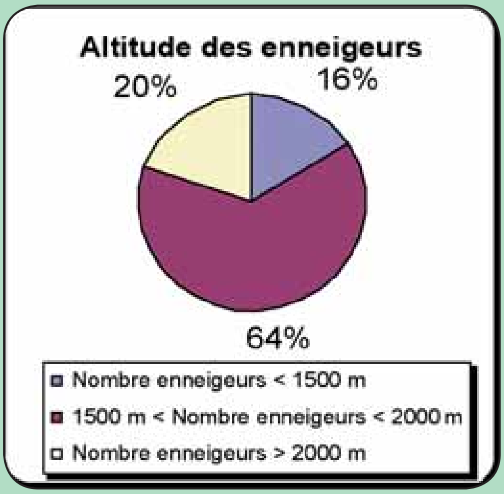

Fig. B2-5: Number of snowguns

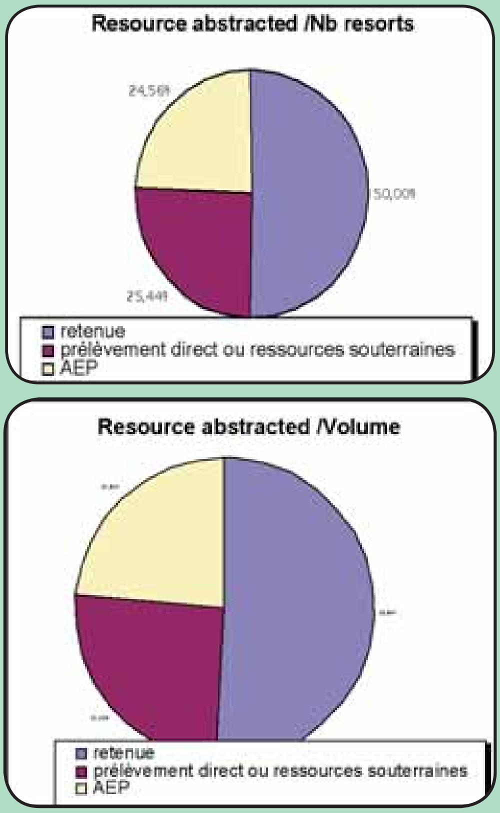

Fig. B2-6: Resource abstracted/Nb resorts Resource abstracted/Volume

Compared with the drinking water requirements of the corresponding resorts, these water requirements appear to be 12% of the annual abstraction volume on average. Considering the various situations, it is obvious that the issue is a serious one. The peak demand occurs during the busy winter period.

In 2008 ODIT France published a study that in France 19% of all ski tracks (4845ha) are equipped with snowmaking facilities. The corresponding water abstraction is 17 Mm^3/year (compared with the drinking water requirements, these water requirements appear to be nearly 10% of the annual abstraction volume on average). According this report the resources used originate in dams (60%), from surface waters (30%) and 10% are from drinking water networks. These figures illustrate the potential impact on the availability of water resources during the winter period. In return snow additives are not used any more in France.

Remaining questions

The 2001 main stakes are:

1. possible conflicts among users (public drinking water, supply, hydroeletricity, environmental needs,…)
2. possible risks for downhill population due to flood hazards from small dams (some are poorly designed);
3. the rapid development of this snowmaking equipment with little concern for water resource preservation, and low water flow within surface waters which have already been affected by the low dilution of discharges from sew age treatment plants;
4. the destruction of wetlands for dam construction;
5. the impact of snow additives has not yet been assessed sufficiently.

The benefits for the tourist economy should be weighed against the environmental impact; this has not yet been evaluated in detail. Impacts such as the delay in snow melting affecting the vegetation cycle along the ski tracks, delaying run-off in surface water, electricity consumption (evaluated to be in excess of 100 million kwh/year) have not yet been explored.

In conclusion, these recent developments at ski resorts definitely require an assessment of the impact on water resources. Even if some local water shortages have been solved, a few questions remain on the sustainability of such developments in tourism in mountainous areas. Should the balance of the ski resort budget be the only concern if a few uncertainties remain unanswered? The concern about climatic change argues in favour of investing in this assessment.

The lack of information available does not make the controversy not any easier but rather more complex instead. As this brief paper cannot provide a detailed outline of the situation, consultation of an extensive bibliography (-on the following page-) is proposed, which is provided by "Alpmedianet" in a recent report available at: http://www.cipra.org/fr/search?SearchableText=enneigement+artificiel

And also:

http://www.wsl.ch/forschung/forschungsprojekte/klimawandel_wintertourismus/Schlussbericht_-_Kurzfassung

National Contributions Regarding Information on Residual Water and Hydro-Peaking

Austria

The main share of abstraction from Austrian surface waters in the Alpine area accounts for hydropower generation, whereas diversion plants, at 80%, are the predominant type of approximately 2.200 small hydropower stations in the whole country (numbers based on WFD Art. 5 Report). Apart from the abstraction of water for electricity production, about the same number of mostly non-active water facilities such as flour mills or saw mills still exist.

The circumstances illustrated lead to pressures – apart from the interruption of river continuity - on the minimum ecological flow in rivers. The percentage of river length, identified as being at risk of failing to meet the 'good status' due to a lack of residual water, is 17% in the country as a whole (1.960 km out of a total river system of 11.500 km with a catchment area greater than 100 km^2). As hydropower generation is concentrated in the mountainous region, rivers within the Alpine perimeter show increased changes in natural conditions. For instance, due to insufficient residual water, 55% of the river stretches in the Austrian share of the River Rhine catchment in the west of the country are at risk of failing to meet the 'good status' requirement.

Regarding hydro-peaking, as these effects are connected with hydropower generation, the main share of impacted river stretches can be found within the mountainous region as well. While, for the whole country, 8% of river length is at risk of failing to meet the 'good status' due to hydro-peaking, this figure is significantly higher for areas within the Alpine perimeter. Again, this figure increases to 37% for the Austrian share of the River Rhine catchment, where a high number of pumped-storage power plants are located.

The Austrian Water Law aims, inter alia, at protecting the ecosystem of all waters. The general provision in §13 of the Austrian Water Law requires that all uses have to be restricted in such a way that a share of the discharge has to be reserved to obtain / maintain the (good) ecological status of waters and other high-value uses of water, respectively – in particular to safeguard the drinking water supply. The precise objectives for surface waters are defined in §30 of the Austrian Water Act - in line with the objectives of Article 4 of the EU Water Framework Directive – to protect, enhance and restore all bodies of surface waters with the aim of achieving the 'good ecological status'. Both provisions provide the legal framework to determine the amount of residual water on a case-by-case basis within the licensing process of granting permits by the competent authorities.

The individual amount of residual water as well as the extent of hydro-peaking is tailored to the local situation during the licensing process and is often derived from model-based calculations. While in the past residual water was a fixed discharge which was stable for the entire year, new permits aim at preserving the dynamics of natural discharges for residual water as well by setting different values for the summer and the winter periods. Such measures aim at addressing the ecological needs of aquatic ecosystems: These can be categorised as strongly dynamic systems in Austria.

Permits for hydropower generation are granted for a period of up to 90 years to provide a certain security for the investment. The conditions under which the permits have been provided may be revised at a later stage, e.g. due to overriding public interest, but the measures must not lead to disproportionate efforts for the holder of the permit.
With the 'Programme of Measures', which is currently under preparation and which will be part of the 1st River Basin Management Plan, considerations are underway in order to improve the situation concerning residual water and hydro-peaking. Regarding the latter, measures for mitigation at already existing facilities may involve high economic costs for the operator and have to be taken into account on a case-by-case basis. Improvements to that effect can only be achieved in the long run. The short and medium-term focus will therefore mainly be on remediation measures regarding residual water.

France

Water abstraction within the French A.C. perimeter is illustrated by the following data for 2006 (collected for levies charged by the River Basin Agency):

This confirms that domestic use remains the primary use (43%) in the French Alps, followed by irrigation (37%).

For residual water flow downstream of a structure, the definition thereof is at the discretion of the administrative State authorities. As the target has been raised recently to a minimum level of 1/10th of the average flow, efforts mainly concern the renewal of permits for existing structures. The French Alps are drained by 12.500.km of surface watercourses, of which 54% (6.800km) flow at an altitude above 800m and 44% (5.500km) flow at altitudes between 200 and 800m. Those watercourses correspond to small watersheds (62% < $100km^2$) and most of them are situated in the upper valleys (92% are ranked Strahler 1). For most of them data is available. Almost 60% (3.500km) are affected either by excessive abstraction or by modifications to their flow regime (sluice discharge, flood control, insufficient low flow…).

Resource Use	Underground 10^3m^3/year	%	Surface 10^3m^3/year	%	Total 10^3m^3/year	%
Drinking & domestic supply	342.600	64	196.000	36	538.600	43
Agriculture : irrigation	13.300	3	453.000	97	466.300	37
Industry (process)	62.200	50	61.500	50	123.700	10
+ cooling towers	26.200	24	83.000	76	109.200	9
Artificial snow production	1.900	24	6.000	76	7.900	0,6
TOTAL	**446.200**	**36**	**799.500**	**64**	**1.245.700**	**100**

Tab. B2-4: Water abstraction within the French Alpine Convention perimeter

As regards sluice discharge operation, no uniform regulations exist covering the entire French Alps perimeter, as the operating rules are laid down in each permit process, including requirements for flow management in line with the conclusions of the preliminary impact study. A stabilisation pond may be required in some cases in order to reduce variations and impact.

Apart from the requirement of minimum flow, the legal framework is quite specific: the rural code requires a permanent guarantee for life, circulation and reproduction of species living in waters before any structure may be erected. In this respect a minimum flow is determined by the inter-annual average flow, ranging from $1/10^{th}$ to $1/80^{th}$, depending on the average flow level of the watercourse and of the structure under consideration. These requirements have been tightened by a recent water law (adopted on December 30^{th}, 2006) requiring that any structure to be built within a river bed be equipped with a device permitting the minimum flow as required and thereby safeguarding on a permanent basis the life, circulation and reproduction of living species existing prior to the construction of the facility. This should be guaranteed by a minimal flow which must not be less than $1/10^{th}$ of average flow of the watercourse (or $1/20^{th}$ for those exceeding $80m^3/s$ and for structures producing hydroelectricity for peak hours).

This minimum flow is laid down in the authorisation permit or in the licensing contract, which may specify various values according to specific periods of the year, on the condition that the annual average value is higher than the minimum flow required. The operator of the facility is obliged to keep the equipment in a state of repair which guarantees the minimum flow in the river bed. For existing structures (built before the law was adopted), these obligations will come into force when the licensing contract or authorisation has to be renewed (after expiry) or by January 1st, 2014, at the latest.

Enforcement of this law is expected to improve notably the quality of water bodies by 2014. However, under some circumstances, it will still be necessary to raise the requirements for minimum flow or to adapt any seasonal adjustments to ensure the preservation of watercourse quality and biological potential in the best possible manner. Know-how and methods should be enhanced as well in order to optimise this artificial management of flows for the benefit of both water quality and the various water uses, especially during consultation processes.

As regards hydro-peaking, the administrative State authorities are responsible for water law procedures concerning both existing and new approvals for hydropower plants. To obtain a permit, a report is required on the issue of residual water flow impact, among other things. This report specifies the requirements determining an ecologically and economically balanced minimum flow proposal for already existing hydropower plants, taking limits set by existing regulations (as mentioned above) into account.

The development of hydroelectricity is governed at a national level in order to maintain current hydroelectric production as well as to plan additional plants for a capacity of for 7 TWh/yr. The issue is how to reconcile the WFD with the Renewable Energy Directive. It seems to be globally achievable if present constraints such as controlling environmental impacts are respected. For example, those constraints assume that minimum flows would be raised in some places up to 1/10th or 1/20th of the average flow as is required by a recent water act, but at the same time would require that hydraulic continuity be restored for some existing structures, or the impact caused by sluice operation be mitigated.

Germany

The problem

The exploitation of hydropower can have a considerable impact on flowing surface waters. Cross-river structures interrupt biological continuity and in most cases also stop the transport of solids. Wherever impoundments are built, the habitat conditions change. In run-of-river power plants, there is a reduced run-off (residual water flow) in the diverted river section during most of the year, which can have a detrimental impact on aquatic ecology and lead to changes in species composition as a result of the reduced rate of flow, loss of aquatic habitat and reduced run-off dynamics. Some hydropower plants use hydro-peaking to cover periods with high power requirements. In the downstream river sections, this may lead to flow fluctuations during the day between the high water levels (hydro-peaking) and low water levels when filling the reservoir (sunk level). Daily fluctuations as occurring during hydro-peaking do not exist in a natural flow regime, thus the aquatic fauna and flora are not adapted to this. Due to these changed abiotic conditions, the communities and species living in rivers are endangered.

Possible solutions

In Bavaria, the administrative district authorities are responsible for granting permission for the use of water. This includes licensing for the use of hydropower plants. In this process, the local Water Authority is required to provide an expert opinion on possible detrimental effects of the planned water use and to inform the permit-granting authority accordingly. For run-of-river plants, the report must include a statement on the minimum water flow needed for the preservation of basic ecological functions of the aquatic ecosystem.

When preparing its report, the State Office for Water Management has to observe the residual flow guide of the Bavarian State Ministry of the Environment and Public Health. This specifies requirements for the determination of an ecologically and economically balanced minimum flow proposal for already existing hydropower plants with a capacity of up to 500 kW. In the event of a new construction, if there is to be a major change to existing plants or in the event of re-activating old plants, the residual flow guide does not apply, and in such cases the minimum run-off proposal takes, first and foremost, the ecological aspects into account.

In the case of large hydropower plants with a capacity in excess of 500 kW, in some cases very extensive residual flow analyses are prepared to determine the adequate minimum flow. The River Isar downstream of the weir in Krün, the River Lech downstream of Lake Forggensee or the River Alz downstream of the weir in Trostberg serve as examples as they are located in the designated area of the Alpine Convention.

In Bavaria, there are no set regulations on requirements for hydro-peaking. The review has to be carried out on a case-by-case basis in the respective approval procedures. As the negative impact can usually not be completely removed without significantly affecting the water use, it is usually not possible to reach the "good ecological status" as defined in the Water Framework Directive in these reaches. In these cases, measures need to be initiated to achieve the "good ecological potential".

Basic requirements and measures for reducing the impact of hydro-peaking include the separate diversion of the works operating water, the provision of compensating reservoirs, reduction in the differences between hydro-peaking and sunk levels, gradual run-up and run-down of turbines and the reshaping of the river bed.

Italy

Italian Alpine rivers are usually highly impacted by the effects of the reduction of flow caused by several abstractions and in particular by hydropower.
The exploitation of water resources for hydropower, although not constituting a "consumption" of the resource or a deterioration in its quality, exerts a significant impact on its natural flow regime. In the Alpine area the complex network of artificial watercourses that transfer water from one point in the river basin to another, or even from one river basin to another, has, in fact, been developed without any planning and has reached such a level and extent as to conflict with the requirements of protection and conservation of the characteristics of the watercourses. Since 1989, Italian legislation has introduced indications aimed at maintaining the minimum flow of rivers and defining the concept of "minimum flow". A further step forward for the protection of watercourses was made in 1999, with the obligation to quantify the "balance of water resources in the river basin" meaning the difference between water resources available or obtainable, and the requirements for the various uses. The preparation of the balance of water resources is aimed at the quantitative protection of the watercourse through the definition of sustainable water consumption and the re-organisation of licences, as well as by achieving objectives regarding environmental quality.
Even though hydro-peaking is an emerging issue in Italy, no specific regulations exist at the moment.
In Italy it is obligatory to respect the "minimum flow", meaning the minimum flow necessary in every stretch of water in order to guarantee the protection of the characteristics of the watercourse and its waters as well as maintaining the typical biocenosis of natural local conditions. Maintaining the minimum flow is an essential factor in meeting the requirements of environmental protection and its clear definition becomes a fundamental criterion in controlling licences for water diversion and discharge.
Italian legislation establishes that the use of water for drinking purposes has priority over all other uses, and therefore over agricultural and industrial uses. The use of water is permitted up to the point where the minimum flow is not compromised.
The value of the minimum flow is established by the Regions as part of their Water Protection Plans. Since each region has developed its own Protection Plan, there are notable differences in the ways in which the minimum flow is calculated and applied, even in relation to the rivers in the Alpine area.
As regards Alpine rivers, the minimum flow is generally defined for each stretch of watercourse by calculating first of all a component on a hydrological basis to which certain corrective factors which take into account, where necessary, the particular local conditions are applied.
The regulations for the application of the minimum flow differ depending on whether they relate to old licences or new ones. In the former case, compliance is mandated on a gradual basis, taking into account the recovery times for natural ecosystems, according to provisions set out in the Protection Plans, whereas in the latter case, the minimum flow parameters are established when the licence is granted and they become an integral part to be applied immediately.
The Protection Plans provided by the regions generally require that the figures for the minimum water flow be issued by the 31/12/2007 for licences which are renewed, and by 31/12/2008 for valid licences. Studies and experiments are currently being conducted in order to define the ecological and environmental parameters to be applied to the hydrologic component. These must, however, be defined by 31/12/2015.
There are instances in which it is possible to depart from maintaining the minimum flow when provision for human consumption is necessary or in times of water crisis. Such departures are, however, permissible on the condition that all possible strategies are adopted for saving water, for limiting losses and for removing wastage and that it can be demonstrated that it is impossible to find alternative supplies.
The authorities responsible for renewing and issuing licences for large water extractions are the Regions, while the Provinces are responsible for the extraction of small quantities. These authorities are also responsible for defining the minimum flow, which is calculated according to the indications contained in the Water Protection Plans.
In Italy, there are no specific regulations relating to hydro-peaking. However, such regulations are being considered by the River Authorities, which are the authorities responsible for this area, with a view to producing guidelines on the eco-compatible management of hydro-peaking in order to reduce the impacts of biotic and abiotic elements, and to approximate a natural flow pattern in river basins that are subject to hydropower impacts.

The actions to be included in regulating new licences or in licences undergoing renewal are currently decided on a case.by-case basis.

Slovenia

The need to determine ecologically acceptable flow (EAF) in Slovenia has increased significantly in recent years for a number of reasons. These include the need to protect river ecosystems, a demand to licence water users (e.g. hydropower production, industry, drinking water supply and irrigation for agriculture), and for the implementation of important legislation at both the national level (e.g. Water Act, 2002) and the European level (EU Water Framework Directive, 2000), with the aim of achievig good ecological status or good ecological potential.

On running waters in Slovenia it is estimated that there are about 440 abstractions for hydropower generation, 290 for fish farming, 40 for irrigation, 80 for industrial purposes, thousands for drinking water and even more are planned (Ministry for Environment and Physical Planning, personal communication). Permits for water uses can be granted for a period of up to 30 years, and are issued by the Ministry for Environment and Spatial Planning, Environmental Agency of the Republic of Slovenia.

The Slovenian Water Act (2002), section 71, states that "in the case of a water abstraction that causes a decrease in water flow or a decrease in water level, an ecologically acceptable flow (EAF) should be determined", and therefore the need to determine EAF in Slovenia is readily apparent. EAF is determined in water licences according to section 125 of the Water Act or in concession contracts according to section 141 of the Water Act or in Water Consensus according to section 150 of the Water Act. EAF is assessed based on expert opinions. This provides the legal framework for determining the amount of residual flow on a case-by-case basis within the licensing process of granting the permits by the Ministry for Environment.

In 1994, a project group of experts from a number of organisations was established by the Ministry of Environment to define criteria and methods for EAF assessment. As a consequence, the 'rapid assessment method' was established with the aim of being quick to apply, based on the use of basic hydrological data and site information, including an inventory of habitats, and ecological and morphological information. The 'detailed assessment method' utilises similar information, but in addition it requires the sampling of aquatic organisms in different habitats of the relevant river sections. After completion of the field surveys and analysis of the data, both methods result in decisions about the EAF to be made at an expert workshop. On the basis of the field survey results and the expert workshop, the existing situation is described in a report for the water abstractor and contains all collected and measured data. The report also presents the findings of the expert panel meeting and their EAF recommendations and is submitted to the Ministry of Environment for the decision to be ratified and the water licence to be granted. The values of EAF typically vary for different seasons in order to take the temporal dynamics of the river system into account. Normally at least two EAFs are prescribed, which are minimum flow requirements, one for the winter period (October-March) and one for the summer period (April-September). Once an EAF has been determined, it has to be maintained in all periods irrespective of the quantity and the duration of water abstraction. The EAF is not constant along the river but varies spatially. depending on the location and types of abstractions present along the river.

The methods described are used in most cases of EAF evaluation, but so far they have not been firmly defined in legislation. At present, the mechanism to monitor and enforce EAF implementation is being discussed but its future success will be vital if Slovenia is to meet key environmental objectives.

There are no specific regulations on hydro-peaking. In the concession contracts for water users, or in operation licences the prescribed conditions are laid down, defining the extent of hydro-peaking allowed and how to manage flows downstream of the dams.

All the information described refers to the whole country and not only to the Alpine region.

Switzerland

In Switzerland, hydropower licenses are normally granted for a period of 80 years. This corresponds to the maximum duration according to legislation on water rights. The Water Conservation Act came into force in 1992. It requires an authorisation for water abstraction and sets out rules on the necessary quantities of residual water (Articles 31 - 33), which are a compromise between use and conservation. The Cantons are basically responsible for approval. They determine the appropriate quantity of residual water for each river or stream and each place in accordance with the legal provisions.

The residual water flow that is actually required to be maintained in the watercourses depends on when the exploitation rights were acquired:

- New water withdrawals (since 1992) and existing withdrawals for which concessions have to be renewed must comply with the requirements on appropriate residual flows.
- In cases where water exploitation rights were granted before 1992, the requirements on appropriate residual flows only have to be complied with when the concessions are renewed. In the meantime, existing residual flow stretches are to be remediated in as far as this is economically acceptable. Remedial measures are to be completed by the end of 2012.

According to a national inquiry, there are around 1.500 inventoried water abstractions, mainly for hydropower purposes. Only around 150 of them were granted later than 1992 with decrees stipulating the appropriate quantities of residual water.

An analysis of the newly (since 1992) granted water abstraction concessions shows that only around 20% comprise a seasonally varying residual water regime.

There are around 100 power stations related to reservoirs in Switzerland that cause hydro-peaking phenomena. Their negative effects have been increasingly recognised in the last years. A study on trends in hydro-peaking revealed that in recent years, at some locations, an increase in hydro-peaking phenomena like peak-flow, peak to base flow ratio or peak-frequency could be detected, which, in most cases, is due to an expansion of the turbine capacity and change in the mode of operation. Proposed countermeasures primarily focus on retention basins, attenuating peak-discharges. The reduction of negative hydro-peaking impacts is currently, however, not expressly regulated in legislation.

Today, the Law on Fisheries (Articles 7 and 9) is primarily used to establish measures. In practice, measures are primarily under discussion for new licenses and large construction projects, where an environmental impact assessment is also mandatory. There are, however, ongoing political initiatives aimed at tackling the identified deficits by revising the water conservation regulations explicitly addressing the hydro-peaking issue.

B.2.3.2 DROUGHTS AND WATER SCARCITY

At the end of its studies in 2007, the Commission of the European Communities, in response to the request for action on water scarcity and droughts from the Environment Council in June 2006 and aiming at addressing and mitigating the challenge posed by water scarcity and drought within the Union, made a Communication to the European Parliament and the Council entitled "Addressing the challenge of water scarcity and droughts in the European Union" (COM(2007) 414 final, 18/07/2007). On 30 October 2007, the Council of the European Union adopted the conclusions of the Communication (13888/07) from the Commission.
According to Commission definitions "drought" is a temporary decrease in water availability due, for instance, to rainfall deficiency, whereas "water scarcity" is the phenomenon that occurs when water demand exceeds the water resources exploitable under sustainable conditions.

Water scarcity describes a situation of long-term water imbalance, where water demand exceeds the level of water resources available. Such cases usually emerge in areas of low water availability or low rainfall, but they can also occur in regions which have high levels of water consumption due to high population density or significant volumes of water being used for agricultural or industrial activities. Water scarcity is a man-made phenomenon. Drought should refer to significant decreases in average levels of natural water availability.

In the communication, the Commission underlined that water scarcity and droughts are problems with relevant socio-economic and environmental impacts in the European Union. Their occurrence has been increasing both in intensity and frequency in recent years, affecting Member States and neighbouring countries at different levels. At least 11% of the European population and 17% of its territory have been affected by water scarcity to date and recent trends show a significant extension of water scarcity across Europe.
In the same document the Commission underlined how water scarcity and droughts have a direct impact on citizens and economic sectors which use and depend on water, such as agriculture, tourism, industry, energy and transport. In particular, hydropower, which is a carbon-neutral source of energy, heavily depends on water availability. Water scarcity and droughts also have broader impacts on natural resources at large through negative side-effects on biodiversity, water quality, increased risks of forest fires and soil impoverishment. The Commission also identifies challenges which need to be addressed and measures as well as strategies for overcoming

Photo B2-15: Pumping water from an Alpine torrent across the Durance gorges near the "Mur des Vaudois", for l'Argentière-la- Bessée electric powerplant (Hautes Alpes, France)

© Š. Prelc
Photo B2-16: Example of irrigation system for apple yards in South Tyrol, Italy

drought and water-scarcity. Actions needed are, first of all, the full implementation of the Water Framework Directive, the effective introduction of a water-pricing policy, adequate land-use planning, the introduction of extensive water-saving measures, integration of water-related concerns into water-related sectoral policies and finally, the implementation of high-quality knowledge and information.

Within the Alpine Convention Area, droughts and water scarcity are not perceived as a major issue due to the relatively high precipitation in the whole area, the snow cap and the glaciers' contribution. Both droughts and water scarcity were experienced only in short periods and in small sparse areas, precisely during the summer period in recent exceptionally dry years from 2003 to 2007.

In Austria and Germany, droughts had negative impacts on agriculture, low groundwater levels and low-flow duration. In recent years France has not been significantly affected by droughts, while in Switzerland these phenomena were only observed during relatively short periods and with limited spatial extent. In Italy, a decrease of precipitation but no drought period has been observed in recent years in the Alpine area. Slovenia has experienced droughts over all its territory, but its major impacts did not occur in the Alpine area.
Water scarcity events had negative impacts on agriculture and put a significant strain on water supply and hydropower generation. In 2003, parts of Switzerland and some water sectors experienced scarcity phenomena to a certain extent. In Italy, phenomena of water scarcity in the Alpine and pre-Alpine area are concentrated in numerous small areas across the entire region, and they are due to the growing pressure of tourism in both summer and winter and to the increase in water consumption for various uses, in particular for hydropower. In Austria, at a very local scale, intensive economic activities (e.g. tourism) may also lead to bottlenecks in water availability in the low-flow periods during winter time. In Germany, no bottlenecks occurred due to water scarcity, while in France facilities have been built to overcome frequent water scarcities experienced in past centuries and therefore the problem is not very serious today, even though the issue has not been completely resolved. In Slovenia, water scarcity is a nation-wide issue but not of major relevance to the Alpine part, since the scarcity of water is mostly a problem for agriculture, for the drinking water supply as well as for hydropower generation.

The geographical layout of the river basins which often extend outside the Alpine area cause the water which is stored as a resource in the Alps and its management, to have a notable effect on areas downstream as well, and it plays a considerable role in preventing and mitigating serious problems in relation to both environment and production.

Therefore, the economic consequences of droughts are limited in their extent if we consider the Alpine area alone, however, they assume entirely different proportions if we adopt a wider view, especially if we consider what has been described above and when looking at the river basin as a whole. This kind of situation was revealed in Italy in the Po river basin, in Germany and in Slovenia. In Slovenia in particular, groundwater resources of the Alps may play a significant role in water-scarcity prevention for other parts of the country, thereby meeting the demand of the whole country.

The occurrence of drought and water scarcity has increased both in intensity and frequency in recent years; this will be even more so in the future under the predicted effects of climate change (more details are provided in chapter D). As forecasts predict, climate change will not pass by without any impact and will also be reflected in more extended water scarcity and drought phenomena during the summer period. This may have important consequences in the Alpine area and related river basins, too. Under these circumstances, the preparation of effective strategies to prevent and mitigate drought risks is becoming a priority task. The study funded by the European Environment Agency (EEA) “Climate Change Impacts and Adaptation in the European Alps: Focus Water”, which will be finalised by the end of 2008, arrived at similar findings.

Conclusions

Within the Alpine Convention Area droughts and water scarcity are not perceived as a major issue due to the relatively high precipitation rate of the whole area, the snow cap and the glaciers’ contribution. Both droughts and water scarcity were experienced only in short periods, and in small sparse areas, during the summer period in recent exceptionally dry years from 2003 to 2007.

Water which is stored in the Alps and its management have a notable effect also on areas downstream and play a considerable role in preventing and mitigating the consequences of droughts.

In recent years, the occurrence of drought and water-scarcity events has been increasing in both intensity and frequency, and it is destined to grow in the future under the predicted effects of climate change. This may have important consequences in the Alpine area and its related river basins, too. Under these circumstances, drafting effective strategies to prevent and mitigate drought risks is becoming a priority task. Common lines of expected intervention can be synthesised into a better management of the available resource. This could be reached first of all by reducing demand on the one hand, but also by the diversification and development of additional water resources on the other hand.

All the countries also agreed on the necessity that a connection between water scarcity, droughts, climate change and their associated adaptation strategies, including the aspects already dealt with in the EC Green Paper on adaptation to climate change in Europe, should be integrated into the implementation of the Water Framework Directive (WFD) and its River Basin Management Plans as far as possible.

Case Study from Italy

Drought management in the Po river basin: social and economic aspects

Hydrographical characterisation[48]:
The Po River is Italy's main river. It is 652 Km long and has a maximum historic water flow of 10.300 m^3/s in its final section at Pontelagoscuro.

The Po river basin covers about 4.000 km^2 of Swiss territory and more than 71.000 km^2 of Italian territory, representing, approximately a quarter of the whole area of Italy.
The Italian river basin includes 3.200 Municipalities located in six Regions:
Piemonte, Valle d'Aosta, Lombardia, Veneto, Liguria, Emilia-Romagna and the Autonomous Province of Trento. 1.756 of these 3.200 Municipalities are located in the area covered by the Alpine Convention.

This wide river basin, bordered in the north and in the west by the Alps and in the south by the Appennines, is made up of 2/3 mountains and hills and 1/3 of plains with different hydrological and geomorphological characteristics. Along its course towards the sea, the River Po is fed by a main network of 141 watercourses characterised by a length greater than 20 km; the width of this main network is about nine less than that of the secondary one. Also the artificial network (reclamation and irrigation), which is closely integrated in and interacts with the natural watercourse network, has a considerable surface. Within the above-mentioned section of the Po river basin, there are about 600 km^2 of glacier areas. Across the Alps there are numerous reservoirs that are used for the production of hydroelectric energy; in addition, on their foothills, large lakes function as natural reservoirs. The 174 reservoirs situated in the Alpine area of the river basin manage 2.766 million m^3 of water per year; about 1.253 million out which are controlled by natural lakes, while the remaining 1.513 million are controlled by the artificial reservoirs mainly for hydroelectric production (143 reservoirs are used exclusively for electric power production while the rest are characterised by multiple usage). In the river basin there are about 890 hydroelectric power plants that produce about 19 TWh per year (48% of the national hydroelectric power) and about 400 thermoelectric power plants that produce, on average, 76 TWh per year (31% of national production).
Inland navigation, historically extending up to about 400 km from the sea to the confluence of the River Ticino, is currently limited due to the presence of reduced sections in the channels between the River Po and marine ports and due to the low water levels during low-flow periods.

The Po catchment is of economic and strategic importance for the country, contributing a share of 40% to Italy's gross domestic product. The basin has a population of nearly 16 million inhabitants, a business density and an occupational rate that are considerably higher than the national average.

Hydrological balance and criticalties[48]:
The mean annual precipitation across the whole basin is 1.106 mm, corresponding to a mean annual inflow volume of 78.000 million m^3. In particular, 47.000 million m^3 of water, corresponding to a little less than two-thirds of the total inflow, are discharged into the sea, while the remaining 31.000 million m^3 are lost by soil evaporation and vegetal transpiration. Total water withdrawal accounts for about 20.537 million m^3 and is divided up as follows: about 80,3% for irrigation, 12,2% for drinking water supply and 7,5% for industrial purposes (except energy production). Approximately 63% of the total is withdrawn from surface sources, while 37% are exploited from groundwater. Even if water-resource availability is high in the Po river basin on the whole, water-scarcity events have frequently occurred due to drought conditions in recent years.

During the period 1975-2006, precipitation in the Po river basin decreased by 20% on a yearly basis and by 35% for the months from January to August. Analogous trends can be found in the River Po discharge series for the Pontelagoscuro section at the river delta, with an annual decrease of 20%, which rises to 40% during the summer season. The figure on the right shows the mean annual discharge at Pontelagoscuro in the period 1975 – 2006 (data source: APAT and ARPA Emilia Romagna).
If the minimum flows at the same final section are considered, it appears that up to 2003 the historical absolute minimum value was 275 m^3/s, recorded in 1949, and that starting from 2003, this value progressively decreased due to the effect of drought, reaching 168 m^3/s in July 2006. In 2007, on the contrary, thanks to proper drought management (described in the following paragraphs), the water flow has been always higher than 296 m^3/s.
Criticalities of the Po river basin arise from various problems connected to landscape complexity and to the hydrological conditions of the river basin.
Numerous activities are considerably influenced by drought: irrigation, human usage, hydroelectric production, inland navigation, thermoelectric power plants and industrial cooling systems. In addition, different environmentally critical situations occur during

[48] Data source: Po River Basin Authority

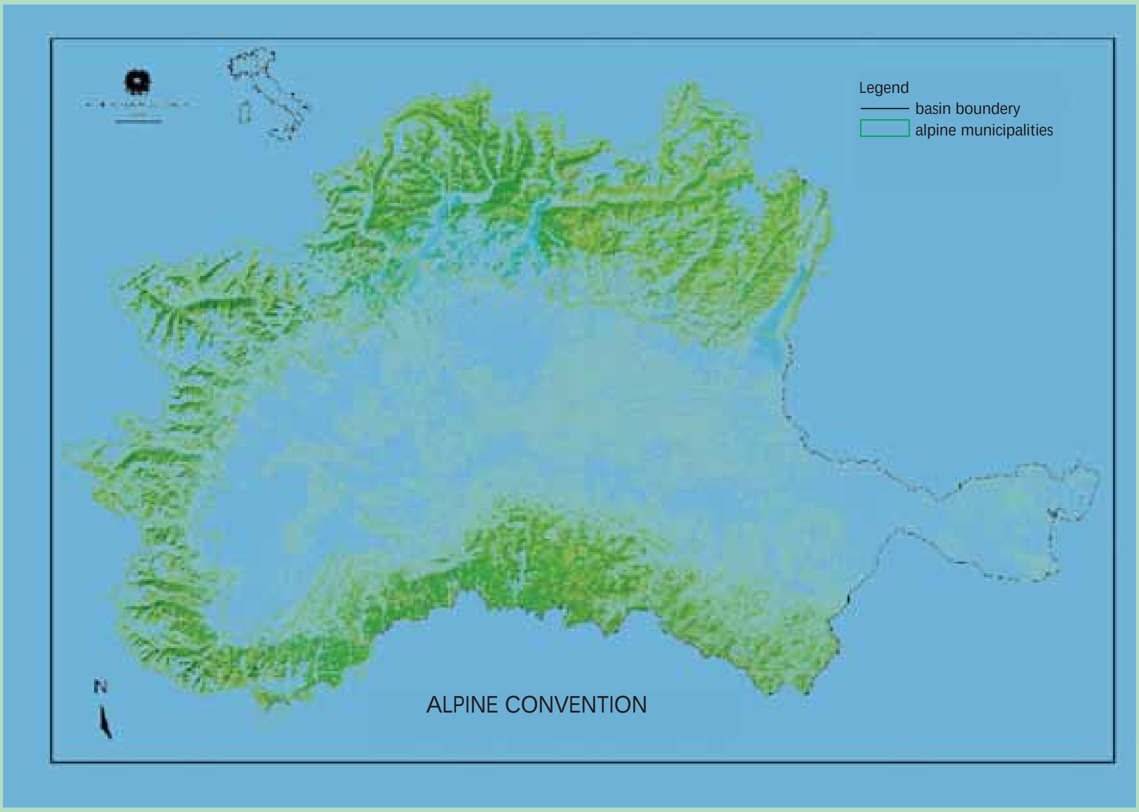

Fig. B2-7: Physical description of the basin and definition of the Alpine Convention area.

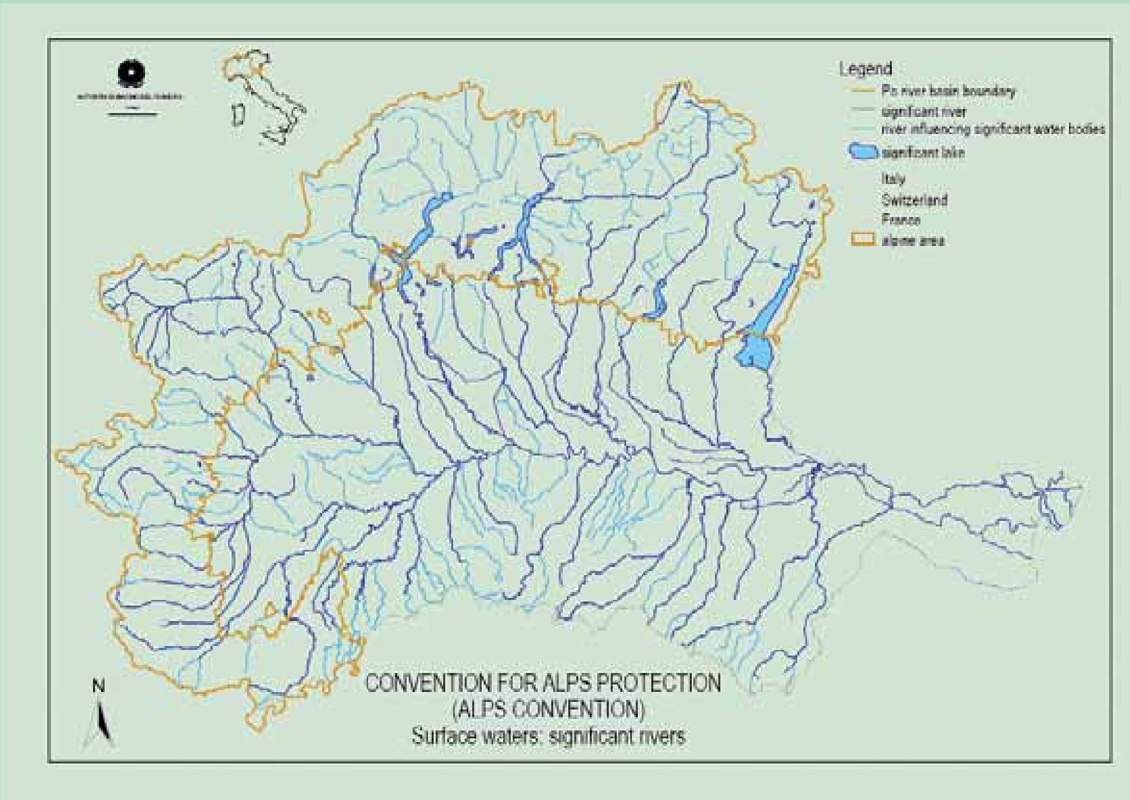

Fig. B2-8: Superficial waters and significant water bodies.

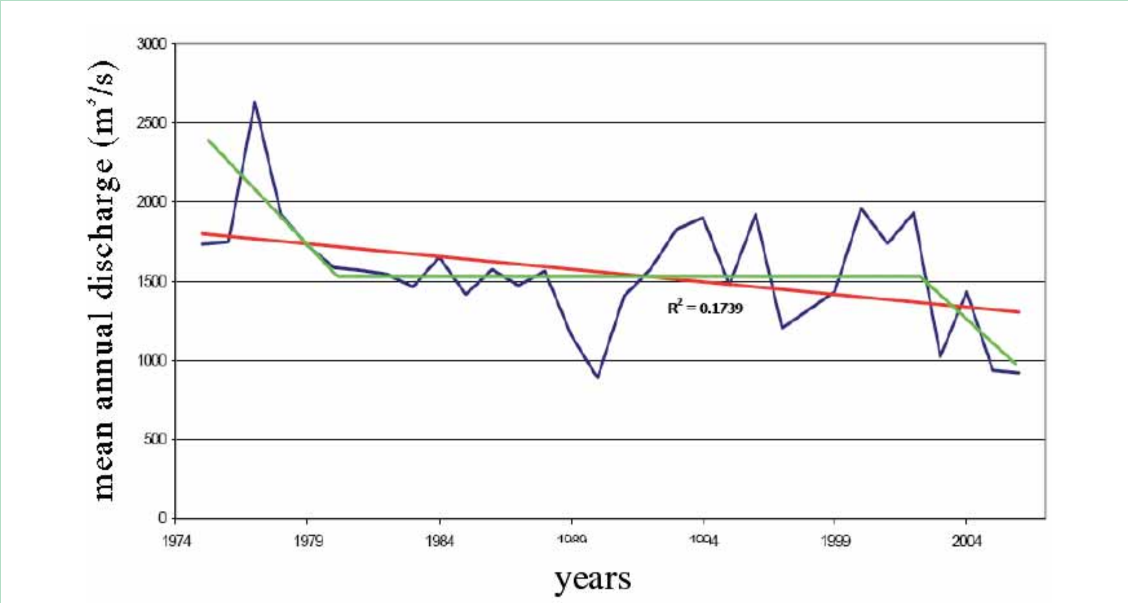

Fig. B2-9: Mean annual discharge (m³/s)

periods of low river levels. The main causes are the lack of a minimum stream flow, the decrease of the waterbody's self-depuration capacity and the increase of salt-wedge intrusion beyond the river delta.

As regards agricultural and industrial criticalities, lack or reduction of water availability reduce production in these sectors, generating enormous economic losses. The lack of local electricity production affects the whole national grid, since thermoelectric power plants in the river basin satisfy a large part of national electricity demand. Moreover, as the cooling systems of thermoelectric power plants withdraw water directly from the river, inadequate volumes of water cause local environmental problems linked to the return of too-hot water. To restore the environmental quality of the river basin, several measures have been approved to improve the self-depuration capacity of watercourses: i.e. reducing polluting loads and changing the water supply sources.
The salt-wedge intrusion beyond the river delta calls for a more complex solution which is not as easy to achieve, because it includes both structural and managerial action aimed at preventing this really dangerous phenomenon. In the worst drought conditions ever recorded, the salt wedge extended as far as 92 km from the river outlet: if the summer flow of the River Po follows the above-mentioned decreasing trend and if, at the same time, the freshwater withdrawals for different uses do not decrease, such a phenomenon could have extremely negative impacts on agriculture and water supply. In particular, it has been estimated that salt-wedge intrusion effects can become irreversible if the flow remains below the minimum threshold of 330 m³/s for a long period of time during drought conditions.

Evolution in drought management:
The managerial model used for the water crisis affecting the Po river basin has undergone major improvement in the last years, changing from fragmentary to almost joint management.

Meteorological and climatic events that took place in the summer of 2003, characterised by limited rainfall contribution and by high temperatures, forced an earlier start to the irrigation season and indirectly caused a continual decrease in water levels in both the river network and the Alpine lakes. These conditions exacerbated the already existing problems faced by the national grid: Italy's summer electricity demand had been underestimated, as a result of which the emergency plan for the security of the electricity system, which is based on a detachment programme for users was activated many times. In addition, the forecast of deteriorating climatic conditions predicted lower water availability and the consequent impossibility to satisfy the energy demand. Therefore the Italian institutions, during an emergency summit, set up the so-called Direction Group, comprising a technical and an institutional team and coordinated by the Po River Authority and including all the bodies involved in the water management of the Po river basin. During the meeting, the Agreement protocol finalising the joint management of the water budget of the Po river basin was formalised. The protocol defined rules and actions for every stakeholder with the intent of assuring both a minimum flow from the lakes, for irrigation and in the Po river itself, and an adequate flow to guarantee the maximum electricity production in the thermoelectric plants. Moreover, the protocol prescribed several lines of action to take advantage of the efficient use of the Alpine resources, which are the only manageable resources inside the river basin. These lines of action included the increase of releases from the Alpine hydroelectric reservoirs, the direct transfer of additional volumes released from hydroelectric reservoirs to the lakes and the reduction of withdrawals. Such measures, put into effect by the joint management of the water budget at river basin scale, halted the trend of decreasing levels in the River Po and allowed both the regular operation of thermoelectric power plants while maintaining withdrawals at previous levels.

The innovative joint management of the Po river basin's water balance, developed during the drought in the summer of 2003, confirmed the merit of the cooperation of all the Institutions involved in the management of the water resource. The team focused on identifying procedures on how to move from water scarcity due to drought to ordinary conditions, centralising the monitoring of water availability and the regulation of lakes, developing technical management support instruments (short to medium-term forecast tools, like drought indexes and event evolution scenarios). On 8 June 2005, taking the drought forecast for the summer period into account, the Direction Group ratified another protocol entitled Participative Activity on Studying and Controlling the Po River Basin's Water Balance, aimed at preventing and managing drought events. This protocol became particularly useful in comparing and sharing actions that regulate water resources at river basin scale. Moreover, it helped in optimising the application of numerical simulation models, which are a useful decision-making support tool for the Direction Group. The joint management of the water crisis furthermore was helpful in overcoming internal discrepancies between territorial agencies, improved the exchange of information among the partners, increased the knowledge of the phenomena, thus allowing a better characterisation of critical aspects, and provided the analysis instruments required to overcome the water-scarcity problems resulting from the drought. In the same way, the experience gained by the Direction Group proved to be extremely useful in severe emergencies and in water-crisis prevention, in real-time monitoring of the evolution of phenomena and in giving clear indication of actions that could be undertaken in order to restore normal conditions.

In 2007, the activities planned by the Direction Group showed first tangible results. As regards hydrometeorological aspects, the year was characterised by a reduced snow pack and less rainfall compared to the previous years. However, abundant rainfalls in June were insufficient to compensate the previous deficit; for this reason, water-saving actions were undertaken in 2007, too, in order to contain the risk of salt-wedge intrusion. The activities coordinated by the Direction Group began in April, earlier than in previous years, when the water basin balance and the forecasts on its evolution made the implementation of water-saving measures necessary, such as accumulating water in Alpine reservoirs and lakes. Such measures were in force until the end of May. In June, when water requests for irrigation increased, the discharge of previously accumulated water resources was started. In this phase the technical team, taking both production and environmental needs into account, proposed relevant guidelines for the utilisation of available water resources. The proposed scenarios consisted in the discharge of water stored in reservoirs and lakes and in the reduction of irrigation withdrawals to guarantee an adequate river level in the River Po to combat salt-wedge intrusion. Moreover, the Direction Group planned the reduction of withdrawals in consultation with the farmers and scheduled water release from mountain reservoirs to contain the precarious irrigation situation. Hydroelectricity producers were obliged to release water volumes accumulated during the spring period, but they could choose the modalities of restitution depending on demands of the electricity market. In this way, salt-wedge intrusion has been overcome, but in implementing the whole procedure, the insufficient decision-making authority vested in the Direction Group was revealed.

Even though there is a broad discussion on and a careful evaluation of critical scenarios, important economic interests that often affect water resources management make it difficult to establish the release or the storage of water to overcome the water crisis in a concerted and voluntary manner. Thus, in 2007, too, after the proclamation of the emergency conditions, the Direction Group had to delegate the planning of the required actions and their application through decrees to the National Department of Civil Protection. The limits in applying the decisions taken by the Direction Group will be overcome only if the Italian law is revised. In line with the provisions of the Water Framework Directive (2000/60/CE), it will necessarily take account of the recovery of all costs, including the environmental ones, in resource management modalities. To this end, the Po River Basin Authority has started to draft the so-called "Low flow management directive". The directive establishes a procedure finalising the co-ordinated management of water resources with the aim of preventing, combating and mitigating droughts effects at river basin scale. It also guarantees sufficient flows for different environmental and other functions. This document will constitute a concerted and shared planning action and will comprise clear and precise rules regarding the behaviour that partners involved in water use must adopt depending on the level of criticality.

Economic implications of drought management: Social and economic effects of the 2003 water crisis were quantified by the Bocconi University at the request of the Po River Basin Authority. The procedure took into account various aspects relating to energy and agricultural production prices. In particular, it provided an assessment of economic losses in the hydroelectric sector based on the difference between the production schedule forecast and actual production after the application of the Protocol. The effect of the Protocol was an "in excess" production of approximately 192 GWh that generated revenues in the amount of 9,5 million euros. The same amount of energy production in a different period of the year, characterised by a higher energy demand, would have produced total revenues of 16,5 million euros, with a loss in revenue from hydroelectric energy production of approximately 7 million euros. As regards the effects of the Protocol on agriculture, the analysis was based on the hypothesis that available water was used to irrigate only a part of the fields in an optimal way, while the remaining part was not watered due to the absence of water. From the reduction of withdrawals and of irrigated areas , the study first assessed the production gap and, subsequently, the shortfalls in yield based on average prices of agricultural produce in 2003. From this analysis it became evident that, owing to the Protocol, agricultural damage worth 620 million euros had been avoided.

It is important to point out that the analysis took into account only the economic impacts of the Protocol application on the main stakeholders, but did not consider any wide-scale implications. The analysis, in fact, did not consider the costs of phenomena such as black-outs and saline intrusion, that were avoided by the Protocol application but which would entail social implications accordingly. As mentioned before, extremely low flow conditions could cause stoppage at thermoelectric power plants due to cooling systems being out of order as well as permanent alterations to the delta environment due to saltwater intrusion. These aspects, although difficult to quantify economically, would definitely have major social and economic consequences for the whole country.

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Case Study from Slovenia

Severe agricultural and hydrological drought in 2003 – future climate scenario already experienced?

In 2003, the worst drought in Slovenia for fifty years was brought on by a prolonged dry period which started in the early spring. In the first half of the year, precipitation was mostly below normal. From March to the first days in June, the quantities of rain were below normal. Lack of rain apart from occasional brief thunderstorms also slashed crops in June. The mean air temperature in June was 5 to 7°C above the 1961-1990 mean. For over half of the month, daily temperature highs exceeded 30°C in the major part of the country. Particularly adverse was the combination of drought and high temperature, thus enhancing evapotranspiration and reducing the soil moisture. Extremely high temperatures caused heat stress, especially to plants less tolerant to drought, like winter wheat.

The drought continued on into July and August. An extremely high number of days with maximum temperatures above 30°C intensified evapotranspiration. In central Slovenia, also in the pre-Alpine regions, 33 days with evapotranspiration greater than 5 mm per day were recorded, which was 22 days above normal. An increase over the past decade in the frequency of days with high evapotranspiration rates has been reported for several locations. In the lower parts of the Alpine region, an evapotranspiration rate >4 mm was recorded on 42 days. Damage due to the lack of water for plants was provoked by the combined effect of higher temperatures and prolonged periods of dryness.

Only 40 to 70 % of the normal amount of precipitation was recorded in the major part of Slovenia in the period from March till August. In this period, the cumulative water deficit for grass increased to 500 mm in the south-western region along the Adriatic coast, between 400 and 450 mm in the north-eastern and south-western regions, and around 300 mm in central Slovenia. At elevations above 1.000 m the deficit was lowest.
In 2003, the highest water deficit in last fifty years was recorded in all main agricultural regions. It caused serious direct damage to agricultural production on 620.000 hectares, which was more than 62% of arable land in the whole country, including the Alpine region.
The hydrological drought coincided with a precipitation deficit. The spatial distribution of river run-off in August 2003 when the drought was at its height is best illustrated by the minimal specific discharges over Slovenia in August. The specific discharges showed the greatest value in Alpine and hilly regions, so the hydrological drought was not as severe there as it was in other parts of Slovenia. The lack of water and low flows were most pronounced in the north-eastern region of Prekmurje and south-western Primorska region where streams usually dry up during very dry periods. So, the drought of 2003, being a regional phenomenon, did not hit the whole country with the same intensity.

In the half-century time series of observations, the hydrologically driest years were in the period 1946-1949, followed by the years 1993 and 2003. As in recent years, the 2003 drought was intensified by the high air temperature, though it was not the worst on record in the Alps.
The groundwater regime is similar to that of surface waters, with the most frequent droughts

Gauging station	The driest year	Period of observation
Mura, Gornja Radgona	1947	1946-2005
Pristava, Ščavnica	2003	1954-2005
Sava, Litija	2003	1927-2005
Sora, Suha	1947	1945–2005
Kamniška Bistrica, Kamnik	1993	1946–2005
Ljubljanica, Moste	1947	1946–2005
Savinja, Nazarje	1949	1926–2005
Savinja, Laško	1949	1907–1939, 1946–2005
Krka, Podbočje	1946	1933–2005
Soča, Solkan	1947	1945–2005

Tab. B2-5: The driest year in the period of observation at some hydrological gauging stations (those located in the Alps are in bold type)

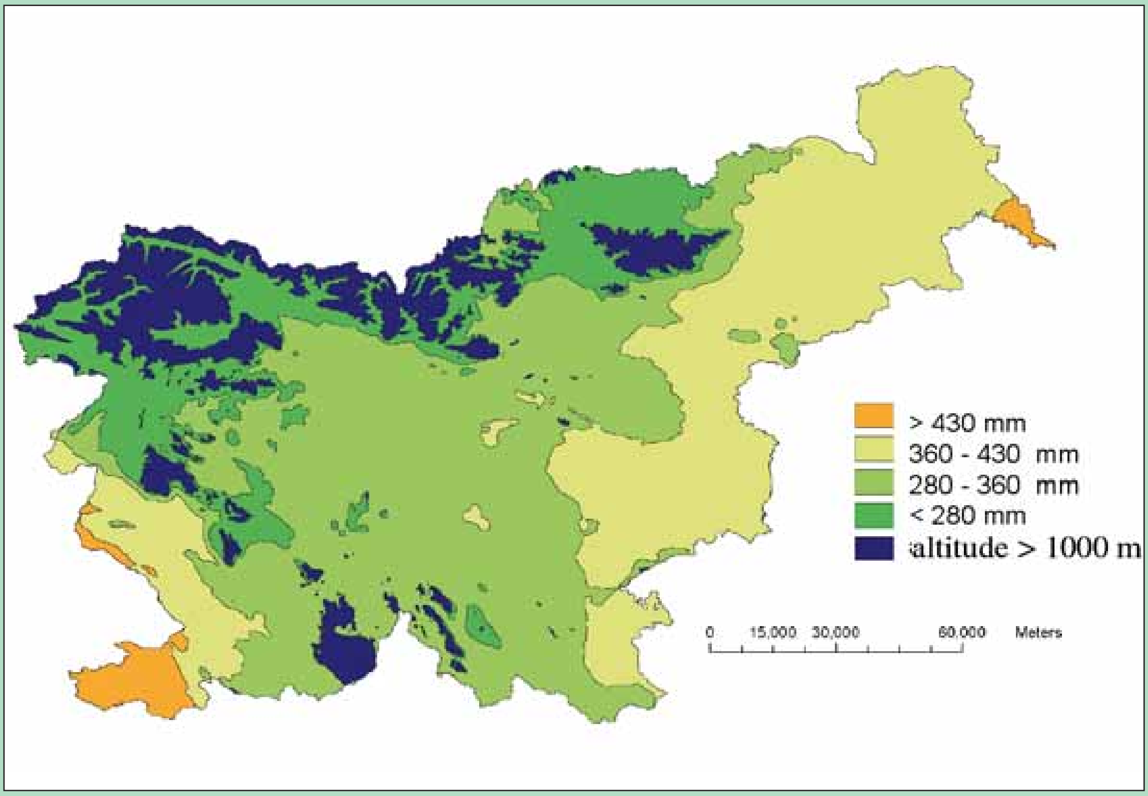

Fig. B2-10: Water deficit in the growing season from March to August 2003 in Slovenia (Source: Environmental Agency of the Republic of Slovenia)

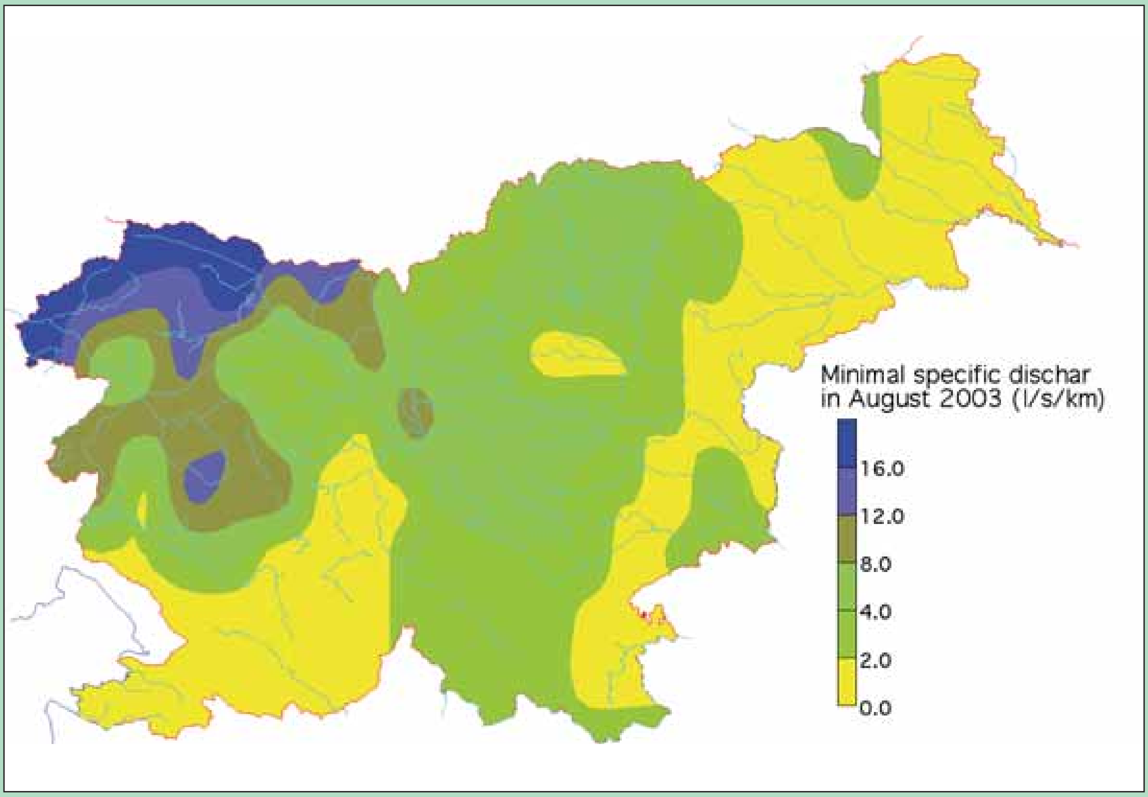

Fig. B2-11: Regional characteristic of hydrological drought in August 2003 in Slovenia (Source: Environmental Agency of the Republic of Slovenia)

occurring in the summer time. However, recently and for the first time, a new phenomenon of very long droughts, lasting beyond normally dry seasons, has been observed.
In the north-eastern Prekmurje region the hydrological groundwater drought lasted, almost uninterrupted, from 2000 to 2004, the 2003 intensive drought being just a part of the multi-annual event.
This new phenomenon might be one of the indicators of climate change.

Agricultural production is very probably the sector most sensitive to climatic fluctuations. Climate change as well as climate variability have a direct impact on the quantity and quality of agricultural production. Global climate models indicate that temperature will rise, but they are very inconsistent regarding precipitation forecasts. Current climate models are less accurate at smaller scales. At a regional scale in Slovenia there is clear evidence of changes in temperature and indications of higher evapotranspiration which generally results in a decline of soil-water availability.
Model results indicate the increase of extreme water deficit in all regions. There is some evidence that the water deficit will be more pronounced in the northern part of Slovenia. According to the current climate scenarios for Slovenia, the increase of extreme water deficit in a worst case scenario will exceed 50% in the northern part of the country. The 2003 drought was clear evidence of a change which was not expected even in projected scenarios. The temperature in the growing season was 3°C above normal and mostly only half of the precipitation was recorded over the season. It was a 'good' training example of possible changes. Changes in precipitation variability affect the occurrence of extreme events, like drought in 2003 and floods in the following year.

There is a clear need to identify the interdisciplinary nature of this issue. Improved adaptation of agricultural production and water management to climate variability and change should be prepared.

Growing concerns regarding the increase in water shortage incidents call for greater efforts in establishing future management strategies for natural resources and their relationship with climate and its variability. Inappropriate management of land use with severe climatic events can result in an increased probability of nutrient loss due to leaching. Prudent water management is needed to distribute water among competing users. The correct estimation of moisture status is important in ecologically focused agricultural decision-making: sowing, irrigation scheduling, cultivation, pest and disease management, fertiliser application. The limited water resources and inappropriate management can provoke adverse effects on water and soil quality. There is potential to improve the management of soil-water supply and thus to reduce risks while also taking agro-ecological zones into account.

There is a need to promote studies and to resort to agro-meteorological services to arrive at an improved understanding of natural climate variability. Current advances in the application of new technologies, such as remote sensing, constitute new sources of data for many applications. These complement ground observations. The role of early warning and weather monitoring for periods of favourable and especially of adverse climatic variation should be emphasised. The application of weather and climate forecast information to improve the response activities is essential. Therefore, dissemination of information and training of decision-makers, managers, State officers and of the general public should be promoted.

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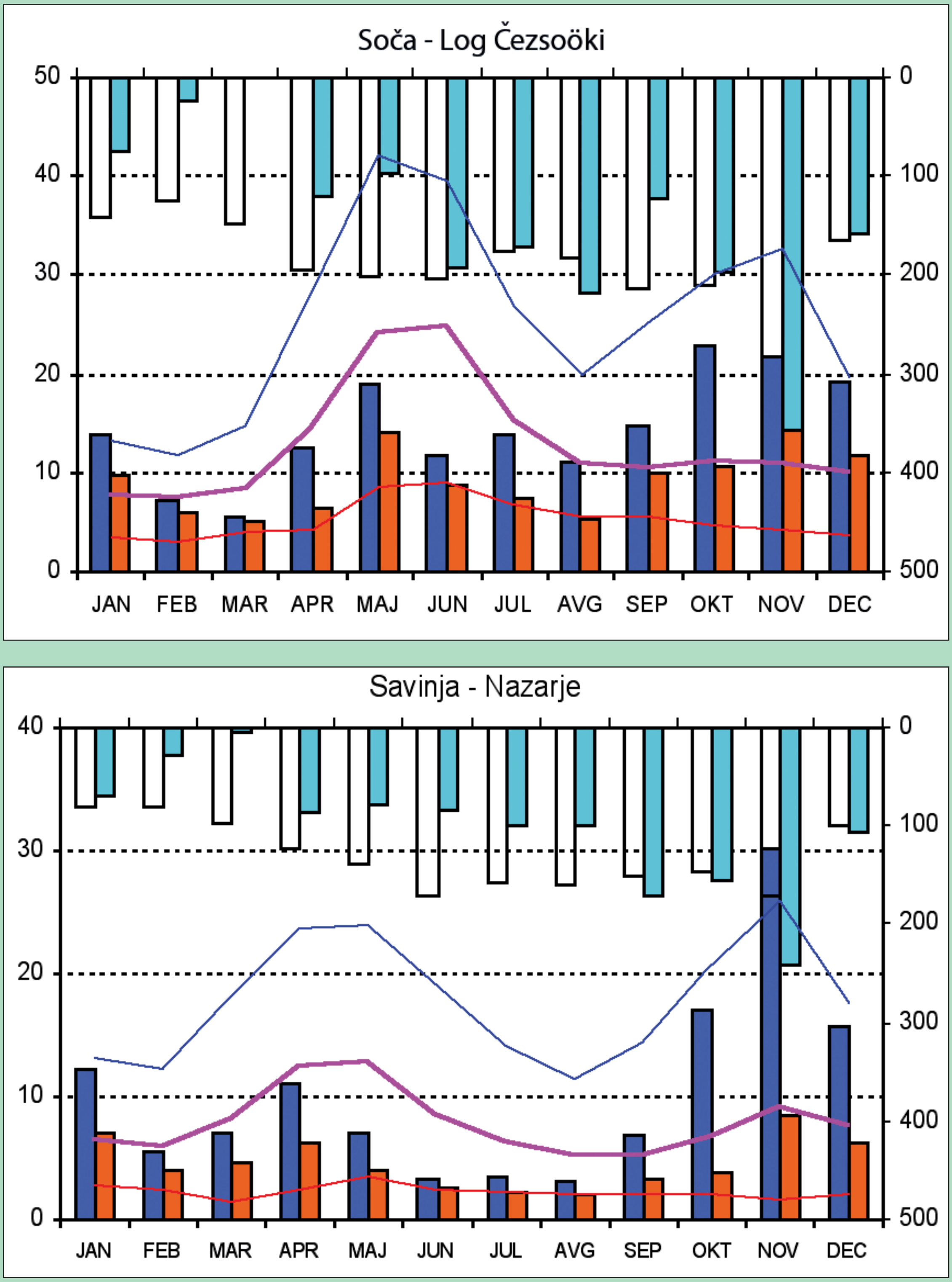

Fig. B2-12: Drought of 2003 as recorded at two gauging stations in the Alps.

Legend:
Mean (Qs) and minimum monthly discharges (Qnp) in 2003 and the monthly discharge values of the reference period: mean (sQs), mean flow (sQnp) and the lowest flow (nQnp) monthly discharges, monthly amounts of precipitation for the 1961-1990 period and the monthly quantities of precipitation in 2003 from the representative rain gauging stations

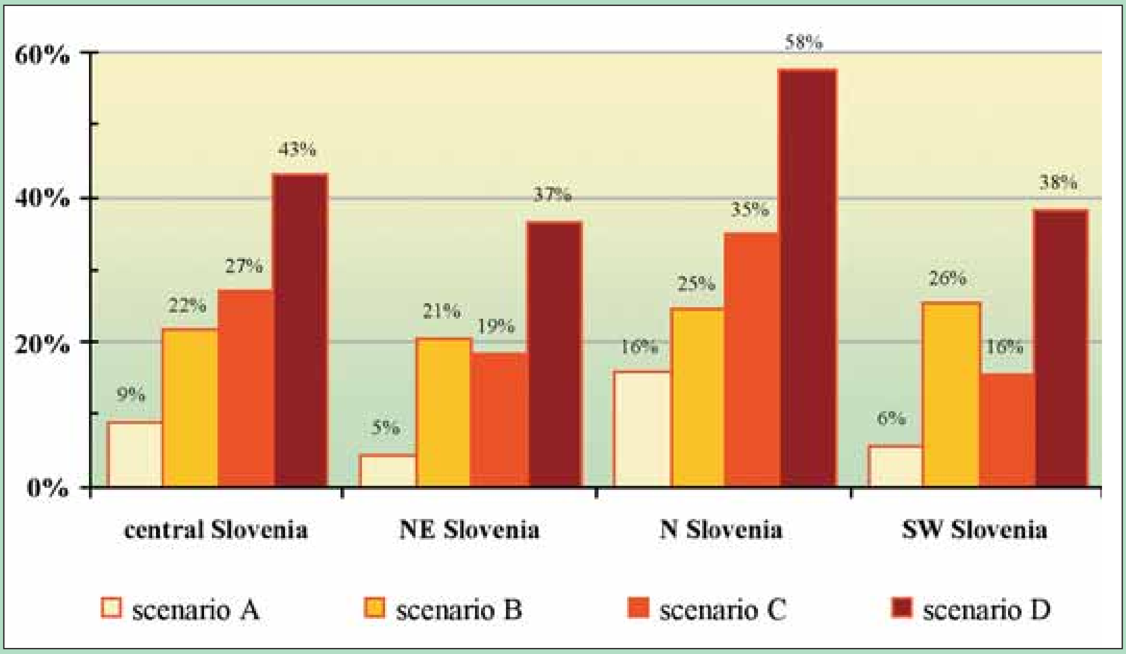

Fig. B2-13: Impact of different climate change scenarios on soil-water deficit in four main Slovenian regions.

Legend:
Scenario A: temperature rise of 1°C and unchanged precipitation regime
Scenario B: temperature rise of 3°C and unchanged precipitation regime
Scenario C: temperature rise of 1°C and 20% less precipitation
Scenario D: temperature rise of 3°C and 20% less precipitation.

National Contributions Regarding Information on Droughts and Water Scarcity

Austria

Generally, droughts and water scarcity are no major issue within the Alpine perimeter of Austria. This results from the fact that the mountainous region experiences relatively high precipitation, which may be as high as 3.500 mm per m^2 and year (northern and southern limestone Alps). The overall average for the whole country is about 1.100 mm/m^2 and becomes as little as 500 mm/m^2 in the east and north of Austria outside the Alpine perimeter.

However, high annual precipitation does not mean the complete absence of droughts, which have been occasionally experienced during the summer period also in the mountainous region in recent years, resulting in related negative impacts for agriculture. In the past, effects have been observed in particular in regions with a low capability to retain water. Such regions are especially areas with crystalline bedrock or sandstone formations with rather thin and poor soils as well as karstic areas, where water can drain off rapidly. The related negative effects were, for instance, extreme losses in fodder production apart from difficulties in water supply in small and scattered settlements.

Although water scarcity and droughts are no major issue at present, Austria may face some challenges in future. According to predictions,, climate change is bound to have an impact and will also be reflected by an increase in the phenomena of water scarcity and droughts during the summer period. This may impact various sectors like the public water supply, agriculture or hydropower generation. The necessary approach to counteract the different aspects of such developments is the reduction of demand, on the one hand, but also the diversification and development of additional water resources, on the other. As droughts imply significant decreases in average levels of natural water availability, water scarcity should be considered as a different matter, related to human activities which result in long-term imbalances between supply and demand. Based on this definition, water scarcity does not really occur in Austria. However, temporally restricted water availability can be the case outside the Alpine perimeter. At a very local scale, intensive economic activities (e.g. tourism) may also lead to water stress in the low-flow periods during winter time in the Alps. In such cases, a balance has to be sought between the interests of different stakeholder while providing incentives for the efficient use of water.

France

Water scarcity and droughts are apparently not a major issue for the French Alps. Benefiting from high rainfall (average ~1 200 mm/yr, compared to a national average of 750 mm/yr) the mountainous region shows an average natural run-off of 1,37 Mm^3/km^2. These average figures do not reflect the strong variations observed as the average rainfall ranges from 600 to 700 mm/yr in the southern part of the Alps (the middle Durance river basin) up to more than 2.000 mm/yr in the upper Alps (Savoie and Haute-Savoie). The snow cap and the glaciers (15 billion m^3) sustain the flow of torrents during spring and summer. The importance of storage in the lakes (5,5 billion m^3, Lake Leman excluded) should be noted.

As a consequence of very low rainfall occasionally observed in the past years, the southern part of the country (Provence and Côte d'Azur) faced water scarcity. As this has been frequently experienced in the past centuries, many facilities have been constructed to cope with water shortages:
derivation canals provide for ditch irrigation of grassland exposed to the sun in the central part of the French Alps. These rustic irrigation devices can be individual ones in the middle part of the Alps and, moving south, they may have been designed for larger farmers' cooperatives.

In the southern area, several canals (5 to 10 m^3/s) were built by the end of the 19th century to provide water for the French Riviera (at first for the "flower industry", later slowly converted to meet the needs of cities). More recently, in the 1950s, larger multipurpose dams (such as the Serre Ponçon dam on the River Durance – 1,3 billion m^3) provide a reliable amount of water for irrigation and for sustaining the river flow as well. Other facilities like the Canal de Provence divert water (15 m^3/s – possibly up to 40) from the River Verdon to provide resources for various uses (domestic, industry and agriculture) in the Provence area. All of this hydraulic infrastructure protects the whole southern region from droughts. Therefore, this region was somehow spared during the recent droughts.

This overall picture should not conceal local scarcities which call for restrictions in water use, which can be enforced frequently every other year. For example, a tight management of water resources to be used for irrigation was necessary in connection with hydroelectricity production from the Serre Ponçon dam. Lowering consumption for irrigation has been encouraged by subsidies from the River Basin Agency to encourage more efficient systems and the growing of plants with a lower water demand.

So far, the drinking water demand has usually been met without difficulty thanks to the facilities mentioned above: local groundwater in the northern and middle part of the Alps (except Annecy and Aix - cities relying on lakes), large regional transfers of surface water in the south, in particular for supplying the city of Marseille (60 km long canal with a capacity of 17 m^3/s).

As in other countries, France has also observed a rapid trend towards glacier recession as well as an increase in average temperatures. Against the background of the predicted climate change, a better management of the available resources will be encouraged, priority still being given to drinking water. The dilemma is how to reconcile increased production of hydroelectricity with minimum flows to improve water quality.

Germany

In the Bavarian Alpine region and in the Alp foreland lying to the north of this area, the hydrological conditions are generally favourable. The mean annual precipitation is over 1.000 mm and is distributed throughout the year, with the highest rainfall in June and July. Part of the winter precipitation is stored intermediately at higher elevations as snow and has a particular impact on the run-off in spring. Larger gravel bodies in the river basins still have a high groundwater storage capacity. These conditions mean that waterbodies on rivers and streams still have relatively good minimum run-offs, also during periods of low precipitation. The mean minimum run-off per unit area for Bavarian Alpine rivers is in the range of some 10 $l/s\ km^2$.
The Bavarian Alps and the Alp foreland provide a plentiful supply of water; the water availability in the past can be seen to have been good and is considered adequate for existing water-related uses: larger industrial consumers of water are primarily to be found along high-discharge rivers; agricultural sprinkler irrigation is not of significance. The drinking water demand can usually be met without difficulty due to the good water resources; groundwater is used at a regional scale, in particular also for supplying the city of Munich with water.

After the exceptionally dry year of 1976, specific dry periods with well below-average precipitation did not occur again until 2003 (from February to September in combination with a heatwave with approximately 30 hot days), in 2006 (in June/July) and in 2007 (April). Precipitation deficits during these periods led to a substantial decline in the run-off, which reached the range of average minimum water discharge (MNQ). Critical situations were not registered, with the exception of possible individual local bottlenecks in 2006 and 2007, thess being due in particular to the short duration of the minimum discharge incidents. The year 2003 was not a disastrous year either in spite of the prolonged dry period, heat and low water levels. The situation with regard to the quality was, with adequate 02 content, mostly stable and without exceptional incidents such as fish mortalities and restrictions of use. This is where the advancements made in the protection of waterbodies and the various possibilities for raising low discharge levels have had a positive impact. There were negative effects outside the area under observation caused by the low run-offs, especially as regards hydropower plants.

In conclusion, it can be said that water-related uses in general were able to cope well with the dry periods of recent years, this being due to the favourable natural conditions and the high status of hydrological infrastructure. The expected impact of climate change, which is also likely to cause more pronounced dry phases and low precipitation periods, will definitely necessitate further adjustment measures. This issue is the topic of current investigation.

Italy

Phenomena of water scarcity in the Italian Alpine and pre-Alpine area are observed in numerous small areas across the entire area. There are no clearly quantified areas of drought, but in the last decade a decrease in total annual rainfall has been observed (Data source: APAT, Arpa Emilia Romagna, Po River Basin Authority, Adige River Basin Authority).
Incidents of water scarcity in the Alpine area are generally due to two phenomena that, in certain cases, may coincide. Firstly, the exploitation of resources from both streams and water springs causes low water flow in rivers; such situations are generally of limited duration but can become chronic. Secondly, the vulnerability of mountain water supplies, often obtained directly from high altitude springs or water tables near the surface, which are therefore very sensitive to variations in the water regime and not able to satisfy peak demands during the tourist season. Phenomena of water scarcity are enhanced during drought periods.

During the droughts in 2003, 2005 and 2007, situations of utmost difficulty regarding the provision of drinking water affected various municipal areas of Piedmont, most of the municipal areas in the foothills of Friuli Venezia–Giulia and various municipalities of the Autonomous Province of Trento. During these droughts, it was necessary to provide emergency services using vehicles with water tanks in these areas. With regard to levels of water flow in rivers, widespread problems throughout the entire Alpine area were reported during the same periods (Data source: Po River Basin Authority, Regione Veneto, Regione Piemonte, nell'ambito delle riunioni delle Cabine di Regia).

Over the last few years, due to the concurrence of global warming and the growing pressure of tourism in both summer and winter and the increase in water consumption for various uses, in particular hydropower, problems of water scarcity have persisted throughout the entire year. The situation becomes critical during peak tourist periods, during which time there are higher levels of demand for different water uses as well as for artificial snow.

Water scarcity and droughts have a direct impact on citizens and economic sectors which use and depend on water, such as agriculture, tourism, industry and energy. Tourism represents the most vulnerable sector, because the occasional lack of resources to satisfy human requirements as well as the difficulties in providing supplies for programmed snow equipment. This sector is also affected during the summer period when the lack of water flow along the rivers brings about major changes to the natural landscape. In relation to agriculture, despite a reduction in the areas being cultivated in the Alpine areas, water scarcity and droughts have a negative effect upon agricultural yield. From an environmental point of view, the lack of water compromises the achievement of quality objectives as laid down in the EC Directive 60/2000.

The geographical layout of Northern Italy is such that the water which is stored as a resource in the Alps, and its management, have a notable effect also on areas downstream and play a considerable part in generating serious problems in relation to both the environment and production. It is therefore essential to be a careful in managing the resources stored in the major lakes as well as in the Alpine reservoirs, as this allows difficulties in agricultural and industrial production to be contained as well as phenomena that place the environment at risk around the major rivers flowing from the Alps to be prevented.

The economic costs of water scarcity and droughts are rather limited if we consider the Alpine area alone, but they assume entirely different proportions from a wider point of view, taking into account what has been described above, and considering the river basin as a whole.

As far as preventive measures to counteract crisis situations due to water scarcity and drought are concerned, an Order of the President of the Council of Ministers was issued in 2007 regarding "Urgent civil protection measures aimed at dealing with the present state of emergency in the central and northern regions of Italy affected by the water crisis which is causing a situation that is seriously harming national interests". A special national commissioner was appointed under this Order with the task of coordinating all initiatives concerning water. The Order provides for a contingency phase in which to deal with emergency situations and a programming phase in which to identify short-term structural measures to be carried out.

In future, the task of coordinating initiatives to deal with phenomena of water scarcity and drought will be carried out by the district authorities established pursuant to EC Directive 60/2000.

Slovenia

The Alps extend into Slovenia from the north and north-west. This is the high-mountain area of the Julian Alps, the Kamniško-Savinjske Alps and the Karavanke Mountains. The area is surrounded by a belt of hills and river valleys. The larger river valleys are those of the Soča, Sava Dolinka, Sava Bohinjka, Kokra, Kamniška Bistrica, Savinja and Drava rivers. According to the geographical regionalisation of the country, the Alpine area in Slovenia covers 8.541 km^2 or 42,1 % of the Slovenian territory, with an average elevation of 731,6 m and an average gradient of 18,4°.

The Alpine area is characterised by high precipitation because of its exposure to south-western winds and orographic lifts, by rapid run-offs due to steep slopes, and by very low evaporation because of the lower temperature effect at higher altitudes. The geographical distribution of precipitation is strongly linked to the topography of the relief. The highest amount of precipitation, on average more than 2.600 mm per year, falls on the windward side of the ridges in the Julian Alps. More than 3.200 mm of precipitation may fall on the highest ridges. This area is one of the most water-abundant areas in the Alps and in Europe. Elsewhere, in the Julian Alps, in the Karavanke Mountains and on the periphery of the high Dinaric plateaus annual precipitation is between 2.000 and 2.600 mm. In all of the above-mentioned regions, the quantity of precipitation can vary significantly from year to year and therefore both years of drought or water scarcity and extremely wet years have been recorded. In general, a statistically significant decrease in the annual quantity of precipitation has been observed at a large number of stations, although there are many sites where changes in the annual quantity of precipitation is not statistically significant, or even increases have been observed. In the Alps, the quantity of precipitation changes within the individual seasons: it increases in autumn, diminishes in winter and spring, while there are no significant changes in summer.

The mountainous character of the Alpine region is also reflected by its evaporation, which tends to be on the lower side for the country as a whole. The value of average annual evaporation in this region is between 550 and 600 mm. These values are scattered across the entire Alpine and pre-Alpine area. The lowest evaporation is below 550 mm per year in the highest parts of the Julian Alps. Like the precipitation regime, some noticeable changes are also detected in evaporation. During the vegetation period (April-September), an increase in cumulative evapotranspiration is observed in the Alpine region. There is a statistically significant trend in the number of days with a high evapotranspiration rate (> 5 mm/day), in the lower parts of the Alpine region (Sava Dolinka valley) for 24% per 10 years. Therefore an increasing trend in water deficit during the vegetation period has also been recorded (3,6% per 10 years).

Drought phenomena and changes in the run-off regimes have been seen throughout Slovenia since the 1990s as a result of the impact of climate change. The scarcity of water is the consequence of precipitation deficits, which are reflected by low flows and low levels of groundwater, and are usually most pronounced in the southern, eastern and north-eastern parts of Slovenia, while in north-western and northern Alpine parts it is not so obvious. During major regional drought events, the specific discharges are highest in Alpine and hilly regions while hydrological droughts are not as severe there as in other parts of the country. Regarding groundwater, the Alpine region is not a critical part of the country due to its climatic characteristics with the highest precipitation in Slovenia. However, water scarcity is experienced locally from time to time in some mountain areas supplied by low-yield local sources.

In Alpine regions hydrological droughts usually occur in winter and in summer. The most severe hydrological droughts are characterised by long continuous periods with low flows, which may last for even longer than one third of a year. Low flows have been especially frequent in the period since 1970. Of the 9 severe droughts in Slovenia in last 40 years (1967, 1971, 1983, 1992, 1993, 2000, 2001, 2003, 2006), six of them were registered in last 15 years. The trends in the minimum annual discharges lasting 1,7 and 30 days indicate a statistically significant decreasing trend especially for mountainous catchments. At the same time, a trend towards increasing water temperatures can be observed.

A growing water deficit and higher frequency of droughts in most of Slovenia have been observed in the past fifteen years, and they are also changing in variability and duration. The scarcity of water has been most visible in agriculture and in the drinking water supply as well as in hydropower supply. The damage due to drought is increasing, especially in agriculture. In the Alpine region economic losses in agriculture are not as noticeable as in other parts of Slovenia. Nevertheless, severe droughts which occurred after 2000 have also caused draught damage to agricultural land in the Alpine region, especially to grazing-land. This has affected animal husbandry. The increase in frequency and magnitude of the dry seasons are likely to become more common and more severe in the Alpine region of Slovenia if the climate becomes warmer. The very dry year 2003 is already ranked among the warmest years on record. On the other hand, water scarcity and personal hardship in this year have underscored the vulnerability of society as a whole. It is a clear signal of increasing societal vulnerability resulting from an unsustainable use of resources and from growing pressures on natural resources in water-surplus areas as well.
The development of industry, tourism and communication infrastructures has already put pressure on some mountain areas in Slovenia. Under a changing climate, some conflicts of interest in these regions between economic development and environmental sustainability are very likely to occur. In the Alpine region during the periods of water scarcity these may arise between different stakeholders such as agriculture and tourism within the country, or between countries because of transboundary waters issues.

The currently observed widespread decrease in snow cover duration at various low and middle altitudes in the Alpine region in Slovenia is associated with a rise in temperature. Winter tourism is likely to be adversely affected by rising temperatures due to its high level of dependence on reliable snow conditions. It is estimated that, if the snow reliability boundary shifts from 1.200 m to 1.800m, Slovenian ski resorts will become unable to operate due to snow unreliability.

The Alps have a high water resources potential for the rest of the country, which has not been fully utilised so far. By accumulating water in water reservoirs in headwaters of large streams, the drought and water scarcity problems during dry seasons in downstream areas may be alleviated.

Apart from surface waters, the other important resource in the Alps is groundwater, which is traditionally the chief source of water supply in Slovenia. So, the groundwater resources in the Alps may play

a significant role in mitigating the consequences of water scarcity at a national level. Recent investigation has shown that the gross yield of the springs in the Alps amounts to 10,6 m^3/sec at periods of low flow. Taking into account that the ecological flow has to be secured, the available or net amount is assessed to be 7,3 m^3/sec. With current water abstraction in the country being about 6,9 m^3/sec, this means that groundwater from the Alpine region would be able to meet the drinking water demand of the whole country. While a problem of poor groundwater quality exists in some alluvial aquifers outside the Alps, groundwater in the Alps is very clean. Standards set by WFD should be regarded as being too low in the Alps, where the groundwater is now of a high quality. This should be a compelling reason for imposing higher water quality standards for the groundwater in the Alps in order to preserve this precious resource. More stringent measures regarding water quantity and water quality are imperative to protect very vulnerable Alpine aquifers.
In managing droughts and water scarcity in the country, further steps in the foreseeable future include the following:

- providing for the precise estimation of the probability of the onset of droughts at local and regional scales, as well as applying state-of-the-art scientific tools and methodologies,
- development and improvement of technology for short-term and long-term monitoring, man-agement and prevention of droughts and integration of GIS, remote sensing, simulation models and other techniques for more precise early warning drought forecasts,
- building up awareness and education of both policy makers and the general public for drought preparedness, as well as a sound relationship to water use, and finally
- institutional strategies, such as the application of regional and national programmes – by the Drought Management Centre for south-eastern Europe which is headquartered in Slovenia.

These steps will be beneficial to the Alps as well, and even more so if the specific problems of the Alps are duly recognized.

Switzerland

In general, droughts and water scarcity are not major issues in Switzerland. Locally and only during relatively short-time periods are droughts and consequently some water scarcity observed, e.g. in central Valais or in the southern part of the Alps. In these regions irrigation systems have traditionally been in existence for quite a long time. One well-known example is the water system that transports melt water from the glaciers to the irrigated meadows in Valais. According to a recent survey of the Swiss Federal Office for Agriculture the temporarily irrigated area amounts to a total of about 35.000 ha in the Swiss Alpine region. The Federal Office for Agriculture subsidies the investments in irrigation equipment in these regions.

During the dry and hot summer of 2003, parts of Switzerland (especially those not benefiting from increased melt water contributions) and some water sectors experienced, to a certain extent, scarcity phenomena. An analysis of the impacts on the water resources has been carried out and published (BUWAL, BWG, 2004: Auswirkungen des Hitzesommers 2003 auf die Gewässer. Dokumentation. 176 S).

In the last 100 years, Switzerland has seen three hot and dry years: 1947, 1976 and 2003. Thanks to the strong physiographic small-scale variability in Switzerland (from lowlands to glaciated areas, from regions exposed to the Atlantic climate to regions influenced by the Mediterranean climate etc.) impacts from dry spells are regionally very different.

Switzerland is also in the fortunate position of featuring many natural storage elements of the water cycle such as e.g. glaciers and the big lakes on the border between the Alps and the lowlands, levelling off natural fluctuations and providing water during dry periods.

However, in some small rivers that are not fed by snowmelt or glacier melt water, critical situations in exceptionally dry periods, such as the summer 2003, may occur, leading to conflicts of interest between the different water users and the ecological requirements. Therefore some Cantons impose regulations and limitations on water withdrawals, especially for irrigation, during dry periods.

Apart from quantity, it is also temperature that may become critical during dry and hot periods. Some of the fish species have clear upper temperature thresholds above which lethal effects occur, as was also observed in some massive fish-mortality incidents during the summer of 2003 e.g. downstream of Lake Constance. An adaptation measure in some areas included the relocation of fish from critical rivers (at risk of drying out) to rivers with sufficient water and tolerable temperatures.

Temperature can also play a role in limiting water uses such as cooling. Since the Swiss Water Conservation Act defines upper temperature thresholds, limitations on discharges and cooling can be imposed. This can affects, for example, the operation of power plants (nuclear or thermal), which need water for cooling and have to lower their power output during dry and hot spells.

With respect to groundwater, the situation very much depends on the underground's storage capacity. Under unfavourable hydrogeological conditions (shallow underground layers), scarcity may occur."

Springs fed by near-surface groundwater layers may also show a significant decline in discharge as a consequence of dry periods. In contrast, thick groundwater layers, such as those in the big alluvial main valleys – which play an essential role in the drinking water supply - also benefit from river infiltration, and profited during the summer of 2003 from high discharges due to an increased glacier melt, have a "long memory": Their behaviour reflects long-term alterations in precipitation but have the potential to filter out short-term meteorological fluctuations.

All in all, most of the drinking water suppliers could provide their services without any curtailing even during the hot and dry conditions during the summer of 2003 thanks to sufficient resources on the one hand and the investment in infrastructure and interconnections established in the last years on the other hand. Problems and restrictions in the water supply occurred in a few small and isolated water supply networks, which mainly depend on single springs. Significant qualitative problems regarding water used for the drinking water supply was not observed during the summer of 2003.

If qualitative problems occur, they do so downstream of water-treatment plants when low water flow leads to weak dilution and therefore to higher pollution concentrations. This may occasionally be the case in winter resorts during the peak tourist season in winter when increased discharges from the resorts coincide with the naturally low flows in the Alpine rivers.

A strategy that is currently being developed at a national level to tackle qualitative problems in rivers which frequently feature problems related to the weak dilution of pollutants (especially micropollutants) is an additional treatment process for wastewater treatment plants.

B.2.3.3 RESERVOIRS AND REGULATED LAKES

This chapter focuses on reservoirs and lakes from a quantitative perspective, i.e. regarding their role and function as storing and balancing elements in the water cycle.
The topography of the Alps provides perfect preconditions for the construction of artificial reservoirs for the storage of water. But there are also many natural lakes located within or on the border of the Alpine arc, with a number of them being equipped with facilities for the regulation of the water table and of discharge. The largest natural lakes are mostly located in the pre-Alpine areas in the transitional zone between Alps and lowlands. Both, reservoirs and lakes are highly prominent and remarkable landscape elements. From the hydrological and water resources management perspective, they represent significant water storage and balancing elements, influencing the hydrological regime. Their main impact on the water cycle is the storage of water, thereby influencing the natural flow conditions of rivers on the one hand (balancing and straightening the naturally given strong run-off fluctuations in time) and serving different forms of water demand on the other. Depending on the volume and regulation scheme, reservoirs and regulated lakes can provide water in periods when the natural flow conditions would not meet the anthropogenic water demand. This function is provided, in the long term, by retaining water in high flow periods when the natural resource is abundant. On a shorter time scale, their flood retention function is of particular importance.
The case study on the River Po basin in chapter B 2.3.2 provides an illustrative picture on the role of reservoirs and lakes in the management of water scarcity in downstream areas.

Section on reservoirs

Map 18 (in this chapter) provides an overview of dams and reservoirs located within the Alpine Convention perimeter.
The majority of (artificial) reservoirs in the Alps were designed exclusively for hydropower generation.
Other purposes are flood control by the retention of water besides the provision of irrigation and drinking water. Additionally, reservoirs and regulated lakes are used for securing a minimum discharge level for downstream rivers during dry periods and thus providing better run-off conditions. Finally, artificial reservoirs and lakes may also function as sediment traps or be an important element for leisure and recreational activities. Increasingly, reservoirs and ponds are also being built for the storage of water for artificial snow production. However, these reservoirs are designed in general for much smaller volumes compared to their hydropower counterparts.

Only a few reservoirs are multifunctional, i.e. use their storage capacity deliberately for multiple purposes like hydropower generation and flood retention.

However, it is important to note that even reservoirs that are not specifically designed for the purpose also have, due to their nature, a water/flood and sediment retention effect (depending on their filling-level).
Other side-effects that go hand in hand with the construction and operation of reservoirs in the Alps are the necessity of constructing and maintaining infrastructure (roads, cable cars, etc.) and the provision of access to remote valleys.

The favourable topographic precondition in the Alps for building reservoirs is, in this respect, a comparative advantage for the Alpine countries. Reservoirs can be used to store electricity when there is a surplus in European energy production and to deliver electricity at short notice if the demand on the European electricity market is high.

Therefore reservoirs act as "batteries", satisfying peak demands and stabilising the European electricity grid. In the last years, this has become increasingly important against the background of developments on the European electricity market in the wake of the EU electricity liberalisation and not least also due to the boom in wind power, characterised by strong fluctuations, requiring a backup energy supply. In financial terms, the provision of peak electricity is very profitable.

Altogether, this explains why reservoirs and pumped-storage facilities have become increasingly important for the European electricity supply system.

Another driver causing a "renaissance" of reservoirs for hydropower (new construction or extension of existing facilities) is the promotion of CO_2-free renewable energy production in the context of climate change mitigation policies.

However, hydropower reservoirs in particular cause ecological problems as the stored water is diverted with resulting residual flow reaches downstream of the dams, characterised by heavily altered flow regimes (no or little

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Photo B2-17: Reservoir and regulated lakes as balancing elements in the water cycle (Vorderrheinbasin)

flow most of the time and no floods with detrimental consequences on the morphology).
Such an example is illustrated in the case study of the River Spöl in chapter B 3.4.

Further downstream (after the hydropower stations release the diverted water back into the river system), the accumulated reservoir volumes in the upstream watershed are, in some cases, so high that they can significantly influence the downstream flow regime (causing mostly a seasonal shift of run-off from summer to winter due to their operational regime). In order to illustrate the amount of water that can be stored in the Alpine reservoirs, the following table provides the accumulated Alpine reservoir volumes for some river basins:

Total volume of reservoirs[49] within the Alpine Convention perimeter located in the	
Rhine basin	ca. 1.800 million m^3
Danube basin	ca. 1.900 million m^3
Rhône basin	ca. 5.200 million m^3

Tab. B2-6: Accumulated Alpine reservoir volumes for some river basins

However, even if these figures may appear gigantic, they need to be put into perspective against the volumes of natural lakes. In the following section on lakes, a table with the volumes of natural lakes in the wider Alpine area is provided, setting another level of magnitude which clearly exceeds the figures for reservoirs.

Another way of putting the accumulated reservoir figures into perspective is to translate them into a uniform mean run-off and compare them with the run-off at a major downstream gauging station in the respective river basin. Doing so for the above mentioned figures, this results in:

- 57 m^3/s for the Rhine, compared to the mean run-off 1.060 m^3/s (period 1901-2000) for the Rhine at Basel
- 60 m^3/s for the Danube, compared to the mean run-off 1.940 m^3/s (period 1996-2004) for the Danube at Vienna[50]
- 165 m^3/s for the Rhône, compared to the mean run-off 1.700 m^3/s (period 1920-2005) for the Rhône at Beaucaire[51]

The purpose of this comparison is not to provide exact figures on flow contributions (this would require further reflections with respect to which tributaries are to be considered and to the actual availability and seasonality of flows from reservoirs), but are simplistic arithmetical examples in order to render these figures more imaginable. Furthermore, most reservoirs are located upstream of lakes with significantly higher volumes, modulating the run-off. However, while the figures show, from a perspective of the entire river basin, that the stored volumes are not negligible, they illustrate also the limited extent as they lie within the year-to-year variations of the considered gauging stations' run-off.

With respect to the operational regime of the large hydropower reservoirs, some modifications in the regulation policy have been observed in the last years. Be it because of changes on the demand side of the electricity market, be it because of changes or the emergence of new interests (e.g. air conditioning systems in summer), be it as an adaptation to climate change or be it due to changes in the inflow and natural water availability, the traditional seasonal patterns have seen some slight alterations (e.g. the typical filling up of the reservoirs during spring and summer to reach the maximum level at the end of September and the turbining of the stored water during the winter period in order to meet the higher electricity demand have become less pronounced, as turbining has now also increased during other periods to satisfy peak demands).

Section on lakes

In most cases, the regulation scheme of lakes is a com-

©J. Zimmermann, WWA Traunstein
Photo B2-18: Pre-Alpine Lake Chiemsee in Bavaria

[49] Figures calculated on the basis of data provided by the AC countries

[50] not yet including the discharges of the rivers Mur and Drava, which are also fed by the Alpine area but flow into the Danube downstream of Vienna
[51] this includes e.g. also the discharge of the River Saône (approx. 400m3/s), with its basin completely outside the Alpine perimeter

promise between the different interests around the lake and the downstream areas.

The local perspective (i.e. the interests from the stakeholders along the lake's shoreline) and the downstream perspective (i.e. the possibilities and impacts of the lake regulation for the water management of downstream river reaches) cannot always be aligned: As an example, there is an intrinsic conflict when it comes to flood control, with the people at the lake wishing to release as much as possible to keep lake levels low in order to prevent inundations and the "downstream-interest" to hold as much water back as possible and use the lake as a retention basin.
A number of natural lakes (but not all) have been systematically regulated in order to guarantee high and low levels compatible with other activities around the lake (flood prevention, tourism, leisure and recreation, navigation, drinking water supply, hydroelectric energy production, ecosystem conservation, etc.) and interests from downstream (flood prevention, irrigation of agricultural land, topping up run-off during dry spells for several aspects, etc.).

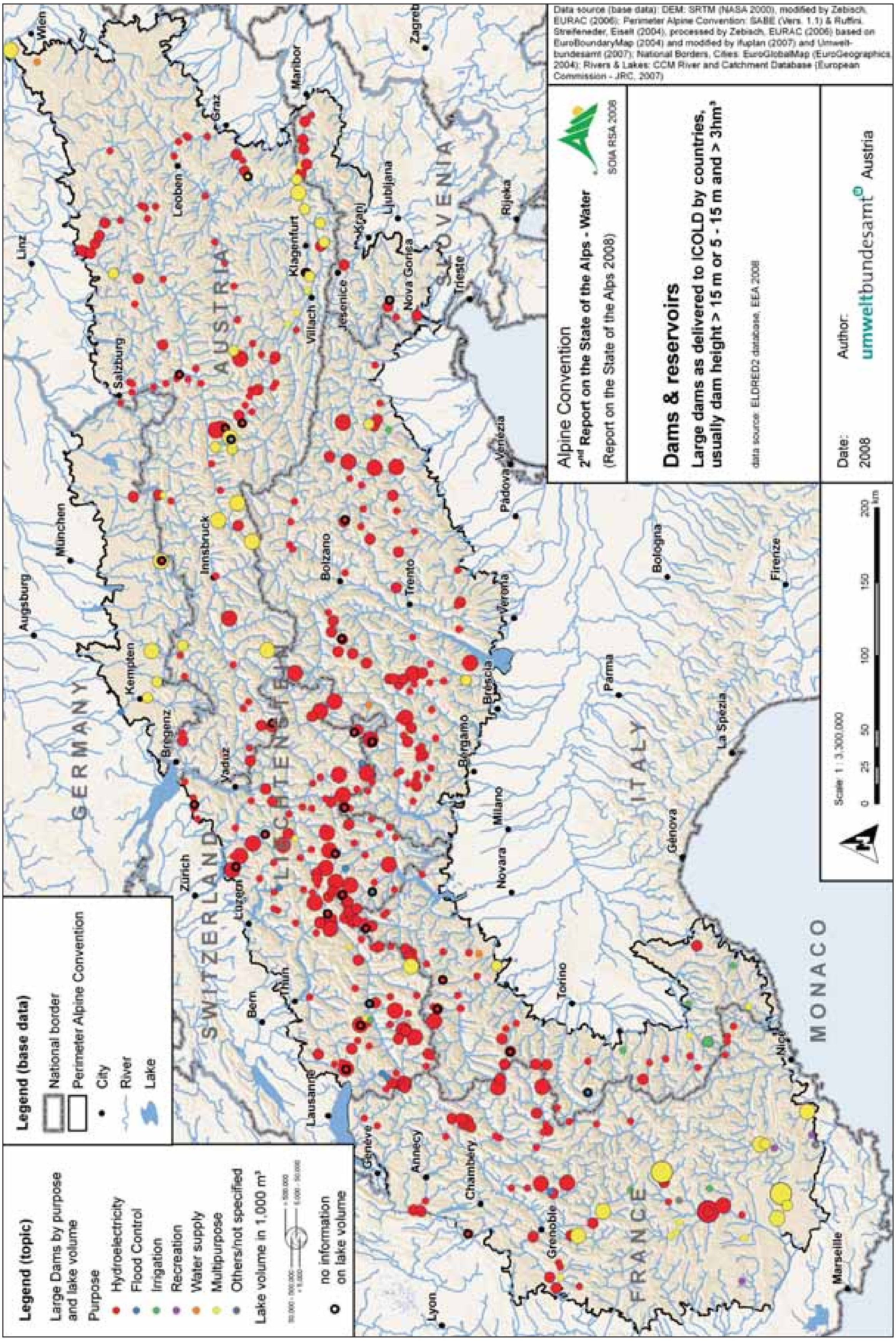
For quite a number of the large natural lakes on the borders of the Alpine area international commissions have been set up who are in charge of the regulation scheme and / or coordinated water protection programmes (e.g. CIPEL for Lake Léman, IGKB for Lake Constance, CIPAIS for the Swiss-Italian lakes etc.). Likewise, syndicates especially founded for lake regulation affairs exist for many lakes within national borders.

The following table lists and provides information[52] on Alpine lakes with an area > 10 km²

Name	Country	Area	Max. Depth	Trophic Status	Volume
		[km²]	[m]		[Million m³]
Lac Léman (Lake Geneva)	CH, F	581	310	mesotrophic	89.900
Bodensee (Lake Constance)	AT, DE, CH	Obersee:473 km² Untersee: 63 km² Total: 536 km²	254	oligo-mesotrophic	49.000
Lago di Garda	I	354,46	346	mesotrophic	49.000
Lago Maggiore	CH,I	197,62	372	oligo-mesotrophic	37.100
Lago di Como	I	133,61	425	mesotrophic	22.500
Vierwaldstättersee	CH	114	214	oligotrophic	11.800
Lago d'Iseo	I	53,21	251	eutrophic	7.600
Lago di Lugano (N)	CH, I	28	288	eu-hypertrophic	6.560
Lago di Lugano (S)	CH, I	21	288	eutrophic	
Thunersee	CH	48	217	oligotrophic	6.500
Brienzersee	CH	30	261	ultra-oligotrophic	5.170
Attersee	AT	46,2	169	oligotrophic	3.943
Zürichsee	CH	90	143	mesotrophic	3.900
Lac du Bourget	F	44,6	145	mesotrophic	3.600
Zugersee	CH	38	198	eu-hypertrophic	3.210
Walensee	CH	24	150	oligotrophic	2.490
Traunsee	AT	24,4	191	oligotrophic	2.188
Chiemsee	DE	79,9	73	mesotrophic	2.048
Walchensee	DE	16,3	190	oligotrophic	1.300
Lago d'Orta	I	15,48	143	oligotrophic	1.300
Lac de Serre-Ponçon	F	32	129	mesotrophic	1.270
Millstätter See	AT	13,3	141	oligotrophic	1.205
Lac d'Annecy	F	26,5	65	oligotrophic	1.100
Wörthersee	AT	19,4	85	slightly mesotrophic	816
Wolfgangsee	AT	12,8	113	oligotrophic	667
Mondsee	AT	13,8	68	oligo-mesotrophic	497
Ossiacher See	AT	10,8	52	slightly mesotrophic	206
Lac de la Gruyère	CH	10	75	no indication	200
Forggensee	DE	14,4	35	mesotrophic	160
Lago di Varese	I	14,34	26	hypereutrophic	153,64
Sihlsee	CH	11	23	no indication	96,5

Tab. B2-7: Information[53] on Alpine lakes with an area > 10 km²

[52 and 53] data provided by the AC-countries



Map 18: Dams and reservoirs

Conclusions

The two main issues regarding reservoirs and lakes in the Alpine space are deemed to be the following.

With respect to reservoirs, it is their energy supply capacity: After the main boom of reservoir construction in the Alps during the period 1950-1970 and after stagnation until the turn of the millennium, reservoirs again increased in importance for the European electricity supply system, satisfying peak demands. This fact can be regarded as being a natural comparative advantage for economically disadvantaged peripheral Alpine valleys and regions. This circumstance may be reflected in i) the construction of some new reservoirs, ii) mostly in the expansion and optimisation of existing reservoirs and iii) in the installation of pumped storage facilities. There is an obvious risk related to these developments that this additional exploitation will increase the impact on ecological conditions. However, it is most likely that energy (supply guarantee) and climate (CO_2-free energy production) policies will act as drivers and continue to promote the development of reservoirs. On the other hand, those in favour of nature conservation have a strong instrument at hand, provided at EU level by the Water Framework Directive and in Switzerland by the existing water protection legislation and by related ongoing initiatives. To sum up, both economic and ecological parties have a firm stand. Procedures focusing on weighing interests are indispensable and should strive for optimial trade-offs, where both concerns are considered. Innovative solutions, the mitigating of the adverse ecological effects of reservoirs (sufficient residual flow, artificial flooding, attenuating basins against hydro-peaking, definition of ecologically less valuable areas with stronger exploitation and determination of ecologically highly valuable areas without exploitation etc.) are suggested.

With respect to lakes, it is their capacity to act as balancing elements in the water cycle: More than ever, their role of providing water for the downstream area during dry periods must be increasingly stressed in the light of climate change, for which dry and hot summer spells are predicted to occur more frequently. It is, however, important to note that the potential of regulating and topping up run-off for the downstream area is limited due to restricted lake storage capacities and the interests of parties at the shores of the lakes themselves. Thus, expectations from downstream areas should be aware of this and regard upstream lakes only as an attenuating factor for satisfying their demands but strive to find solutions with regard to the demand side.

National Contributions Regarding Information on Reservoirs and Regulated Lakes

Austria

The mountainous character of Austria's landscape and high precipitation are an ideal basis for the generation of hydropower in connection with the construction of artificial reservoirs and the use of natural lakes. The assessment for the Article 5 Report of the EU Water Framework Directive (WFD) revealed 62 standing water bodies with an area larger than 50 ha (regarding the area of the water surface) in the whole country, 19 of these 6 are artificial reservoirs and the rest are natural lakes.

15 of the 19 artificial reservoirs are located in the mountainous region of Austria. Additionally, a high number of smaller reservoirs were built during the last decades, culminating in a total number of 95 Alpine reservoirs in the country, which were designed exclusively for the purpose of hydropower generation. The number of reservoirs for artificial snow production is also increasing steadily.

Apart from man made reservoirs, a limited number of lakes are used for hydropower generation as well, resulting in variations in the natural water level. However, the variations are rather minor compared to artificial reservoirs. Out of Austria's 43 natural lakes with an area larger than 50 ha, artificial water level variations in excess of 1m occur in 6 cases (Lakes Achensee, Heiterwangersee, Hintersee, Hintersteinersee, Plansee, Vorderer Gosausee) , which therefore have undergone significant modification. The purpose of regulation and the function of the related facilities is hydropower generation in all 6 cases, with the natural lake acting as a water reservoir.

Apart from electricity production, the water levels of Austria's man-made reservoirs and regulated lakes are often managed with the purpose of mitigating floods at a local level. Because water is used for energy production during winter time, the reservoirs are re-filled during the summer and can, to a limited extent, be used for the storage of water in case of flood risk. Therefore, their operation is most effectively managed on the basis of forecast models for precipitation and the discharge of rivers.

Specifications for the management of reservoirs are part of the licenses issued by the competent authorities and may set threshold values for the maximum discharge in case of hydropower generation, for instance, (with the aim of reducing the level of hydropeaking and the interrelated negative impact on ecology).

France

The 5 largest French natural lakes are under improvement

According to the EFWD ranking, the French Alps have nine natural lakes that include five of the largest expanses of water on the French side of the Alps (Lakes: Léman – shared with Switzerland-, Bourget, Annecy, Paladru and Aiguebelette). They have a total area of 660 km^2 and a volume of 94.000 million m^3. During the second half of the 20th century, the development of their catchment areas strongly affected their quality: eutrophication resulting from urban and agricultural activity, phosphorous, bacteriological pollution resulting from discharges of wastewater, the presence of pesticides, micro-pollutants from road run-off, effluents from industry, towns and the atmosphere, excessive coastal artificialisation, "over-visiting" of some areas, biological discontinuity with tributaries, etc. In response to this situation and to the Loi Littoral (Coastal Zone Law) of January 3rd 1986 (which has the double objective of protecting sites and the natural heritage of lakes covering more than 1.000 ha, while at the same time preserving the economic development of these areas) working programmes have been launched and paid for by local authorities, the State and the French River Basin Agency. 600 million euros have been invested with the sole objective of addressing urban pollution in the catchments of four large Alpine lakes (Léman, Bourget, Annecy and Aiguebelette).

The impact of these programmes is visible today: the trend of deterioration in water quality has been reversed and despite the slow response of these fragile ecosystems, only two of them will not be able to reach a satisfactory ecological state by 2015 (Bourget and Paladru which are currently meso-eutrophic).

18 hydroelectric reservoirs considered as meeting good quality target by 2015

The other 18 artificial lakes (or "reservoirs") listed in the EWFD have been created by the division of rivers by hydroelectric dams. They represent a total area of 88 km^2 and a volume of 3.800 Mm^3. They sometimes operate as part of a cascading system (as in the case of Verdon and Drac) of several hydroelectric power plants. These man-made environments often support other major uses (for four of them, production of drinking water and irrigation, and, in the case of the Serre-Ponçon reservoir, include high tourism activity) and are almost always associated with activities ofhigh socio-economic value such as tourism, swimming, and fishing. In some cases, they represent environments of high ecological value. In general, they all present good quality, with a good ecological state being targeted for 2015.

Remaining concern about environmental expectations for most of these lakes

Whether they are natural or artificial, the water levels of these 27 lakes are systematically regulated by structures modifying their natural behaviour so as to meet, in general terms, hydroelectric energy production requirements. In some cases (in particular large natural lakes and also large reservoirs in Provence over the Durance and Verdon rivers) agreements guarantee high and low levels compatible with other activities around the lake (flood prevention, tourism, navigation, drinking water supply, etc.). However, this shoreline management is rarely carried out from an environmental standpoint. Such management is thus very often unsatisfactory for the lake's ecosystem (such as reed beds). Their upstream and downstream tributaries can also be affected, particularly during low water periods and despite respect for minimum biological flows of downstream rivers (compensation water).

Only a few natural lakes are public domain (Bourget, Léman, Annecy), the others are owned (or under concession contract) by Electricité De France (main French electric company) which is the case for most of the artificial reservoirs mentioned or, more rarely, owned by communes or even privately-owned. In the case of Lake Léman, the levels are maintained by several Swiss regulatory acts and a Franco-Swiss protocol, known as the Protocole d'Emosson (name of a Swiss reservoir operated jointly with Switzerland across the border). Besides this case and as a general rule, the management of levels is carried out by way of water regulations for emptying the structures (usually determined by the Prefect as part of the obligations included in the permit process).

A need for a shared vision regarding management and its translation into practice

Other relevant stakeholders (water users, communities, etc.) participate in the definition of this management through voluntary actions that go beyond the owner's regulatory obligations. In this way, some lakes (Bourget, Paladru, Aiguebelette, etc.) are the subject of consultation with stakeholders in order to improve management of the environment and its uses (such as described in the study case "solving conflicts"). In the case of Lakes Verney, Pétichet and Laffrey, consultation enabled disputes between users to be avoided and the definition of "guidelines" which will then be translated into water regulations. This type of approach would be improved by systematic development to ensure that past accomplishments are not challenged, in particular in the face of future developments (regional development, global warming, etc.).

In the years to come, for progress to be made knowledge of these often poorly understood environments has to be enhanced, in particular concerning the presence of cyanobacteria which can hinder certain uses of high social or economic value (drinking water, swimming). Finally, since these environments are particularly fragile and difficult to restore due to their slow response or inertia, they should be the subject of a particularly vigilant preservation policy.

Germany

There are 6 large artificial dams or flood control reservoirs in the designated Bavarian Alpine region, the main task of these reservoirs being flow regulation. Most of these systems are also used for leisure and recreation purposes.
Water reservoirs worth mentioning are:

- **Lake Forggensee** on the upper reach of the River Lech: The oldest water reservoir, with a total reservoir capacity of 166 million m^3, pri-marily serves to generate hydroelectric power and is operated by the company E.ON. To this end, the level of the lake can be lowered by a maximum of approx. 15,5 m from the normal reservoir level. The plant generates 150 million kWh per annum on average.
  The reservoir additionally serves as a means of flood control along the entire stretch of the River Lech. The available retention volume was originally approx. 15 million m^3, then, follow-ing the Whitsun floods in 1999, the retention volume was increased to approx. 22 million m^3 by modified water management requirements. By lowering the level in advance, the retention capacity can be increased even further.
  The reservoir is located in a very popular tourist area. There is therefore also a focus on leisure and recreation activities. The sunk water evel of the reservoir in winter months must therefore be completely restored by the beginning of the tourist season in June.

- **Sylvenstein reservoir** on the upper reach of the River Isar: The reservoir, operated by the State of Bavaria, has been designed for flood control and also for topping up the run-off of the River Isar during dry periods. To this end, the total storage capacity of 124 million m^3 is divided into a flood control area with some 79 million m^3 and the low-water topping up area with 40 million m^3. Discharge at mean water level is regulated via a hydropower plant which has an average annual output of approx. 20 million kWh. During the period from 1994 – 2001 the reservoir was upgraded by providing for a second flood discharge and by raising the dam by 3m to create a larger flood retention area. The lake is a popular tourist destination. The water abstractions upstream of the reservoir and the corresponding artificial bed-load management are, today, major issues addressed by different pressure groups.

- **Lake Grüntensee** (upper reach of the River Wertach, total capacity 16 million m^3) and the Surspeicher reservoir (upper reach of the River Sur, total capacity 5,7 million m^3) are predominantly used for flood control, they are fitted with hydropower installations and also play an important role in the region's tourist trade.

- **Lake Rottachsee** (total capacity 28,4 million m^3) is located on a backwater of the River Iller. This reservoir was primarily built to improve run-off conditions of the rivers Iller and Danube. It is only of minor importance for flood control and today, leisure and ecology play an important role as secondary functions.

  Some natural lakes in the Alpine region are also used for flood control. Discharge from the lakes **Ammersee** and **Tegernsee** is controlled by means of weir systems, for example. In the event of floods, the level of the lake can be raised by the weir and this can cap run-off peaks of the rivers Ammer and Mangfall flowing into the lakes, and then discharge them with a delay after the flood wave.

The natural lakes of **Walchensee** and **Kochelsee**, which are situated close to each other, fulfill a special function. Along with the water diverted from the River Isar, the water of Lake Walchensee is used to generate electricity by a large power station with a head of around 200m. The plant has an annual output of approx. 300 million kWh as surge current. Lake Walchensee can be lowered by up to 6 m in the winter months.
The lower-lying Lake Kochelsee acts as a buffer for the water discharged from the power station and dampens run-off peaks of the River Loisach, which flows through the lake, during flood periods

Italy

There are numerous reservoirs in Alpine Italy, whose distribution is concentrated around the main areas of the mountain basins of the major rivers. When referring to reservoirs which are classified by Italian law as major reservoirs, there are around 210 reservoirs containing an overall capacity of 2.200 million cubic metres in the same area. The main use of these reservoirs is solely to produce hydropower. In fact, around 90% of them are used for hydropower alone, while the remaining reservoirs are used for agriculture or multiple purposes. 90% of the water stored in reservoirs in the Italian Alpine area is regulated on a seasonal or annual basis.
The water stored in the form of snow and glaciers in Alpine river basins represents an essential resource for the formation of the water level of mountain river basins but also, and in particular, the basins below them. The water supplied by the Alpine reservoirs, in addition to contributing directly to the water level, is also essential in situations of water shortage since it represents the only resource that is easily usable within the river basin.
The main changes that have taken place in the regulation of the volumes stored in the reservoirs used for hydropower are closely connected with the introduction, starting in 2003, of the energy bank that regulates levels in the cost of power in relation to actual demand. This innovation has led to major changes in the regulation of the reservoirs, and therefore in the amounts of water released. Traditionally, the regulation regime provided for the accumulation of water during the autumn and winter periods and its release during the spring and early summer periods, enabling maintenance operations to take place when the reservoir was empty, generally during the month of August. As from 2003, water has also been accumulated during the late spring period and released to coincide with the temperature extremes in summer and winter, in other words, when power reaches its highest sale price.

With regard to modifications in the regulation regime of reservoirs, in order to deal with the effects caused by climate changes, it should be pointed out that over the last few years there has been a contraction in the release periods during precisely those periods when those climate effects have been most evident, in particular during periods of highest summer and lowest winter temperatures.
A large number of natural lakes are to be found in the Alpine area. The largest of these, in terms of dimension as well as overall regulated volume, equivalent to around 1.290 million m^3, are the five major lakes in Lombardy – Maggiore, Como, Iseo, Idro and Garda. These major lakes, together with their

regulation regime, make a substantial contribution to meeting the water requirements in the areas downstream, guaranteeing during the summer period the necessary flow for irrigation of agricultural land and, at the same time, playing a fundamental role in protecting the same areas by absorbing flood water.
Alongside the use of the water in the lakes, there has also been an evolution in their use for recreation and tourism which, in addition to the development of numerous leisure facilities, has led to the development of a well-structured navigation system.

The water resource of the Alps represents an essential contribution for the maintenance of the regulated lakes, in exactly the same way as it does for the mountain reservoirs. The contribution of rain alone in the river basin is not sufficient to sustain the balance of the lake itself.
The regulation regime of lakes is naturally sensitive to changes in climate as well as to patterns in water requirements for mountain and valley systems. Over the last few years the regulation regime of lakes has had to deal with changes in the management of mountain reservoirs in order to guarantee an adequate flow into the irrigation system, while taking account of requirements connected with their use by tourism.

The regulation of the major Alpine lakes is carried out by specially formed Regulation Consortiums which increase or decrease the water flow according to the various uses of each lake. These Consortiums play an essential role in controlling water levels in the river basin. This is due to their long experience in water regulation and also because they balance the various consumption requirements for the resource. Lake Maggiore, which is also situated in Swiss territory, has two international commissions that are separately concerned with studying environmental problems and analysing regulation levels of the lake.

There are many inter-related interests in the management of the resources stored in the mountain reservoirs and lakes. They often conflict with each other, with the opposing needs, on the one hand, of producing hydropower and, on the other, of the irrigation system below the Alpine territory. Another fact that must not be ignored is that the variations taking place in the levels of snowfall and rainfall are bringing serious environmental problems to the fore, the intrusion of sea water and the lack of vital minimum water flow levels, which must certainly be dealt with and resolved by using the volume of water stored in the Alpine areas.
As far as the coordinated management of resources and therefore of conflicts is concerned, it should be pointed out that since 2003 a programme has been in place for the hydrographical basin and for the River Po basin. A detailed description of the management model is to be found in the case study on the programme.

Slovenia

In the Alpine region of Slovenia there are 12 major reservoirs of national importance. Of this number only one reservoir is multifunctional having its primary role in irrigation, and a secondary role in flood protection and additional recreational functions. The remainder, 11 reservoirs on the rivers Soča, Sava, Drava and their tributaries are primarily intended for electricity production. Some of these reservoirs are used for recreational purposes too, mainly boating and angling.
The majority, 9 of these reservoirs, are for run-of-river hydropower schemes with daily fluctuations. Only two reservoirs have larger accumulations, but still only for a one-week period and are therefore not suited to the seasonal management of the water regime downstream. Since more than 97% of the water supply in the country comes from groundwater, these reservoirs are not important for this purpose either. The Alpine region of Slovenia is one of the regions with the highest precipitation rates in the Alps and in Europe and has a high potential for tackling the consequences of climate change. Unfortunately, the existing reservoirs do not have an adequate capacity for this purpose.

There are hundreds of small reservoirs in the Alps, reflecting their multifaceted importance for people in this area throughout history and in present times. The functions of these reservoirs are the following:
- production of electricity in small hydropower plants with an installed capacity < 10 MW,
- flash floods protection of areas downstream of mountain torrents,
- interception of material transport and floating debris (gravel, timber etc.) from mountain streams to the downstream river recipients,
- fishing (fish ponds, fish hatcheries, angling),
- maintaining sensitive mountain ecosystems, primarily highland wetlands,
- recreation and tourism,
- monuments of technical heritage (high dams from the 18th century, saw mills, grain mills),
- monuments of cultural and historical heritage (old fish ponds and artificial lakes near old castles).

The use of the reservoirs has changed over time. One example is the restoration of high dams from the 18th century used up to the middle of the 20th century for flushing timber used in the Idrija mercury mine. One of the restored dams and reservoirs is, apart from being one of the technical heritage monuments under government protection, used for the production of electricity. Another small reservoir in the Pohorje Mountains, previously used for timber flushing to the River Drava for the transport by river as far as Romania, has recently been restored to preserve precious mountain wetland. A third example is the old hydropower plant dating from 1914 - HPP Završnica on the River Sava tributary. The old power plant has been preserved as a technical heritage monument, while the water from the reservoir has been diverted to the new generation unit of the HPP Moste on the River Sava. These examples show the vitality of the Alpine area and the high concern given to the preservation of heritage in a way adequate to modern times.

There is not a single case of lake regulation in the Alpine region of Slovenia to maintain the water regime downstream or for water supply reasons. The only lake regulated in the region is Lake Bled. The purpose of regulation is to improve water quality and maintain constant lake levels. Lake Bled is one of the most popular tourist attractions in Slovenia. Initially, the lake was regulated to maintain constant levels for scenic and recreational reasons. Due to the ever increasing pressure from tourism, ever more quantities of nutrients have been introduced into the lake, thus augmenting the process of eutrophycation. As a consequence, there have beenrecurring periods of algae bloom almost every year. The problem has been solved by diverting part of the flow of the nearby pristine Alpine river, the River Radovna into the lake, and by siphoning out water from the deep layers of the lake.

The remainder of the lakes in the Alps are not regulated. Moreover, many of them are protected to keep them in a natural state. The largest perennial lake in the country, through which waters of the one of the two sources of the River Sava flow, Lake Bohinj, is a protected area within the Triglav National Park. In the same park there are high mountain lakes, the seven Triglav lakes.

Divje jezero, a small lake in vicinity of Idrija, is protected as a nature reserve, as a unique Vaucluse-type karst spring, among other reasons. Črno jezero, a small high-mountain lake in the Pohorje Mountains, is protected as part of a highland marshes reserve. Due to the ecological value and their low water volume, natural lakes are not intended to be regulated in the future either. Also, all these lakes are in an area of high precipitation, so, at present, there is no imminent danger of their being affected by climate change.

There is no such thing as one single management practice regarding reservoirs and regulated lakes. Some are managed by the State, others in a mixed mode, partly by the State and partly by stakeholders – concession holders, while some are managed by concession holders only. There are no international lakes in Slovenia, but the management of some reservoirs is covered by bilateral agreements with neighbouring countries. The operation of hydropower- scheme reservoirs on the River Drava is in a mode synchronised with upstream schemes in Austria. The modalities are regularly negotiated and agreed bilaterally by the Drava River Commission. On the River Soča, , the ecological minimum river flow, at the point where the river crosses the state borders is maintained at all times by regulating upstream hydropower reservoirs by way of a bilateral agreement with Italy.

Since Slovenia does not have very large reservoirs and lakes like some other countries in the Alps, water management of reservoirs and regulated lakes is specific. Water management for maintaining the water regime downstream is not very prominent, but nature, population and heritage protection issues feature very high on the agenda.

Switzerland

(Multifunctional) reservoirs:
The big reservoirs in the Swiss Alps have almost all been exclusively built for hydropower purposes only, thus are not multifunctional reservoirs. Only at the Mattmark reservoir in the Canton Valais is a certain volume reserved for flood retention. However, all other reservoirs have - despite not having been explicitly designed or managed for - a certain intrinsic, seasonally changing retention effect (according to their filling-level, which is low in spring and high in autumn). This positive effect on reducing the flood peaks along the downstream reaches has been evidenced during several flood events. A few reservoirs have also been built for flood and sediment retention only. For the upper Rhone River flood forecasting for the management and optimisation of a multi-reservoir system during floods has been developed.

An inventory of all Swiss dams and reservoirs can be found at http://www.swissdams.ch
In total there are 82 reservoirs situated in the Swiss Alpine Convention perimeter with a volume of above 1 million m^3. More specifically, the accumulated volume of these reservoirs amounts to around 1.600 million m^3 for the Rhine catchment, 1.200 million m^3 for the Rhône catchment, 515 million m^3 for the Po river and 175 million m^3 for the Danube. These figures show, on the one hand, the significant storage capacity and a certain potential to change the flow regime inducing slight seasonal shifts. On the other hand, comparing these figures to the volumes of the natural lakes in the foothills of the Alps (e.g. Lake Léman: 89.900 million m^3, lake Constance: 49.000 million m^3) puts them into perspective.

Regulated lakes and their management:
All major lakes in Switzerland, except for Lake Constance and Lake Walensee, are regulated at their outlets. The regulation schemes depend, in general, on the water level and the season/time of the year: these schemes and their management is a compromise between flood control around the lake, nature conservation, recreation, navigation and flood control downstream of the lakes. In principal, the Cantons are responsible for the management of the lakes. For inter-Cantonal and international lakes, regulation has been coordinated accordingly. For some regulated lakes, which have an impact on other Cantons situated downstream, the Confederation has a supervisory role. For some lakes optimisation projects are currently under way, including new weir and control facilities with partly adapted regulation schemes incorporating improved hydro-meteorological forecast procedures.

B.2.4 RIVER HYDROMORPHOLOGY

Natural Alpine river landscapes are highly dynamic systems. The transport of water and sediments such as rocks, boulders, gravel and sand depends mainly on the gradient and the discharge. During low water, the water is branched between wide gravel banks, during floods the river forms a braided system covered by water. The river's hydromorphological processes, especially during floods, encourage the relocation of gravel banks, which is an important enabler for the restoration of habitats for animals and plants. Alpine rivers host a wide variety of biotopes in the water, on the gravel banks and in the adjacent alluvial forests. One of the best examples is the River Tagliamento in the region of Friuli (northern Italy) as shown in the following case study. Many of the animal and plant species in Alpine river systems are endangered today.

Most of the Alpine rivers have undergone canalisation in the last decades of the 19th and in the first part of the 20th century in order to improve flood control for settlements and agriculture, to build roads and railway lines and, in many cases, for the exploitation of hydropower. A study performed by CIPRA in 1992 already revealed major impacts on river hydromorphology. The case study on the Alpine Rhine (see below) provides an illustrative example thereof. In other Alpine rivers as well, dams and weirs were constructed for different purposes, interrupting the longitudinal and, in many cases, also the lateral connectivity/continuity of the river systems, impeding the migration of animals in and along the river, especially that of fish. Formerly braided river systems are nowadays narrowed into channels or dammed. There are many sections in Alpine rivers where the water is extracted into channels to run hydroelectric power plants. The reduced transport of sediments trapped in weirs encourages the erosion of the river bed downstream. Some consequences of this kind of interference are: an impact on the hydromorphological processes in the river channel, reduced flooding of the inundation areas, lowering of the groundwater level and loss of biotopes for animals and plants. Today, natural Alpine river systems are very rare, most of them are protected as nature conservation areas, hosting endangered species of animals and plants.

In the last two decades of the 20th century, discussions on the restoration of such canalisedzed Alpine rivers started. Pilot projects were and other projects still are underway in all Alpine states. The objectives of such projects are:

- to reconstruct the longitudinal and the lateral connectivity/continuity,
- to restore the hydromorphological processes by removing bank protection and allowing the widening of the river bed and improving sediment transport,
- to reduce the extraction of water out of the river (ecologically oriented minimum water flow)and also mitigating hydro-peaking effects,

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Photo B2-19: The undisturbed river bed is a domicile for various aquatic life forms.

- to improve the habitats in the river and in the inundation area with techniques such as bio-engineering in connection with maintenance work,
- to return space to the river system.

The results of these restoration projects show that there are many possibilities to improve river ecosystems. The requirements are: space for the river, time and qualified engineers to monitor these hydromorphological processes and also the necessary financial resources for funding them. The experience acquired is now used for implementing the planned measures in order to meet the requirements of the Water Framework Directive.

The longitudinal continuity for fish needs to look closely at the watersheds and the fish living there. The rivers of the Alps flow into the Mediterranean Sea, into the Black Sea, and into the North Sea which is connected to the Atlantic Ocean. The solutions for the re-establishment of longitudinal connectivity/continuity in Alpine rivers depend on the migration of fish species Salmon born in the tributaries of the rivers which flow into the North Sea migrate between the Atlantic Ocean to feed and the upper branches of the Rhine system to spawn. Eels feed in the river and return to the Caribbean Sea once in their lives to spawn. These species do not live naturally in the Danube system, but in most of the other river systems draining the Alps.

Fish species migrating to the ocean, need longitudinal continuity for migrating in both directions, so that they can survive. In most river systems this migration is interrupted by weirs today. To restore the longitudinal and the lateral continuity it takes combined efforts to develop technical solutions and master plans, showing a general strategy, technical solutions and the steps to implement the best measures. To achieve longitudinal and lateral continuity for the different fish species and river systems up into the tributaries, respectively, river-basin-wide concepts are needed.

Conclusion and Assessment

In the whole Alpine area rivers have been extensively modified during the last 150 years. The case study on the Alpine Rhine is a representative example of this development. In former times, the Alpine Rhine was like a torrent demanding large parts of the valley for discharge and sediment transport. With a major river training programme starting in the 19th century, it turned into a canalised river with poor morphology. On the other hand, the valley is today populated by a half million inhabitants and has been come to play an eminent role for the socio-economic development of Austria, Switzerland and Liechtenstein.

According to the data of the member states, approximately half of all larger rivers are affected by this development. The changes mainly concern altitudes up to 800 metres a.s.l. where humans and nature compete for ground in the valleys, which is scarce in the Alpine region. A large part of the settlements and of traffic routes as well as a great part of the land suitable for agriculture was reclaimed by humans from rivers in this period. For flood protection purposes and hydroelectric power generation natural watercourses sustained impairment by longitudinal and transverse construction works even at higher altitudes. The continuity for fish and other aquatic organisms is strongly compromised today. In virtually the great part of the Alpine rivers, straightening, removals, canalisations, transverse buildings, weirs, water-retaining structures, abstractions or other adaptations of rivers to the needs of humans were realised to a certain extent.
Each of these interventions was necessary from a local point of view at that time. A holistic view of the aggregate effect of all these interventions on habitat quality and of the effects on biodiversity has only emerged recently as the boundary conditions for river management have significantly changed.

Today, with the advanced understanding of water biology and the Europe-wide implementation of the Water Framework Directive and comparable regulations in Switzerland, the important role of river morphology and continuity as an outstanding factor for the overall ecological status has been widely recognised. The Water Framework Directive pursues an integrated approach by means of fish monitoring methods. Fish are at the top of the food chain and react very sensitively to unfavourable interventions such as structural deficits or deficits in discharge. Furthermore, the comparison of the status of the rivers with other non-impaired rivers (reference waterbodies) helps to find ways of improving the situation in line with the Water Framework Directive.

An objective for the member states of the Alpine Convention - after the assessment of the status has been completed - will be to establish programmes of measures in order to reach the good ecological status or the good ecological potential. The year required by the Water Framework Directive (WFD) for reaching the good ecological status is 2015, after this, the achievement of objectives is to be examined and then the planning scheme is reviewed at 6-year intervals.

The Alpine states have already gained several years of experience in establishing ecological measures in the course of providing flood protection works. Flood protection measures are coupled, wherever this is possible, with river expansion, the re-establishment of the continuity of water bodies and the improvement of protective structures. Therefore, there is no doubt that new flood protection measures in the Alpine states will be implemented in line with the objectives of the Water Framework Directive.

Examples exist in other Alpine states as well. As the Water Framework Directive is being implemented, revitalisation projects will be realized in the future not only in the connection with flood protection but also as projects in their own right. One objective, among others, is to grant to the Alpine rivers again more space and more bed load dynamics to enable river-morphological exchange processes. In terms of its dynamics, river morphology may vary widely from being fixed and being totally modified as exemplified, for instance, by the Alpine Rhine to unimpaired conditions such as in the Tagliamento.

The Common Implementation Strategy (CIS) of the WFD provides for a classification of heavily modified water bodies based on different uses such as their use for the generation of hydroelectric power. To that end, it needs to be examined whether options that are environmentally more favourable might be available. That is the basis for the examination of applications for new hydroelectric power uses with respect to their sustainability. Today, any extension or the granting of any new permission to use water power is subject to the provisions of the WFD. The necessity of respecting river morphology and continuity is an opinion which is now shared unanimously by all experts and which has also changed the administrative practice.

Case Study from Italy

The River Tagliamento

Hydromorphology, hydromorphological interferences and hydromorphological goals of the Water Framework Directive

Hydromorphology is the study of structures and dynamics of running water. It examines the effects of flow dynamics on a given stretch of water, on adjacent wetlands as well as on the structure of the beds and banks of watercourses. Furthermore, it studies their cross section and longitudinal-section variability.
Hydromorphological interferences represent anthropogenic changes in the river bed, in the bank and the adjacent wetlands of a stretch of running water. Interferences can affect the flow dynamics of a water flow as well as its morphology. In the Alps, interferences can be defined as clearly visible long-term measures that are barely or completely reversible and result from settlement development, flood protection, water power use, agriculture, sewerage, recreational and industrial use, gravel extractions and forestry.
According to the Water Framework Directive (WFD), which was implemented within the framework of the Water Resources Act* and other water-related acts at provincial level, hydromorphology is an important feature which can be used to describe the actual state and the potential of a stretch of water. By 2015, a good hydromorphological state and a good hydromorphological potential must be achieved. The next step towards these goals will be the drawing up of operational plans and programmes of action by the end of 2009.

The condition of a stretch of water is mainly defined by a number of biological and chemical quality components. Hydromorphology (structure and dynamics) plays a supporting role in this analysis as a so-called 'secondary quality parameter'. The decisive influence of water flow morphology on biodiversity in aquatic habitats and, thereby, on respective symbioses, makes hydromorphology a key component in the regulatory mechanism of biocenoses. In particular, spoilt and modified hydromorphological structures mean low biodiversity and, therefore, poor ecological conditions. Moreover, it is important to highlight that the preservation of a single water section it is not sufficient for the achievement of ecological objectives; preservation measures need to be applied to the entire watercourse.

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Photo B2-20 : Tagliamento

Flood risk assessment

The Tagliamento river bed is characterised by a typical mountainous morphology for about 26 km from its spring, where it merges with River Lumiei. Starting from this point, the valley becomes wider to contain the river basin, which then divides itself into several streams. The river bed reaches a considerable size in the area of Campo di Osoppo and later, in the village of Pinzano, it narrows down to a width of 160 m.
Further downstream, in the Pinzano passageway, the river reaches the plain increasing again its river bed size to 3 km in the area near Spilimbergo. This section of the river is characterised by numerous branches. The level of the river bed upstream of the village of Rivis is lower than the surrounding area. During normal flow conditions, the river only fills the furrows burrowed by the water flow itself in its gravelly bed; and it is only during flood conditions that its bed fills completely. Downstream of the village, the difference in altitudes between the river bed and the surrounding areas gradually decreases. In these areas the river bed is characterised by strong dikes that have been steadily raised in height and reinforced throughout the years. In the area between Madrisio and the river mouth, the Tagliamento grows very narrow turning into a snake-shaped stream with a width of 180 m in the section near the village of Latisana. Finally, at its mouth the river forms a delta that defines the southern boundary of the Marano lagoon, separating it from the valley system originally linked to Caorle lagoon.
From among the main morphologic aspects, altimetry is one worth focusing on. This is, in fact, a factor which can highly influence flood dynamics. The average gradient of the basin is high in the mountain part (from 1,2% at its springs to 0,5% to the Pinzano section) and it gradually decreases until is reaches 0,15% near Villanova, 0,04% at Latisana, becoming negligible when reaching its outlet.

The average annual meteoric water influx amounts to 4,7 billion m^3, which, considering water losses due to infiltration and evaporation (25% of the total average meteoric water influx), accounts for a mean annual flow of 92,5 m^3/sec at the Pinzano passageway and of 70 mc/sec at the mouth section. The clear difference in the river flow between these two sections is mainly due to infiltrations that occur when the river flows in the high plain. The River Tagliamento has the flow regime of a torrential river and its capacity is directly affected by the precipitations rates

Fig. B2-14: The Tagliamento river basin (Source: http://www.tagliamento.org/ 05/02/2008)

in the area. In fact, there is a great shift between the low flow period, when the river capacity only reaches 20 m^3/sec and the high flow period, from April to May and from October to November, when the flow can easily exceed 3.000 m^3/s with a catchment response of only 12 – 20 hours.
Due to the hydrographical and morphological characteristics of its basin, the river is usually affected by disastrous floods times of intense rainfalls. Tragic floods occurred in 1823, 1851, when the village of Rosa (San Vito al Tagliamento) was destroyed yet again, in 1820 and in 1965. The maximum flood flow ever registered was in November 1966, when at the Pinzano section the river flow reached almost 4.600 mc/sec. The flood claimed 14lives , rendered 5.000 people homeless and injured as many as 24.000 residents in 54 nearby municipalities. More than 20.000 ha of land were flooded, amounting to about 77 billion liras in damage.
After the flash-floods in 1965 and 1966, the government launched preventive measures in order to decrease the river's hydraulic risk (DE MARCHI report). The Decree of the Prime Minister of the 25th August 2000 approved the plan which is still in force today: "Piano stralcio per la sicurezza idraulica del medio e basso corso" (Plan on the hydraulic safety of the midstream and downstream sections of the river flow). The plan outlines an integrated series of interventions to be carried out in the midstream and downstream sections of the river flow, amounting to a total outlay of 165.294.000 euros, in order to gradually increase the river's hydrological safety. The plan supports in particular the establishment of flood moderators by building three flood retention areas upstream, while downstream it promotes the improvement of the Cavrato floodway and the latter section of River Tagliamento to make it suitable for the transit of in-stream flow.
This strategy has generated strong controversy since the proposed interventions interfere with the natural flow of the river and with the Natura 2000 site located in this area. Alternative strategies propose reducing hydraulic risks by enlarging the floodplain areas and by the creation of wetlands.

The extraordinary value of River Tagliamento and its protection

The River Tagliamento has an extensive gravel bed with a network of branching channels, a large alluvial water body, large quantities of flotsam, and it hosts many islands in all stages of development. After every flood, the structure of the river bed is modified and it is possible to observe a dynamic evolution in the landscape. Furthermore, the mosaic of habitats in the river has favoured an extensive biodiversity ranging from aquatic, amphibious and terrestrial organisms. These are typical features of wild rivers. Standing water habitats in the active course of the river and tributaries greatly enhance biodiversity, although they themselves represent only a minor section of the overall aquatic area. Of particular interest are also the transitional zones between land and water. The Tagliamento has an average bank line of 25 km per 1 kilometre of river course. In canalised sections the ratio drops to 2:1. There is a significant correlation between the length of the bank line and young fish biodiversity; moreover, there is a strong relationship between this length and the retention capability of the river in terms of organic material. Finally, the fauna of the banks serves as a sensitive indicator of the ecological integrity of fluvial topographies.

Alpine wild river areas such as that of the River Tagliamento feature strong dynamics, while in relation to the whole system, a fairly high level of constancy is vital. In fact, despite local variability, a high level of overall continuity in each single habitat is crucial for the survival of the various species of plants and animals. The Tagliamento, with a length of 170 km and a corridor area of 170 square kilometres, connects the Alps to the Mediterranean and its corridor is a main migratory route for flora and fauna. Due to its extension and its function as a linking corridor, the Tagliamento plays a key role in the ecosystem of the whole Alpine area.

The Tagliamento can be morphologically divided into four sections: **headwaters** (a typical mountain river with a steep gradient, a narrow bed and coarse-grained sediment in form of rubble and boulders); a **branching section** (with a broad bed, shallow gradient and rubble and gravel as sediments); a **meandering river** part (in which the active stretch of water is narrow and sediments consist of sand and clay); and finally a **canalized section** that lacks in morphological dynamics. The 90 km branching section of the Tagliamento is particularly unique in the whole of the Alps. Non-straightened banks, a natural flooding regime, vegetation and deadwood as well as sufficient sediment mass flow preserve the features of a braided river.

The sections of 'Valle del medio Tagliamento' and of 'Greto del Tagliamento' are defined as "natural habitats of common interest" (FFH) in the 92/43/EG Fauna-Flora-Habitat-Directive. Along the stream course of the Tagliamento, there are nine different FFH habitats with unrivalled size and consistency compared to other Alpine rivers. Habitats such as these have been in serious decline in the Alps, they are either rare or highly endangered. In the face of the continuously deteriorating state of biodiversity in Europe, the

The Varmo tributar

Dignano

Rosa (S. Vito)

Pinzano
Source: http://www.tagliamento.org/ (12.2.2008)
Photos B2-21 – B2-24 : Tagliamento

Member States were obliged to designate FFH habitats, which, together with the areas protected by the Conservation of Wild Birds Directive, form the coherent European ecological Natura 2000 conservation network. The aspect of coherence, i.e. connectivity, is one of the main goals of the FFH Directive in this respect. As far as the Tagliamento is concerned, 21 square kilometres of its habitats are designated FFH habitats, equivalent to around 14% of the existing habitats along the river. Thus, coherence is not guaranteed if considering the huge interrelated biotope system stretching from the Alps to the Mediterranean. A range of publications highlighted the exceptional position of the Tagliamento as the last great wild river landscape, "Centre of Biodiversity" and as a model ecosystem for Alpine river areas in Europe, and stressed the importance of implementing the Water Framework Directive (Martinet & Dubost 1992, Kuhn 1995, Kretschmer 1996, Müller 1993, Lippert et al. 1995, Müller & Cavallo 1998, Tockner et al. 1999, 2003 etc.).

Conclusion

River Tagliamento is the only Alpine river that has still preserved the natural dynamics and the morphological complexity of natural Alpine rivers. This river represents a natural and unique resource within the international territory and it is a point of reference for the preservation of other ecosystems within the Alpine area. The study of this river could, in fact, be an aid in restoring natural flow conditions of other rivers which have been destroyed by human activities. On the other hand, due to its hydrographical and morphological conditions, the river flow is often subject to disastrous floods, claiming lives and causing great economic damage.
This is why the preservation of the river' natural conditions needs to go hand in hand with the need of reducing hydraulic risks.
The River Tagliamento is thus an important case study regarding the application of art. 4.7 of the WFD where the failure of achieving a good ecological status is the result of new modifications to the physical characteristics of the water body. Under certain circumstances it might be necessary to depart from the environmental objective of the Directive; should this be the case, the following criteria must be met:

(a) ensure that all the possible solutions to mitigate the adverse impact on the status of the water body have been sought;
(b) all the reasons for modifications shall be specifically outlined and explained in the river basin management plan;
(c) the reasons for modifications shall be of over-rid-

ing public interest and/or the benefits to the environment and to society in achieving the objectives set out in paragraph 1 are outweighed by the benefits that the new modifications or alterations can bring to human health and safety or to sustainable development;

(d) due to technical feasibility or disproportion-ate costs, the beneficial objectives served by those modifications on the water body cannot be achieved by any other means despite the fact they represent a significantly better environmental option.

According to the Directive, alternative approaches and strategies must be sought and compared during the planning stage of the project in order to decrease hydraulic risks and to protect public safety while guaranteeing a lower environmental impact.

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Case Study from Switzerland

Morphology of the River Rhine
(The Alpenrhein: upstream Lake Constance)

The Alpenrhein is the stretch of the river Rhine starting from the conjunction of the two tributaries Vorderrhein and Hinterrhein until the mouth into lake Constance (see picture 1).

The Alpenrhein has a length of 90 km and constitutes the border between Switzerland and Austria and between Switzerland and Liechtenstein, respectively. The Alpenrhein was formerly a "torrent", occupying great parts of the valley floor (until the midst of the 19th century).

Amongst other reasons, deforestation in the 17th-19th centuries led to an increased erosion in the basin and consequently to higher sediment input into the river system. This in turn caused aggradation of the river bed to an extent that the level was partly higher than the adjacent valley.

Especially in the 19th century the valley was therefore hit frequently by flooding, which hampered the socio-economic development and caused considerable hardship to the population.

basin ariea: 6.123m^2, drains from Swiss, Austrian, Liechtenstein and to a tiny extent also from Italian territory.

Mean elevation 1.800 m a.s.l., highest point is the Tödi summit (3614 m a.s.l.), deepest point is Lake Constance (395 m a.s.l).

Glaciation is around 1,4%.

Mean discharge 240 m^3/s, 100-year flood ca 3.100 m^3/s.

Around 500.000 people live in the valley.

Fig. B2-15: Characteristics of the Alpenrhein (the Alpine Rhine river) and its basin.

As a response, the local river training works became more systematic in the second half of the 19th century, culminating in the treaty of 1892 between Austria and Switzerland.
Institutionally a common, transboundary river-training commission (IRR, Internationale Rheinregulierung), responsible for the operational flood control works along the Alpenrhein was founded.
This triggered comprehensive river training works, including channelling and two cut-offs, measures all of which aimed at increasing both the run-off and sediment transport capacity.
But also within the basin, measures to reduce the sediment input were initiated.
In the 20th century, further treaties were effected in order to adapt and finalise the works, including the river's mouth section stretching several kilometres into Lake Constance.
The current morphological status is the result of all these efforts to protect the valley from flooding. Embanked almost along the whole river course, the Alpenrhein is morphologically heavily influenced today by flood protection works (dikes and boulder-reinforced banks), and represents a rectified and, over long stretches, monotonous river course which is disconnected from alluvial plains and tributaries (see photo B2-25)

The goal of protecting the valley from flooding has been achieved and the enhanced protection and the reclamation of land have significantly fostered socio-economic development.

In fact, the population has increased considerably, the settlement areas have been extended and economy and agriculture have benefited from improved land conditions. Meanwhile, this spread of socioeconomic activities into zones formerly occupied by the river represents such a damage potential today that the reduction of risk which has been achieved is gradually being forfeited.

All inall, the development outlined is quite typical of the major Alpine river valleys. As mentioned above, the sediment regime plays a crucial role, well illustrated by the volume of 2-3 million m^3 of sediments annually conveyed into Lake Constance. The sediment regime's balance (influenced by the contribution from the tributaries and the whole basin, gravel mining and the river bed geometry) has a major impact on erosion and aggradation phenomena along the river course, thereby influencing the run-off capacity.

This is therefore a matter of constant concern and a cause for interventions. River training works and gravel mining have led to significant erosion in some sections in the past.

Whereas initially this was a desired development

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Photo B2-25: The Alpenrhein at a downstream section

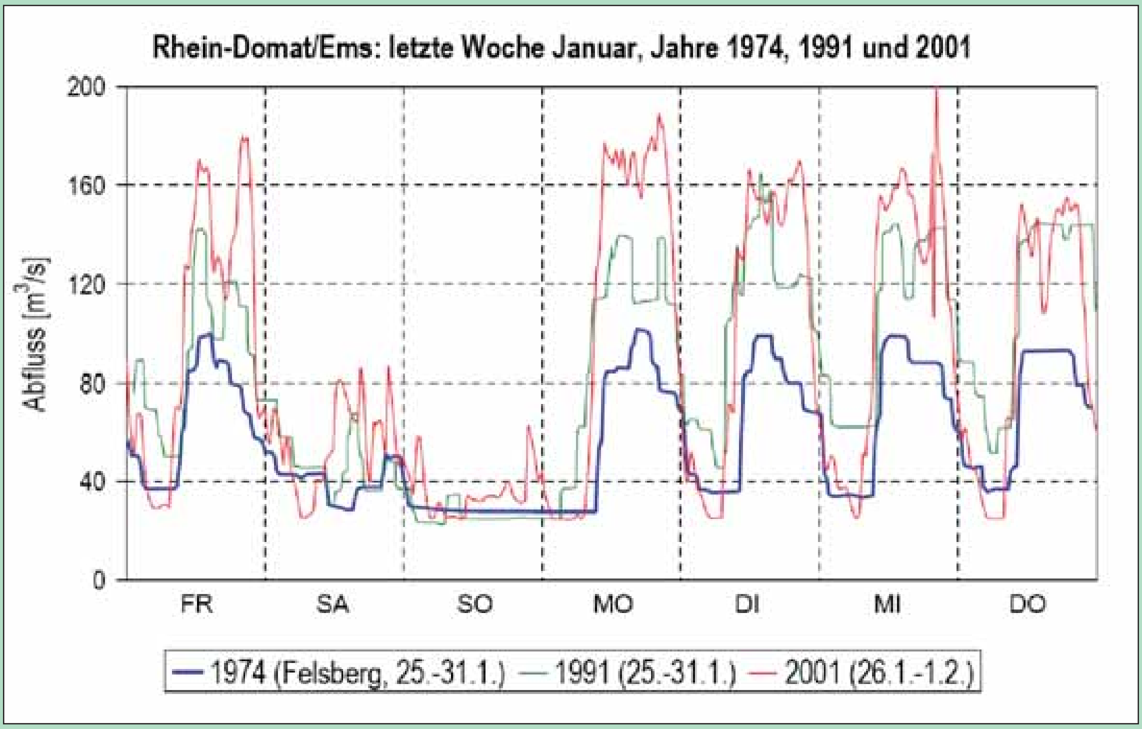

Fig. B2-16: Weekly hydrographs in Janury for three distinct years at a gauging station on the Alpenrhein, depicting the typical pattern caused by hydro-peaking

since it enhanced flood protection, it has evolved to an extent where it has negative impacts such as, for instance, by threatening bank stability and lowering groundwater tables and affecting wetlands.

Apart from the poor morphological status, the transversal connectivity has been impaired as well. On the one hand, former tributaries of the Alpenrhein had to be disconnected when building the dikes along the Alpenrhein. As a consequence, many creeks in the valley are now collected by parallel canals. On the other hand, other tributaries had, in the past, been "functionally" disconnected because of erosion in certain sections of the Alpenrhein, so that the height difference at the mouth of some tributaries hindered fish migration. For some tributaries this has been tackled in recent years by reshaping the river mouths (e.g. with ramps or step-pool structures).

As to fish migration and longitudinal connectivity: There is only one run-of-river hydropower plant (Reichenau) along the Alpenrhein. Until a few years ago, the dam represented a total barrier for the upward migration causing almost the extinction of the "Seeforelle" (lake-trout). Due to the construction of a fish pass, the population has somewhat increased again. Two river sills, built as block-ramps, are deemed to be a barrier for some of the fish species as well. All in all, the fish stock is classified to be very low, caused primarily by the aforementioned morphological deficits and the impact of hydro-peaking.

Besides morphology, the flow regime is significantly influenced too, above all by hydro-peaking (see picture 3). The importance of hydropower for the flow regime can be best illustrated by the total sum of around 800 million m³ that can be stored in all reservoirs (built for hydropower production) located in the catchment area.
Apart from the daily alterations in the water levels, their operation leads to a certain shift in run-off from summer to winter (including a certain potential to retain water during flood events and to lower the flood peaks in the downstream stretches). It is currently an ongoing debate on how to tackle the undesired phenomena and ecological impacts due to hydro-peaking. Economic reasons do, however, clearly speak in favour of constructive (e.g. retention basins to lower the peaks) rather than operational (e.g. limiting the maximum turbine discharge) solutions.

For a long time, flood control was the dominating concern with respect to the management of the Alpenrhein. Since the 1980s, there has been growing awareness that the gains in land and in improved flood protection are being penalised by significant ecomorphological deficits. The need for a more integrated approach has become generally acknowledged, not least reflected by the foundation of an intergovernmental, transboundary commission: the IRKA ("Internationale Regierungskommission Alpenrhein"), a cooperation amongst the Cantons of Grisons and St. Gall (CH), the Land of Vorarlberg (A), and Liechtenstein (FL). IRKA launched an action programme in 1998 (the so called "Aktionsprogramm 2000+") aiming at carrying out common projects in cooperation with the above-mentioned IRR with the goal of establishing an integrated river management concept (the so-called "Entwicklungskonzept Alpenrhein").

Flood protection continues to be the main priority of this concept since the valley of the Alpenrhein represents a densely populated and economically very dynamic area today that requires an increased flood protection level. At the same time, the responsible authorities and governments are aware of the need to integrate other aspects in a more sustainable manner. Thus, the Entwicklungskonzept focuses also on the topics ecology, groundwater and socioeconomics (with hydropower as one key issue) and strives for integrated solutions and coordinated measures. After having carried out thorough analyses on the status quo and the desired development goals (in that process also the public has been integrated), the Entwicklungskonzept, published in 2005, constitutes the synthesis of this endeavour. The coming years will be dedicated to the elaboration of the management plan and the implementation of the proposed measures.

Further information can be found at

- www.Alpenrhein.net
- The so-called EU-Water Framework Directive Article 5 Report (Characterisation of river basin: pressures, impacts and economic analysis) for the Alpenrhein/Bodensee is availabe at: http://wasser.lebensministerium.at/article/articleview/37314/1/5738

National Contributions
Regarding Information on River Morphology

Austria

Austria is a country with mainly mountainous character. Therefore, space suitable for settlements and economic activities is rather limited, concentrating along narrow valleys and the few basins within the Alpine perimeter. The population living in these often very densely settled areas is exposed to an increased risk from floods or other natural disasters. In response to to these circumstances, efforts were made in order to protect land and settlement areas, resulting in a range of human interventions like flood control measures, which affected the natural habitat and stream flow of Alpine river systems. Additionally, the use of rivers for hydropower production also caused structural changes and introduced barriers to the migration of aquatic life. Furthermore, considerable efforts were undertaken in the past to drain areas in the valleys and convert them into productive agricultural land. All these measures contributed to the loss of wetlands and once braided river systems in the Alpine area.

An analysis of the present situation regarding the status of waters is currently being carried out in two steps. In a first step, the risk of river systems with a catchment area greater than 100 km^2 of failing the 'good status' objective was assessed for the Article 5 report of the EU Water Framework Directive (WFD) already in 2004 . In a second subsequent stepfrom 2005 to 2008, smaller catchments were included as well and the final characterisation of the status of Austrian waters will be published by the end of 2009 in the 1st River Basin Management Plan according to Article 13 of the Water Framework Directive (WFD).
The method applied to for the assessment of morphology and river continuity disruptions is uniform in the whole country and based on numerous components, aiming to allow a holistic appraisal of the current status of Austrian freshwater bodies.

As regards rivers with a catchment area greater than 100 km^2, 55% (6.302 km out of a total of 11.488 km) are not at risk of failing the 'good status' for morphology, whereas for 21% of the river length the risk is currently not exactly definable because of a lack of knowledge. However, additional results from ongoing monitoring will enable a final characterisation at a later stage.
Regarding river continuity disruptions, 30% (3.487 km out of a total of 11.488 km) are not at risk of failing the 'good status' and for 30% the risk is unclear at the moment for the same reasons as for morphology. The remaining 40% of the river length are impacted by more than 3.100 transversal structures in the whole country, or in other figures: One barrier every 3,7 km on average. The main functions of these technical devices are flood protection, hydropower generation, stabilisation of the river bed or the abstraction of water. However, apart from the aforementioned deliberate effects, transversal structures also entail negative effects by acting as a barrier to the ecologically important migration of aquatic life or to sediment transport, resulting in increased downstream erosion, to mention just one aspect.

The situation as described raises the question of potential measures to counteract these negative effects in order to restore impacted rivers to a more natural state. This aim is striven for in the Austrian Water Act (WRG) together with provisions contained in the WFD, where it is specified that all practical steps should be taken where feasible, to prevent any further deterioration of the status of waters next to improving the conditions for achieving the 'good status'. As a result, fish passes for newly constructed hydropower plants are standard nowadays and modern flood protection schemes also fulfil ecological needs by giving rivers more space to develop natural habitats for aquatic life. Hence, increased efforts will be undertaken in order to reconcile different interests with regard to Austria's freshwater systems. For already existing impacts,a concept is currently being worked out with the 'Programme of Measures' as part of the 1st River Basin Management Plan, defining activities for the revitalisation of rivers. The costs for the measures, as a matter of principle, have to be borne by the individual causing alterations to the natural conditions. However, financial incentives to enhance the realisation of projects are provided by the State.

France

Rivers affected by various human activities

The French Alps are drained by 12.500 km of rivers of which 54% (6,800 km) are at an altitude of more than 800 m and 44% are at between 200 and 800 m (5.500km). These rivers drain small catchment areas (62% are smaller than 100 km^2) and they are mostly located at the heads of valleys (92% are Strahler order 1).

The economic activities which physically impact rivers in the French Alps are diverse:

- there is a lot of existing and growing tourist activity and accommodation at the heads of river basins, which increase withdrawals (artificial snow production, drinking water supply, etc.);
- intensive hydroelectric production which is essential at a national level (there are more than 70 dams with a height of more than 10 m in the French Alps);
- higher and higher pressure on the valley floors caused by demographic and industrial development as well as by transport networks.

Half of the rivers are fairly well known. 60% of them (3.500 km) are moderately or heavily impacted by the presence of transverse structures which interrupt their natural biological continuity (blockage of sediment flow, slowing down of water passage, blockage of fish circulation, rivers transformed into reservoirs, etc.). Nearly 60% are also affected by hydrological deterioration resulting from excessive extraction or modifications to their natural flow (locks, etc.). Finally, the functionality of closely connected environments (linking the river and its surroundings) has deteriorated in 50% of them (2.900 km) due to excessive denaturalisation of the major/minor bed (straightening, adaptation, channelisation, incision of the bed, presence of roads and flood barriers, urbanisation of valley floors, etc.). This risk of deterioration is currently increasing due to the high potential for urban growth on valley floors.

Highly modified water bodies unable to reach a natural state target

Nearly one waterway in five (more than 1.000 linear kilometres) has deteriorated to such an extent, and in such an irreversible manner, that a return to anything approaching a natural state does no longer seem compatible with the continuation of a major activities (hydroelectricity, flood prevention measures, urbanisation or transport routes) at socially acceptable costs: the European Water Framework Directive classifies these bodies of water as having been highly modified.

Restoration measures being listed and to be planned

The hydromorphological improvement of these Alpine watercourses is a real challenge, which has to be dealt with in stages. Initially, this would involve the implementation of restoration measures depending on how much a watercourse has deteriorated from a target physical state:

- good quality rivers should be preserved by taking into account the natural areas associated with the correct maintenance of rivers in urban and rural planning polices in order to avoid the development of projects likely to alter their condition (precautionary principle).
- for rivers that have not seriously deteriorated, relatively simple measures need to be under-taken capable of reestablishing their morphology and a dynamic sediment flow compatible with the requirements of natural environments (preventing engineering works from becoming obstacles),
- for the rivers requiring more complex organisation and procedures, several pilot operations would have to be carried out before any major decision is taken.

One question is remaining who can afford financing such restoration measures?

Germany

The hydromorphological processes of Alpine rivers depend on the extremes of water flow and sediment transport. Such rivers may migrate in a wide floodplain, changing their course during floods by relocating wide gravel banks. With this ongoing process of bed migration the morphological structures with habitats for plants and animals are being renewed.

Most of the larger river systems in the Alpine region of Bavaria have been canalised in the past, starting in the second half of the 19th century to improve rafting and shipping. In the first three decades of the 20th century, weirs and channels were built for the extraction of water from rivers and its transport to hydropower plants. With this extraction, the minimum flow in the river bed was reduced and the ecosystem of the river heavily damaged. As technology advanced it became possible to build dams with the power plants directly into the river, transforming such rivers into a cascade of lakes, which also allows hydro-peaking. Most of the hydropower plants were built between 1940 and 1990. Connected with such projects was the improvement of flood control. The use of water power and flood control works tamed the natural flow, especially during floods, interrupting the natural transport of sediments. More than 90 % of the larger Alpine rivers became more or less modified in the 20th century, depending on the technical solutions. Connected with this works were the losses of habitats for birds, fish, and macrozoobenthos as well as for plants.

Today there are efforts, wherever possible, to improve the ecological status of these rivers. This means to restore an ecologically oriented minimum flow in river sections with water extraction. For the improvement of habitats for animals and plants removing bank protection structures may be one viable option as experience has shown, allowing again the hydro morphological processes with bank erosion and sediment transport to occur. Fish passes are built for the migration of fish up and down the river and there are also efforts to provide for the transport of sediments through weirs. Along the Alpine rivers in Bavaria some very good examples of river restoration projects, carried in the last ten years, can be found. Their objective has been to find a compromise between ecological demands, the interests of nature conservation, outdoor recreation, flood control and the hydro-power companies. While these projects cannot restore the former natural status of these river, they do improve the ecological functions of the river system so as to achieve the good ecological status or the good ecological potential as required by the European Water Frame Work Directive.

Italy

Italian Alpine hydrological network extends over an area of 52.000 km^2. Its total length is almost 32.000 km and is characterised by a very high hydrographic density and altitude gradients; almost 50% of the network is located between 1.000 and 4.810 meters.

These natural morphological conditions (small basins, high hydraulic heads, rich water availability) have favoured an intensive exploitation of natural resources mainly for hydroelectric production during the middle of last century, when about 200 large dams (h>15m; V> 106 m^3) were built.
Many other hydraulic structures have been built afterwards for hydroelectric production, and green certificate incentives have elicited a huge request for licences for microhydro projects.

Other relevant resource exploitations impacting on hydromorphology relate to tourism and urban development, which necessitated the construction of flood defence and landslide defence infrastructure and the implementation of water supply schemes.
The whole country is, indeed, vulnerable to flood and landslides and being, at the same time, densely populated, it is affected by numerous defence structures as well as by land sealing.
Since the safety of this population and its settlements is a vital issue, the entire hydrological network is impacted by structures, ranging from high mountain wooden weirs to control flow and sediment transport for downstream defence, to roads and dams.
The hydrological regime has therefore been altered by flow control schemes, continuity is frequently interrupted and morphology has changed, resulting sometimes in substantial modifications of natural habitats and the loss of biodiversity.
Studies on river functionality have been carried out in order to support water protection planning. They assess the impacts of infrastructures as a cause of habitat deterioration and the loss of biodiversity.
At present, two different problems are addressed:

- impact of existing structures on hydromorphology;
- regulation for permitting/forbidding the erection of new.

As regards the first problem, many structures have been in existence for such a long time and serve such vital purposes that their removal with the aim of restoring the natural conditions of water bodies would generally involve unsustainable costs.
Possible measures, depending on the specific situation, should include re-establishing river sediment

dynamics, which determine habitat conditions, as far as possible.
Since the situations vary so widely, no general formula can be applied; instead, a case-by-case approach has to be adopted, analysing separately each case and the extent of restoration achievable.
As regards the second problem, in order to reconcile climate protection and risk mitigation with natural resources protection, new structural interventions (including micro-hydropower) should be allowed only if hydromorhological (and so the ecological) functions of water bodies involved are preserved, assessed at catchment scale.

This translates into legally binding measures in planning acts which provide for the establishment of protected areas relevant for river processes and forbidding interventions other than enhancing existing hydraulic structures and hydropower plants or the multipurpose usage of water.

Integrated planning (energy, economic development, flood risk management) is key in defining effective river protection and restoration policies.

Slovenia

Morphological situation

- Description and, if available, quantitative information on the situation regarding river conti-nuity disruptions

Data sources and content:

- Slovenian survey of large dams (Slovenian National Committee on Large Dams), register of Slovenian water infrastructure (Table B2-8) Available data for most of the large dams: year built, dam type, constructive heigh and other detailed technical characteristics, dam purpose (driving force), dam administration etc. (http://slocold.ibe.si/S/akt/Kat_def.html-l2)
- Ecomorphological categorisation of Slovenian rivers (IzVRS, 2002);Lateral structures (e.g. weirs, drop-offs, ramps) considered in defining the class of morphologi-cal alteration;
- Register of Slovenian water infrastructure – incomplete data on lateral structures;register under development.
- Description and if, available, quantitative information on the situation regarding river mor-phology

WB	Name	River	Hydraulic height (m)	Driving force
SI146VT	Reka Logatec	Reka	-	Flood protection
SI64804VT	Vogrščak	Vogrščak	31	Flood protection, agriculture
SI64804VT	Kozlink	Kozlink	-	Agriculture
SI6VT330	HPP Solkan	Soča	22	Energy production
SI6VT330	HPP Plave	Soča	-	Energy production
SI6VT330	HPP Doblar	Soča	-	Energy production
SI111VT7	HPP Moste	Sava	48	Energy production
SI3VT359	HPP Dravograd	Drava	8,9	Energy production
SI3VT359	HPP Vuzenica	Drava	13,8	Energy production
SI3VT359	HPP Vuhred	Drava	17,4	Energy production
SI3VT359	HPP Ožbalt	Drava	17,4	Energy production
SI3VT359	HPP Fala	Drava	14,6	Energy production
SI111VT5	Jasna	Pišnica	-	Tourism
SI1VT137	Završniško jezero	Završnica	-	Energy production

Tab. B2-8: Large dams in the Alpine Convention area

Class of morphological alteration	Class description	Total length (km)
1	natural status	37,9
1-2	near-natural status	284,3
2	slightly altered	177,8
2-3	moderately altered	138,8
3	extensively altered	127,4
3-4	severely altered	13,5
4	entirely altered	2,4

Tab. B2-9: Total length of reaches in the Alpine Convention area belonging to the either of the 7 classes

Data sources and content:

- Ecomorphological categorisation of Slovenian rivers; on the basis of morphological pressures 7 classes of river corridor morphological altera-tion have been defined. For each water body the length of the reaches for each of the 7 classes are available (Table B3-9).
  Morphological pressures considered:
  vicinity of roads, bank reinforcements, channel deepening, planform corrections (straightening), resectioning, lateral structures, removed ripar-ian vegetation, accumulations and reservoirs, interrupted connectivity with groundwater body, non-natural use in riparian zones and in adjacent land, water abstractions etc.
- Register of Slovenian water infrastructure – register under development.
- Indication on the magnitude of the problem regarding the morphological situation (propos-al: based on WFD Risk assessment)

On the basis of impact magnitude (on achieving good ecological status) defined by experts, different weights were assigned to each class of morphological alteration.

Using the weighted average, the final morphological risk score was calculated.

There are 50 water bodies within the Alpine Convention area (13 of them being partly and 37 of them being completely located in the full area), mostly on the rivers (48). Five of them are candidates for heavily modified water bodies.

According to the WFD Risk Assessment, 16 water bodies in the Alpine Convention area will (possibly) not achieve good ecological status due to morphological alteration (7 water bodies are covered by the Convention only in part).

Measures taken

- Description of measures taken in our country in order to improve the situation regarding river morphology

There are case studies potentially relevant to the improvement of river morphology (e.g. Restoration of the migration path on the River Sava, Rehabilitation of the sediment flow control dam on the River Kokra) (Bizjak et al., 2006)).

- Challenges in the implementation of measures (e.g. question of funding)

In the period of the first River Basin Management Plan, studies are to be undertaken and of background documents are to be elaborated for the Action Plan on hydromorphology.
They will form the basis for the Action Plan and, consequently, provide the framework for a strategic and efficient planning process, based on both ecological and socio-economic criteria.

Funding resources:

- water fund,
- stakeholders,
- donors,
- European funds,
- other sources.

Responsible bodies

- Which institution(s) is (are) involved in ques-tions regarding hydromorphology
- Institute for Water of the Republic of Slovenia
- How are the responsibilities distributed?
- The Institute for Water of the Republic of Slovenia – field- and office-study data gathering and analysis, analysis of pressures and impacts, strategic planning, providing lists of basic and supplementary measures for achieving good ecological status or good ecological potential.

Others

- Additional information regarded as important and useful

Assessment and conclusions

- Assessment and conclusions by the expert

In the Alpine Convention area the main morphological pressures are sediment flow control dams in headwaters and other lateral structures that interrupt sediment transport and biota migration.

Morphological pressures have not been recognised as being as significant as hydrological pressures. Due to adequate river gradient and water discharge, there are 317 water abstractions for small hydropower plants.

That represents more than three quarters of all water abstractions for small HPP in Slovenia.

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Switzerland

«Adequate space for watercourses» is one of the key development goals defined in the Swiss guiding principles for promoting sustainable watercourse management.

It means

- a cross-section that is adequate to accommo-date flood run-off and sediment transport
- adequate space for the development of natural structural diversity of the habitats
- adequate space for (longitudinal and lateral) habitat connectivity
- sufficient room for recreational activities
- land use sufficiently distant from watercourses to avoid pollution.

A systematic survey of the eco-morphological status of river banks, river beds, hydraulic works, weirs, longitudinal barriers and the definition of the necessary space constitute the basis for revitalising impacted rivers and to enhance the aquatic habitats.

To that end, an eco-morphological assessment method has been developed (http://www.modul-stufen-konzept.ch/e/oekomor-e.htm) and widely applied in recent years by the Cantons with the financial support from the Confederation. An intermediate evaluation of those watercourses that were recorded until July 2005 came to the following results and conclusions:

- Watercourses in lower, intensively utilised altitude zones in particular are strongly impact-ed, with 50% of the watercourses below 600 m a.s.l. showing insufficient structural diversity. With increasing altitude the figures decrease: Between 600-1200 m a.s.l. 26%, between 1200-2000 m still 11% and above 2000 m a.s.l. 2% are classified as being ecomorpho-logically inadequate.
- In the mountainous regions it is in particular the main rivers at the bottom of the valleys that are characterised by a poor ecomorphological status as a result of, in many cases, uninterrupted river training works constructed in the past for flood protection and land reclamation purposes.
- Within settlement areas, on average 85% of the watercourses have to be classified as having an insufficient ecomorphological structure.
- Small watercourses (up to 5 m in width) are in general in a better state than big rivers (> 5 m in width). The share of small rivers from the total length of watercourses is 96%.

  Besides the structural conditions the longitudinal connectivity is also part of the above-mentioned assessment method and migration barriers have therefore been recorded with a special focus on height gaps > 50 cm. They repre-sent another serious impairment to the ecological functions of the water bodies.

The results and main conclusions drawn from the gath-ered data are:

- Most of these artificial barriers are located in the altitude zone of 600-1200 m a.s.l. The main reason is that there are both numerous goods and uses to be protected in this zone and that the prevailing gradient requires barriers as protection measure. Below 600 m a.s.l. the gradient is less crucial, and above 1200 m a.s.l. there much fewer intensive human uses to be protected.
- Small watercourses with an average of 1,6 obstacles per watercourse-kilometre are, in general, more affected by barriers than big rivers with 0,6 barriers / km on average. This is mainly due to the lower gradient of big rivers.
- Within settlement areas the density of artificial barriers is highest with 2,5 obstacles /km. The reason is obviously the necessary high level of protection given the infrastructure and the high potential damage.

In legislation at the federal level there is no explicit obligation to revitalise water bodies. Revitalisation is carried out above all in connection with flood protection measures and with agricultural improvements. Moreover, as far as possible, the near-natural state must be restored in the context of interventions on rivers and streams. With certain exceptions it is prohibited to cover over rivers and streams, or to turn them into drains. Some Cantons have established funds with which they finance revitalisation projects. The Hydraulic Engineering Ordinance stipulates that Cantonal authorities are to define the minimum area that is required to safeguard the natural functions of a watercourse. There are an increasing number of good practices that can already be found throughout Switzerland. Especially local river channel widening has gained increasing popularity (see for example www.rivermanagement.ch).

As to longitudinal barriers, the federal fishery act requires for the authorisation of measures the safeguarding of free fish migration. Fish ladders are periodically evaluated and show varying performance. Hence, by-pass channels are recommended where possible for circumventing barriers.

Many of the big river training works in Switzerland will approach the end of their lives in the next decades. This will offer opportunities of integrating river restoration measures in the planning of the future schemes. This is, for example, already happening in the case of the third River Rhone correction. Altogether, the need to improve morphological conditions has been widely recognised and for about two decades steady improvements have been made, indeed. It is, however, deemed that these revitalisation works make a too slow a progress. As a consequence, there are ongoing political initiatives to regulate revitalisation more explicitly at the legal level and to work out financing solutions. This includes also the promotion of a more nature-like sediment transport, a major determinant for the ecomorphological status.

B.3 ALPINE WATER - SOCIAL AND ECONOMIC ASPECTS

B.3.1 PROPERTY RIGHTS AND PROVISIONS FOR THE ACCESS TO WATER

Being a first necessity good to be shared among all possible users, the legal status of water was defined in every country already a long time ago, slowly becoming more precise with more regulations as various further kinds of use arise. The right to utilise water – i.e. the question of what property rights actually encompass – is one of the oldest legal matters in the world and cannot be disconnected from public interest since any use - even minor and private – causes impacts on other users. The preamble of the Water Framework Directive (WFD), enacted in 2000, provides the following common statement: "Water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such[54]."

This quotation could be considered to be a starting point, justifying most restraints regarding the use of water according to vested public interests.

It seems that legislation in most countries avoids offering a uniform definition for the ownership of water; they mainly provide rules for the access to water. For example, as the WFD introduces the objective of "good status" for all bodies of water by 2015, 27 countries are committed to jointly manage all their freshwater resources at a basin-wide scale. The directive sets out a long-term perspective for the management and protection of bodies of water such as rivers, lakes, coastal waters and groundwater. All of its recommendations are made without mentioning a common regulation regarding the ownership status of the water. Only quantity and quality status are pointed out.

Updating most of the existing water legislation in the European Union, the WFD obviously consolidates existing national policies for property rights. Even if it does not mention directly property rights, it represents a major step forward for a common water management policy; therefore every state has to confirm its ability to reach the goals set out in the WFD. It seems that all national legislation dealing with access to water, has been oriented towards giving every public authority the ability to manage water resources, therefore restraining private property. This trend dates back to long before this WFD.
We could regard the WFD as providing a common formulation for the approach adopted by most states regarding the restraint of property rights. It is listed quite explicit in the "Programme of measures" in Article 11 of the WFD, § (e) and (g):

"Basic measures" are the minimum requirements to be complied with and shall consist of:
(e) controls over the abstraction of fresh surface water and groundwater, and impoundment of fresh surface water, including a register or registers of water abstractions and a requirement of prior authorisation for abstraction and impoundment. These controls shall be periodically reviewed and, where necessary, updated. Member States can exempt from these controls, abstractions or impoundments which have no significant impact on water status;"
(g): "for point source discharges liable to cause pollution, a requirement for prior regulation, such as a prohibition on the entry of pollutants into water, or for prior authorisation, or registration based on general binding rules, laying down emission controls for the pollutants concerned, including controls in accordance with Articles 10 and 16. These controls shall be periodically reviewed and, where necessary, updated;"
These rules are generally valid, independently from property rights in each Alpine state, which differ from state to state (whether subject or not to WFD).

In Switzerland, the right of disposition of water resources lies, according to the Constitution, with the Cantons. For the use of public waters, which goes beyond simple common uses, e.g. for abstracting water, other uses that may alter the water resources and the right to discharge into waters, the Cantons are sovereign in regulating, in accordance with federal laws, the obligation of obtaining approval.

Public control can be considered to be the first requirement for the preservation of "public interest". Looking at the national presentations regarding the situation within every Alpine state at the end of the chapter confirms the unanimous trend towards giving priority to full public control. This is mainly ensured by the need of prior authorisation for the utilisation of Alpine water resources. Therefore, permissions, issued by the responsible public authorities, are in most cases obligatory. These permissions have to be restricted in time since "management of water resources" also has to include the ability for administrative bodies to modify permissions or related imposed conditions in order to be able to adapt to changes in the overall (either environmental or social) framework. This aspect can be considered as an important element of a

[54] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, ABl 2000 L 327/1, Water Framework Directive, WFD

modern water policy. On the other hand, a certain "planning security" for investments (e.g. hydropower) is also necessary and the reason for not having too flexible an approach for permission adaptations.
However, unlike in the present framework which requires these considerations to be taken into account, – in the past, and given a different water policy pursued then, permissions were therefore often issued for long time periods and sometimes even without specifying an expiration date. These circumstances may cause difficulties for today's water management as they restrict the possibilities for necessary adaptations to permissions due to legal constraints. In such cases, an alternative approach for solving possible water management conflicts may and often does include compensation payments for holders of such permissions.

Dreaded "sell-out" of Alpine water: concern with good cause or unwarranted emotionally uplifted issue?

We have seen that most rights of ownership referring to water are subject to public authority approval and the use is under official supervision. In the following it is aimed to highlight some issues from the international perspective. The topic "water-sale" is repeatedly in the centre of political discussion, popping up in election debates time and again, and the dreaded "sell-out" of Alpine water resources is often perceived as a matter of concern in public perception. In this context, the question of an "export" of water (in pipelines for instance) to regions with increased water demand is regularly raised. In fact, the latter is to a limited extent already practically the case for the Alpine region. Drinking water for the city of Vienna for instance, situated near the foothills of the Alpine arc, is abstracted from an Alpine karst massif and transported via pipelines over distances between 100 and 200 km to the end users. This project was realised as early as in in the second half of the 19TH century. A comparable example is the German city Stuttgart – water is abstracted from Lake Constance and provided after long-distance transfers.

However, a study[55] has revealed that such practices are, apart from the need of approval by public authorities, restricted with respect to their economic viability. The costs per m^3 for the transport through pipelines increase with the distance, making the water transfer economically attractive only for limited distances. Therefore, the attractiveness of alternative solutions like seawater desalination for instance, where the related costs have significantly decreased due to technological innovations in recent years, increases for longer distances from the Alps to potential users and the prospects for the export of water fail due to high related costs.
An additional point, which makes the long-distance transfer of Alpine water throughout Europe unattractive, is that regions struggling with water scarcity and droughts are situated closer to alternative regions (compared to the Alps) which could provide water (e.g. the Apennines to southern Italy, north-western Greece to Athens, northern Spain to southern Spain). These considerations apply to bulk water transport. While the economic assessment may be a different one for bottled water, it is of minor consequence from a quantitative perspective.
However, even in the case that a long-distance water transfer were to become an attractive approach for solving the water problems of some (outer-) European regions in the future, the decision of doing so would remain within the competences of each Alpine state itself. Within the framework of the authorisation process for the utilisation of water on the basis of the national legislation in every Alpine state, a balance has to be sought between the interests of the different stakeholders, taking into account environmental needs. It is believed that water distribution questions, as also displayed by the case study on the River Po catchment in chapter B.2.3.2, will probably become more and more prevalent in the future against the background of predicted climate change impacts. The required legal framework for meeting these challenges by means of active water resources management is in place.

This is the case in Switzerland but also in member states of the European Union. With respect to EU countries, concerns regarding the self-determination of EU countries in the field of water uses were raised and discussed in the context of the (meanwhile stagnated) ratification process of 'The Treaty of Lisbon[56] . Article 192 of the Treaty (ex Article 175 TEC) is actually dealing with measures affecting the "quantitative management of water resources or affecting, directly or indirectly, the availability of those resources". However, Article 192 clearly states that on such measures the Council has to act "unanimously" in the decision making process, allowing every EU member state to decide on such measures within the national borders on its own and giving the opportunity to block related plans if they are not desired by the member state itself.

Hence, as also pointed out at the international conference "The Water Balance of the Alps[57]" in September 2006 in Innsbruck, as far as the dreaded "sell-out" of water in the Alps is concerned, there is no real danger for the national water resources in the Alps due to the existing European legal situation. Although the common water policy does allow the development of a water policy for the EU, a compulsory regulation to that effect that the Alpine states are obliged to deliver their water resources to demanding regions abroad, does not exist. Also, while the EU Water Framework Directive (WFD) does allow a coherent system of management, it does not contain

[55] Contrast Management Consulting im Auftrag des BMLFUW. (2003). Ökonomische Nutzung des in Österreich vorhandenen nachhaltig nutzbaren Wasserdargebots. Wien

[56] Consolidated Version of the Treaty on the Functioning of the European Union, C115/47

[57] Psenner, R., et al. (2007). The Water Balance of the Alps. What do we need to protect the water resources of the Alps? Contribution from K. Weber to the proceedings of the conference held at Innsbruck University, 28-29 September 2006. Innsbruck University Press. Innsbruck.

obligations in respect to a "water export". Additionally, national laws on water in the Alps make sure that water may only be delivered abroad if neither the supply of the regional and national population is endangered, nor negative consequences for the water balance, quality, ecological functioning of waters or other national interests would arise. Therefore, a "sell-out" of Alpine water is not to be expected, neither from a juristic nor an economic perspective in the near future.

Conclusion

It is a common exception that private property rights for water may remain (mostly for groundwater resources) with the land owner. Even if in some countries like France and Italy water is specified to be a common patrimony of the whole Nation or a "shared asset", in all countries legislation refers to:

- the ownership of the place where the resource is situated like ground, river bed, lake or basin;
- the use such as privately for households, privately for industry or agriculture, for energy production or in the public interest.

Only "minor uses" (like household needs) are not subject to any prior permission. In most other cases, either licenses or declarations are mandatory. The limits vary, as shown, e.g., by the Austrian example: if groundwater is abstracted via a pump, even if it is just for household needs, permission is needed, or the rate of abstraction is proportionate to the size of land.

Common points regarding regulations in the Alpine states (e.g. the definition of minor uses, concrete remarks on common property conditions) can be summarised as following:

- all uses above insignificance need prior authorisation;
- although property rights may vary, in practice regulative instruments secure water management in the public interest;
- common aims in the field of water management (recovering quality, sustainability, coordination between various uses…) are shared by all coun-tries and have recently also been spelled out by the Water Framework Directive (WFD) for EU members, therefore limiting property rights, which was, to a great extent, already the case before the WFD came into force.

To sum up, the utilisation of Alpine water resources can be considered as being regulated by public authorities to a great extent. Private use of water is mostly subject to prior authorisation for the sake of public interest.

National Contributions
Regarding Information on Property Rights and Provisions for the Access to Water

Austria

Surface water in Austria is either in public or private ownership. This distinction is specified with in detail in §§1,2,3 of the National Water Act. Whereas most of the larger rivers are designated in the Austrian Water Act as a public good (registered as public rivers in the Water Act, see Annex A), the rest of surface waters belong to private individuals.

Uses of public and private waters for which prior authorisation is not required are the abstraction of drinking water for humans and livestock without mechanical devices; uses of public waters without prior authorisation are also bathing, use of ice cover, collection of plants, sand, gravel... as long as the watercourse, water quality, river bank, public interests… are not impacted.

In Austria, the ownership of groundwater is linked to the ownership of land. Thus, the owner of the land also owns the groundwater beneath the surface. Nevertheless, use of groundwater by the land owner is restricted to the abstraction of water to cover his domestic need as long as only “hand driven” means are used or the rate of abstraction is proportionate to the size of land. All other uses need prior authorisation by the competent authority.

Permits are issued by the competent authorities. These are usually the authorities at district level (Austria has in total about 100 districts); the governors of our 9 Laender are the competent authorities for waters at the border with neighbouring countries and water uses of regional relevance (e.g. hydropower plants above 500 KW, abstractions from groundwater in excess of 300 l/min, abstractions from surface waters in excess of 1000 l/min as well as abstractions for the water supply of more 15.000 inhabitants, discharges from wastewater treatment plants above 20.000 p.e., extraction of gravel from aquifers…). The federal minister of agriculture and forestry, environment and water management is also competent authority for particular water uses of mayor importance (e.g. reservoirs with dams with more than 30 meters in height or a capacity of more than 5 million cubic meters, water supply exceeding 400.000 inhabitants, installations with potential mayor impact on neighbouring countries). The distribution of competences is listed in more detail in §§98, 99 and 100 of the National Water Act.
In conclusion it may be stated that for both groundwater and surface water, individual property rights are strongly restricted in order to safeguard interests of the general public and to assure a fair sharing of uses.

France

In France, according to a national water act enforced in 1992, water is specified to be a common patrimony of the whole Nation and its preservation and development are of public interest. Each citizen is entitled to have access to the use of water for drinking and health purposes. Therefore, there are no property rights in any kind of natural water resource, only a right of use of water exists for the owner of the stream or lake (beds and banks) or, in the case of groundwater, for the owner of the land above. The owner can either be the Central State, a public decentralised body such as “régions”, “départments” and municipalities, or private owners according to the status of the water body. Therefore, neither public nor private ownership of the water exists, neither for groundwater nor for surface water.
Household uses do not require any prior authorisation. All other uses need prior authorisation by the competent authority.

For any other uses according to the impact of the project on the water resource or aquatic ecosystem, an authorisation or a declaration/notification is required above thresholds indicated in a specific nomenclature (abstractions, discharges, hydropower plants, sewage treatment plants etc.). The representative of the Central State at local level (Prefect of the “département”) is entitled to issue the licences or admit the declarations/notifications. It has to be pointed out that even projects only submitted for a simple declaration (according to the legal requirements) may be rejected under special circumstances.

Besides the most important watercourses (Isère, Rhône, Arve, Drôme, Durance…), a large majority of Alpine watercourses are covered by private rights: the river bed and banks belong to the neighbouring landowners; they can forbid any access to water. The water itself is always a public domain and owners are not allowed to reduce its flow below a certain level. Maintenance of the river bed is the owners’ responsibility. If necessary, a community can act as a substitute through a public interest procedure, to take action to a restore natural flow. Otherwise, any major intervention which may possibly disturb the river flow must be declared or authorized by the State. The State representative (under Prefect authority) can ask for adjustments of the project in order to satisfy recently enforced water acts.
It should also be mentioned that in case of exceptional or chronic water imbalances (drought, short-

age, flooding, etc.), specific rules are gradually or automatically enforced by the Prefect, such as restriction of such use (considered as waste) or limited abstraction.

Germany

To meet the many water use requirements (public water supply, sewage disposal, generation of energy, leisure uses, watering of agricultural land and a great deal more) it is necessary that all water bodies are managed by the State. The possibilities of use by the owner therefore have to step back to a large extent.

Property rights to water are stipulated in Article 4, Section 1 of the Bavarian Water Act: "The ownership of land applies to the existing surface water and not to the groundwater." There is therefore no private ownership of groundwater.

Surface water is included in the title to land on which the surface water is located, however, the right of using the water has been largely revoked.

Almost all impacts; uses or modification of the water bodies require approval by the State. The bodies responsible are the local authorities, (district administration offices, State offices for water management)

There are exemptions from this duty of obtaining a permit. Of these, the most important ones are:

a) Public use
   Anyone (thus not only the owner) is allowed to use a surface water body for the following purposes: bathing, washing, collecting water in containers, giving water to and washing animals, sport activities on ice, boating with small rowing or sailing boats. These uses are of historical origin. They are to be interpreted strictly. Public use does not include uses of economic significance.
b) Use by the owner
   The owner can use the water body for his personal needs, insofar as this does not have an adverse effect on others, does not detrimen-tally alter the property of the water, does not have a significant impact on the water regime and no other damage to the water balance is to be expected.
c) Wells
   Groundwater may be taken for certain purposes without obtaining a permit from the authorities. The most important ones of these are for drinking water requirements for the ownhousehold, for watering a home garden, for providing farm livestock with drinking water, for draining soil.
d) Harmless removal of rainwater
   Rainwater from land with low contamination (e.g. residential areas) may be fed into surface water bodies or allowed to trickle into the subsoil without obtaining a permit. In doing so, specified protection measures must be observed.

Italy

The assumption on which Italian legislation is based is that water is considered to be a shared asset to be protected and used according to criteria of solidarity[58].
All water belongs to the State and is publicly owned, including underground and surface water which has not yet been collected in reservoirs or tanks, excluding rain water which has not yet reached a watercourse or has not yet been collected in reservoirs or tanks[59].
The concept of public ownership of water has developed considerably over time. In fact, the 1933 legislation[60] regarded as public water only water which was likely to be used in the general public interest and which was registered in lists approved by decree. Only in 1994 was all water, whether surface or underground water, deemed to be public[61].

As a result of all water being deemed public, its use by anyone, whether a physical or legal person, public or private, can lawfully take place in the long term only by the obtaining of a licence for use or a temporary permit granted by law for the period of one year.
The drawing and use of underground water for domestic purposes by a landowner does not require authorisation provided that it does not compromise the water table[62] , nor the collection of rain water in reservoirs and tanks for agricultural purposes or for individual buildings[63].
The licence to use public water is restricted to its use being identified; it follows that the holder of a licence is authorised to use the resource in the quantity permitted, only for the use permitted and he has no other right to use the same water for other purposes, even though feasible.
Water for public use consists of large and small extractions[64]. Large extractions are regarded as those which exceed the following limits:

a) for power production: average annual rated power kW 3.000
b) for drinking water: 100 litres per second

[58] Legislative Decree of 3 April 2006, no. 152, art. 144
[59] Presidential Decree of 18 February 1999, no. 238, art. 1
[60] Royal Decree of 11 December 1933, n. 1775, art. 1
[61] Law of 5 January 1994, no. 36, art. 1
[62] Royal Decree of 11 December 1933, no. 1775, art. 93
[63] Legislative Decree of 3 April 2006, no. 152, art. 167
[64] Royal Decree of 11 December 1933, no. 1775, art. 6

c) for irrigation: 1000 litres per second or even less if a surface area of 500 hectares is to be irrigated
d) for land reclamation: 5.000 litres per second
e) for industrial uses, meaning for uses other than those expressly indicated in this article: 100 litres per second
f) for fish farming: 100 litres per second
g) for water provision in fire prevention and used for energy renewal: 100 litres per second.When the extraction is used for more than one purpose, it is assumed that the limitation is that of the predominant purpose.

Whoever intends to extract or use public water must apply for authorisation or the granting of extraction rights from the competent authority. Exempt from such applications are extraction and use of underground water by the landowner himself for domestic use and the collection of rainwater in reservoirs and tanks for agricultural purposes and for individual buildings.

Prior to 1998, the responsibility for granting permissions for large extractions resided in the State, and in the Regions for small extractions. With Legislative Decree no.112/1998, all technical and administrative functions in relation to the management of water were transferred to the Regions and to the autonomous local authorities, ownership alone being retained by the State.
Only in two cases is the procedure for licences for extracting public water not regulated by the individual Regions: when licenses for extraction concern the interests of more than one region in the same water basin, in which case licences are issued by a joint agreement of the Regions concerned; and when licences involve the transfer of the resource between different regions, going beyond the limits of the same water basin, in which case the administrative procedure is carried out by the State.
The Regions also have the right to transfer management of small and large extractions to the Provinces, reserving the rights in relation to legislation, programming, guidelines and control. Licences for large extractions generally remain under the control of the Regions, while for small extractions the task is transferred to the Provincial Authorities.

Water extraction licences are temporary: the period cannot exceed 40 years for irrigation and fish farming, while for all other uses the maximum is 30 years. An exception to this is large water extraction for hydropower (average annual rated power exceeding 3.000 kW)[65].

[65] Legislative Decree of 3 April 2006, no 152, art. 96 (8)

Save for renewal of the licence at the end of use, i.e. upon the expiry of the licence, all works and equipment created for water use pass to public ownership without compensation and free of all privileges, charges or other rights.

Slovenia

The principle of the Slovenian Water Act is that anyone can use water as long as there are no unpleasant effects on the quality and quantity of the water resource. The Water Act defines surface waters, groundwater and the sea as public resources to be managed by the State. The State itself is entrusted to ensure that the water is used efficiently and sustainably, and that available water resources are protected in the long term. The water is considered to be owned by the State, including both surface water and groundwater.

The use of water can be general (bathing, skating, diving, drinking and other personal uses for which no devices or structures are needed) or special (use exceeding the limits of general use). The Water Act lies down that a water right has to be acquired to use water for special purposes. The right is granted for a limited period (for 30 years at the most) and must be paid for (water right and water use fees). Any special use of waters or water land is subject to a water right in the form of a water permit issued by the Environmental Agency or a concession granted by the Government. A water permit is required for purposes such as: drinking water supply, process water, bathing areas and spas, heat production, irrigation of agricultural land, powering of a watermill or sawmill, aquaculture, and artificial snow making. The Government grants concessions for purposes such as: beverage production, bathing areas where thermal, mineral or thermo-mineral waters are used, electricity production in hydropower stations, extraction of alluvial deposits, and commercial aquaculture.

Revenues from water rights and water use fees are collected in the Water Fund and are used for water management.

The most important procedures are those that offer the protection of aquatic environments, of natural morphological changes and of the quality of existing water reserves, primarily by prohibiting or restricting certain activities. The main task of water management is to achieve and maintain the good status of waters and related ecosystems through the adjustment of human activities to the natural water regime. Only then follows the adjustment of the water regime to an activity, which must be carried out very carefully. Prior assessment of long-term effects on the water regime and on humans as part of the ecosystem must be considered properly as well. The Environmental Agency directs procedures for the preparation of guidelines and opinions on spatial planning acts in the field of water management in order to ensure that an activity is adequately adjusted to the natural water regime.

Switzerland

According to article 664 of the Swiss Civil Law Book of 10 December 1910 (ZGB) for public water bodies, there is in principle no private property; instead, they are under the control of the state in whose area they lie. The power of disposition of Swiss water resources lies with the Cantons as set out in Article 76 paragraph 4 of the Swiss Federal Constitution of 18 April 1999 (BV). However, the federal government takes decisions on rights concerning international water resources, in consultation with to the Cantons concerned (Federal Constitution Article 76 paragraph 5). According to federal jurisdiction, not only waters above ground are regarded as public waters, but also the large groundwater streams and sources that comprise the beginning of a stream. The remaining sources and local groundwater resources are, according to Article 704 of the ZGB, part of the plot of land where they are found. Consequently the owner of this plot of land is also the owner of the source and the source or groundwater is at the owner's disposal. However, the public law of the Cantons can restrict water abstraction to small domestic requirements, and can further limit the rights of the owners of sources in the general public interest. Furthermore, under certain circumstances the owners of sources may be required to yield their property rights to the source (ZGB Article 711).
For public surface waters, utilisation that does not go beyond simple common use, in other words is a conventional and generally acceptable use, is not subject to approval.
However, if there is a predominant public interest, the Cantons may enact prohibitions, restrictions or other special local rules. Utilisation that does not require approval includes the use of surface waters with ships, boats and surfboards, and for bathing or swimming. For the use of public waters which goes beyond simple common use, the Cantons are sovereign in regulating the obligation to obtain approval in Cantonal law. Examples of such types of utilisation are the construction of boathouses and harbours, the abstraction of water as drinking water, for irrigation or for cooling, the use of the water to produce heat or electrical energy and any use of subterranean waters (e.g. water abstraction or withdrawal of heat using a heat pump).
Moreover, through Article 29 of the Law on Water Protection of 24 January 1991, federal law provides for the obligation to obtain approval for the abstraction of water over and above the common use from rivers and streams with continuous flow of water and from lakes or groundwater resources which have a marked influence on the flow of water in rivers and streams that have a continuous flow of water. Federal law also provides for the necessity of obtaining water right licenses for the use of water power. In accordance with Article 38 of the Law on Hydroelectric Power of 22 December 1916, the license is conferred by the competent authority of the Canton within whose area the stretch of water in question is located. Water rights on stretches of water that touch the national boundary are conferred by the Federal Department of the Environment, Transport, Energy and Communications.

B.3.2 CHARGES REGARDING THE USE OF WATER

Water uses have been identified to be water supply, wastewater treatment with the discharge of the treated water into water bodies, agricultural irrigation, industrial process water, the abstraction of cooling water and of water for the artificial snow production as well as water abstraction for hydropower generation. Water appears to be one of the greatest treasures in the Alpine space. However, it is subject to seasonal variations and reacts sensitively to human interventions. The availability of water seems to be quite similar in the Alpine perimeter, however, when looking at it in detail there are quite some differences at the regional level.
In this context it is of interest who is responsible for the licences or approvals for the use of water in the Alpine states, for the regulation of financial consideration, how such financial considerations is collected and which authorities grant the permits for the use of water.

Information has also been requested on the access to and the availability of water for drinking water purposes. In the Alpine space the access to and the use of water for drinking water purposes in have top priority and are of high political relevance in society, because water is regarded by the community to be common property. Another question to be explored has been to what extent the Alpine states consider also the discharge of treated water into the bodies of water to be water use and how they promote the improvement of wastewater treatment.

Assessment

All Alpine states have stringent approval practices for the different kinds of water use. In addition, the applicants have to present concrete information on water demand, provide reasons for the necessity of using the water as well as information on possible impacts on the environment. Based on this, the regulatory authorities determine, if relevant, also any financial consideration or compensation for impacts on the environment.

This exercise has made it clear why the regions with high water reserves on the northern side of the Alps demand less in financial consideration for the use of water than southern regions with lower water resources and stronger seasonal variations in the availability of water.

In the German part of the Alps and pre-Alps water is available in abundance. This may be the reason why in its historical development water was considered to be a public good not owned by anybody. The only restriction was not to interfere with other uses. In recent decades the ecological aspect has become more and more important. Moreover, Germany considers water to be indispensable for livelihood, in particular for drinking water supply which should not be subjected to economic interests.

Germany does not collect any charges for the access to and the use of water save some few exceptions.. But there is a requirement to provide evidence that the negative effects on the environment will be limited and acceptable.. The issuance of a licence to use water is partly connected with extensive monitoring programmes and obligations to reduce and mitigate possible environmental influences. Former negative environmental influences are to be compensated in part by these obligations as well, e.g. the renaturation of water bodies. As far as there are effects on the environment which cannot be compensated, no approval will be granted for the intended use. Charges are levied for the supply of drinking water and for wastewater treatment, but these charges only cover the investment costs as well as the current costs for the operation and maintenance of the systems.

There are only two exceptions where the use of water is charged:

- Fees have to be paid in case water is used for hydropower production but only for bigger plants exceeding a capacity of 1.100 kW. The money flows into the general national budget.
- For the discharge of wastewater fees are to be paid as well, especially for the impact of treated wastewater on the water bodies. The level of these fees depends on the pollution remain-ing in the treated wastewater. The objective is to force operators to optimise their treatment plants for best possible purification. The rev-enue from the wastewater charges is used for monitoring water quality, for improving exist-ing wastewater treatment plants, e.g. in terms of the retention of nutrients, as well as for the renaturation of water bodies. In France and Slovenia, too, the revenues from the charges for wastewater discharges are invested in the improvement of wastewater treatment plants or wastewater systems.

While in Slovenia all water uses are subject to charges, water users in Switzerland have to pay primarily for the production of electricity from water power. In Switzerland the charges collected for the use of water power use flows to the Cantons or to the communities. Italy charges uses for hydropower generation as well as for agricultural irrigation and drinking water supply. Since 1998 the charges collected flow to the regional and local authorities. In France levies have been imposed since 1970 by river basin institutions for the various water uses (abstraction and pollution discharged). The funds collected are reinvested for improvements (e.g. wastewater treatment plants, renaturation) implemented by any public or private water user.

Basically the “user pays” principle is applied in all Alpine states due to the fact that operators who impact water bodies in a negative way are obliged to fulfil stringent conditions imposed in the course of the licensing process or have to pay charges for the protection of nature and landscape. Whether or not the use of water is charged depends mainly on the regional situation and historical developments. There is no need to unify a charging system as long as the fulfilment of basic requirements, such as environmentally acceptable uses, is granted.

According to Article 9 of the Water Framework Directive (2000/60/EC), the member states of the European Union will adopt a scheme for the recovery of costs incurred for the provision of water services during the next years.

Conclusions

As can be seen in the national contributions, charges collected are mainly covering infrastructure and investment costs of the traditional water services (drinking water supply and wastewater treatment). The main exemption is the hydropower sector, where some countries are also collecting charges for the use of water resources. Additional information can be obtained from the study performed by Hans Wyer "Die öffentlichen Ausgaben der Wasserkraftnutzung im Alpenraum" in 2006. In Switzerland in particular, charges imposed for the use of water resources for hydropower generation are an important source of income for mountainous Cantons and mountainous municipalities. The idea underlying such attempts is that the regions in which the hydropower stations are situated should benefit from the use of the resource. However, it has to be pointed out that due to differences in the ownership of installations, in traditions and the historical development, various approaches for generating benefits for the regions concerned have been adopted in the various parts of the Alpine perimeter. An additional aspect is that this issue has to be seen also in light of transfer payments coming from outside the Alpine perimeter, for instance to realise protective infrastructure against natural hazards.
Further discussions on these issues may be expected in line with filling Article 7 of the Energy Protocol and Article 11 of the Spatial Planning Protocol, respectively with life through the implementation of Article 9 of the EU Water Framework Directive.

National Contributions Regarding Information on Charges Related to the Use of Water

Austria

One of the main objectives of the Austrian Water Act is the protection of water, which is a matter of public concern. To ensure this, the use of water, i.e. the abstraction or retention of water for water supply, agricultural or industrial production and hydropower generation as well as the pollution and modification of the physical characteristic of water as a result of the discharge of wastewater or cooling water, requires an approval.
Approval criteria are: the need for water, the setting of standards to meet quality objectives or to limit pollution.

Sectors and charges
If considerable negative impacts on the environment (water) can be expected or estimated in advance, approval will be denied. The costs to achieve and fulfil the approval criteria, e.g. costs for wastewater treatment and/or water saving technologies, fish passes, etc. are paid for by the (future) holder of the authorisation.

In one Austrian region, charges for the "utilisation of nature or for landscape protection" are collected from the holder of the authorisation in addition to requiring an approval. This concerns charges in connection with water abstractions for artificial snow production (30, – euros per m^3 of annual water abstraction) and surface discharge or abstraction of water for hydropower generation (1, – euro per litre and second of the design capacity).
In almost all Austrian regions, the removal of gravel from watercourses is charged (20 - 40 cents per ton) too. The bodies responsible for setting the charges for the "utilisation of nature or landscape protection" are the regional governments.

Regarding water services, the responsible municipalities collect charges for public water supply and wastewater disposal from the end-user at a local level. When setting the tariffs, the principles of proportionality and cost recovery have to be followed. With 92% of cost recovery for water supply and 84% for wastewater treatment, the tariffs for the consumers internalise the major part of the costs for both services. However, additional financial support for environmentally relevant investments is granted by the public authorities on a case-by-case basis.
In general, the charges are set on the basis of regional laws or ordinances enacted by local authorities, only in singular cases by contracts.

Use and distribution of allocated funds
Charges for the "utilisation of nature or landscape protection" are allocated to funds which are used for measures of nature or landscape protection including research and development but also public relations. In most cases, there is a distribution of the allocated charges between the region and the communities.

The allocated charges for the above-mentioned water services remain in the communities and are used to cover the fixed and the variable costs for the construction, maintenance and operation of the (treatment) plants, pipes or sewers.

Effects related to compensation schemes
As the approval for a water use will be denied if essential negative impacts on the environment (water) can expected or estimated; "compensation" in the form of technical conditions is an approval requirement.
As regards any existing rights of a third (party), the criterion for approval is, that - if interferences in those rights are necessary for public reasons – adequate compensation has to be paid, e.g. for management restrictions.

The charges for the "utilisation of nature or landscape protection" are also used to cover costs for measures to compensate interferences with nature that are caused by the water use.

In summary, it can be stated that restrictions of negative environmental effects resulting from the use of water or the pollution of water are not controlled via economic instruments in Austria for the above-mentioned sectors. Instead, the application of regulatory instruments and standards is the way chosen to move forward towards sustainable water management. Hence, the internalisation of the external environmental costs is partially achieved by applying conditions, which are imposed on applicants for permissions for the use of water or the discharge of pollutants. This regards the abstraction of water on the one hand, where a consensus amount of water for abstraction has to be approved by the competent public authority and which is inspected regularly and can be adjusted, if necessary. On the other hand, the discharge of polluted water is controlled via regulations, specific for certain branches of industry, which define the maximum allowed concentrations of pollutants in the effluent. These limitations have to be complied with and polluters undertake to make any necessary investments and bear any related costs.

France

As the water is stated by law to be a common patrimony of the Nation, no charge for the use of water can be collected by anyone; water cannot be sold, only services for water can be charged. If the approval for a water use is denied for obvious unsatisfactory water preservation, "compensation" may be required in the form of technical conditions as a condition for approval. As regards existing rights of a third party, the criterion for approval is that - if an encroachment on these rights is necessary for public reasons – adequate compensation has to be paid for management restrictions. The charges for the "utilisation of nature or landscape protection" are also used to cover costs for measures alleviating the damage caused by the (water) use.

Besides this first consideration, pollution and abstraction levies have been collected since 1970 in order to develop a water policy under the activity of 6 River Basin Agencies (RBAs) on a nation-wide basis. The Alpine region is within the perimeter of the Rhone, Mediterranean and Corsica RBAs (the whole watershed of the Mediterranean Sea for France).

This RBA is a public institution under the control of both the Ministry for Sustainable Development and the Ministry for Finance. Financially autonomous thanks to the levies collected, this institution provides subsidies according to a water policy as agreed upon under the control of a Basin Committee. This Committee is composed of members representing 3 interest groups: 1)- various State departments concerned with water preservation, 2)- elected bodies from districts and cities, and 3)- various water users such as farmers, industrial stakeholders, fishermen, ecologists and consumer NGOs. Nationwide, the annual budget of the six RBAs is about 2 billion euros, the Rhone RBA's budget being ~350 million euros/yr (for $^1/_4$ of France, a population of 14 million, half of the country's tourist activities).

This institution is not an operator and does not own or build any facilities; it could collectively be termed "a financial booster" for water preservation, providing budget for any kind of investment (public or private, studies or facilities) driven by either a public or a private partner. The whole budget of the RBA comes from the levies it sets and is channelled back into water related investments (including studies, facilities and equipment, but also salaries of the staff).
Various kinds of levies are collected according to the "polluter principle": abstraction of water, river course diversion, pollution of water bodies. Considering the 2004-2006 program (4 years) the levies collected for the Rhone RBA of 1,5 billion euros can be broken

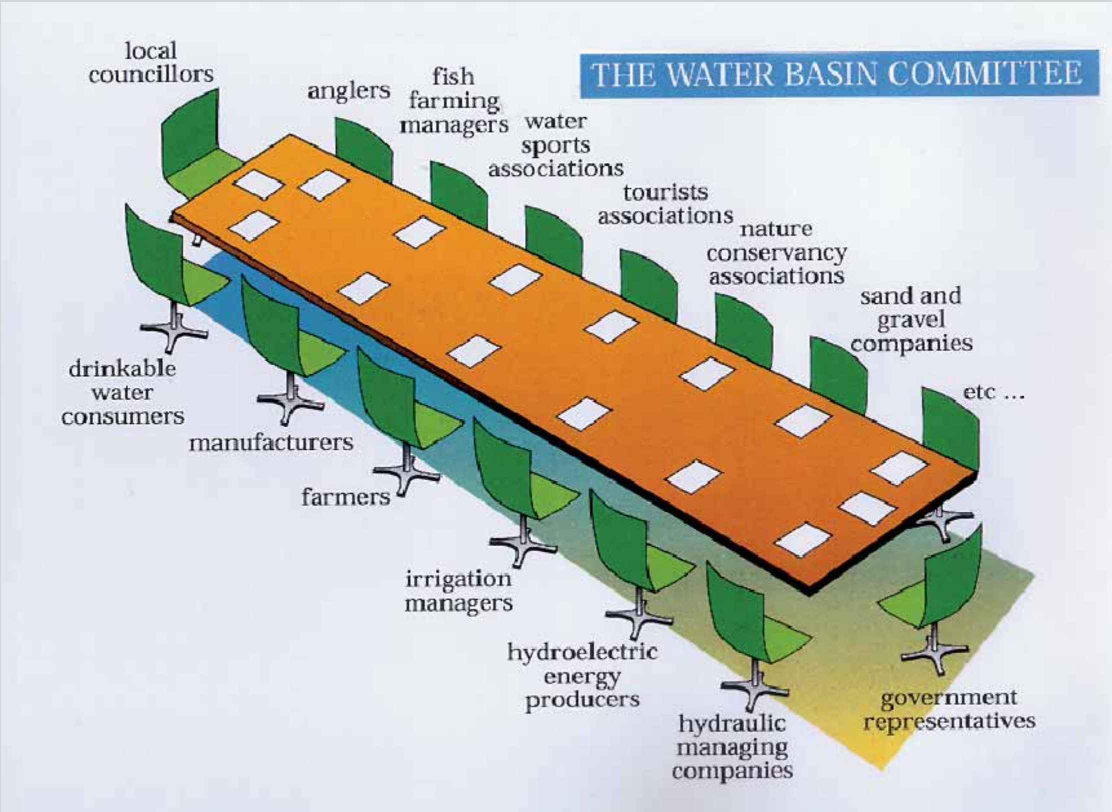


Fig. B3-1: The water basin committee

down as follows: 16% for abstraction, 74% for domestic pollution and 10% for non-domestic pollution (industry and agriculture). It should be mentioned that domestic pollution is charged according to raw pollution (= before treatment) and is entitled to refunding depending on the efficiency of the existing wastewater treatment plant. For industry, only net pollution is charged. Levy rates are decided by the River Basin Committee under government control. The rate levels depend on many parameters (quality and quantity parameters) and on the local impact: i.e. according to the water balance of the resource for the abstraction levy, quality impact on the water body for pollution. Most of the Alpine area pays, for example, for irrigation (sprinklers) 3 euros/1.000m^3 for surface water and 5,6 euros/1.000m^3 for underground abstraction. For the domestic pollution levy (to be included in the domestic water bill by the operator of the service) the rate was 0,19 euros/m^3 in 2008. Too many rates exist to be mentioned here (diffuse pollution, cooling towers, drinking water solidarity...).

As mentioned above, those charges are channelled back to the contributors who invest in or operate systems for the preservation of the water resources. The average rate of subsidies is 30% of net cost for equipment and 50% for studies. It should be noted as well that higher rates (up to 50% subsidy) are granted in solidarity towards rural areas in the Alps, in most cases municipalities below 2.000 inhabitants.
As regards the internalisation of external environmental costs, this has obviously been achieved only partially via these levies. The abstraction of the resource and the discharge of polluted water are – first of all - supposed to be controlled via regulations. These limitations proved to be difficult to enforce by the water police departments; providing subsidies successfully helps polluters to comply with regulations (being at the same time compelled and helped according to the “carrot and stick” scheme!).

Germany

As set forth in the German national contribution B.3.1, water users require a permit from the authorities. This permit can only be granted if all adverse effects on the common good have been compensated and in particular if all required measures for protecting water bodies have been taken.

The costs for these measures shall be passed on by the water users to the customers in the form of water charges. In this way, costs for the protection of water bodies shall be financed to a large extent according to the polluter pays principle. This applies in particular to public water supply and wastewater disposal, which are principally the tasks of the municipalities. In these cases, the municipalities charge fees for their services, which shall cover the costs in compliance with the applicable calculation regulations.

In the Alpine region, high costs may be incurred if property located in high Alpine regions has to be supplied with water or if this property requires sewage disposal. In such cases, it is usually the owner of the property who has to arrange for an appropriate water supply (e.g. through tapping a spring, from cisterns) and appropriate sewage disposal (own septic tank or own outfall pipe to a municipal sewage plant in the valley).

As regards sewage disposal, general environmental costs are additionally passed on to the polluter through the Wastewater Charges Act. According to this act, all dischargers of wastewater into water bodies shall be subject to a charge levied by the State of Bavaria. The charged amount shall depend on the quantity and the degree of noxiousness of the wastewater.

Further cost regulations shall be examined within the framework of the implementation of Article 9 of the Directive 2000/60/EC –Water Framework Directive.

Italy

In Italy, in order to use public water, it is necessary to obtain a State licence which is charged on a calculation based on the use and average quantity authorised by the licence and the units and minimum rates set for each type of use. The uses generally licensed are: irrigation (agriculture), civic, domestic, human consumption, energy production (hydropower), industrial, livestock. There are also lesser uses of little relevance for the Alpine area.
Since 1998 the charges have been set by the Regions by virtue of their own administrative functions and responsibilities. Furthermore, the Regions are responsible for the procedures regulating charges. The licences are renewable every three years.
Given the responsibility of the Regions in relation to charges, in order to assure a standardisation of approach throughout the national territory it has been proposed that the Ministry of the Environment introduce regulations for establishing the general criteria for determining charges relating to the use of public water, taking into account the environmental costs of the resource and providing, in addition, for reductions in the fees where the licensee re-cycles the waters.
The annual payment for the use of public water is fixed by Resolution of the Regional (or Provincial) Ruling Committee.

The calculation of the charges for all uses (excluding hydropower and irrigation based on land area) is performed on the basis of the "permitted flow" expressed in "l/s" or in "modules" (1 module = 100 l/s). For agricultural use based on land area, the unit of measurement is the hectare of land irrigated. For hydropower the charge is calculated on the basis of the average annual number of kilowatts (kW) of rated power.

In the regions of the Alpine area the unit charge per year for irrigation varies from a minimum of 0,43 euros l/s[66] to a maximum of 0,48 euros l/s[67], while in the case of charges according to land area it varies from a minimum of 0,38 euros per hectare [1] to a maximum of 1,02 euros per hectare[68]; for drinking purposes it varies from a minimum of 18,41 euros l/s [1] to a maximum of 20,59 euros l/s [2]; for hydropower it varies from a minimum of 12,57 euros kW 1 to a maximum of 14,04 euros kW [2]; for industrial use it varies from a minimum of 136,22 euros l/s[69] to a maximum of 158,91 euros l/s 2. For all uses, however, there is an annual fee to be paid.

For licences for hydropower, in addition to the State licence, there is also the possibility of establishing a surcharge to be paid to the local communities in compensation for any damage incurred as a result of the licence.

The charge for the use of water is an annual one and must be paid in advance, by 31 January of the year concerned. The charge is paid to the Regional Treasury by post office payment. The Region decides independently in what way the charges are to be distributed between the local authorities.

By 2010 the Regions, who are the authorities having responsibility in this area, must have adopted pricing policies which are apt to encourage an efficient use of water resources and to achieve and maintain environmental quality objectives. This is to be facilitated by ensuring that the various sectors using water make an adequate contribution to the recovery of costs for water services, including environmental costs, according to the polluter pays principle.

[66] Figure from Friuli V.G.Autonomous Region, 2007
[67] Figure from Lombardy Region, 2008
[68] Figure from Piedmont Region, 2007
[69] Figure from Veneto Region, 2007

Slovenia

According to the National Waters Act in Slovenia, every use of public water, the acquisition of rights to use the water (either a water permit or a concession) is subject to payment. A fee is also to be paid for water pollution in accordance with environmental protection regulations.

Water fees should be paid for the following water uses or water-related activities:

1. the private supply of drinking water or the supply of drinking water provided as a commercial public service;
2. technological purposes;
3. the activity of bathing areas and natural health spas pursuant to the healthcare regulations;
4. the extraction of heat;
5. the irrigation of agricultural land or other areas;
6. the production of electricity in hydroelectric power plants directly connected to the public electricity network;
7. the propelling of water mills, saws or similar installations;
8. the cultivation of water organisms for repopulation or private consumption;
9. a port, if the investor is a person under public law;
10. the production of artificial snow;
11. the erection of a floating installation pursu-ant to the regulations on maritime navigation and navigational safety on inland waters.

The unit price of the fees is different for almost every purpose listed. Some of the sectors contribute money to the State budget, some to the municipal budget, and part of money goes to commercial public services.

The system is well established and works smoothly. However, it is not possible to present the exact amount of charges for each sector for the Alpine region itself, since the borders of administrative districts which are the basis for collecting the money do not correspond to the area of Alpine Convention.

The body responsible for laying down the charges to be paid for the use of water is the Ministry for Environment and Spatial Planning

The procedure of setting, collecting and distributing the charges depends on the use of water, but generally there are two ways:

a) the user predicts the amount of water which will be used (but in accordance with the permit or concession); during the year, regular pay-ments have to e made in monthly instalments, and once a year the user receives a notice from the Environmental Agency of the Republic of Slovenia, which defines the yearly cost for a certain kind of use

b) the supply of drinking water provided as a commercial public service is paid monthly ac-cording to the measured amount of water sup-plied;

The charges are set and the respective sectors are defined in State legislation.
The collection of the charges is the responsibility of the Environmental Agency of the Republic of Slovenia and of local commercial public services.

One of the charges is a tax on water pollution. The entities required to pay this tax are municipalities or public companies, which are registered for the treatment of wastewater and meteoric water. The main part of the water pollution tax is used by the same entities themselves for investments in projects to reduce the environmental burden by building wastewater collection and treatment systems as well as by refurbishing existing ones. The entire amount of the collected charges may be used for such investments, but if not, the balance has to be contributed to the State budget.

The system of charges provides funds for the national programme of constructing and upgrading wastewater treatment systems to meet the requirements as set out in the WFD. In the Alps as a very sensitive area, where it is vital to keep the waters clean, the use of these funds will result in a better ecological status of the waters.

Water management falls within the competence of the State, except for the tasks which, pursuant to the Waters Act, fall within the competence of local communities.
It can be concluded that water management is well organised and there are also good results.

For the use of water, the holder of a water right is obliged to pay water fees in proportion to the water right, while the State or local communities make sure that efficient use is made of this money.

The system in place is still being upgraded, some of the legislation is being amended right now. The aim of these changes is to improve the security of water availability and to implement polluter pays principle fully across all sectors.

Switzerland

In Switzerland a water charge must be paid by the holder of a concession to abstract and use water for hydropower purposes. This represents a payment for the use of this resource and is paid to the public body (either Canton or community) who grants the concession. The federal government establishes the maximum water charge per kilowatt gross production. This maximum currently amounts to 80 Swiss Francs per kilowatt gross production. Within this limit Cantons and communities are free to demand the payment based on their principles.

Small hydropower plants with less than 1000 kW gross production have been exempt from the water tax since 1997.
On average the revenue accrued from these charges amount to around 400 million Swiss Francs per year, which corresponds to about 1,2 centimes per kilowatt-hour.
Over two thirds of this revenue goes to the mountainous Cantons for which the water charges represent a significant percentage of the total Cantonal tax revenues (e.g. Uri 22 %, Grisons 16%, Valais 11%).

A certain amount of the water charge revenue is used for nature conservation and river restoration: The Confederation can claim up to 1 Swiss Franc per kW for compensating public bodies who renounce, based on a contractual agreement, the granting of a concession for hydropower exploitation and put the potential project area under protection for at least 40 years instead.
In some Cantons a part of the water charge on hydropower use is feeding a Cantonal fund, from which revitalisation measures are financed.

As to water abstractions for drinking water: some few Cantons levy a concession charge, the revenue of which is being used for financing water supply related projects, other Cantons do not have special charges for the resource use as such.
As to the discharge of treated wastewater: in general there is no specific charge imposed for the right to discharge treated wastewater in the recipient water bodies.
Of course, the consumer has to pay a fee for the service of water supply and wastewater discharge and treatment which covers the infrastructure, operation and maintenance cost (information thereto is given in chapter B.3.3 on water tariffs).

B.3.3 PUBLIC OR PRIVATE – MANAGEMENT SYSTEMS FOR WATER SUPPLY

Public water service for households as we know it today was developed during the past century. Even though some people still rely on rain water supply, individual wells, cooperative plants or individual spring catchments, most of the Alpine citizens benefit from public supply systems, which have mostly been developed in the past 50 years (e.g. in France only 50% of the population was connected to a public water service in 1952, while today it is 99%; in Austria 87% of the population is served by central public water supply schemes at present).

The following few basic definitions and clarifications for the different categories of water supply management should provide a better common understanding of the terms used:

- **"public"** means either state, province, district, municipality or a group of municipalities
- **"cooperative"** refers to a group of beneficiaries which benefit from the facility
- **"private"** refers to investors or operators providing a service (investment or operation) for their own financial benefit
- **"mixed-assets"** could also be mentioned for specific companies with a private status, but including public assets
- **"individual"** means that in some cases water users rely on a facility which is solely owned by them and for which they have paid

Water supply facilities are frequently owned and managed by public authorities. However, in some cases the finances required for equipment have sometimes, for various reasons, been provided by private organisations. Therefore the current ownership of facilities with private shareholding remains complex to be described and also depends on the public will to control this public service.

In France, for instance, the mayor is by law responsible for providing water services, and what is considered to be a public service is owned by the municipality (the so-called clients have no choice by whom they are being supplied with water). Therefore, although previous investments have been provided by private organisations, in most cases the municipality obtains full ownership of facilities. However, there still occasional exceptions due to the lack of capital and the impossibility to increase loans or to rapidly raise water rates.

Another option is to conclude a contract for a period of 20 to 30 years with a private company to finance building activities and to operate such facilities (usually a plant). However, this is an exception, as private contracts between public and private organisations are limited to a period of 12 to 15 years.
As one can easily expect, due to history, legislation and politics, many combinations can be found for both, investments and operation, within the different countries sharing the Alpine space. This leads to various forms of ownership and management of water supply facilities and also to manifold forms of the so called Public-Private-Partnership ("PPP") in case of private involvement.

In this respect, the debates with regard to changes from one possible solution to the other - "privatisation" or "back to public" – have to be mentioned. Many consumer organisations are concerned about not getting a clear understanding of water rates. These fears are to a certain extent justified because the consumer does not have the ability to directly influence water tariffs. This is caused by the fact that the business of providing drinking is a monopoly and the terms are based on contracts between public organisations and private companies. The debate is difficult since various factors and circumstances have to be considered. They include long-term investment, fundraising for a municipality, provisions for maintenance and renewal, private profits, staff skills but also competences. Water rates also depend on various possible policies, including solidarity among tax payers and consumers as well as the question if the rates charged should cover all the expenses of the service provided.

The discussion is not only held at national levels but also in the international context. In this regard the debates with respect to the EU Services Directive 2006/123/EC[70] have to be mentioned. However, since neither primary nor secondary EU legislation contains regulations which commit EU member states to privatise or liberalise the water supply sector[71], the decision to do so remains within the sole responsibility of every member state.

Since it was revealed that possible approaches for securing water supply are manifold and diverse in the Alpine countries, the national contributions at the end of this chapter are aiming to present a more specific overview of the situation in each country with relevant figures. Furthermore, the conclusion will provide a summary table of water prices for domestic services.

[70] Directive 2006/123/EC of the European Parliament and of the Council of 12 December 2006 on services in the internal market
[71] Knauder, 2007. Wasserrahmenrichtlinie und Privatisierung im Wasserrecht. Ausverkauf des Österreichischen Wassers? LexisNexis Verlag. Wien.

Conclusions:

The overview of the various Alpine countries confirms

- the sufficient availability of water resources for domestic use even if some concerns may arise during exceptionally dry periods;
- that in every country only a small percentage of the population relies on individual water supply schemes. If so, this is mainly caused by the remote conditions in the mountainous areas;
- that water services always remain a public responsibility which involves local authorities. Variations in the ownership of public service facilities and the status of their operators do exists and are evolving in some countries or are at least frequently discussed. The trend seems to move in the direction of maintaining "public" control over this public service, although privatisation is being debated in some countries.

The following table 14 provides a rough overview of water pricing for domestic consumption within the Alpine Convention perimeter. It can be noticed that every country is charging for water services according to the volume delivered[72]. When applicable, prices for wastewater collection and treatment, taxes and fees are also included as a comment. For some of them, the average prices mentioned are estimates.
However, the data provided in table 14 does not allow a strict comparison of the water charges

- since it is based on various sources and calculations: some values are weighted according to population, minimum and maximum can be extreme values or corresponding to 10%, additional fees might not be listed, fixed charges might include wastewater disposal,
- because of fixed charges like connection fees, the price per m^3 depends on the quantity delivered, and
- dates may be different.

[72] Two specificities for mountainous areas lead to special dispositions:
- for some municipalities water is delivered free of charge because of the low population of the municipality, existing networks, individual sewage treatment and an abundance in resources (in France permission to do so has to be given by the Prefect);
- in other situations, the water is not metered due to frost hazard and the public service is charged according to a fixed amount per household or per bed.

Case Study from France

Water costs in water supply and public-private management

Topography does not favour the interconnection of public networks

One characteristic feature of the French Alpine area is the diversity of the water sources collected for public delivery purposes. Due to the topography of mountainous areas, a municipality of 1.000 inhabitants may rely on more than 10 different sources (springs or boreholes) whether or not they are interconnected. Some districts (= French "Départements") have over 1.000 water sources for the supply of water and an equal number of water supply networks. The French Alpine area collects drinking water from approximately 5.000 to 6.000 abstraction sites (20% of total for France!). As a result, the preservation of these resources remains a challenge (even if the risk is low) as preservation perimeters are not yet been defines for two thirds of them in the Alps.

Public and private partnership debate is no longer the focus of major disputes

While the ownership of the facilities is mainly public (a municipality or a group of municipalities), there are rare exceptions regarding equipment (pumping stations, treatment plants, local delivery networks…) built under a concession contract between a municipality and private companies. In this case, the facility built and managed by a private company becomes public property at the end of the contract (~30 years on average).
The way in which facilities are operated is decided by the municipality. The mayor can either chose a public or a private entity for operation and maintenance. Private operators (Veolia, Suez, Saur…) run about half of the French facilities, but mostly in urban areas (~60% of the population). In mountainous areas most of the water supply systems are operated by relying on municipal personnel, either alone or in a group of municipalities ("syndicat de communes"). Alpine cities like Besançon, Annecy, Chambery, and Grenoble operate their water supply by using municipal employees. When a private company operates the facilities, it is authorised to do so by way of a contract tailored to the situation of the municipality: obligations of the service, maintenance of the equipment, rates for the charges. Public tendering and annual statements of account (published every year) are mandatory. Consumers have access to contract information and even the cities (bigger than 30.000 inh.) must be involved in the approval process of the contract.

Full recovery of the cost of service through the water bill

Every water user is charged for the water supply service for the connection to the water system, depending on the water consumption metered (as an exception, some few mountainous municipalities do not meter the water delivered because of frost risks for the meters, in this case a fixed amount is charged). The rates are fixed by municipal decision every year depending on the balance of the budget for the service, which is legally independent of the municipality's budget if the population is over 3.000. Tariffs include the cost of the investment (loans reimbursement and should also include a provision for depreciation), the cost of operation and maintenance (abstraction, treatment and delivery), and various taxes including VAT and River Basin Agencies levies. In most cases, these charges include both water supply and wastewater collection and treatment, whenever a public service is in place.

99% of the French population is connected to a public service

Over 99% of the French population nationwide is connected to a public drinking water service network. Only few isolated farms, especially in the upper Alps, rely on their own water supply. According to the law, the mayor of the municipality is responsible for this public service. The service is charged according to the consumption metered for every household connected to the system.
As regards sewage collection and treatment, the public service covers about 84 % of the households, corresponding to 85% of the population (river basin wide). Nevertheless, although on the one hand 99% of the population is connected to a public drinking water system, the situation is quite different for sewage collection and treatment, as 32% of the 1.750 municipalities of the Alpine perimeter do not benefit from a public system.

These 558 municipalities (with a total population of 200.000 inhabitants, up to 400.000 inh. including seasonal consumers) rely on individual sewer systems.

Public and private operation can even cooperate within one city

In the Lyon city area (57 municipalities grouped in a community), for instance, all drinking water supply networks and the entire sewage system are publicly owned in addition to a drinking water plant for the provision of drinking water in case of emergency, which was financed, built and is maintained by a pri-

Country	Minimum €/m³	Maximum €/m³	Average €/m³	Comments (Most of the figures provided are for water supply only)
Austria	0,33	2	1	The average additional fees for wastewater disposal are in Austria about 1,69 €/m³ Total ~2,69 euros/m³
France	0	4	1,32	Including connection fee (0,40); to be added: sewage collection & treatment (0,60), and various taxes (0,31) amounts to a total of 2,23 €/m³
Germany	0,52	3,95	1,85	BDEW-Wasserstatistik 2007, including connection fee and tax
Italy	0,78	0,96	n.a.	Covers the costs for the water service, drains and purification
Slovenia	0,12	0,45	n.a.	
Switzerland	0,4	2	1	According to a study on charges levied in the 30 biggest cities in Switzerland; for the waste water disposal the figures are an average of around 1.25€/m³ with min/max values of 0.4 and 2 respectively; total: 2.25€/m³

Tab. B3-1: Overview of domestic water prices

vate company under a 30 years contract called “concession” (the same company is also running most of the public drinking water systems). The sewage disposal system and one sewage treatment plant are maintained by civil servants; another sewage treatment plant is privately operated.

Water charges vary according to the budget of each municipality

In order to provide a detailed description of the charges paid for these services in the French Alps, a sample of municipalities included in a previous study, has been selected. This sample includes: 370 municipalities (among a total of 1750), 1,388 million inhabitants (i.e. 69,5% of the population). The sample includes mostly urban municipalities and only marginally rural ones. All data collected represent prices charged to domestic consumers in 2005.

In order to allow comparisons nationwide, according to a national decree, comparisons should be made between domestic water charges in France based on a fixed annual rate of consumption of 120 m3/household. It should be noted that the real average consumption is in fact higher than this (i.e. 150 – 170 m³/household/yr).

It should also be mentioned that, according to law, the budget for public water services should be balanced by the revenues from water bills. Only municipalities below 3.000 inhabitants are allowed to provide subsidies to this budget through other revenues like income tax.

The collection of water run-off and the fire service relying on fire hydrants should be financed through the ordinary separate municipal budget (mainly paid by the tax payers).

The average annual water bill is close to 300 euros/household/yr

Within the French Alpine area, the average price calculated according to the population (including standing charges, water consumption, sewage service, River Basin Agency levies, VAT and any other taxes) amounts to: 2, 23 euros/m³ tax inc. (268 euros TI / year/household)

Prices range from 0 to 4 euros/m³:

- 6,5% of the municipalities charge less than 50ct/m³; some very small mountainous mu-nicipalities with very tight budgets do not charge for water, which is delivered by springs, through obsolete networks and which is very poor in service. Municipalities which are not able to provide sewage water service are also included. As this sample includes mostly urban population, it does not describe statistically the situation in isolated areas. Moreover, some municipalities do not meter the water delivered because of frost risks and abundant availability of water (in order to do so, they need permission from the Prefect).
- on the other hand, 5,5% of the municipalities charge more than 3 euros/m³; this is the case for most of the ski resorts which, during their

peak seasons, are faced with crowds of people burdening the water supply system (including wastewater treatment) within a few days. The average prices in cities are ~25% higher than in rural areas.

For an annual consumption of 120m^3, the average annual bill of 268 euros (tax included) /household includes the following items:

- Standing charges: 15% (0, 40 euros), ranging from 0 to 95 %!
- Water consumption: 40% (0, 90 euros), rang-ing from 0 to 95 %!
- Sewage service and wastewater service: 26% (0,58 euros) ranging from 0 to 40%!
- River Basin Agency levies: 14% (0, 31 euros) from 0 to 20 %!
- Pollution levy: varies according to population and consumption; (starting in 2009, the pollu-tion levy will be the uniform amount of 0,19 euros/m^3 for pollution treatment, and of 0,13 euros/m^3 for sewage collection);
- Abstraction levy: varies according to scarcity of the resource & abstraction volume declared by the service (0,028 euros/m^3 basis in 2009).
- VAT: 5% (5,5% on most items)
- Other taxes = quite rare.

A breakdown of domestic water charges in the French Alps:

The figure below, (including standing charges within each category of service: drinking water & pollution treatment), provides a breakdown of the various components:

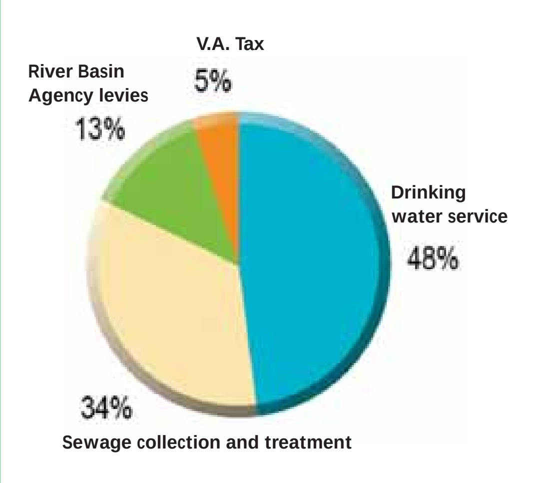


Fig. B3-2: A break down of domestic water charges in the French Alp

National Contributions Regarding Information on Management Systems for Water Supply

Austria

The Alpine region of Austria can be characterised as being rich in water, as only 3% of the available water in the entire country is used for human purposes and thereof less than half in households. The water distributed through the Austrian water supply schemes is abstracted in equivalent shares of 50% either from groundwater or springs, enjoys therefore a high degree of basic protection from pollutants and complies in most cases from the beginning with the high quality standards. Hence, water can be delivered to the consumers in most cases in a natural and untreated way without any prior removal of pollutants to render it suitable for consumption; as a measure of precautions, the water may undergo disinfection before it is delivered

About 1 million out of a total of 8,1 million inhabitants, i.e. 13% of the Austrian population, depend on individual water supply plants, house wells or small co-operative plants for a small number of households, whereas the majority of 87% or 7,1 million people live in areas which are served by central water supply schemes. In total, about 5.000 water supply entities exist in the whole country, delivering about 670 million m^3 of water per year.

Water supply (as well as wastewater treatment) is considered to be a core responsibility of municipalities in Austria. Water supply facilities are either 100% owned or dominantly controlled by municipalities or regional authorities. Public Private Partnerships play a rather secondary role.

Water supply is to a large extent organised in a decentralised way in Austria. Due to this and the absence of any major regional monopoly so far there is no need seen in setting up a separate regulatory body
Water supply is provided to households, industry and manufacturers by the same supplier, unless a bigger company secures its water supply separately by abstractions of its own.

Charges for drinking water are within a range from a minimum of 0,33 up to 2,- euros per m^3, resulting in an overall average of 1,- euro per m^3. The disparity in the tariffs arises mainly from the spatial variations different water supply schemes have to deal with.

France

The various water uses can be described as follows:

- 1 billion m^3 for irrigation mostly (90%) from surface or spring water;
- 600 million m^3 for public water supply (60% from underground resources);
- 300 million m^3 for industry (50% from underground resources).

Over 99% of the population is connected to a public service for domestic water supply; in mountainous region some isolated farms still rely on a private system (less than 2%). Public water supply is always (and by law) the responsibility of the mayor of the municipality. Except for some equipment, most of the facilities for the public water services are publicly owned.

The mayor is the authority responsible for the provision of water services.. The municipal council has to determine whether this service will be operated by municipal personnel or by contracting a private company. Due to historical reasons, and mainly due to financial difficulties in building up provisions, many municipalities have contracted private companies to finance the facilities by way of concession contracts (the facility is financed, built and managed by the private operator for a fixed period laid down in the contract – usually 30 years). This approach is becoming an exception and is limited to some link equipment in the supply chain.

The average household price for public water service supply is 2,7 euros/m^3 for a household consuming 120 m^3/yr. The prices may vary considerably depending on budgets and investments made (from zero to 5 euros/m^3). A provision for future investments has recently been authorised for municipal water service budgets. Every municipality can set a range of prices according to local constraints, such as: decreasing prices for large consumers, higher fixed charges in tourist resort areas.

The controversy over public and private ownership has simmered down thanks to recent laws. As described in details in the corresponding case study, this debate still remains an issue in France, but it is much less intense than a few years ago. Media campaigns focused on this controversy in the wake of various political scandals 25 years ago. Several "transparency" laws have helped to clear the situation: transparency for the budget of political campaigns, publication of the budget for the water service according to a mandatory accounting template, a clear template for the water bill, obligatory public call for tender for the renewal of private contracts, and so on. A limit set for the duration of delegation contracts (from 12 to 15 years) increased the examination of ongoing contracts. Some 2-5% of the municipalities switch system every year. A recent law has defined various indicators to be published for the operation of the water service (either operated by public or private personnel). These constraints have helped both sides, on one the hand municipalities can debate over contracts, while on the other hand private companies can rely on arguments easy to promote and to defend. Today, it appears that the mayors' choice is mainly based on an economic analysis of how to finance not only new investments but also the renewal of facilities (especially obsolete networks).

Germany

The German Alpine region has abundant water resources with a high mean annual precipitation of >1.300 mm as compared to 790 mm in Germany. At approx. 240 million m^3/yr, slightly more than one quarter of the roughly 900 million m^3/yr of water produced in Bavaria for the supply of public drinking water comes from this region, although only 1,3 million inhabitants or 10% of the population of Bavaria live there. Due to the high volume of water, districts and towns located in the north of the Alpine region are also supplied with water from this area.

Nearly 99% of the drinking water is abstracted from groundwater (approx. 68% from wells and about 31% from springs). The proportion of surface water and bank-filtered water is extremely low, i.e. slightly more than one per cent, compared to the federal German average of roughly 26%. Due to the often inadequate cover layers, the groundwater used in the Alpine region is particularly sensitive to hygienic pollution, which is why appropriate remedial measures frequently have to be taken in the areas affected. Given that only 1,5% of the population in Germany lives in the Alpine region, the area has a disproportionately high number of water supply companies of approximately 480 (= just under 8% of the water supply companies in Germany). The share of small water suppliers with an annual water output of less than 0,1 million m^3/yr is slightly more than half (55%). Nearly 90% of the water suppliers are organised in public companies. There is a small number of Ltd companies (companies with limited liability), but they operate primarily in the public sector. Nearly 10% are organised in private-sector cooperatives.

Water rates vary between 0,20 euros/m^3 and 1,65 euros/m^3. In addition, up to 10,33 euros is also levied as a monthly connection fee. Altogether, 2,3% of the population in the German Alps is not connected to the public water supply, which is more than twice compared to the total average in Germany. These households obtain their water from their private wells or springs (about 3.600).

Currently Bavaria and Germany are not pursuing liberalisation of the water market. Water supply and sewage systems are to remain the sole responsibility of municipalities, exercised in well-defined regions. The federal and State authorities and associations hold the view that quality assurance and cost-effectiveness can be further optimised in municipalities. Major steps in this direction are: consistent industry profile, voluntary benchmarking, more cooperation at municipal level, viable corporate structures in terms of size and form and, if appropriate, greater involvement of the private sector in accomplishing tasks. At present, the municipal water supply and sewage companies in Bavaria are being offered voluntary participation in benchmarking projects on very favourable terms as well as the preparation of individual operating and organisation manuals for the supply of water, in order to pinpoint their own strengths and weaknesses and to be able to initiate corresponding potential improvements.
All in all, the supply of water in the Bavarian Alpine region is in very good condition in terms of its quality and quantity. Currently, liberalisation of the municipal water supply system is clearly rejected.

Italy

In Northern Italy, fresh water consumption per capita is sub-divided into the following sectors: around 147 m^3/person per year* are consumed for household purposes, 532 m^3/person per year* for irrigation, 204 m^3/person per year* for industry, and 174 m^3/person per year* for power generation[73]. This shows that water used for irrigation represents the most significant area of consumption accounting for more than 50% of total consumption. Around 3.228 million m^3 of water resources have been exploited in Northern Italy for water services, of which around 69,4% (2.241 million m^3) comes from wells, 19,7% (635 million m^3) from springs and 10,9% (351 million m^3) from surface water[74]. The organisational structure in the water sector has undergone a process of reform and reorganisation across the entire sector by virtue of Law no.36 of 1994, which has established a new management system, the servizio idrico integrato (integrated water service). The organisation of the unified water service at local level provides for the water services to be organised on the basis of ambiti territoriali ottimali "ATO", (optimal territorial areas) which are identified in relation to the overall nature of the river basin or sub-basin or contiguous river basins.

The summary table below lists each ATO within the area of the Alpine Convention, together with the percentages of provision from the main sources. The main resource used is that of wells.

The role of the "Area Authority" is particularly important because it regulates the relationship between the local authorities (municipal and provincial authorities) within each ATO and coordinates functions and activities in relation to the water service. The management of the Integrated Water Service is carried out under a licence from the Area Authority, which decides the format in which it is to be issued. The local public services can be run by: limited companies chosen after a public call for tender; public and private mixed capital companies in which the private shareholders are chosen through public tender offers; "in house" companies whose capital is entirely public. However,

[73] Figures from Ministry of the Environment, 2001
[74] Prepared by the Ministry of the Environment from COVIRI figures, 2006

Region	ATO	Sources of supply		
		Wells	Springs	Surface water
PIE	ATO 1 Verbano	58,0%	37,0%	5,0%
PIE	ATO 2 Biellese Verc	42,0%	41,0%	17,0%
PIE	ATO 3 Torinese	71,4%	9,5%	19,1%
PIE	ATO 4 Cuneese	36,5%	58,6%	4,9%
LIG	ATO Imperia	89,8%	10,0%	0,2%
LIG	ATO Savonese	n/yr	n/yr	n/yr
LOM	ATO Bergamo	47,7%	52,3%	0,1%
LOM	ATO Brescia	57,0%	40,0%	3,0%
LOM	ATO Como	66,0%	6,0%	28,0%
LOM	ATO Lecco	27,0%	37,0%	36,0%
LOM	ATO Sondrio	6,0%	94,0%	0%
LOM	ATO Varese	99,0%	0,8%	0,2%
FVG	ATO Orientale GO	n/yr	n/yr	n/yr
FVG	ATO Occidentale PN	n/yr	n/yr	n/yr
FVG	ATO Centrale UD	n/yr	n/yr	n/yr
VEN	ATO Alto Veneto	0%	95,0%	5,0%
VEN	ATO Veneto Orientale	55,8%	44,2%	0%
VEN	ATO Veronese	70,0%	25,0%	5,0%
VEN	ATO Brenta	83,0%	17,0%	0%
VEN	ATO Valle del Chiampo	87,7%	12,3%	0%

Tab. B3-2: Listing of each ATO within the area of the Alpine Convention, together with the percentages of provision from the main sources the ownership of the infrastructure remains public. The relationship between the Area Authority and the manager are regulated by a specific agreement called a "service contract", which must specify, among the various aspects, the legal basis on which it is managed, the duration of the licence (no more than thirty years), the methods for controlling that the service provision is carried out correctly and to guarantee a certain level of service for consumers.

In the North of Italy, the average charge for water services varies from a minimum of around 0,78 euros/m^3 to a maximum of 0,96 euros/m^3 [75]. The consumption charge covers the costs for water services, drains and purification. The current charging method, in force since 1996, is based in substance on the definition of a particular charge, which for the year concerned is based on the total of operational costs, depreciation costs and return on investment capital over the previous year, increased by the programmed level of inflation and the price limit, which represents an estimation of the maximum increase in the charge that is socially acceptable. The method has the great advantage that charges covers the management and investment costs over the medium to long-term period entirely, providing clarity over time for managers and investors, as well as introducing the concept of return on capital invested.
Recently, a debate had been sparked against the "privatisation" of water resources in Italy, claiming that water is one of the basic human rights. The Italian Parliament is currently considering various draft laws to block the possibility of granting licences to private companies for the management of integrated water services.

Slovenia

Slovenia can also be characterised as a country rich in water. Since the Alpine Convention area does not follow the borders of administrative units, it is not possible to give exact account for the Alps. The information provided is relevant for the whole country.

In 2006 , 6,3 million m^3 of water were abstracted for irrigation, i.e. 175% more than in 2005. In 2004 and 2005, 84% and 85% of the total water abstracted for irrigation was from water-storage reservoirs. Last year, 49,9% of the water abstracted for irrigation purposes was from surface water, while abstraction from water-storage reservoirs declined to 48.3%. The total quantity of water abstracted for agriculture in Slovenia is not known exactly because some smaller users do not have water rights for abstraction. With 0,5% of water abstraction in relation to the total consumption in economy, agriculture has the lowest share.

Groundwater, including springs, is the most important source of drinking water in Slovenia. More than 90% of the total population of Slovenia depends on it. Results of the 2002 census show that 90,6% of the total population of Slovenia has access to drinking water from public water supply systems owned by municipalities, while 7,8% of the total population of Slovenia depends on individual water supplies. Only 1,2% of the total Slovenian population uses rainwater, mostly in the south-eastern part of the country. Municipalities can manage water supply in five different ways. The most popular approach is the establishment of a public enterprise that manages water supply schemes. Often, several municipalities create joint enterprises.

Water prices per m^3 of used water is determined and approved by city councils. This price has to be approved subsequently by the Ministry of Economy.
Drinking water consumption charges per households, range from a minimum of 0,1208 euros up to 0,44801 euros per m^3. As to water rights, the State collects money from every user. The rate for drinking water is 0,0555 euros per m^3, while for irrigation it amounts to 0,0083 euros per m^3. Users who consume less than 2.500 m^3 of drinking water per year in case of individual water supply, and users who consume less than 5.000 m^3 of water for irrigation per year are not subject to charges.

The management of water supply systems is a controversial issue in Slovenia and it is the focus of frequent discussions. It often triggers very strong reactions in the public, mostly regarding smaller systems that provide water to 50 - 300 people.

[75] COVIRI figures, 2006

Switzerland

The Alpine regions of Switzerland can be characterised by high, or even very high precipitation rates (with the exception of Canton Valais). Only around 2% are actually used for water supply. Furthermore, a large part of the Swiss Alpine areas constitutes significant water reserves in the form of glacier ice. Currently, problems with respect to secured water supply during dry spells seem to be only local and temporary. The latter occurs in areas with little precipitation and/or unfavourable geological conditions, without important soil layers possessing adequate storage capacities and no glaciers in the basin. However, even in these rare cases this problem is gradually resolved by way of water supply syndicates/cooperatives, uniting technically and/or organisationally local water suppliers. Retreating glaciers, along with an increased water demand for tourism, artificial snow production and agricultural irrigation, may in the medium term lead to some difficulties in water supply during dry spells at local level. This issue can be addressed by establishing interconnections between local water suppliers. At a regional scale, however, even against the background of the aforementioned developments, no difficulties with respect to drinking water shortages are foreseeable.

Water supply in Switzerland is locally organised and financially self-sustaining. There are currently around 3.000 independent water suppliers, which operate under diverse legal forms, in most cases run either by public authorities or communal cooperatives but also as public limited companies. Some are also run as stock corporations with the stock majority in public hands (these are mostly multi-utility suppliers for water, energy, gas etc.). There is a tendency to merge very local suppliers with larger units for the sake of supply security, professionalisation of service and cost-effectiveness. While there is constant pressure on the municipalities to deliver cost-effective water supply and to render the services and related costs more transparent, there is no relevant political force asking for or being in favour of privatisation.
The average price per cubic-meter is around 1,6 Swiss francs (i.e. ca. 1 euro) and is thus fairly low. This price is representative of a standardised household and includes the consumption-dependent charge as well as the fixed basic fee and meter rent. A survey of the 130 largest Swiss municipalities has shown variations between 0,5 and 4 Swiss francs per m^3. The reasons for higher prices are the costs for multi-stage treatment, which amount to 40 centimes per m^3 (necessary in particular for lake water) and electricity for pumping. Both issues are normally less relevant in the Alpine areas profiting from excellent raw water quality and a significant share of the water from springs located at higher altitudes.
Swiss public water suppliers provide a total annual volume of around 1 billion cubic meter, with 40% from springs, 40% pumped from groundwater aquifers and 20% from surface waters (mostly from lakes).

It is worth noticing that, in any case, up to 90% of the total costs of water supply are fixed costs and not volume dependent. Annually, the water suppliers in Switzerland spend around 1,5 billion Swiss Francs in operation and maintenance costs, around 600 million Swiss Francs are invested in infrastructure.

Apart from charges related to the consumed water volume, the necessary supply and discharge network is also partly financed by nonrecurring connection fees (the contribution of these connection fees to the total fees collected varies, according to the above-mentioned survey, between 0 and 25%).
Household consumption is on average 160 litres per person daily and it has witnessed a constant decline over the last 30 years. The total consumption per capita dropped to from 500 litres per day to about 100 litres in 1981. Today, it amounts to 404 litres per capita. Structural reforms and optimised production processes have led to significantly lower consumption by industry.

As to charges for wastewater discharge, a survey of 130 largest Swiss municipalities has shown variations between 0,5 and 4 Swiss francs per m^3 with an average around 2 Swiss francs per cubic meter. Again, the costs of the wastewater system (sewage network and treatment plants) are mostly fixed costs, related to the infrastructure. A certain percentage of the revenue (in most cases from 0-30%) for the wastewater also derives from nonrecurring connection fees, which vary strongly depending on the municipality.

B.3.4 HYDROPOWER GENERATION IN THE ALPS

The Alpine space is poor in terms of natural resources like fossil oil or coal compared to other regions in Europe. Therefore, the use of the "mechanical power" of water has ever been of vital interest for the Alpine population in order to meet energy needs.

Using the energetic potential of water is not new to the people living in the Alps. For centuries water was used for the operation of flour, saw or hammer mills – technologies, which were introduced in order to substitute human manual labour. A considerable number of still remaining but mostly non-active facilities and millstreams document the long-lasting tradition of this energy sector. Later on, during the 20th century, this early form of use of hydropower was replaced by modern hydropower plants for electricity production as we know it nowadays. Potentials for hydropower generation were further developed in the Alpine space, resulting in the present situation which is illustrated in Map 19 and listed in Tab. B3-4, showing approximately 550 hydropower stations with a power output greater than10 MW in the Alpine space. Apart from these hydropower plants, thousands of smaller schemes are additionally in place. The reason for the attractiveness of hydropower generation in the Alps can be found in the perfect pre-conditions. Steep

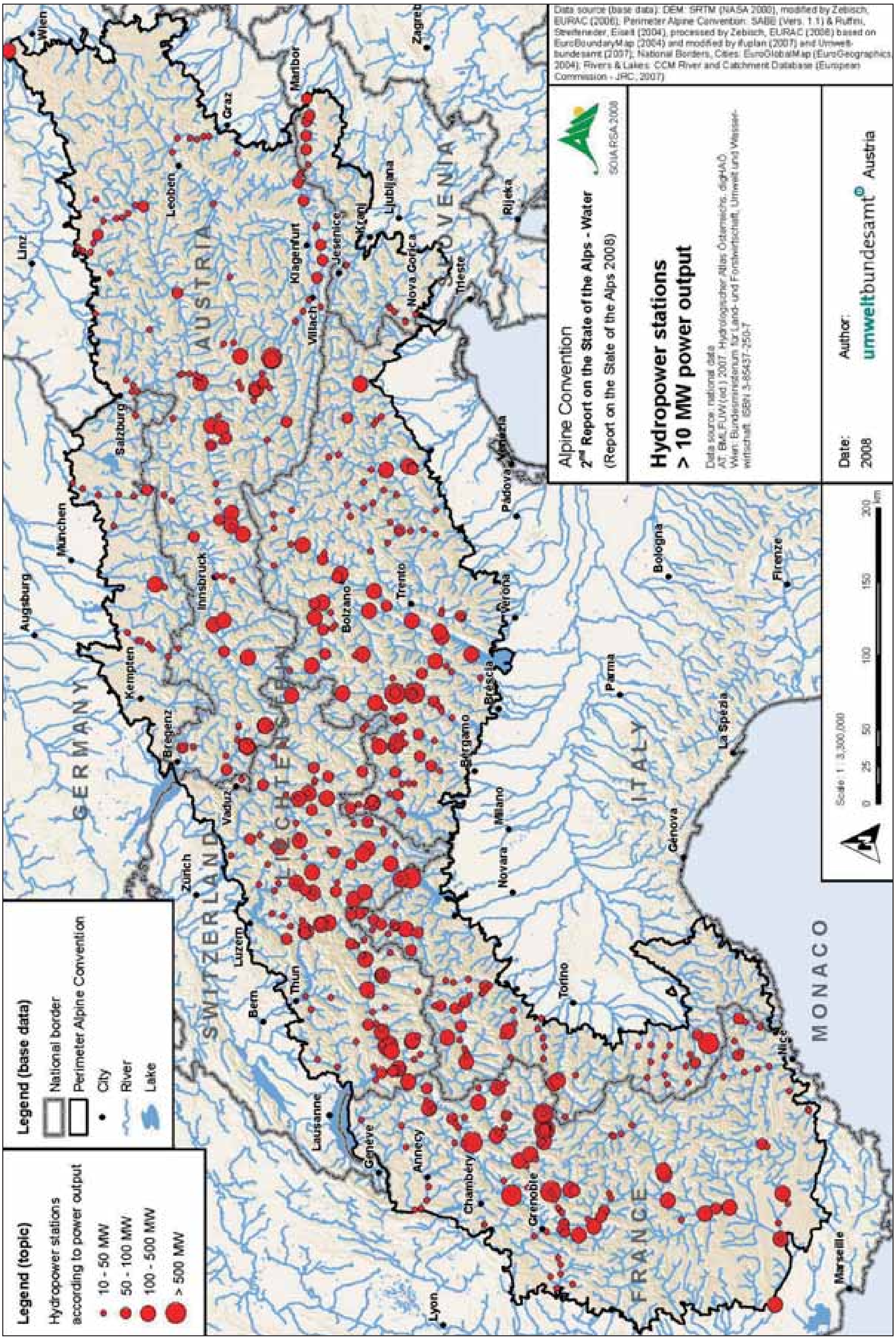
Country	Number of Hydropower Stations (Power Output > 10 MW)[76]	Total Power Output in MW of Hydropower Stations (Power Output > 10 MW)
Austria	112	8.235
France	128	12.552
Germany	16	523
Italy	169	14.403
Slovenia	12	516
Switzerland	117	9.654
Sum Alpine Arc	**554**	**45.883**

Tab. B3-4: Hydropower stations with a power output greater than 10 MW in the Alps

© Tauern Touristik GmbH

Photo B3-1: Alpine Reservoirs provide energy in peak-times of electricity demand. Kaprun Mooserboden Reservoir, Austria

[76] Apart from facilities with a power output > 10 MW, thousands of small hydropower plants are additionally in place



Map 19: Hydropower stations with a power output greater than 10 MW in the Alps

Author unknown
Photo B3-2: Tradition of dam building in the Alps /historical picture, Klavže near Idrija, Slovenia

slopes in combination with high precipitation, which can exceed 3.500 mm per year in some areas, result in highly lucrative plants for electricity production and make hydropower generation an important economic factor for Alpine countries. Developments in this energy sector also contribute considerably to the economy of the construction industry and related branches. In some cases, Alpine reservoirs even contribute towards the generation of income in the tourism sector, with dams situated within an impressive landscape as an attractive destination for visitors and tourists.
Energy yield depends on the amount of precipitation, which tends to fluctuate from year to year. In this context, a distinction has to be made between run-of-river power stations, which contribute towards covering the basic electricity demand, and Alpine storage and pumped-storage power stations, which provide additional electricity at peak times of demand. The latter two types are of special interest for Alpine water management, as the mountainous landscape offers high variations in elevation, which are perfect conditions for Alpine reservoirs. Since electricity is difficult to store, such reservoirs can be considered to be a practical means for accumulating energy in nadir times of electricity demand (either by storing run-off water or by pumping water to reservoirs at higher altitudes) and releasing it in peak times of demand.

Of particular importance is the circumstance that the time-lag for providing electricity, which is fed into the power grid, is very short for Alpine storage power stations in comparison to other types of power plants (e.g. nuclear or thermal power stations). The same applies to new pumped-storage power stations, where a swift change from the pump-mode to the working-mode for generating electricity is possible. Alpine hydropower is therefore an important factor for balancing the variations in energy demand and contributing towards the stabilisation of the European electricity supply system.

However, the long tradition in the use of the energetic potential of water has brought in its wake considerable changes in the natural environment of the Alpine space, as this was already identified in chapter "B.2 Pressures and Impacts". In summary, the main impacts are in particular

- the interruption of the river continuity, preventing aquatic forms of life like fish from migration, which is necessary in certain life cycles for reproduction,
- changes in river morphology and therefore resulting in losses of habitats and spawning grounds,
- lack of sufficient residual water downstream of water abstractions, impacting the flow and water temperature regime, reducing the potential range of habitats for aquatic organisms,
- hydro-peaking, which flushes river stretches and causes considerable loss of biodiversity,
- alterations in the transport of sediments (higher erosion downstream of run-of-river dams; no/less erosion and bed load transport downstream of reservoir dams (no floods anymore) causing corresponding impacts on morphological processes and loss of biotopes apart from potentially falling levels of the groundwater table but also
- the transformation of characteristic landscapes and the natural scenery in the case of artificial reservoirs.

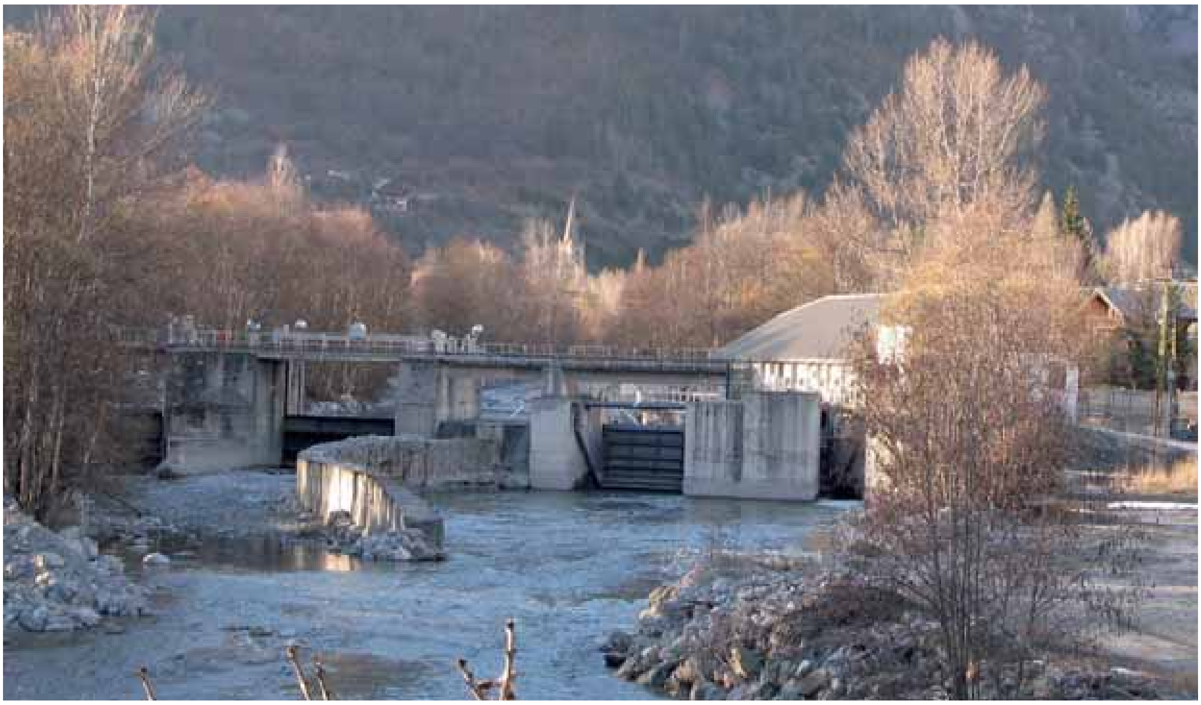
Within the last decades, approaches have been developed with the aim of reducing the negative effects of hydropower generation on the environment. Fish passes - in cases where fish have their habitats -, sufficient and dynamic ecological flow or efforts to reduce hydropeaking e.g. with detention basins are standard for new facilities today and integrated elements of newly granted permissions. Although it is clear that new projects still interfere with the natural conditions, at least the impacts can be limited to a certain extent through the implementation of such measures.

However, the situation regarding new installations has to be distinguished from already existing power stations, where permissions were granted at a time when imposed conditions did not take into account environmental objectives to an extent which is considered to be standard today. In such cases, sometimes disproportionate changes (e.g. in river flow, morphology, interruption of river continuity, etc.) have taken place. This situation interferes with the objectives set by modern legislation in place like the EU Water Framework Directive or comparable legislation in Switzerland. In order to achieve the good ecological status or the good ecological potential for a water body, measures also have to be implemented in the case of already existing facilities which do not comply with environmental standards. A prioritisation and step-by-step approach for the implementation of instruments to improve the water status has therefore to be the content of an appropriate programme of measures. The case study on the river "Spöl" in Switzerland at the end of this chapter provides an example of potential measures which may be apt to reduce the negative environmental impacts of an already existing Alpine reservoir for hydropower generation on the environment.

When estimating possible future scenarios, the above-mentioned different aspects of hydropower generation and energy production have to be looked at against the background of energy demand as a key driver in Alpine water management. In this regard trends in recent years have dynamised the developments in this sector. The main factors include the constantly growing energy demand in the past going hand in hand with the considerable rise in the prices for fossil fuels like oil, gas and coal, which are directly affecting prices for electricity. As a result, the increased profitability of new hydropower projects due to the price increase for electricity is fuelling ambitions in the industry to invest in new facilities.

The developments in recent years have also fuelled the discussions on how to balance different environmental protection targets – tackling climate change through renewable energy production and achieving the good status for all waters at the same time.
The action programmes for reducing greenhouse gases in the states and strategies for the future energy policy in Europe provide further food for the debate. In this regard it is to be expected that proposed legislation at EU level such as, for instance, following the principle of "20/20/20 by 2020" (a 20% increase in energy efficiency, a 20% cut in greenhouse gases and a 20% share of renewables in total EU energy consumption, all by the year 2020)[77], is likely to put further pressure on water resources in the attempt to increase the share of renewable energy in the form of hydropower. Nearly all national contributions highlight further projects for the exploitation of the remaining hydropower potential.
However, the potential for the generation of electricity from hydropower in the Alpine space has already been developed to a considerable extent. The following example from Austria aims to illustrate the situation for an Alpine country. According to the latest assessment[78] (2008), there is an additional hydropower potential of about 18 TWh worthwhile to be utilised in the future, accounting for about one third of the total potential of 56 TWh in the whole country. Deducting areas within National Parks and World Heritage Sites, the remaining potential is estimated to be 13 TWh. The overwhelming share of more than 90% of the present total electricity production of 38 TWh from hydropower is contributed by 156 facilities of medium and large size in Austria (similar ratios are reported by Germany and Switzerland). The remaining share of less than 10% is generated in Austria by more than 2.100 small stations with a power output of less than 10 MW. In addition to these installations, approximately another 2.000 micro-hydropower plants exist, exclusively serving private consumers[79]. A similar disproportionate ratio is reported in the German contribution, where more than 75% of all installations with less than 99 kW contribute less than 3% of the total annual production.
Areas appropriate for settlements, transport and industry are limited to the narrow valleys within the Alpine perimeter. The need resulting therefrom to protect these areas against natural hazards, including floods, and the high extent of hydropower generation have impacted most of the rivers. This is why river stretches, which are largely in natural condition (= in high status), are increasingly gaining in value since they have become more and more unique in the Alpine space. At the same time, these river stretches constitute an important share of the remaining potential for future hydropower generation. As these rivers have mostly small discharges they are particularly endangered by small hydropower plant projects. The obvious discrepancy as regards small hydropower plants between the limited potential of contributing towards overall electricity production on the one hand and, accordingly, the high number of necessary facilities on the other (impacting a corresponding amount of river stretches), may raise questions with regard to the overall rationale and sustainability of such attempts to increase the share of renewables. Map 19 highlights today's status quo with a high number of small and a few large

[77] Package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020, SEC(2008) 85/3, European Commission
[78] Pöyry, 2008. Wasserkraftpotentialstudie Österreich, Endbericht. Pöyry Energy GmbH. Wien.
[79] Source: EU Wasserrahmenrichtlinie 2000/60/EG - Österreichischer Bericht über die IST-Bestandsaufnahme. Bundesministerium für Landwirtschaft, Forstwirtschaft, Umwelt und Wasserwirtschaft. Wien.



© Agence de l'Eau Rhône – Mediterranée et Corse
Photo B3-3: Next to the large-scale facilities of 500 MW and more indicated on Map 19, thousands of small and micro hydropower stations are in place in the Alpine area.

hydropower stations. This Slovenian situation illustrates the conditions, which are fairly representative of the entire Alpine arc. Against the background of the successive implementation of the EU Water Framework Directive (WFD), this issue is currently gaining in importance. A matter of particular concern is the question of the deterioration of high status stretches due to new projects. In line with the provisions of Article 4 (7) of the EU Water Framework Directive (WFD), they can only be justified as a result of new sustainable human development activities if an overriding public interest exists and if all practical steps are taken to mitigate the adverse impact on the status of the water body[80]. Whether these criteria can be met is an issue which has to be assessed in a critical manner on a case-by-case basis and in particular also for small hydropower stations. To sum up, in the context of securing energy supply and with regard to climate change, hydropower is an important source of renewable electricity, whose production makes an important contribution towards reducing CO_2 emissions. However, also the need to maintain the ecological functions of hydropower-affected water stretches has to be taken into account in order to ensure a balanced approach, contributing towards the achievement of climate but also water and nature protection objectives, which are required to be met by law.

At the end of the chapter the situation regarding hydropower generation in the Alps is addressed individually for all countries in the Alpine area.

[80] Article 4 (7) of the Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy, Water Framework Directive

Conclusions

Hydropower generation is one of the key issues in Alpine water management. Apart from being a key economic asset for the whole Alpine perimeter, the benefits of hydropower as a highly reliable and largely CO_2-free renewable source for electricity production and its contribution towards satisfying the energy demand of the Alpine states is of considerable importance besides the additional value of helping to stabilise the European energy grid.
However, since growing energy demand, increased prices for electricity as well as CO_2 reduction targets for act as drivers in Alpine water management, advising further expansions and additional facilities, these developments are causing pressures on the ecological status of river systems. In this context, new projects for hydropower generation are currently again at the heart of controversial debates.

Apart from providing energy and tackling climate change, there is the additional need to meet water and nature protection objectives as further targets for environmental protection and sustainable development. The construction and operation of hydropower stations is linked to unavoidable impacts on the river stretches and wetlands. Thus, while the advantage of almost emissions-free energy production through hydropower is undisputed, there is a need to optimise hydropower facilities in order to strike a balance with the ecological requirements of the affected water systems and adjacent land ecosystems. Furthermore, river stretches which are in or near natural conditions have become more and more unique in recent years and are threatened to be modified, which leads to a conflict of interests.

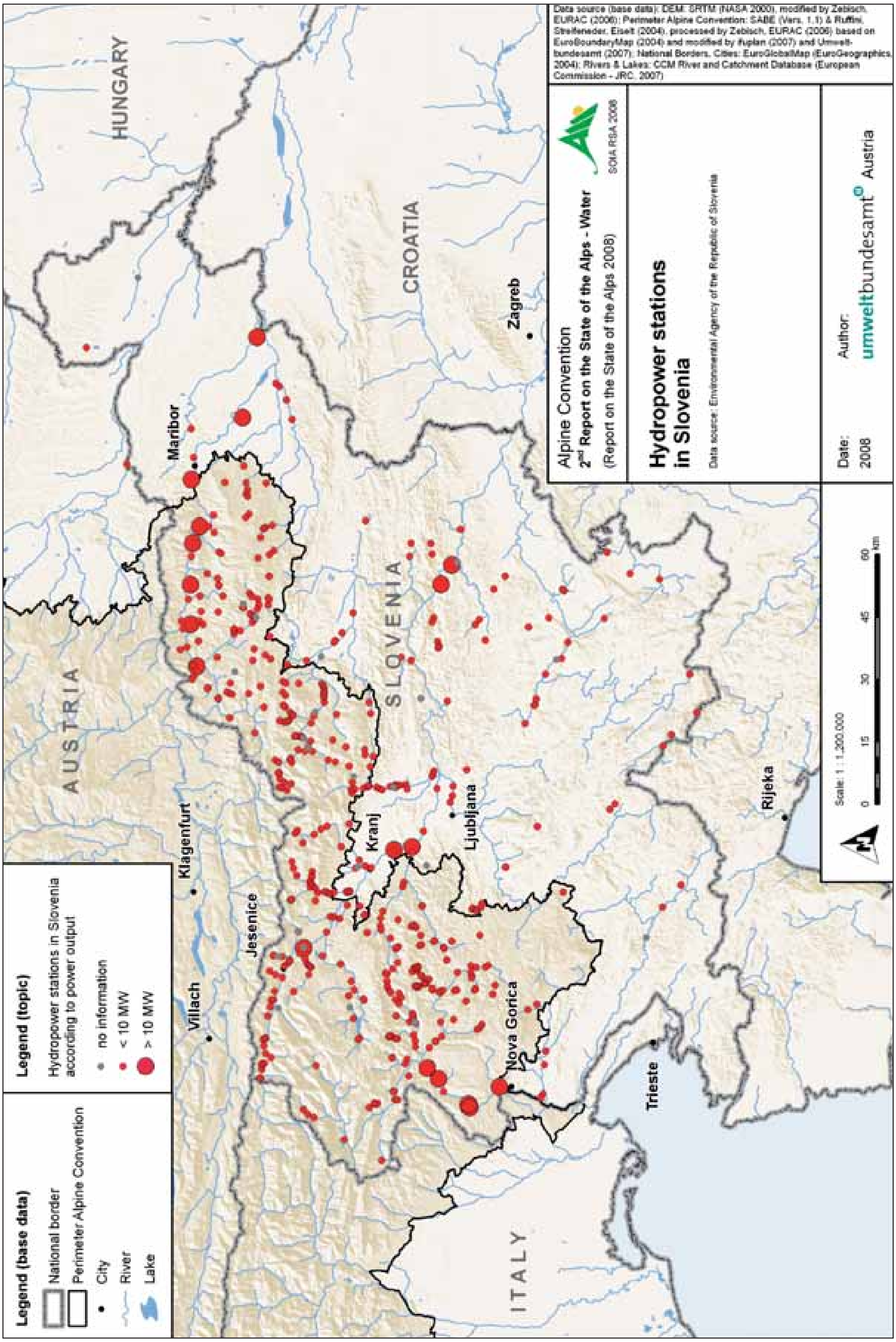
National provisions for a sustainable use of water with the aim of solving this conflict are in place in all the Alpine states. The implementation of the EU Water Framework Directive (WFD), for instance, defining ambitious objectives for environmental protection with a pragmatic approach in the case of exceptions, is considered to be a strong instrument in support of balancing the interests of different stakeholders as well as a vital contribution towards sustainable development. This also applies to the situation regarding already existing facilities, where necessary upgrading in order to meet ecological targets is expected to be a practical outcome in achieving the goals of modern environmental legislation. What should be especially highlighted in this respect is the potential win-win-situations, where both energy yield and the ecological situation can be improved by modernisation measures applied to existing facilities.
On these grounds, there is a strong argument for continuing the discussions between all stakeholders in order to achieve sustainable solutions concerning hydropower generation and environmental requirements in line with the dialogue taking place at European level.
At the workshop[81] in Berlin in June 2007 on a common implementation strategy for the EU Water Framework Directive (WFD) with regard to hydropower generation, the following key conclusions have been identified:
Holistic approaches for hydropower use are needed. The focus should be at catchment level and not only site-specific or at water body level. Advantages are recognised in form of pre-planning mechanisms to facilitate the proper location and identification of suitable but also non-suitable areas for new hydropower projects. A 'master plan' for the future development is highlighted as an appropriate instrument in order to enable a transparent planning process, taking into account remaining potentials with regard to energy production apart from environmental criteria as well as other water uses. At least 3 categories of areas could be distinguished: suitable, less favourable and non-favourable areas. The identification of these categories should be carried out with the involvement of all stakeholders based on transparent criteria, including revisions within a period of time. Small and large hydropower should be treated equally with regard to promotion. These drafted steps are considered to be an appropriate instrument for achieving sustainable solutions to future challenges, since objectives regarding renewable energy supply, climate change but also nature protection have to be met.

With regard to further exploitation of the hydropower potential two particular issues should be addressed in more detail:

- What should sustainable solutions look like if we consider that even if the total remaining potential for hydropower generation were to be exploited, the gain in additional energy yield would merely cover the projected increase in energy consumption for some years? After this period, the pursuit of additional renewable energy sources would be resumed, save the vanishing remaining potential for hydropower generation and the corresponding ecological impact due to the added facilities.

- The latter question applies in particular to small and micro-hydropower schemes with respect to their contribution towards achieving the objective of increasing renewable energy production, which should be assessed and evaluated against their impact on Alpine river systems.

[81] Water Framework Directive and Hydropower, Common Implementation Strategy Workshop, Berlin 4-5 June 2007, Workshop Summary Report. http://www.ecologic-events.de/hydropower/index.htm



Map 20: Hydropower stations in Slovenia

Case Study from Switzerland

Conflict Hydropower Generation – Ecology

Case study Spöl: Increasing the flow regime dynamics downstream of a reservoir by artificial floods

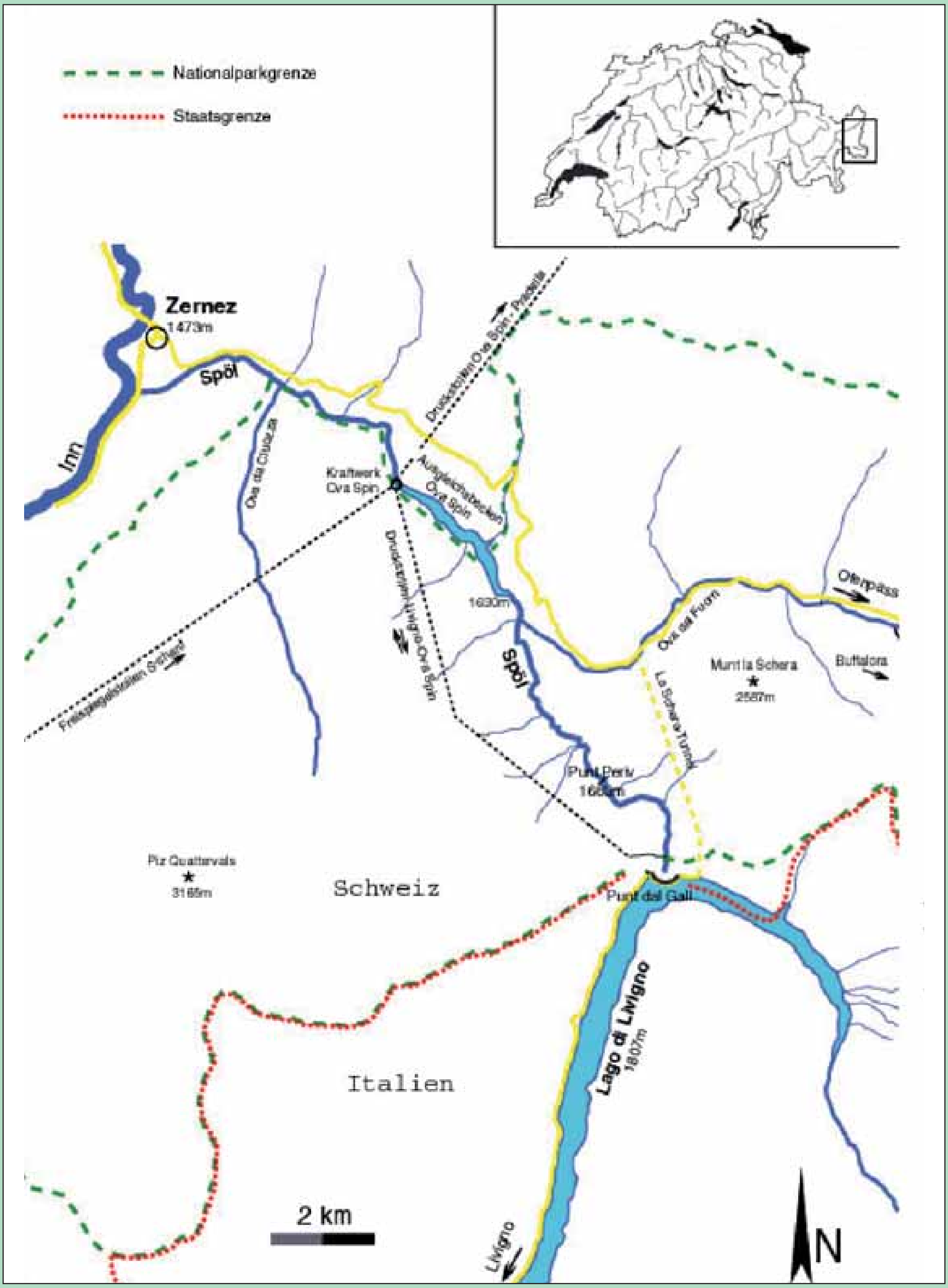


Fig. B3-3: Overview of the study site (Reference: www.hydra-institute.com).

Hydropower facilities in the Alps are leading to an ecological deterioration of the affected water bodies downstream of reservoirs due to a reduction of total run-off as well as to the elimination of run-off dynamics. This is also the case for the River Spöl, located in the Swiss National Park, close to the Swiss-Italian border (see Figure 1).

The River Spöl was formerly a mountain stream, which contributed a considerable amount of water to the River Inn. From 1962 to 1969, the Livigno dam was built (see Figure 2). Since then the mean discharge of the river Spöl downstream of the dam was reduced to 1 m^3/s, which corresponds to 12% of the natural discharge. Until 1999, the residual flow regime was managed as specified in the gray-shaded column of Table 1.
The residual flow regime, and especially the absence of floods, led to a severe alteration in river morphology including the following negative effects:

- Aggradation and homogenisation of the river bed as a result of insufficient tractive force for sediment transport
- Formation of alluvial fans
- Filling of the river bed with fine material
- Alteration in the composition of benthosfauna
- Increase in aquatic plants and algae
- Spread of tree vegetation into the river bed

Two flushings carried out in 1990 and 1995 to test the functionality of dam's bottom outlet showed positive effects on the river's fauna and structure. This encouraged a study concerning the alteration of the residual flow regime, which involved ecological and economical aspects. To this end, artificial floods are triggered every year between June and August.
The water volume necessary for the artificial floods is no "extra-water" provided by the hydropower company but is water saved by slightly decreasing the residual flow during summer. Thus, the new regime with artificial flooding implies no disadvantages for the operator of the power station since there is no loss of water from the company's perspective and no reduction as to electricity production.

The comparison of figures of residual flow with and without artificial floods is shown in Table 1.

Comparing the annual discharge hydrographs in Figure 3 for the different periods we can see, first of all, the substantial decrease in discharge when comparing the natural state (green line) to the situation affected by the dam (red line) as mentioned before. The mean discharge decreased by approximately 88%. The residual flow regime including artificial floods (blue line) tries to approach the unaffected flow regime.
The positive ecological impacts resulting from artificial flooding are:

	Original residual flow regime	**Residual flow regime including artificial floods**
1 October – 15 May	550 l/s	550 l/s
16 May – 30 September	2.470 l/s from 6 am to 6 pm, 1.000 l/s from 6 pm to 6 am	1.450 l/s as well as • 2 artificial floods with approx. 10 m^3/s during 6 to 8 hours and • 1 artificial flood with approx. 30 m^3/s during 7 to 9 hours

Tab. B3-5: Residual flow regime during the summer and winter period for the original regime (until 1999) and the regime including artificial flooding (since 2000).

(Reference: www.bkw-fmb.ch).
Photo B3-4: Punt dal Gall dam at Lake Livigno

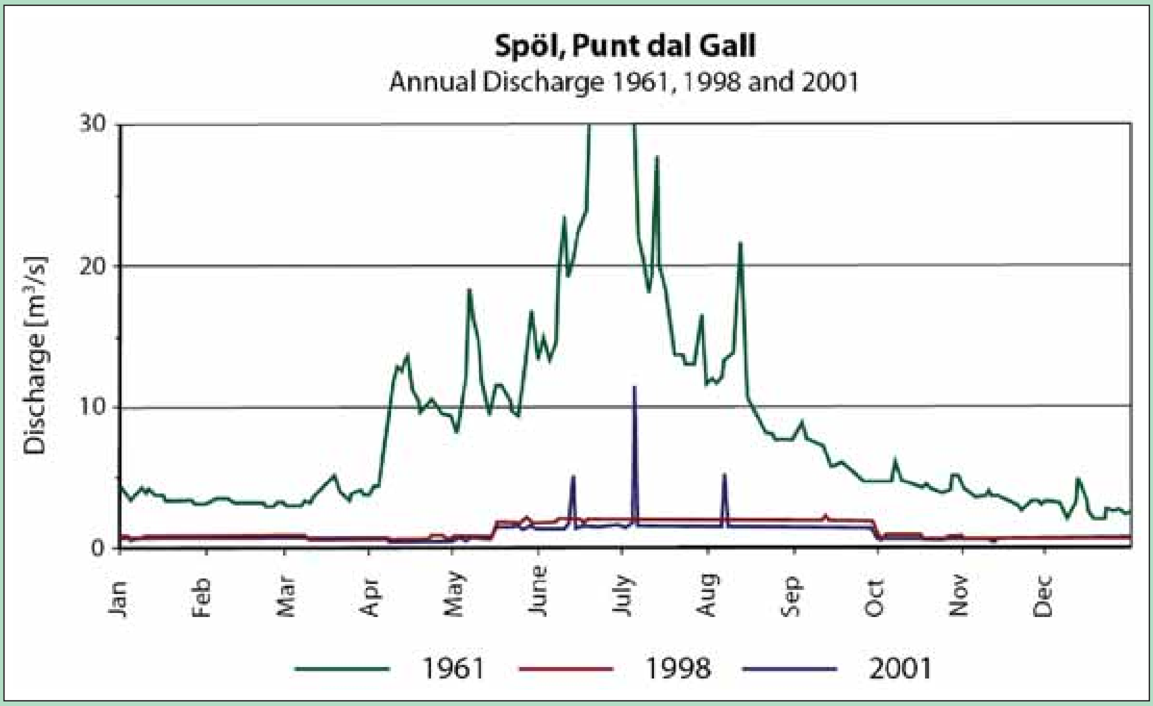


Fig. B3-4: Annual discharge hydrographs at the residual flow reach of the River Spöl, where 1961 represents the unaffected state, 1998 the discharge affected by the dam, and 2001 includes the artificial flooding (after Sigmaplan AG, 2005).

- Erosion of alluvial fans
- Rearrangement of the river bed
- Formation of new gravel banks
- Reduction of the moss and algae cover
- Enhanced conditions for fish spawn
- More typical mountain stream invertebrates

The artificial flooding of the River Spöl represents one of the rare cases in the Swiss Alps with a dynamic residual flow regime and might serve as a model for others.

The main conclusions which can be drawn from the ecological studies that accompanied the above-described flushing experiments are as follows:

- A dynamic residual flow regime reduces the negative impacts of flow reductions in the af-fected river stretches.
- More dynamics with occasional flooding provides a higher ecological benefit than increasing constant residual flow.

The Swiss Water Protection Law requires a redevelopment of water withdrawal schemes if they have a substantial impact on a river. Based on the positive experiences, these artificial floods will be integrated in the redevelopment policy of the River Spöl's residual flow regime.

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National Contributions Regarding Information on Hydropower Generation

Austria

Electricity supply in total generated a gross value added of 3,59 billion euros in 2005 in Austria, with two thirds of the produced electricity originating from hydropower generation. Hydropower is thus the main source of renewable energy in the country. With about 40.000 GWh and a capacity of 11.000 MW, hydropower contributes roughly two thirds on average to the annual Austrian electricity production of about 62.000 GWh in total. Not the whole share of the electricity produced by hydropower originates from plants situated in the Alpine region of Austria, although the Alps are certainly of major importance for the hydrology of the outer Alpine rivers, where additional plants are located. For instance, a share of approximately 13.000 GWh is generated by facilities along the River Danube.
A further aspect with regard to hydropower generation is its contribution towards balancing the variations in energy demand across Europe. This objective is mainly supported by the 95 Alpine reservoirs in Austria, generating about 28% of the entire electricity produced by hydropower.
According to the Austrian Article 5 Report of the EU Water Framework Directive, there are in total 156 hydropower stations with a bottleneck capacity of more than 10MW in the country, contributing 89% to the overall electricity production from hydropower. In contrast, the remaining 11% of the electricity from hydropower is produced by 2143 registered facilities with a bottleneck capacity of less than 10MW. In aggregate, this results in to a total number of about 2.300 hydropower plants in Austria to which approximately 2.000 very small private facilities have to be added.

Hydropower generation in Austria is still in the process of further development. The currently planned projects will contribute approximately additional 500 GWh by 2010. This increase is driven in particular by ambitious targets to increase renewables as well as by a rise in the price for electricity, which enhances the economic viability of new projects.
The construction of new plants or the extension of already existing facilities often results in conflicts between economic interests and ecology. Due to the steady decrease of untouched aquatic ecosystems during the last decades, this has become an issue of growing concern among the Austrian public. Drafting a "master plan", which weighs the viability of possible future projects against the value and uniqueness of a certain ecosystem located in the same region, which would be negatively affected by the project, could be a valuable tool in finding a compromise. Austria is currently in the process of developing such a "master plan" as well as of compiling a catalogue of criteria for the assessment of ecological aspects.

France

French national consumption is expected to possibly rise from 467 TWh/yr in 2003 to 527 TWH/yr in 2015. Hydroelectricity from the French Alpine area accounts for some 4% (~20TWh/yr) of the total national annual production (of 535 TWh/yr nationwide, 12% of which comes from hydropower). According to the Renewable Energy Directive, hydroelectricity stands as an important option. Even such a small percentage remains a strategic resource as it is able to provide for peak-hour production. With a total installed capacity of ~9 000 MW, a variety of plants exceeding 50 MW of installed capacity (Rhône excluded) can be distinguished (A.C. perimeter): 19 rely on reservoirs, 6 rely on sluice discharge, 6 on river flow and 4 are energy pumping stations.

Every hydroelectric facility requires a permit – either a concession or an authorisation - issued by the Prefect (local representative of the State or Ministry of Industry) on the basis of a complete file (including impact study, risk assessment, flow design, public enquiry,…). Concessions are required when the power installed exceeds 4.500 KWh; ownership of the facility is returned to the State after expiry of the concession, which is granted for a period of 30 to 50 years (maximum 75 years). Authorisations are issued for facilities delivering less than 4.500 KW. Ownership of such facilities remains with the applicant.

According to the WFD process for evaluating financial investments to be scheduled in order to a reach good status for water-bodies, current improvements are focusing on the preservation of biodiversity through: sound flow management, fish ladder facilities, and reduction of the impact from sluice operation, and increase of minimum flow (present facilities are mostly designed for 1/40th or 1/80th of the average flow).
A recent water law has specified the minimum flow downstream of a hydroelectric facility to be in excess of 1/10th of the average flow (or a flow equal to the incoming flow if it is lower). Present facilities are mostly designed for 1/40th or 1/80th. In some cases, it still is possible to deliver a lower flow: 1/20th where the average natural flow exceeds 80m^3/s or for several facilities covered by special decrees. It is also possible to obtain exceptional permission for lower minimum flow provided that the average minimum flow satisfies the above requirements on an annual basis and

that the actual flow is never less than one half of this requirement. These requirements apply henceforth to every renewal of any existing concession and authorisation and at least for every facility before January 1st, 2014. This would reduce hydroelectrical production by some 2 TWh/yr.

At the same time the national objective is to improve the hydroelectric potential (7 TWh/yr nationwide). In the Rhône watershed most of the possible sites are already being exploited , and at the moment there are very few projects in the pipeline (the main one is to replace six existing low-height dams by just one along the River Romanche near Grenoble). In the near future this objective could possibly be achieved by adopting the following approaches: 1st) - optimisation of existing facilities (oversizing, turbining minimum flow for possibly 2 TWh for the Rhône watershed…), 2nd) - new facilities (4 TWh expected from 60 plants within the Rhône watershed) and 3rd) - 6 energy transfer - pumping plants (0.1 TWh). At the same time, some reports mention a possible target of decreasing demand by up to 30 TWh/yr, balanced by an an increase in windpower production by 10 TWh/yr and 12 TWh/yr coming from biomass.

Many questions remain as regards the future potential of existing facilities against the background of climate change, which might affect production because of reduced flow. The main challenge in France for the next decade will be the implementation of the law requiring an improvement of the minimum flow by 2014 and achieving the national objective of enhancing the hydroelectric potential.

Germany

Hydropower is one of Bavaria's major resources of energy. Rivers and streams with high run-off as well as adequate gradients make the conditions for the use of hydropower particularly favourable in Bavaria.

Of the electricity generated from renewable resources (73,9 TWh) in Germany in 2006, 29,3% are generated by hydropower. This is the most important source of renewable energy, after windpower. Measured against Germany's total electricity production, hydropower is, however, rather low, contributing just about 4%.

60% of German hydropower comes from Bavaria. This is where hydropower accounts for a 15 – 18% share of generated electricity and is a major pillar in the total energy mix of nuclear energy, renewable energies and fossil fuels.

In Bavaria there are some 4210 hydropower plants in operation. 762 of these plants (= 18%) are in the designated area of the Alpine Convention. The mean annual hydroelectric output is approx. 13.100 GWh/yr, of which 2.905 GWh/yr (= 22%) are from the Bavarian Alpine region. The total installed hydropower capacity across Bavaria is 2.854 MW, of which 25% or 700 MW are generated in the Alpine region.

The hydropower plant structure in the Alpine region is mostly in the form of river diversion-power plants which account for 79% of all plants, the remaining plants are run-of-river or reservoir hydropower plants, and just 2 are pumped-storage power plants. As measured by their installed capacities, the run-of-river/reservoir power plants are marginally in front of the diversion-power- plants. The mean annual output of the run-of-river/reservoir power plants is 1.665 GWhyr and that of the diversion power plants is 1.230 GWh/ayr

When listing the plants according to size, the majority of the hydropower plants are small (< 100 kW) and medium-sized plants, just 16 plants have an installed capacity of > 10 MW, whereas some 90 % of the generated electricity comes from the large hydropower plants (> 1000 kW). Further details are given in the table below:

From the energy-political standpoint a further development of hydropower is desired, however, there is a strong resistance to such activities in many cases. In a joint key point paper drawn up by the Bavarian State government and major hydropower plant operators in Bavaria, the will to step up the production of hydropower in Bavaria is underscored. It was estimated that

Listed according to installed capacity	Number of plants		Electric output		Annual output	
	number	%	[kW]	%	[GWh]	%
< 99 kW	574	75,3	15.327	2,2	70,0	2,4
100 kW - 999 kW	131	17,2	38.889	5,6	206,0	7,1
1000 kW - 9999 kW	41	5,4	123.266	17,6	589,4	20-3
> 10000 kW	16	2,1	522.725	74,7	2.040-2	70,2
Total	**762**		**700.207**		**2.905,5**	

Tab. B3-6: Hydropower plants in designated area of the Alpine Convention

the residual hydropower potential available from the "large" hydropower plants would provide an approx. 8% increase in the annual output, and an increase of approx. 2% could be expected from the "small" hydropower plants.
Growth is first and foremost to be achieved by the modernisation and upgrading of existing plants in addition to the construction of new hydropower plants. Before any new hydropower plants are built it will be necessary to carry out extensive environmental impact assessments (nature/species protection, continuity of waters, balance and compensation measures).

Italy

The following information relates to the area of Northern Italy but can be considered as being representative of the situation in the area covered by the Alpine Convention.

In 2006 the net production of hydropower in Northern Italy was almost 21% (32.291 GWh) of the total net production (154.590 GWh) over the same area. The net hydropower bottleneck capacity was 15.252 MW.
The total number of hydropower plants over the area of northern Italy is 1.647, which can be grouped into three different kinds: powered from flowing water, from reservoirs or from river basins.

The majority of plants are powered from flowing water (no. 1.422) and supply a net production of energy equivalent to 13.036 GWh, 8,4% of the net total. For these plants the net hydropower bottleneck capacity is 3.423 MW.
As regards plants powered by reservoirs (no.107), although they are fewer in number in comparison with the plants powered from river basins (no.118), they provide 7,1% of the total contribution of net hydroelectric energy production, with a bottleneck capacity of 8.282 MW. Below there is a summary table:
It is not possible to estimate the economic value of hydropower produced in Italy due to the continuous fluctuations in the power market. However, it would seem relevant to point out that in 2006, where there was a demand in Italy for 337.458 GWh of electrical power, 86,7% of which was satisfied by National production and the remainder (13,3%) by importats from abroad, the net production of hydropower in Italy was equivalent to 42.883 GWh and satisfied 12,7% of national requirements.
75,3% of national hydropower is produced in Northern Italy.
Currently there is a system in Italy that favours energy production from renewable sources, including hydroelectric power, which involves the issuing of so-called "Green Certificates" by the authority managing the national grid. The Green Certificates can be issued in favour of a specific plant for a maximum period of eight years, introducing, in fact, an incentive for the replacement of plants by renewable energy sources.
There is no master plan at national level for the de-

Hydroelectric energy	**Figures (Terna ,2006)**	
Production	**GWh**	**% of total**
Net power production in Northern Italy – 2006	**154.590,10**	100%
Net hydropower production in Northern Italy – 2006	**32.291,40**	20,90%
from reservoir	10.912,50	7,10%
from basin	8.352,60	5,40%
from flowing water	13.026,30	8,40%
Power	MW	
Net bottleneck capacity in hydropower plants in Northern Italy-2006	**15.252,10**	
from reservoir	8.283,20	
from basin	3.545,80	
from flowing water	3.423,00	
Plants	No. of plants	
Number of hydroelectric plants in northern Italy- 2006	**1.647**	
from reservoir	107	
from basin	118	
from flowing water	1.422	

Tab. B3-7: Contribution of net hydroelectric energy production velopment of hydroelectric energy; this task is delegated to the regional authorities as part of the "regional action plans for energy". The major perspectives in the hydroelectric sector for the future relate essentially to the creation of small hydroelectric plants, with an bottleneck capacity of up to 10 MW, as well as bringing back into operation, where expedient, water systems that have fallen into disuse over the past decades. Due to the system of incentives, there has been a reawakening of interest over the last few years in small-scale plants, which had previously been ignored because they were regarded as economically unviable.

Hydropower provided an opportunity and driving force for growth and employment until the 1960s, during which period the major hydroelectric plants and large artificial reservoirs were completed. After a decade when there was a substantial interruption in the construction of new plants, there was a renewal of interest in the use of water resources that gave rise to wide-scale debates both among local authorities as well as individual citizens and organisations.
Great awareness among the Alpine population about the problems relating to the protection of the quality and quantity of water resources, about safeguarding and making best use of the landscape, about the protection and conservation of ecosystems and aquatic environments, are contributing towards generating, at local level, wide-scale opposition to the granting of new authorisations for hydropower.

Slovenia

In 2005 the total electricity production in Slovenia amounted to 15150 GWh of which hydroelectric plants produced 3.407 GWh.
Hydropower generation is the main source of renewable energy, while other sources like solar energy and wind energy have a symbolic share only. However, the share of hydroenergy is not constant, but rather changes from year to year according to the annual and seasonal variations of power needs, and according to hydrological conditions. In the last decades the share of hydropower generation has been typically within range of twenty to thirty percent of total electricity production. The share of small hydropower schemes is around five percent. Slovenia does not have large reservoirs with seasonal reserves. Most of the hydropower schemes are run-of-river hydroelectric plants with small reservoirs for compensating daily oscillations or, at best, for a short term of several days. Diverted flow is an exception rather than a rule, with only a quarter of the large hydropower plants being of this type.
All large hydropower plants with an installed capacity of over 10 MW are on three major rivers: the Drava, the Sava and the Soča. Out of 16 large plants, 9 are within the Alpine Convention area, but all should be considered to be dependent on the waters from the Alps. The headwaters of all three rivers and many of their tributaries are in the Alps. Out of the total number of 419 small hydropower plants with an installed capacity below 10 MW, three quarters or 317 are within the area of the Alpine Convention.

Slovenia is very active in projects harnessing hydropower. The gross potential of all rivers is about 9.100 GWh, with an economically feasible yearly production between 7.000 and 8.500 GWh. At the time being, only about one half of this potential is used. The plan until 2015 is to increase the installed capacity from 846 MW to 989 MW and to increase yearly production to 4.237 GWh. Out of 14 older hydropower plants 10 have been retrofitted with new electro-mechanical equipment and two are currently under reconstruction. These reconstructions lead to increases in capacity without new intervention into environment. On the Riva Sava, two new hydropower plants were completed recently, two are currently under construction and construction of two more will start soon. There are plans to build 10 new plants on the River Sava in the future with an installed capacity of 342 MW. The plans of building hydropower schemes on the River Mura with a big hydropower potential are doubtful due to environmental considerations. There are also projects to improve the availability of hydropower during daily peak demand. One pumped storage scheme is under construction and construction of another one will start soon. The existing national plan up to 2023 includes some of the listed run-of-the river power plants and both pumped storage schemes. It is likely that it will be revised accordingly in the future due to pressure to harness more renewable sources of energy.

The construction of new power plants is a big issue appearing in mass media time and again, most hotly debated, usually due to the activities of environmental NGOs and the opposition of local communities. The discussions are frequently irrational and their outcome is sometimes detrimental both to economy and to the environment. Most telling is a recent example of retrofitting an existing fiftyyear-old power plant that has been halted. The retrofitting plan would have provided for a small compensation reservoir below the dam to improve the availability of the plant and to solve the problem of hydro-peaking downstream. The reservoir was hotly opposed because of the loss of two small wetlands (that were planned to be compensated by establishing new ones downstream) and of "fog" in an area of already existing reservoirs and the natural lake. The result of dispute is that the hydro-peaking problem has not been solved so far.

The ecological bomb of hundreds of small hydropower plants does not raise much public concern. It is difficult to control these plants due to the large number and their usually remote locations. The ecology of pristine Alpine streams is affected by water diversions and hydro-peaking.

The construction of small hydropower plants was initially prompted by the Soviet invasion of Czechoslovakia in 1968 and designed to serve the needs of the newly established system of territorial defence. Today, small hydro is regarded to be "green" energy and its production is promoted by paying higher prices, regardless of economic and of environmental effects that are debatable.

As a rule, investors in large hydropower schemes are ready to take adequate measures to remedy environmental impacts and, after completion, run operational monitoring programmes. The majority of problems associated with these projects result from poor public relations and the failure to maintain proper contacts with local communities. There are successful projects that are well accepted by local communities, some other good projects were shelved due to sometimes unsubstantiated environmental concerns. On the other hand, the fallacy of many "green" energy small hydropower plants in the Alps is not sufficiently recognized.

Switzerland

The share of hydropower in Switzerland's total electricity production is around 55%, thus constituting the most important domestic primary energy source. With respect to renewable electricity production, hydropower contributes 97%.
In 2006 hydropower in Switzerland reached a total maximum power of ca. 13.400 MW and a total production of 35.500 GWh. To these figures, run-of-river power stations contributed 3.680 MW of total maximum power and 16.650 GWh in production. The respective figures for storage power stations are 9'675 MW and 18'830 GWh. Thus, 47% are generated by run-of-river power stations, 49% by storage power stations and about 4% by pumped-storage power stations. Two thirds of this energy comes from the mountainous Cantons of Uri, Grisons, Ticino and Valais. Roughly 10% of Switzerland's hydropower generation comes from facilities situated on water bodies along the country's borders.
Noteworthy for the quality of the Swiss electricity production are in particular the storage and pumped-storage stations. Thanks to their storage capacity, a great share of the electricity production can be provided on a very flexible basis, satisfying the demand-side with peak-energy.
Thanks to its topography and high levels of annual rainfall, Switzerland has ideal conditions for the utilisation of hydropower. Towards the end of the nineteenth century, hydropower experienced its first wave of expansion, which was followed by a genuine boom between 1945 and 1970, a period during which numerous new power plants went into operation in the lowlands, together with large-scale storage plants in the Alps.
Based on the estimated mean production level, hydropower still accounted for almost 90% of domestic electricity production at the beginning of the 1970s, but this figure dropped to around 60% by 1985 following the commissioning of Switzerland's nuclear power plants, and is now around 55%. Hydropower therefore remains Switzerland's most important domestic source of renewable energy.
Hydropower also creates jobs and provides significant funding, most notably to mountainous Cantons and municipalities, through various charges and taxes. The hydropower market represents a value of around 2 billion Swiss francs (basis = delivery from power plant at 5 cents per kilowatt hour), and is therefore an important segment of Switzerland's energy industry.

Large-scale hydropower
Large-scale hydropower plants (capacity greater than 10 MW) account for around 90% of Switzerland's total hydropower production.

Today, there are 532 hydropower plants in Switzerland with a capacity of at least 300 kilowatts. More specifically, 117 hydropower stations with an installed power above 10 MW are located within the Alpine Convention perimeter.

Small-scale hydropower

In Switzerland, the term small-scale hydropower plant refers to facilities that produce a mean mechanical gross capacity of up to 10 MW.

Small-scale hydropower plants have been around for a long time in Switzerland. At the beginning of the twentieth century, there were already around 7.000 in operation. But with the advent of low-cost electricity from large-scale power plants, many of these ceased production.

Today, there are more than 1.000 small-scale hydropower plants in operation, with an installed capacity of approximately 760 MW and an output of 3.400 GWh per annum.

Electricity production in small-scale hydropower plants can be attractive from both an economic and an ecological point of view, and an increase in output is feasible, as long as ecological aspects are duly taken into account. The potential is estimated to be at around 2.200 GWh per annum.

In addition to small-scale hydropower plants in rivers and streams, it is now possible to utilise other sources, e.g. excess pressure in drinking water systems.

Promotion of hydropower

The federal government wants to promote the future use of hydropower to a greater extent through a variety of measures. In order to exploit the realisable potential, existing power plants are to be renovated and expanded while taking the related ecological requirements into account. The instruments to be used here include cost-covering remuneration for feed-in to the electricity grid for hydropower plants with a capacity up to 10 megawatts, and the measures aimed at promoting hydropower are included in the "Renewable Energy Action Plan". In terms of quantity, the goal is to increase the mean estimated production level by at least 2.000 GWh versus the level recorded in 2000 by renovating existing hydropower plants and constructing new ones.

B.3.5 WATER MANAGEMENT FOR SOLVING CONFLICTS

Water-Use Conflicts

Water-use conflicts result mainly from water scarcity and droughts, abstraction for irrigation, from increasing necessity of space for rivers, water pollution, water dams and water storage or the preservation of ecological and environmental aspects such as hydromorphological aspects or minimum vital flows.

The needs in water consumption and pressures on waters have changed and water conflicts have increased, consequently adaptive management to such dynamics is required.

Different ways of dealing with water management conflicts are for example (non-exhaustive list):

- Agreements (bi- and, transboundary, multilateral: Danube Convention) and sub-basin commissions
- Conferences
- Legislative framework (licensing systems, involvement of water users)
- Planning instruments
- Studies as a basis for identifying and solving conflicts

Agreements on common water management are, at several levels, a crucial means for solving conflicts between different water users (hydropower production, tourism, agriculture, and neighbouring states) or pressures on ecological requirements. Such agreements are usually based on the respective legislation, which backs such agreements, and involve the necessary bodies set up to negotiate, manage and monitor the implementation of actions and rules.

The critical management issues have changed over the years and are reflected, inter alia, in the subjects of conferences. "Water – conferences" take place at local, regional and European levels, but also worldwide. Examples are the International Fishery Congress in Vienna at the beginning of the 20th century , and taking place every 3 years since 1997, the "World Water Forum", or the UN International year of Freshwater in 2003 on the supply of drinking water worldwide. The World Water Week in Stockholm has taken place every year since 1991 with the support of more than 200 convening organisations and institutions.

The Dublin Principles, adopted in 1992 by more than 100 countries, focus on the implementation of water management by way of a participatory approach and also focus on the resolution of water-use conflicts in particular as regards freshwater.

The Water Framework Directive of the European Union is the crucial legislative framework for water management and water-use conflicts which has to be taken more strongly into consideration at international level. Directive 2000/60[82] was adopted in 2000 and entered into force in 2003. It intends to create a legal framework for water management within the EU and beyond. The Water Framework Directive requests the EU Member States to identify the river basins within their territory and build river basin districts. For each river basin district, a competent authority has been appointed. Furthermore, EU Member States shall develop, for each river basin, a River Basin Management Plan which shall outline the monitoring and control details as well as a number of other steps taken or to be taken in order to reach the objectives of Directive 2000/60. They shall be established by 2009 and will be reviewed and updated in 2015 and every six years thereafter.

Finally, studies carried out at local and all other levels, which draw concrete conclusions, play a crucial role in discussions and decision-making processes for the resolution of water-use conflicts. An example of such studies is the "Impact of an extreme dry and hot summer on water supply security in an Alpine region" in the region of Kitzbühel in Austria[83].

This introduction is followed by three case studies on water-use conflicts and on the management of surface waters: one focuses on the River Danube, one is on the River Drac in France and one on Lake Idro in Italy. This shall not result in the misleading conclusion that conflicts over groundwater, glaciers or wetlands are of minor importance. Water-use conflicts over surface waters are probably more visible and have, so far, concerned a broader share of the population.

Conclusions:

- Water management issues are dynamic and therefore require an appropriate approach;
- Bodies for water management (competent authorities) are in place;
- Problems have to be solved at the appropriate level (local at local level etc.);
- Existing agreements have to be updated on a regular basis;
- Political representatives and, in general, all stakeholders have to be involved in the ongoing processes of water management, using the available instruments;
- Awareness of previous conflicts which have been solved and highlighting them to stakeholders;
- In order to be sustainable, compromises have to be sought between economic, ecological and social aspects.

[82] Directive 2000/60 establishing a framework for the Community measures in the field of water policy, OJ EU 2000, L 327 p.1
[83] Vanham D., Fleischhacker E. and Rauch W.; „Impact of an extreme dry and hot summer on water supply security in an Alpine region",

Case Study
River Danube Protection Convention

The history of cooperation along the Danube shows how conflicts and visions of water management have changed over the years. The basic understanding of the actual cooperation along the Danube River has always been that the "..best way to protect and manage water is by close international cooperation between all the countries in the river basin – bringing together all interests upstream and downstream."

Prior to World War II, the European Commission of the Danube, which dates back to the 1856 Treaty of Paris and is composed of representatives from each of the riparian countries, was responsible for the administration of the River Danube. Its primary goal was to ensure free navigation along the River Danube for all European countries.
World War II resulted in new political alliances, and consequently in a new management approach. At the conference in Belgrade in 1948, the East Bloc riparian states shifted control over navigation to the exclusive control of each riparian.
The Belgrade Convention also provided the Commission with semi-legislative powers, although these were restricted to navigation and inspection. By the mid-1980s it became clear that issues other than navigation, notably problems regarding water quality, were gaining in importance within the Danube basin. Recognising the increasing deterioration in water quality, the eight (at that time) riparian states along the River Danube signed the "Declaration of the Danube Countries to Cooperate on Questions Concerning the Water Management of the Danube (Bucharest Declaration)" in 1985. The Bucharest Declaration underlined the principle that the environmental quality of the river depends on the environment of the basin as a whole, and committed the countries to pursuing an integrated approach in water management, beginning with the establishment of a uniform basin-wide monitoring network. Progress was made in basin-wide coordination at meetings in Sofia in September 1991.
The countries and the international institutions interested in this matter set up an initiative to support and reinforce national programmes for the restoration and protection of the River Danube. By way of this initiative, the so-called Environmental Programme for the Danube River Basin (EPDRB), the participants agreed that each riparian would:

- adopt the same monitoring systems to assess environmental impact;
- address the issue of liability for cross-border pollution;
- define rules for the protection of wetland habitats,
- define guidelines for the development of con-servation areas which are of ecological impor-tance or of aesthetic value.

An interim Task Force was established to coordinate the endeavours. Its work was supported by a Programme Coordination Unit (PCU) based in Vienna, Austria.
One of the major tasks of the EPDRB was the development of the Strategic Action Plan (SAP), with the provision that "consultation procedures should be strengthened." In moving from planning to implementation, it was determined that the proposed SAP should include the following:

- measures must be "concrete" and achieve results in the short term;
- major environmental threats must be addressed by way of realistic cost assessments and a reduction of constraints on problem-solving;
- the SAP should be up-dated regularly;
- widespread consultation during the prepara-tion phase is desirable, in particular consulta-tion of parties who are responsible for its im-plementation.

During late 1993 and early 1994, another major activity related to the River Danube was also being carried out: Parallel to the development of the Strategic Action Plan for the Danube River Basin by the EPDRB, the countries involved were developing the Convention on Cooperation for the Protection and Sustainable Use of the River Danube (Danube River Protection Convention).
When drafting the SAP, it was agreed that it should be designed as a tool to support the implementation of the Danube River Protection Convention, which was finally signed in Sofia (Bulgaria) on June 29, 1994.

Case Study from France

Water-use conflicts in the Drac Valley focusing on the discussion between the different stakeholders

Whenever a local conflict occurred, the French water law enacted in 1992 mandated the elaboration of local master plans in order to arrive at a type of management which was not only tailored to local issues, but had also been elaborated by the water users themselves. The case study described below, illustrates how a tense situation along the River Drac (close to the city of Grenoble) was alleviated using this process.

A French valley facing urbanisation and the preservation of water resources

The River Drac is one of the most important tributaries of the River Isère (a tributary of the Rhône). The surface area of its catchment basin is 3.500 km^2 and the average flow at the confluence is nearly 100 m^3/s. A wide range of human activities are carried out in its lower valley, the main ones related to water being:

- **hydroelectric production** using more than 40 dams of which 6 are essential for the national production of electricity. This industry causes damage to aquatic environments and to other uses. Flow variations represent the chief safety hazard, as fishing and water sports are increasing in an uncontrollable manner (in 1993, as a result of water being released, 10 children drowned upstream of the city of Grenoble).

- **The drinking water supply** from the allu-vial groundwater of the River Drac is essential for the 400.000 inhabitants in the area of Grenoble, as well as for the development of several industries relying on water availability such as atomic research centres, the nano technological industry, etc. Without an optimal public water supply policy, water consumption could even exceed the natural availability of groundwater.

Previous agreements were insufficient

Even with the existing earlier agreements, increasing activity has contributed to growing discord: availability, pollution, ecological conditions, etc.
In the late 1990s, to solve incidents and/or conflicts which arose, the elected local representatives decided to take a new step in water management by defining regulations (which had already been enacted) and programmes to improve the use and protection of water.

This has been implemented in several steps:
- Firstly - in 2000, the elected representatives defined an administrative structure with a per-manent secretariat to carry out technical stud-ies.
- Secondly - they agreed on the composition of a Local Water Committee (LWC = "CLE" Commission Locale de l'Eau): comprising three parts: 1) water users, 2) elected representatives and 3) representatives of government departments. This so-called "water parliament" provided the opportunity for every member to express his problems, projects and expectations or wishes about water. The main principles of this institu-tion - democracy, consultation under a legal status - were established according to the French Water Law enacted in 1992, promoting these LWCs and requiring that they should be approved by Prefects.
- Thirdly - in 2007, despite numerous difficulties due to conflicting interests, the LWCs defined objectives for the protection of aquatic ecosystems and ratified the main programmes and regulations to achieve them. A Water Development and Management Plan (WDMP = "SAGE" Schéma d'Aménagement et de Gestion des Eaux) has been adopted by this Committee and legally registered by the Prefect of Isère Département. From this point on and for the next two decades, every decision impacting water resources and water use must be in compliance with the above-mentioned WDMP which rep-resents the water policy of Isère.

Reaching successfully for new commitments

Among all the agreements voted on and passed, the most essential ones which should be mentioned are as follows:
- **A guarantee that underground water be recharged** by water released from upstream in case of toxic contamination or lower under-ground water table levels in order to safeguard the drinking water supply for 400.000 inhabit-ants ;
- **Better management of water levels in reservoirs** by hydroelectric producers in order to promote tourism (Lake Monteynard, known as a windsurfing location all year round);
- **Agreement between fishing and water sports activities** to increase security and prevent conflicts by zoning;
- **Controls on hydroelectric development and urbanisation** (may not be permitted) in identified areas in order to protect the environment;
- Each **dam will be checked for improvements** in order to reduce the impact on other water us-

ers and on the environment; for example, a series of 6 dams will be replaced by a single one, without reducing the production of electricity. This action is mainly aimed at improving environment quality. This kind of investment (destruction of dams, replacing electric plant equipment) can be subsidised by the River Basin Agency depending on the magnitude of the benefit to the environment.

In conclusion, this conflict-solving process has proved to be the answer to many other conflicts in France, some in the Alpine Convention area. In the French Alps, some 7 local "Water Development and Management Plans" have been elaborated so far, most of which are being implemented already.
Their success relies on their elaboration, which is defined by law and includes various parties who have been invited to express their opinions. This seems to be an efficient way of reaching an understanding whenever a complaint is made about water use.
It appears easier to hold a dialogue when the form it takes is backed up by law.

Case Study from Italy

Conflict between different user groups at Lago d'Idro and possible solutions

Photo B3-5: Lake Idro, Italy
Source: http://www.interchalet.com/katalog/images/Objektbilder/big/s19924.jpg

Lake Idro, called Eridio in former times of history, is a glacial lake at an altitude of 368 meters above sea level in the Province of Brescia on the border with Trentino. It covers a surface area of 10,9km^2 and its maximum depth is 122m.
The Lake, whose origins are in the River Chiese, a tributary of River Po, is fed by a river basin district of 617 km^2 and it has an average altitude of 1.480 m above sea-level. It is the first natural lake in Italy whose waters are regulated by an artificial obstruction built between 1920 and 1930. There are two major reservoirs in the northern part of the basin whose regulation influences the availability of lake water.
Over the centuries Lake Idro has always been of major importance to the functioning of various industries, especially for agricultural activities and for the production of electric power. In recent years the lake has become a noteworthy place for the development of the tourist industry and for the preservation of ecology and of the environment.
In 1995, in line with Article 4 of the European Commission Habitats Directive 92/43/EEC, the northern part of the lake was recognised as a "Site of Community Importance", SCI IT3120065 named "Lago d'Idro"[84].
The natural survival and reproduction of the species living in the SCI is noticeably influenced by the water level and by its fluctuations.
The problems related to the management of water resources in the Lake Idro district are numerous and closely interrelated. Over the years, these problems have led to intense conflicts between the different water users. Over a decade ago the different stakeholders began to search for a suitable solution which would guarantee the fulfilment of industrial, agricultural and tourist requirements and, at the same time, preserve the natural environment, but only recently have all these efforts come to fruition.

Water Resource Management At Lake Idro

Lake Idro was artificially regulated at the end of the 1920s and the first operational regulations for the volumes of water stored were set out in the "Additional rules for Lake Idro management, December 5,1933". These regulations specified a maximum variation of the lake levels of 7,00m, between 363m and 370m a.s.l.
Over the years, the wide water level range specified by the regulation has heavily impacted the lake's ecosystem (i.e. emergence of untreated discharges, shore erosion, development of slow water circulation and problems with the ichthyic fauna). The consequent dissatisfaction of the population forced the competent authorities to review the rules and to set a probationary period for new ones. In 2001, after having studied five irrigation seasons, the Po River Basin Authority implemented the new operational regulations with the consent of all the water users. The new rules limit the maximum fluctuation of the lake levels to 3,25m, between 366 and 369.25m a.s.l., they set a minimum required flow for the River Chiese of a constant 2,2m^3/s during the irrigation season and coordinate the lake regulation with the northern reservoirs.
The new regulations were never implemented because of the storage restrictions established by the Registro Italiano Dighe (RID) for hydraulic safety reasons. A number of field surveys and geological inspections showed that there is a persistent and slowly developing landslide above the dam, which reduces the functionality of the hydraulic regulation structures.

In 1992, because of the sinking of the bottom outlet tunnel, the Registro Italiano Dighe imposed a reduction of the maximum operating level of the lake to 368m a.s.l. The subsequent consolidation programmes did not succeed in restoring the structure and therefore the RID imposed even stricter restrictions. Between 2003 and 2004 the RID implemented two new restrictions which set the maximum level at 367m a.s.l., i.e. at the spillway crest elevation of the dam. Subsequently the bottom outlet was declared as being out of use, so that the lake level could be controlled only by the private diversion outlet for hydropower generation, preventing the flow from reaching the River Chiese for 20km.
The new operating levels and the broad variability of the water levels of 3,25m as established in the regulations, not only caused dissatisfaction amongst the population living around the lake and in the region

[84] A Site of Community Importance (SCI) is defined in the European Commission Habitats Directive (92/43/EEC) as a site which, in the bio-geographical region or regions to which it belongs, contributes significantly to the maintenance or restoration at a favourable conservation status of a natural habitat type or of a species and may also contribute

below the lake, but they also prompted the European Commission to initiate an infraction procedure against Italy regarding the effects of lake management on the SCI 3120065.

The state of high tension reached as a result of the critical circumstances as well as the relevant negative environmental and economic consequences, prompted institutions (i.e. the Environmental Ministry, Lombardy Region, Prefecture of Brescia, Province of Brescia, independent Province of Trento, Registro Italiano Dighe) to initiate a debate to reintroduce the former lake management systems, reducing the maximum fluctuation in water levels at the same time.

The debate led to the signing of the "Agreement document on Lake Idro" in 2006. By signing this agreement, the Lombardy Region committed itself to implementing RID provisions in order to remove restrictions on storage. The Lombardy Region undertook the following measures:

- the establishment of a working group which, together with the Municipalities, the Prefecture and the Province of Brescia would be in charge of drawing up an emergency plan for the hydro-geological and hydraulic risk of Lake Idro,
- entrusting the monitoring activities regarding the landslide to the Regional Environmental Protection Agency,
- entrusting characterisation activities and pre-liminary design of the new control structures,
- signing an Agreement with the Autonomous Province of Trento in order to harmonise programmes for the protection of the waters in Lake Idro and in the River Chiese. This last agreement establishes many intervention programmes for the protection of this environ-mental heritage, giving a prominent place to its waters as well as to its interregional landscape, which is rich in history and has major potential for the development of the tourist industry. The Agreement provides for various joint actions in the management of this State water property such as: the release, renewal and management of concessions for hydroelectric production in the river basin on the upper reaches of the River Chiese and for irrigation and hydro-electric production in the river basin in the sublacustrine part of the river. Furthermore, it provides for the release and renewal of trading concessions and maintenance work related to the

Source: www.earth.google.it
Fig. B3-5: Lake Idro, Italy

regulation of Lake Idro and it sets out the procedures for the adjustment of the minimum required flow in the River Chiese basin. The implementation of all the measures set out in the agreement will be supervised by a coordination committee, comprising delegates from Lombardy Region, from the Autonomous Province of Trento and from the Lombardy Municipalities in the coastal areas.

In April 2007, because of the Lombardy Region had fulfilled the major commitments undertaken in the Agreement of November 2006, the RID partially removed the limits on the storage volume and set the new ordinary operational level at 368,50 m a.s.l. (369m a.s.l. being permitted under specific circumstances only). The first immediate consequence was the restoration of the minimum required flow in the River Chiese due to the discharges from the lake coming through the spillway on the dam at 367m a.s.l.
In May 2007, the water users signed a further agreement on the coordinated management of the water resources in the lake for the 2007 irrigation season only. The hydropower company agreed to limit diversions in order to maintain the minimum elevation over the dam crest and, in case of an obvious drought emergency, to supply further volumes of water stored in the reservoirs located at the upstream end of the lake. This agreement represents the first example of concerted and coordinated management of Lake Idro's water resources and it demonstrates that it is possible to resolve differences between stakeholders in order to achieve water management which allows the preservation of the lake's ecosystem while fulfilling the demand of both the downstream industrial activities and of the tourist sector in the district bordering the lake.

Although different opinions regarding the need to build new control structures still persist, the ongoing debates between public institutions and the water users are expected to bring the desired results in the next years: coordinated management of the lake will be able to safely provide for all the different needs, while protecting the natural environment.

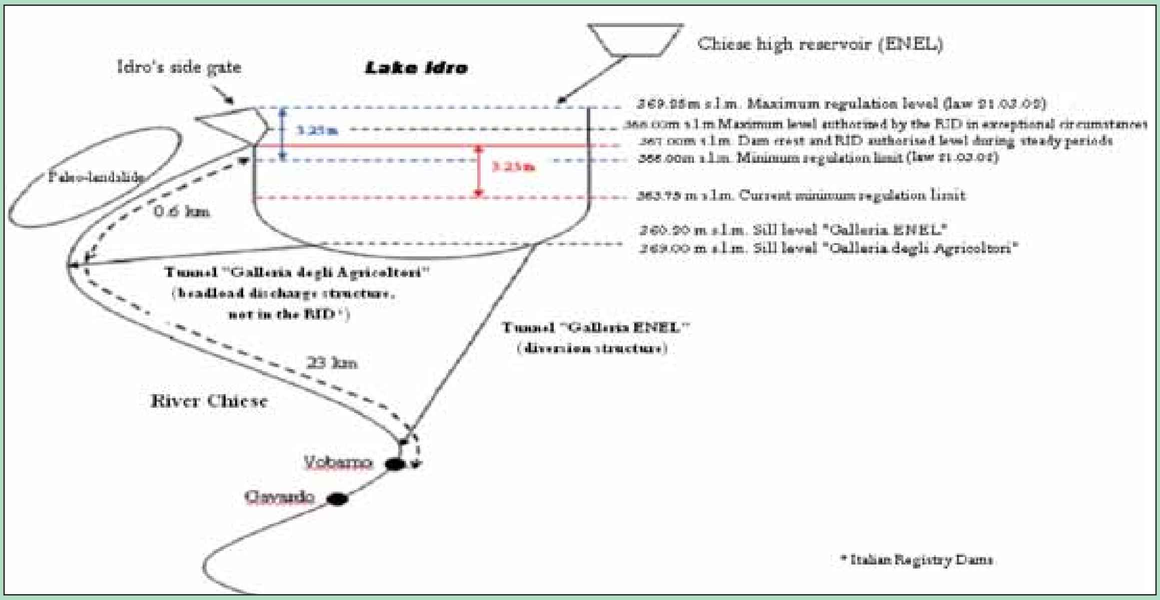


Fig. B3-6: Regulation and utilisation scheme for Lake Idro

C PROTECTION AGAINST WATER - RELATED NATURAL HAZARDS

Due to its natural conditions, the Alpine range is extremely exposed to natural hazards. Avalanches, landslides or rock falls occur with extreme velocity and intensity. The damage caused is significant, but is usually limited in its spatial extent. In terms of damage, floods and debris flow cause the most substantial losses amounting to several billion Euros, as for example in 1999, 2002, 2005 (about 2 billion Euros in Switzerland alone, due to the events in August) or in 2007. Under climate change conditions (see chapter D), storms may increase in frequency and the same could apply to heavy rainfall followed by floods or even disastrous avalanches, such as in winter 1998/1999. In some regions, earthquakes may also exert significant damage potential, of which the public is not as aware due to the fairly long recurrence period.

The integral risk management approach is mentioned explicitly in the climate declaration of the Alpine Conference as being an important part in the strategy for adaptation to climate change.

In torrential catchments, especially as far as protection from rock falls, avalanches and erosion are concerned, the remediation and reforestation of protection forests is of high importance. Next to stabilising the steep slopes, protection forests also contribute towards safeguarding human settlements and infrastructure from avalanches, rock-falls and mudflows. So they help to prevent potential damage to settlements, infrastructure, to industry and to other facilities. Natural hazards cannot be avoided. Today there is a general consensus in the Alpine range that only consistent investigation of protection measures and the application of integral risk management can be the answer to the challenges posed by natural hazards. According to the Water Framework Directive and comparable regulations in Switzerland, technical measures such as those for flood protection, should also make a positive contribution towards the achievement of the good status of the water bodies. The concept "of providing rivers with more space where feasible" is widely accepted. This necessarily implies the acceptance of inevitable residual risks. Today all the countries and regions concerned have developed relevant instruments and tools for the implementation of this integral approach. The "Platform Natural Hazards of the Alpine Convention – PLANALP" is the appropriate forum for a continuous exchange of experiences and for the optimisation of integral risk management.

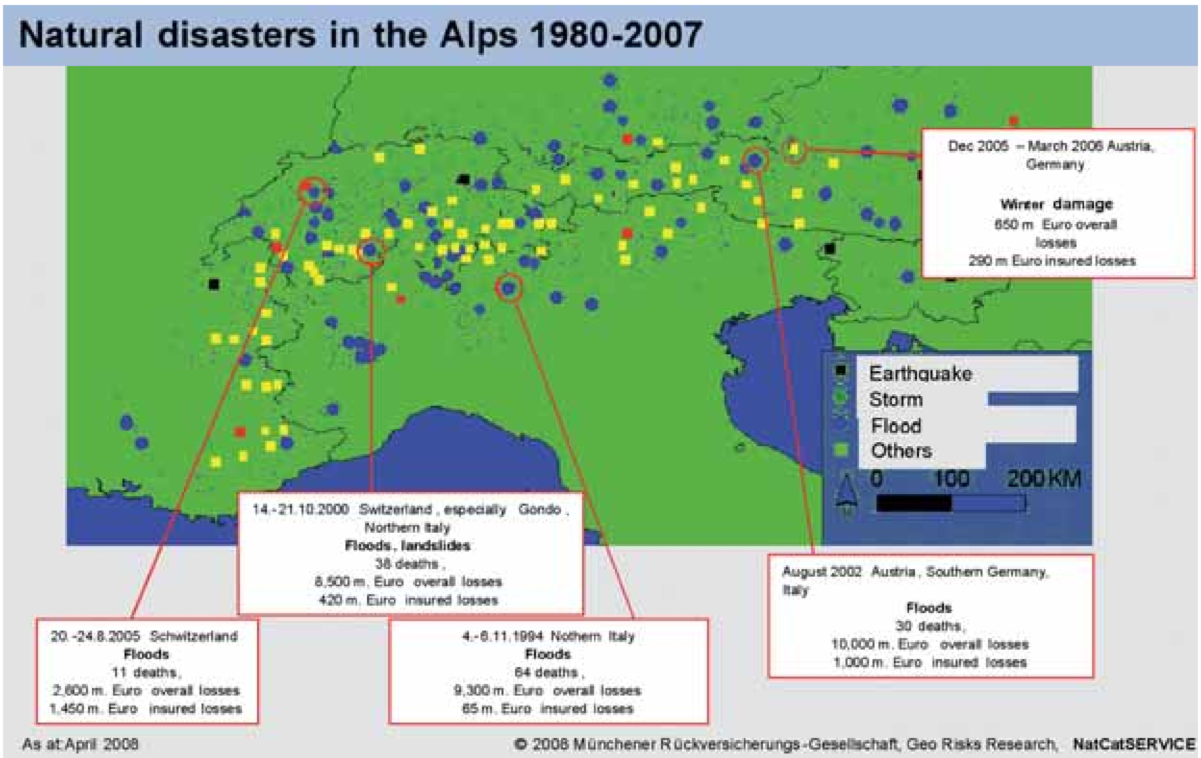


Figure C-1: Number of Natural Disasters in the Alps 1980 - 2007 counted by Munich Re Group

© Schweizer Luftwaffe
Photo C-1: Torrent/debris flow event at Brienz, Switzerland on 24/08/2005

© dpa-Fotodienst
Photo C-2: Flooded Eschenlohe, August 2005

In October 2008, the PLANALP experts elaborated the following recommendations to the member states for dealing with natural hazards:
"In conclusion, it must be stated that the population, buildings and important infrastructure facilities can only be protected effectively if the authorities, owners, insurance companies and the population enter into a risk dialogue that targets existing natural risks and elaborates a plan of action. In drawing up this action plan, a comprehensive solution should be chosen that allows ongoing protection from natural hazards.
Within the scope of the Alpine Convention, governments are required to give **the following measures top priority:**

Mitigation
- **Reduce the burden on the environment by acting in a sustainable way. Treat non-renewable and limited resources with care.**
- **Ensure the long-term provision of the resources needed for integrated, holistic natural hazard management.**

Adaptation
- **Promote and support integrated risk management that fully exploits the potential of possible protective measures in a coordinated way. These protective measures include prevention (land use planning, early warning systems, care of protective forests, re-naturalisation of water-**

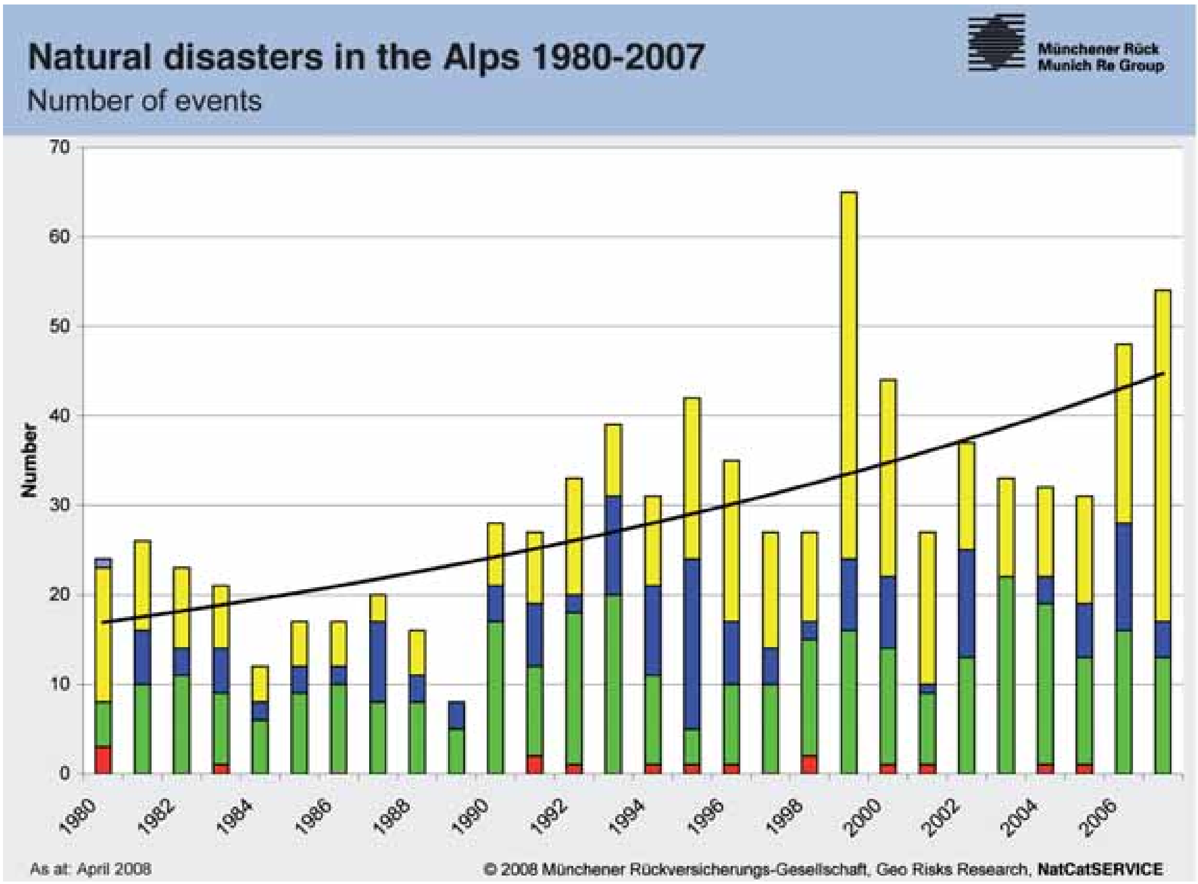


Fig. C-2: Natural Disasters in the Alps 1980 - 2007 counted by Munich Re Group

ways, protective structures) and disaster management (intervention), repair and rebuilding.

- Considering the increasing frequency and intensity of events, it is vital that existing and planned protective measures be reviewed in terms of the conceivable overloading of protective structures.
- **Targeted, consistent risk dialogue with all of the parties involved,** in order to strengthen prevention efforts and promote risk-consciousness and the acceptance among **the public of risk-appropriate action.**
- **Promote knowledge to ensure risk-appropriate land use via targeted training.**
- **Promote and support the early recognition of potential hazards influenced by climate change, such as avalanches, flooding, mudslides** and earth slide hazards[85]."

[85] PLANALP Recommendations, proposal of the presidency for the 7th Meeting on Oct. 29th 2008 in Munich

Conclusions

The Alpine region shows a very high likelihood of natural hazards. In addition to floods, debris flow, avalanches, earthquakes in some regions, rock falls, slope movements and landslides, storms also feature amongst the natural hazards. In general, flood events constitute the highest risk and damage potential to valleys in the Alpine region. In the precipitous catchments of torrents, flood hazards are frequently combined with a high volume of bed load sediments and wood debris which can cause log jams and unpredictable courses. The debris flows into torrents frequently overburdens the structures. On the other hand, excessive retention of sediment loads may lead to incised river beds, lowering of groundwater tables or the disconnection of wetlands from rivers.
Measures for the improvement of flood protection are seized in all Alpine states. Therefore, technical upgrading is intensified with regard to flood control. In the last years, in particular, natural hazards with great damage potential have occurred both frequently and intensely. The Alpine countries have been forced to increase their annual investments. This is necessary because more complex solutions have to be developed for flood control systems. Furthermore, every new infrastructure element and every new measure regarding rivers should comply with the Water Framework Directive and with the comparable regulations in Switzerland. An ecosystem-oriented point of view, including the appropriate management of sediment loads - which should also integrate the needs of stakeholders, land owners and land use - is the best way of attaining this goal.
Efforts in the installation and further development of flood forecast services are being improved continuously. Governments are attempting to detect risk areas, to describe the natural hazards and to make risk assessments for settlements, trade, infrastructure and man-made landscapes. These natural hazard descriptions and risk assessments are amongst others, harmonised, along with other issues, within the scope of the Platform Alpine Natural Hazards in the Alpine Region (PLANALP). PLANALP was established for this purpose by the Member States of the Alpine Convention.
The approaches in the Alpine states are largely identical. The development of hazard zone maps with respect to single natural hazards is based on a calculation of statistical frequency of 100 to 150 years. Most Alpine states are currently developing or have already implemented danger or risk zone maps. These plans enable the dangers to the settled areas and their infrastructure as well as future land use planning to be handled more effectively.

Endangered areas are differentiated as follows:
- the danger of flood, torrents and avalanches is so high that permanent settlement is impos-sible or possible only after unreasonably high efforts to ensure protection,
- permanent settlements and traffic are im-paired, further development is restricted and only possible by imposing conditions,
- areas which should be reserved for preventive measures.

The EU-Directive on the Assessment and Management of Flood Risks constitutes a new benchmark for the Alpine states. After a preliminary assessment of flood risk, both the flood dangers and flood risk maps are being developed with the help of a standard for low, medium and, if necessary, for high probability. On the basis of these maps, flood risk management plans are to be developed by 22/12/2015. The approach used in Switzerland is comparable and the hazard maps have to be completed by 2011.

Member States of the Alpine Convention	Annual investments on natural hazards in millions (m)	Area / percentage of the alpine perimeter *	Inhabitants / Percentage in the Alpine area* in millions (m)
Austria	280 m €	54339 km² (28,46 %)	3,136 m (23,79 %)
France	Data not available	40899 km² (21,42 %)	2,198 m (16,68 %)
Germany	42 m €	11151 km² (5,84 %)	1,333 m (10,11 %)
Italy	340 m €	52652 km² (27,58 %)	4,454 m (33,79 %)
Liechtenstein	4	160 km² (0,08 %)	0,029 m (100 %)
Monaco	--	2 km² (0,001 %)	0,029 m (0,23 %)
Slovenia	12 m €	6766 km² (3,55 %)	0,375 m (2,85 %)
Switzerland	400 m €	24940 km² (13,07 %)	1,625 m (12,33 %)
Total		190912 km²	13,183 m

Tab. C-1: The public investments of the Alpine states in prevention measures against damage caused by natural hazards on the Alpine perimeter (Alpine Signal 1, Permanent Secretariat of the Alpine Convention 2003)

Case Study from Austria

Großache – Flood protection with added value

As a result of the flood protection project Kirchdorf (Tyrol) the Großache has been provided with more flow space by deepening the river bed and widening the river banks. This innovative strategy has not only created long-lasting flood protection but is also compatible with requirements for nature conservation and recreational use.

In order to guarantee protection against floods with a statistical return period of 100 years (HQ 100), the river bed was deepened by 1,8m for a length of 6,5km and the cross-section was widened to 60 - 100m. In the surrounding area of the river, an area of 20ha was provided for water retention.

Additional benefit: river banks are diverse and include sections of riverside forest and areas with gravel and boulders. Walkers and cyclists use the attractive river side tracks. Gently inclined bank slopes allow for better and less restricted access to the river. The water is a popular attraction especially for children.

Construction time: 1996 - 2001.

Photos C-3–5:The Großache today. The river bed has been widened and restructured. Construction works under way

Similar examples also exist in the other Alpine states. In the course of the implementation of the Water Framework Directive (WFD) revitalisation work will be carried out independently in the future and will not only be in connection with flood protection. One of the chief objectives is to return the Alpine rivers to a state in which they have more space and bed load for morphologic exchange processes in the rivers. The existing river morphology ranges from fixed and, as far as river-morphologic dynamics are concerned, totally modified examples such as, e.g. the River Alpenrhein to unimpaired conditions such as the River Tagliamento.

The Common Implementation Strategy of the WFD for example, stipulates the classification of heavily modified water bodies according to different uses, such as the use of hydroelectric power generation, and also stipulates an examination of whether there are better environmental options or not. This provides the basis for examining requests for the use of hydroelectric power based on sustainability. Extensions of permission or new grants for water power uses are now subject to the regulations of the WFD. The necessity to respect the river morphology and continuity is today unanimously agreed on by experts and is becoming administrative practice.

National Contributions
Regarding Protection against Water-related Natural Hazards

Austria

Due to the location of large parts of Austria within the Alpine arc and to related climatic conditions, the country is at considerable risk of being affected by natural disasters. Destructive floods, debris flows, land slides, rock fall and avalanches threaten areas in the mountainous regions, in particular. Without protection from natural disasters, Austria's river valleys would not be usable for permanent settlement. Alpine flood events are characterised by short acceleration times and strong sediment (bed load) transport. Driftwood causes extraordinary risks of inundation if bridges are obstructed.
After the flood events of 1997 and 1999, wide areas in Austria were again hit severely by exceptionally rare floods in August 2002, some of which had never been recorded before. These floods claimed nine lives, had very detrimental effects on settlements and caused damage of approximately 3 billion Euros in total. Three years later, in the summer of 2005, Austria's west experienced extreme rainfall of up to 250mm a day, which led to disastrous floods yet again, causing damage of about 700 million Euros in total.

Floods are natural phenomena that cannot be prevented. However, modern flood protection can reduce the disastrous effects of floods to an acceptable intensity. Therefore, the planning of the Federal Water Engineering Administration and Austrian Service for Torrent and Avalanche Control is committed to the principles of sustainable flood protection, building on the interaction of prevention, protection and provision combined in an integrated flood risk management strategy, taking into account that extreme flood events can neither be prevented nor fully controlled (residual risk). Future efforts therefore concentrate on the following objectives:

- protection of human lives is the top priority
- reduce the potential of flood damage
- better regulations for the development of settlements, especially with regard to spatial planning
- provide rivers and torrents with more space
- enhance decentralised retention of water
- improve flood warning systems
- raise flood risk awareness and prepare the inhabitants in the flood-plains well for the possible event of floods
- coordinate all planning activities affecting the flood-plain and
- provide adequate risk transfer mechanisms.

All flood prevention strategies by either structural or non-structural measures are based on a key planning instrument, the hazard map. This well-established instrument preserves all the necessary information concerning the intensity and frequency of flood events and displays the areas affected by floods (red or yellow zones). Hazard maps serve as the basis for land use planning, construction and safety planning.

The national organisation and structure of flood protection in Austria is divided into three parts:

- The Federal Water Engineering Administration is responsible for the management of all waters, except waterways and torrents. It fulfils this task in cooperation with provincial author-ities and with the Federal Ministry of Agricul-ture, Forestry, Environment and Water Man-agement
- Torrent control lies within the competence of the Forest Engineering Service on Torrent and Avalanche Control in the Federal Ministry of Agriculture, Forestry, Environment and Water Management
- The Federal Ministry of Transport, Innovation and Technology is in charge of the mainte-nance and development of waterways, how-ever, the related rivers are not situated in the Alpine area of Austria.

In the last years Austria has spent about 220 million Euros on an annual average on flood protection by federal, provincial and municipal authorities. As from 2007 this value has been increased to 280 million Euros as a result of a Memorandum of Understanding between the responsible policy-makers. This amount is distributed among the competent public organisations as follows:

- Federal Water Engineering Administration: about 140 million Euros
- Forest Engineering Service on Torrent and Avalanche Control: about 100 million Euros
- Federal Waterways Authority: about 40 million Euros

On average 57% of the measures implemented by the Federal Water Engineering Administration are funded by federal funds (e. g. disaster relief fund), with contributions from the federal provinces ("Länder") making up about 23% and those of municipalities and other stakeholders accounting for about 20%. Over the past 10 years the Federal Water Engineering Administration has invested over 500 million Euros of federal funds in measures concerning preventive flood protection.

From the period from 2007 to 2016 more than 2,5 billion Euros are scheduled for preventive flood protection throughout Austria.

France

Most of the French Alpine municipalities are subject to some possible natural risk ranging from earthquake to flood and from snow avalanches to mud slides. Water related hazards mainly include floods (50% of the municipalities are concerned), avalanches limited to upper valleys, but earthquakes and mudslides must also be mentioned as they threaten numerous large dams in the area. The necessity for multi-risk approaches (including technological risks as well) is demonstrated by this last example.

Many investments have been made in order to draw up maps on such hazards and to elaborate documents on regulations applying to urbanisation (mostly land planning not permitting any construction) and on safety procedures (coordination between various stakeholders, as well as on the division of various responsibilities). Three issues are at stake: firstly, improving identification of possible risks, secondly, updating prevention measures as well as the simultaneous management of both natural and industrial risks and thirdly, increasing public awareness, notably that of elected stakeholders.

Flood control remains a major challenge with multi-annual master-plans being implemented (the last one extends from 2007 to 2013). These programmes are taken into consideration in local master plans for rivers. The main technical implementations to be mentioned are: flood warning stations, land planning which specifies clear restrictions on flood plains, possible retention in some reservoirs which require seasonal management with regard to available capacity and sufficient protection for the evacuation of sudden storm flow.

One example, currently under implementation, should be mentioned: in the short term, a landslide with a volume of 3 million m^3 might occur across the River Romanche, causing sudden damming of the river and thus paving the way for a flash flood (of nearly 200.000m^3) right above the city of Grenoble and close to several Seveso-ranked chemical plants. In order to prevent such a threat, 100 million Euros have been invested in a road diversion, in a gallery for water evacuation and in dyke compartments for flash flood control. A further specific example is the control of avalanches (preventing access to the avalanche cone, information for tourists, etc.) which sometime requires artificial triggering by explosives.

Germany (Bavaria)

After major flooding in 1999, the Bavarian State Government established an action programme on flood control. About 2,3 billion Euros will have been invested in flood control by 2020. Actions focus mainly on the Alpine region due to the extraordinary damage caused by events in the past.

The programme specifies three fields of activity:

- Enhancement of natural retention by way of measures which increase water retention in the surface and in natural flood areas.
- Technical systems for flood control measures for the protection of settlements and the construction of large water reservoirs. The dimensions of flood control installations in Bavaria are based on an event calculated by a statistical return period of 100 years (HQ 100). This discharge is augmented by 15% to take any possible changes in climate into account. This increase was agreed on due to the results of a joint climatology project (KLIWA) between Bavaria, Baden-Württemberg and the "Deutscher Wetterdienst" (German Weather Service).
- Furthermore, the Bavarian State Government will implement further preventive measures for citizens and local district authorities. Such measures include a ban on construction in risk areas as well as providing online warning and information services for citizens and local district authorities e.g. about flood events (flood warning service - www.hnd.bayern.de) and avalanches (avalanche warning service - www.lawinenwarndienst.bayern.de). Other services provide information on the state of natural Alpine hazards (information service of natural Alpine hazards - www.ian.bayern.de) and on areas at risk of flooding (information service on flooded areas - www.iug.bayern.de). In addition to these measures people are strongly advised to take out insurance against natural hazards in order to reduce financial risk in case of damage.

On average more than 42 million Euros per year have been invested in Bavaria over the last few years in these three fields of activity. The first signs of success were evident during the floods in 2005. Despite higher discharges in some areas compared to 1999, the overall damage costs were substantially lower.

Italy

A law was passed in Italy in 1989 that provided regulations to ensure that each area has a hydro-geological system that is compatible with the safety of the population and with the protection of human activities and with its cultural and environmental heritage. About ten years ago this culminated in the launch of a specific planning process based on the Piani di Assetto idrogeologico (PAI - Hydro-geological Structure Plans)
The PAIs, drawn up for each hydro-geological basin, are now operative throughout the whole of Italy and function by way of:

- identifying and highlighting those areas where there are dangers of flooding, landslide and avalanche and classifying them according to the anticipated phenomenon and its severity;
- adopting specific prevention measures that regulate the use of land in hazardous areas in order not to increase the conditions of risk present;
- Identifying a coordinated series of structural and non-structural operations in order to reduce danger factors and also the vulnerability of areas exposed to risk.

From a study of the PAIs it can be seen that 9,8% of the national territory is covered by areas of high hydro-geological risk, 58% of which by landslide and 42% by flood. There are settlements, infrastructure and production areas in more than 2/3 of these areas.

Between 1994 and 2005, more than 6 billion Euros were spent on emergency operations following disasters in the area of the River Po alone. The total amount of damage caused between 1991 and 2005 by flooding alone was in the region of 13 billion Euros (APAT 2006), in other words an average of around 900 million Euros per year. If we add to this the effects of landslides, which are often of modest size but are numerous over the entire national territory, and for which there are no consolidated figures, the average total damage caused by hydro-geological events (flooding and landslides) exceeds a billion Euros per year.

Between 1991 and 2006, around 5,5 billion Euros of State funding were used for hydro-geological risk prevention in Italy, in order to carry out over 8.200 normal, emergency and strategic operations.

The PAIs indicate that the overall requirements necessary for making the whole country safe are enormous, totalling around 40 billion Euros. It is therefore necessary to make optimal use of the resources available according to criteria based on maximum efficiency. Initiatives are also being studied in order to identify appropriate operations in sectors other than land protection (for example, tourism, transport, infrastructure, etc.) and to encourage the use of private resources for carrying out operations to mitigate hydro-geological risk.

Attached: List of the main floods in Italy from 1951 to 2003 (source: APAT annual statistics 2005)

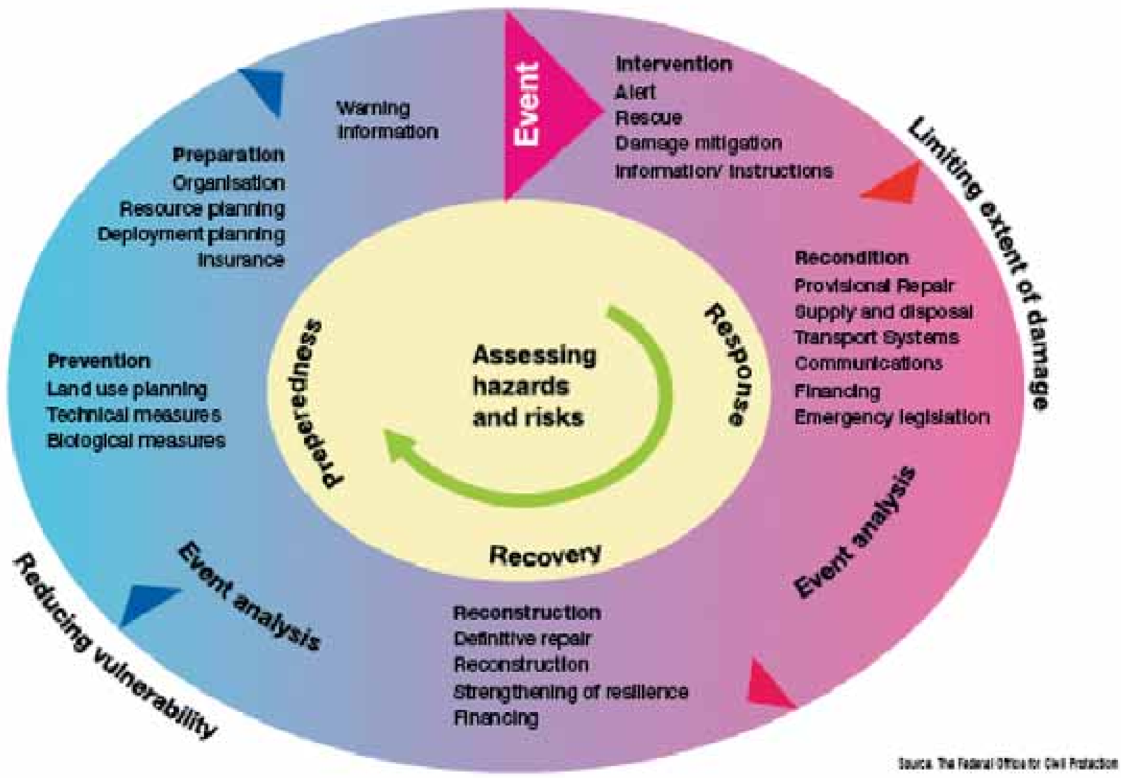
Slovenia

In past 10 years 4 major storm - flood events and several minor events have been registered. This, Slovenia has experienced a natural water-related hazard event practically every second year.

Slovenia faces various forms of erosion, among which water erosion is particularly significant. The most significant are torrent outbursts and floods, extreme sediment transport and debris flow events, landslides, rock falls and avalanches. 44% of the area is potentially at risk by erosion, one third of the area is considered as unstable or only stable to a limited extent. Almost one quarter of Slovenia's territory lies within torrential watersheds, where the dimension of the erosion phenomena is larger and may cause major damage when precipitation is intensive. In the last 15 years natural disasters have claimed more than 2% of GDP on average, a large percentage of these natural disasters were caused by torrents. There have been years, however, when the damage caused by natural disasters has been significantly greater. For example, in 1990, flood damage alone was over one-fifth of GDP. The areas of torrent catchments coincide, to a large extent, with the predominantly mountainous Alpine region covered by mountain forest. The anti-erosion role of the forest is invaluable.

Since the beginning of organised torrent control in Slovenia in 1884 (1875), quite a lot of work has been carried out, and safety from erosion and torrents has been improved substantially. Works undertaken from 1884 till 2003 on torrents and against erosion in the Alpine region: 3.475 relating to consolidation and retention dams, 3.081 on consolidation sills, 56 km of vegetative bank protection works and 146 km of other bank protection works. The standard of design and execution in construction work on torrent control has been continuously improved, by means of new knowledge, new materials and new construction technology.

The majority of torrent control structures have been



The cycle of integrated risk management: an integrated and holistic risk management assumes that all types of measures for natural disaster reduction are considered. Generally, measures of preparedness, response and recovery (reconstruction) should be equally implemented.

Fig. C-3: The cycle of integrated risk management actually erected at the right locations, taking the best possible way of integrating them into the landscape into consideration. Unfortunately, many of these structures are old and damaged. The great majority of the damaged structures (63%) were erected before the Second World War. About 20% of the damaged structures were erected between 1955 and 1990. Recently-built structures are in better shape. The fact that so many torrent control protection structures are old and damaged should cause great concern, as they were constructed in a number of systems and damage to these systems could have disastrous consequences. In some cases damage could be even worse than if there had been no protective structures at all.

Because of the obvious non-maintenance of the great majority of torrent structures, Slovenia will have to apportion a larger percentage of funds to their maintenance and increase the portion of funds dedicated to prevention measures afterwards, in order to preserve the balance conditions in torrential catchments.

Slovenia has a very well-organised system of protection against natural and other disasters which is mainly based on the obligation of the state and of the municipalities to prevent and eliminate dangers and to implement prompt measures in the event of a disaster. In order to detect and monitor natural and other disaster hazards, as well as to manage and implement of protection, rescue and relief measures, a uniform monitoring, notification and warning system has been established. The Slovenian National "Emergency Response Plan in the Event of Floods" was elaborated by the Administration of the Republic of Slovenia for Civil Protection and Disaster Relief in co-operation with other ministries. Every year the Republic of Slovenia allocates approximately 0,5% of the national budget for protection against natural and other disasters, and municipalities earmark 3 per cent of their annual municipal budgets for this purpose.

Natural disasters throughout the world in recent years are proving that climatologists are right in assuming that, due to global climate change, events will occur more frequently and that incidents will more extreme.. Slovenia is a mountainous and hilly country, where development of erosion and torrent phenomena is closely linked to the natural environment.
On several occasions during the previous decade, from 1990 to 2000, the country was stricken not only by high waters each year, but also by extremely high waters which caused floods with catastrophic consequences in some river basins.
The most extensive flooding with the highest river discharges, having a 100-year recurrence interval, occurred in 1990, apart from flash floods in 1994 and 1995, and in 1998 and 2000.

The last natural disaster in September 2007, in which the typical torrential floods caused damage in the amount of over 220 million Euros shows that Slovenia will continue to face the same or even more damaging natural disasters.
That event also claimed 6 casualties. For the immediate relief of the consequences of this storm and of related flooding the Slovenian government provided an additional 6,7 million Euros for reconstruction programmes. At the moment, the Government is deliberating the complete reconstruction programme. The early warning system worked well in the 2007 event.
Everybody involved in first aid and in other works carried out by Civil Relief and by other public services and concessionary services in the field of water management did their job well, too.
The main problem is the complex procedure to earmark the money needed for reconstruction.

Depending on the circumstances, Slovenia will have to invest considerably more funds in risk management. Each of these disasters reminded us that the costs of prevention are much lower than the costs of reconstruction.
With regard to prevention measures, which are mainly based on the stabilisation of erosion prone areas by combining different engineering, bioengineering and biotechnical measures, the erosion processes can be mitigated and the energy of torrent outbursts reduced. Only by constant maintenance in the torrents' hinterlands is it possible to maintain the targeted degree of safety.

Mapping of water-related hazard zones represents a prerequisite for the sound management of the areas threatened. In 2007, Slovenia adopted the law concerning national "guidelines" for hazard mapping. Together with the "Decree on conditions and limitations for spatial planning and construction in hazard zones" it is the right move towards reasonable land use planning and control of water-related hazards. The Water Act also provides legislative instruments to control and prohibit anthropogenic interference in the areas threatened by frequent floods, high waters, debris flows, and avalanches.

Switzerland

As a mountainous country with considerable variations in altitude over a relatively small area, Switzerland is particularly vulnerable to the various types of natural hazards. Swiss society is in a position to reduce existing risks to human life and material assets to an acceptable level, however, there is no such thing as absolute safety. The integrated risk management concept (see the following diagram Fig. C-3) underlines the strategies of actions against natural hazards.
The pie-chart illustrates which natural hazards represent a threat to Switzerland and indicates the associated estimated cost of risk posed to Switzerland by all natural hazards of about 1.800 million Swiss francs per year.

More specifically with respect to floods, Fig. C-5 shows the damages in Switzerland between 1972 and 2005, illustrating the increasing scale of the damages caused by floods. Since 1972 alone, the total cost of flood damage in Switzerland has exceeded CHF 11 billion (adjusted for inflation). At around CHF 3 billion, the large scale havoc wreaked by the storms of August 2005 generated the highest costs.

With regard to the cost of prevention measures, according to a survey Switzerland already spends CHF 2,9 billion or 0,6 percent of gross domestic product annually on measures to provide protection against natural hazards. Of this expenditure, 60 percent falls on private entities and the rest is made up by the state. Flood protection and storm protection account for most of the money spent. Almost half is used for prevention.
In order to provide better protection and to set adequate measures, an assessment of the natural hazards based on uniform criteria, which have been adopted nation-wide is aimed at. To that end, hazard maps which are co-financed by the federal authorities are due to be completed by 2011.
If it comes to protection measures against floods, priority is given to the maintenance of protective structures to preserve the flow capacity of watercourses. Particular priority is attributed to spatial planning measures, i.e. keeping free riverine zones, retention areas and discharge corridors for extreme events, thereby preventing an increase in damage potential. This approach of “space for the rivers” also has a positive side-effect on the eco-morphological status.
Structural measures are only considered when other measures prove insufficient, this priority being enacted in the Federal Law for Flood Protection.
One of the lessons Switzerland has learned from the recent floods is that it is impossible to provide absolute protection against extreme events. Therefore

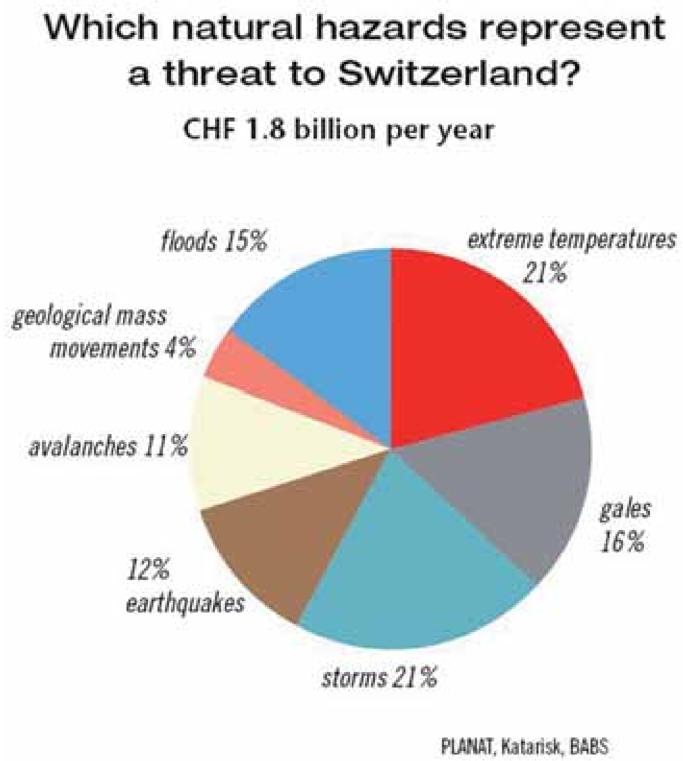
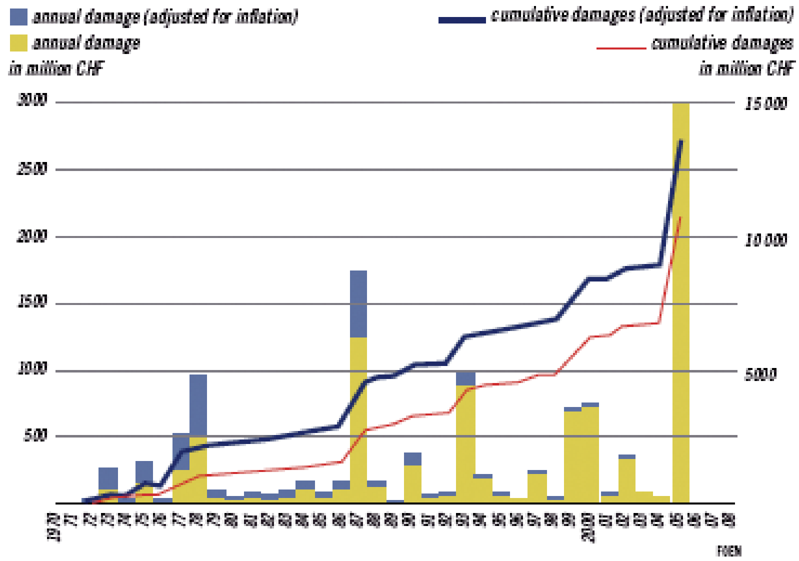


Fig. C-4: Natural hazards that represent a threat to Switzerland

Flood damage in Switzerland between 1972 and 2005



The scale of the damage caused by floods is increasing. The storms of August 2005 – with heavy flooding in Central Switzerland and Bernese Oberland – were the most expensive extreme event ever suffered by Switzerland.

Fig. C-5: Flood damage in Switzerland between 1972-2005

the integrated risk management approach comprises the management of the residual risk as well, which includes organisational readiness for crisis-situations, alarm-raising and evacuation, local examination of assets and insurance cover for any eventual damage.
Further information on natural hazards in Switzerland can be found on www.planat.ch, the website of PLANAT, the National Platform for Natural Hazards. This extra-parliamentary commission, created by the Swiss Government, is responsible for coordinating concepts in the field of prevention against natural hazards. The main objective is a change from pure protection against hazards to that of the management of risk.

D CLIMATE CHANGE IN THE ALPS AND ITS IMPACTS ON WATER RESOURCES

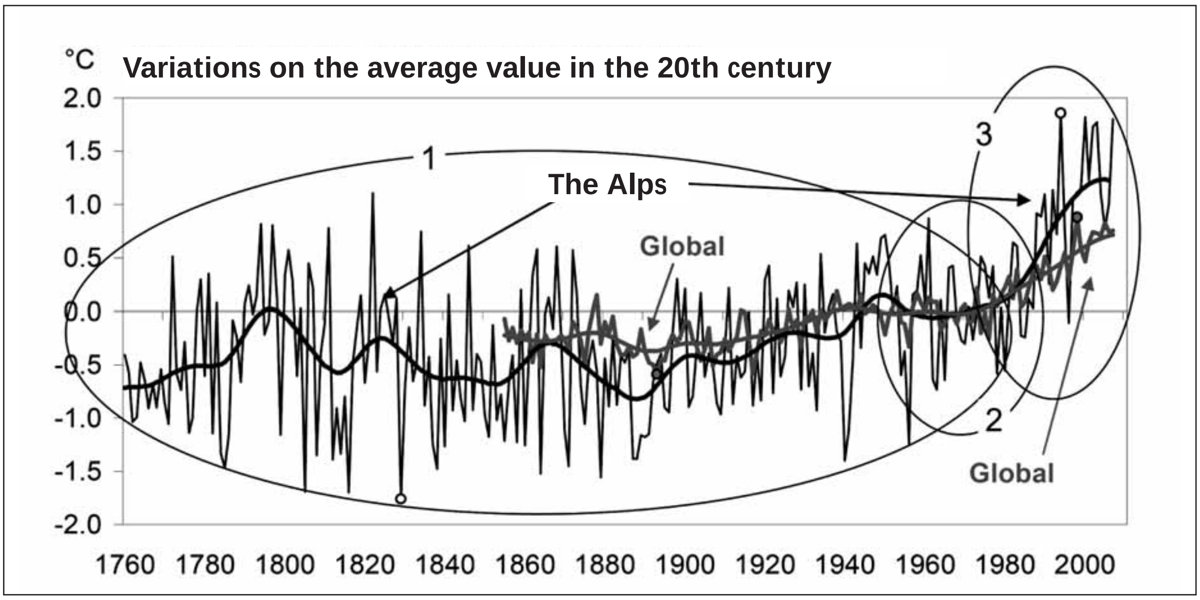


Fig D-1: Average annual air temperature in the Alpine space 1760-2007 (black) and the global average 1858-2007 (grey)
1: last natural period – solar flux and volcanic activity dominant
2: increasing influence of human activity – the period of aerosols
3: start of the global warming period
(Jones et al., 1999; Auer et al., 2007 (modified))[86]

Alpine climate is highly complex, due to the interactions between the mountains and the general circulation of the atmosphere. The ridges have an average elevation of 2.500m above sea level with a maximum of 4.800 m which can constitute a barrier for atmospheric circulation. This influences the climate regimes in the region, namely Mediterranean, Continental, Atlantic and Polar (Beniston, 2005a). The Alps can be divided into four or five climatic sub-regions: the north-west, the northeast, the southeast, and the southwest sub-regions and the high-elevation sub-region following the main crest of the Alps. The different climatic sub-regions in the Alps are described in more detail in chapter B.1.2 on "Description of the Alpine Water Resources". Climate change needs to be considered in interrelation with these climatic sub-regions. Furthermore, due to the highly complex topographic and climatic conditions in the Alps, the level of the climatic sub–regions which have been identified may not be differentiated enough for the development of adaptation strategies.

Observed changes in temperature and precipitation in the Alps

According to temperature measurements over the past centuries, the warming in the Alps over the last century exceeded 1,5 °C, which is more than twice the global warming average. The years 1994, 2000, 2002, and particularly 2003 were the warmest on record in the Alps in the past 500 years[87]. Temperature and precipitation variation over the European Alps show considerable spatial differences according to both seasonal mean features and short-term and long-term variability. However, the summer of 2003 was probably the driest in the context of the last 500 years.

Projected changes in temperature and precipitation in the Alps

Climate models are extremely complex simulations of scenarios. These simulations are based on past data and on social, political and economic developments. The effects and consequences for the future will be estimated

[86] Auswirkungen des Klimawandels auf die Österreichische Wasserwirtschaft, 2008, page 10

[87] Contribution of Prof. Lučka Kajfež-Bogataj, University of Ljubljana, IPCC WG2 Vice chair on Climate change in the Alps

using different scenarios. The discussion on climate change is very dynamic.

The findings of this chapter are mainly based on PRUDENCE[88]. The project PRUDENCE is part of the EU's 5th Framework Programme for Energy, Environment, and Sustainable Development and its objective was to address and reduce deficiencies in projections of future climate change; to quantify our confidence and uncertainties with regards to predictions of future climate and its impacts, using an array of climate models, impact models and expert judgment on their performance. Furthermore, experts shall interpret these results in relation to European policies for adapting to or mitigating climate change and supply a number of important assessments for decision-making with regard to policies on a regional scale.

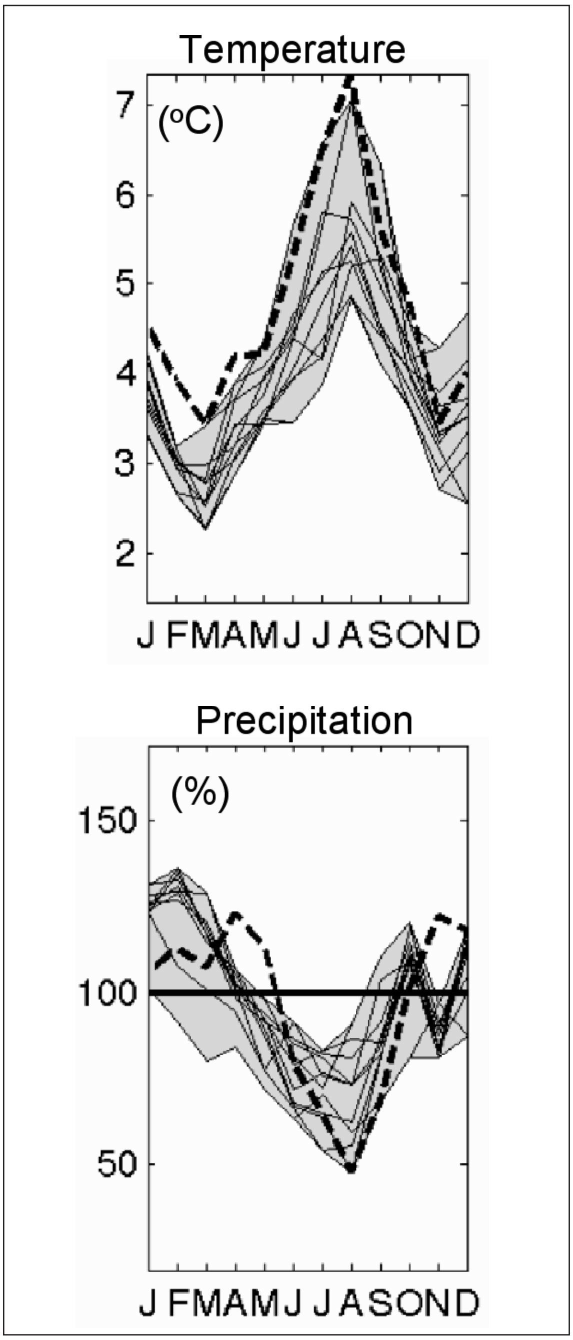


Fig. D-2: Signal temperature and precipitation 2071-2100 minus 1961-1990, A2 scenario for the Alpine region (modified from Jacob, 2006)

Furthermore, several Interreg projects from the INTERREG IIIB Alpine Space Programme with regard to water issues under climate change conditions have been or are about to be finalised, such as, for example "ClimChAlp" and "FORALPS" or "METEORISK". New projects such as "Alp-Water-Scarce", "AdaptAlp", "PermaNet", "CLISP", "ClimAlpTour" and "ECONNECT" as well as additional projects oriented towards mitigating climate change with a focus on energy have been adopted for the fourth phase of the INTERREG Programme "Alpine Space" and deal directly with climate change as well as directly or indirectly with water management issues.

In this century, Alpine warming is projected to continue at a rate which is more pronounced than the global mean. In most models, circulation changes enhanced the warming in winter (due to an increase in westerly flow) and in late summer (due to a decrease in westerly flow). Several studies have indicated increased temperature variability in summer, both on inter-annual and daily time scales and reduced temperature variability during winter. Projected monthly changes of temperature and precipitation are based on a series of climate change scenarios produced by the Swedish Rossby Centre as a contribution to the PRUDENCE project (Räisänen et al., 2004). Simulations using two driving global models (HadAM3H and ECHAM4/OPYC3) and two IPCC SRES[89] emission scenarios (A2 and B2) resulted in four climate change scenarios from 1961–1990 to 2071–2100.

A warming climate as projected will enhance the hydrological cycle in the Alps.

This implies higher rates of evaporation, too. These physical mechanisms, associated with potential changes in precipitation amount and seasonality, will affect soil moisture, groundwater reserves, and the frequency of floods or droughts. On the other hand, in summer, especially in the south of the Alps, droughts will be more frequent according to the projections from the models.

Changes in precipitation will vary substantially on relatively small horizontal scales in Alpine areas i.a. due to the complex topography. The details of this variation depend on changes in future atmospheric circulation. More significant changes are expected in the increasing frequency of precipitation extremes than

[88] Prediction of Regional Scenarios and Uncertainties for Defining European Climate Change Risks and Effects, http://prudence.dmi.dk

[89] SRES scenarios are emission scenarios developed by Nakićenovič and Swart (2000) and used, among others, as a basis for some of the climate projections

in the magnitude of extremes (Beniston et al., 2007). Changes occurring in runoff from glaciers include initial increases in total glacier runoff and peak flows, and considerable amplification of diurnal melt runoff amplitudes, followed by significantly diminished runoff totals and diurnal amplitudes as glaciers continue to shrink[90].

Changes in precipitation patterns may have an even greater impact than rising temperature.

Unfortunately projections of changes in precipitation patterns in mountains are tenuous in most GCMs (General Circulation Models) because the controls that topography has on precipitation are not adequately represented.

In summer, most models simulate decreased precipitation south of about 55°N. The annual mean change from 1980–1999 to 2080–2099 is from –4% to –27% in the Alpine area in the worst case scenario A1B (IPCC)[91].

The most consistent and dramatic decreases are predicted to take place in summer, with increasing evaporation, but the mean winter precipitation in this area also decreases in most models.

Consequences of the changes for snow, ice and permafrost

Temperature changes are very likely to result in a decrease in the number of frosty days, and the same can occur with regard to snow, ice and permafrost.

Hantel and Hirtl-Wielke (2007) studied the sensitivity of Alpine snow cover in relation to temperature and established that a rise in the European temperature of 1°C has the potential to reduce the duration of snow cover in elevations of extreme sensitivities by about 33% in the winter season, depending on the region. This corresponds to a maximum reduction of the snow cover of 30 days in winter at a height of 700 m for 1°C warming.

For every degree increase in temperature, the snowline will, on average, be raised by about 150m, but at lower elevations the snowline is very likely to increase by more than the estimated average. For a 4°C shift in mean winter temperature in the Alps, as projected by recent RCM (Regional Climate Models) simulations for climatic change under a strong emissions scenario (the IPCC A2 emissions), snow duration is likely to be reduced by 50% at altitudes of 2.000 m to 95% at levels below 1.000 m.

The glacier equilibrium line rises from 60 to 140m per degree Celsius increase.
This would mean that many small glaciers at lower altitudes would disappear and volume reductions between 30% and 70% for larger glaciers are predicted by 2050[92].
A rise in permafrost, which is also expected, would reduce the stability of formerly glacierised or perennially frozen slopes

Consequences of changed climate patterns on the environment, economy, society and impacts on the water cycle

Due to climate change, the regime of catchments might change to constantly reduced water levels in summer, which has an impact on water quantity as well as on the temperature of surface waters.

As a consequence, it is very likely that the need of water for agricultural purposes and for electricity production will come into competition with the needs of river water ecosystems. A loss in hydro-electrical energy production might occur[93]. In order to preserve and release water, reservoirs could be considered as a measure to adapt to both floods and droughts[94].

By 2050 reduced precipitation in summer, for example, in Switzerland is forecast (OcCC, 2007) and consequently, lower water availability which would mean significant effects on hydroelectricity production. Changes are expected in Alpine watersheds (middle and upper levels), which, up to now, have been dominated by snow and glacial melting.

Alpine watersheds will, however, also be dominated by snow melting in future. Furthermore, impacts on thermal or nuclear power stations which use the river water for cooling are expected because of the lower cooling capacity of waters due to lower water availability.
The question is: which mechanisms will be applied in case of decreasing water availability (water scarcity and droughts) to solve any emerging conflicts among different water users (agriculture, industry, hydroelectricity production, drinking water supply etc.) and especially, which amount of water will be allocated to the hydroelectricity production[95]?

Due to the decrease of reliable snow cover from 1.500m-1.700m at the end of the 21st century, winter tourism is expected to change significantly.

[90] Contribution of Prof. Lučka Kajfež-Bogataj, University of Ljubljana, IPCC WG2 Vice chair on Climate change in the Alps
[91] Swedish Rossby Centre as a contribution to the PRUDENCE (Prediction of Regional Scenarios and Uncertainties for Defining European Climate Change Risks and Effects) project (Räisänen et al., 2004)

[92] Climate Change and Water _ IPCC Technical Paper VI _ June 2008 _ page 28, 129 [WGII 12.4.3]
[93] Hydropower potential is expected to decline by 6% for the whole of Europe by the 2070s, as a consequence of an increase of 15-30% in northern and eastern Europe and a decrease in Mediterranean Europe by 20-50%. (IPCC, 2008, page 95, 129)
[94] IPCC, 2008, page 95
[95] „Climate Change and Hydroelectricity", Final report of the Pre-Study, Mountain Water Network, 2007

Warmer winters force ski resorts and infrastructure to move higher up on the mountains, where tourism demands often clash with environmental protection requirements at areas of high altitude, especially when glaciers are concerned[96].

Lakes in the Alpine regions are particularly sensitive to climate change. These are the areas where the highest and most rapid temperature increase is expected[97]. Due to the complexity of interactions, biological changes induced by climate change are still uncertain. Minor variations in climate can have dramatic effects on biota, especially in the Alps, where many species, which are living at the limit of their capabilities, are at risk of perishing (Eisenreich, 2005)[98].

Changes in local precipitation, snow cover patterns and glacier storage are likely to affect discharge from predominantly mountainous territories in terms of timing, volume and variability and will influence runoff characteristics in the lowlands as well[99]. The EEA (European Environment Agency) study on vulnerability and adaptation to climate change in Europe also mentions the effects of the climatic shift on water balance in respect of navigation in the surrounding low-lands[100].

As a further consequence of the climate change, the increasing risk of land-slides and sediment loads in rivers and lakes, destabilization of infrastructures, and the growing need for additional avalanche barriers and flood protection facilities are predicted[101].
Strong rainfall events commonly lead to flooding and landslides, rock falls and debris flows in regions of complex topography. Such climate events may occur in the vicinity of populated regions, causing huge impacts in human and economic terms.
In winter and spring the number of floods is expected to increase as is the risk of damage as well as the necessary investments for protection against high waters and floods[102].

Climate change effects on predominantly Alpine river catchments in the Southern Alps

The problem arising from the increasing exploitation of water resources can be considered as a risk affecting the whole Mediterranean area, and its most evident aspects are the recurrent drought episodes that have affected the catchment of the River Po in the last 15 years, and particularly the “extreme droughts” of recent years, e.g. the 2003 heatwave in Europe, which was accompanied by an annual deficit in precipitations of up to 300mm.
This contributed to an estimated 30% reduction in gross primary production on the whole continent (Ciais et al., 2005). Many major Alpine rivers (e.g., Po, Rhine and Danube) were at record low levels, weighing negatively on power plant cooling, on inland navigation and irrigation (Beniston and Diaz, 2004; Zebisch et al., 2005). The climate change induced modifications on the Alpine water-cycle regime and its main impacts affected the whole Po river basin area, the Alps being the major contributor to the river regime and to the economy of the whole catchment.
The forecast impacts on water resources may seriously affect the status of natural and anthropogenous systems. Therefore, together with mitigation measures, it is necessary to implement strategies of adaptation to the modified hydrological conditions consistently together with the mitigation measures, in order to avoid a negative impact of these measures on the resilience of hydraulic systems.

Effects of climate change on predominantly Alpine river catchments in the Central and Northern Alps[103]

Long-time series in Switzerland show major glacier shrinkage, an increase of (winter) precipitation, and an increase in evapotranspiration and, at least for the northern part of Switzerland, stable runoff conditions. In southern regions, runoff seems to be diminishing at high altitudes.
Seasonal snow cover is heavily influencing the runoff regimes in mountainous regions. By 2000, shrinkage was more pronounced in the European Alps, due to the lower mean altitude compared to the Swiss Alps,

Year	European Alps		Switzerland	
	Ice (10^9 m^3)	Water (10^9 m^3)	Ice (10^9 m^3)	Water (10^9 m^3)
1850	200	182	110	100
1973	100	91	75	68
2000	75	68	55	50
2006	67	61	49	45

Tab. D-1: Water storage in European Alpine Glaciers from the Little Ice Age until the present day (Maisch et al., 2004; Zemp et al., 2006; Frauenfelder et al., 2005; Huss et al., 2007)

[96] Vulnerability and adaptation to climate change in Europe, EEA Technical Report, No7/2005, European Environment Agency
[97] In the European lakes, during the last 40 years, an increase in temperature between 0,1 and 1,5°C has been observed(IPCC, 2008, page 37)
[98] How will the Alps respond to climate change?“, Lučka Kajfež-Bogataj, University of Ljubljana, IPCC WG2 Vice chair
[99] IPCC, 2001
[100] Vulnerability and adaptation to climate change in Europe, EEA Technical Report, No7/2005, European Environment Agency
[101] „How will the Alps respond to climate change?“, Lučka Kajfež-Bogataj, University of Ljubljana, IPCC WG2 Vice chair
[102] „Klimaänderungen und die Schweiz 2050. Erwartete Auswirkungen auf Umwelt, Gesellschaft und Wirtschaft.“, OcCC, Beratendes Organ für Fragen der Klimaänderung und sc / nat, ProClim-Forum for Climate and Global Change, Forum of the Swiss Academy of Sciences
[103] Schädler Bruno, Weingartner Rolf: Impact of 20th Century Climate Change on Water Resource in Mountainous Regions of Switzerland

the surface diminished by 50% and volume losses amounted to 62% (Zemp et al. 2006). Due to the extraordinarily warm summer in 2004, another 10% of the ice volume has disappeared in Central Europe (Frauenfelder et al., 2005; Huss et al., 2007)
Changing climatic conditions together with increasing temperature and changes in the precipitation regimes have a distinct influence on the runoff regimes and on water balance. The daily stream flow records of 13 near natural watersheds in Switzerland were analysed beginning in 1931 (Birsan et al., 2005). In some of the watersheds a change in runoff regimes toward higher runoff in winter and lower runoff in the other seasons was identified, however, without a consistent trend pattern. Obviously, regime types (Aschwanden and Weingartner, 1985) are changing from ice-influenced regimes and snow-influenced regimes to regimes which are more influenced by snowmelt and rainfall regimes.

Depending on the climate region and on topography, precipitation amount varies considerably: the highest values and the highest variability are observed in the south of the Alps, in the Ticino river basin. The lowest values are measured in the inner Alpine valley of the River Inn, which is protected from winds from all directions.

As far as the River Rhine basin runoff is concerned, values remain constant as the amount of the rising evapotranspiration is compensated by almost the same amount of rising precipitation. With regard to the River Rhone, precipitation seem to increase more, resulting, together with a contribution from melting glaciers, in a higher runoff, whereas the runoff of the River Ticino and, to a lesser extent, of the River Inn, diminishes due to a decrease in precipitation.
The contribution of ice melting to the mean runoff is often overestimated even if 53 billion m^3 of glacier ice disappeared in Switzerland during the 20th century. The contribution to the mean runoff amounts only to about 1% for the total area in Switzerland. However, in the case of individual small watersheds close to the glaciers, the contribution of melt water from the glaciers is important for the runoff regimes of these areas.

Measures, projects and programmes at an international level to cope with climate change and its impact on the water cycle in the Alpine region

Different declarations, green books, communications, agendas and commitments at international level, determine the analysis, conclusions and measures to cope with climate change and its impact on the water cycle. Some examples of these are:

- Communication of the Commission on water scarcity and droughts in the European Union
- EU Green Paper on Climate Change
- EU White Paper on Climate Change
- Declaration of the Alpine Conference concerning climate change in the Alps and
- Corresponding Action Plan to the declaration of the Alpine Conference
- Initiative "Model Region" Alps and Climate Pact of CIPRA International

Furthermore, finalisation of a study financed by the European Environment Agency on "Climate Change Impacts and Adaptation in the European Alps: Focus Water" is planned for the end of 2008 focusing i.a. on the need of adaptation.

The Communication of the Commission on water scarcity and droughts in the European Union is addressed in the chapter B.2.3.2 on "Droughts and Water Scarcity" of this report and therefore no further reference is made to it in this chapter.

The Green paper and the White paper of the Commission, the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions

(Green Paper: Adapting to climate change in Europe – Options for EU action, 2007)

The Green paper will be followed by the EU's White paper: After the publication of the Green Paper "Adaptating to climate change in Europe - options for EU action", the European Commission is currently - during the preparation of this report - working on a White Paper with policy options to address the impact of climate change. The White Paper is expected to be adopted by the beginning of 2009 and will be accompanied by an impact assessment.

CIS guidelines: Climate Change and the EU Water Framework Directive

Climate change is an important issue in the context of the implementation of the EU Water Framework Directive. The policy paper[104] on a common implementation strategy for the Water Framework Directive on the topic of climate change has been prepared by the European Commission and the EU Water Directors.
In the paper it is suggested that climate change should at least be considered in the first River Basin Management Plans, both in national and international plans, which will be finalised by the end of 2009.
In subsequent cycles, the management plans need to be made climate resilient as a default and firmly based on scientific evidence, notwithstanding the fact that knowledge and new data are constantly evolving.

[104] European Commission's CIS Policy Paper on Climate Change June 2008 http://circa.europa.eu/Public/irc/env/wfd/library?l=/framework_directive/climate_adaptation&vm=detailed&sb=Title

Alpine Convention declaration on climate change in the Alps and action plan

The Declaration on climate change (adopted during the Alpine Conference at Alpbach, Austria, November 2006) intends to elaborate appropriate strategies and activities for the Alpine area in order to adapt to the consequences that will result from climate change.

The strategies and activities are also aimed at specific sectors and include regional characteristics, needs and abilities for this adaptation; the Declaration deems efforts for the promotion of international research projects as necessary, in order to achieve better understanding of the effects of climate change on the Alpine area (among other things, on land use, changes in land use, on water balance due to the forecast more frequent occurrence of extreme rainfall events and on drought periods and the consequences on the vitality of mountain forests) and therefore create the basis to draft or implement effective adaptation strategies.
The Alpine Conference invites the Alpine states and the EU to include the following recommendations for action in the framework of national policies and in the common Alpine policy in order to avoid further progressive climate change and to help adapt to it:

1. **Avoid the furtherance** of climate change by taking appropriate measures for the reduction of greenhouse gas emissions and by supporting the absorption of greenhouse gases

2. **Adaptation** to the effects of climate change by developing concrete strategies to include adaptation measures in segment policies, to guarantee the organisational, legal and appropriate budget framework conditions, to implement new or intensify current actions, raising awareness and targeting research.
A separate action plan (adoption planned at the Alpine Conference in Evian, France, March 2009) as a follow-up of the Alpine Convention Declaration, is under preparation.

The Initiative "Model region" Alps and the Climate Pact of CIPRA International

The International Commission for the Protection of the Alps (CIPRA) developed a vision of a regional model "Alps" for climate protection in 2008. This vision was presented to the Permanent Committee of the Alpine Convention in March 2008. In this vision, water is addressed as a crucial issue for adaptation measures. This is reflected in the stipulations demanding that dangerous zones be fully covered in spatial planning, addressing the issue of artificial snow production by drawing up an inventory for regions and communities on water use for snow production. Furthermore, this will be used as a basis for assessing the compatibility of additional snow guns and revoking subsidies for snow guns, for abandoning the further development of ski lifts on glaciers and of closed landscape elements in high mountainous area and finally for the elaboration of an Alpine-wide strategy for the sustainable management of waters and biotopes along watercourses.

Summary

Climate change in the Alps is a complex mixture of short to long-term forces, related to the intensity and persistence of weather patterns and enhanced radiative forces linked to anthropogenic greenhouse gases[105]. The recent warming trend is now producing results such as reduced snowfall at lower altitudes, shrinking glaciers that can be expected to deteriorate even further as a result of with climate change. In future, increased floods[106] and rock falls are expected. Projected changes for mountain regions suggest that the European Alps are likely to have slightly warmer winters with more precipitation than in the past, while the summer climate may become much warmer and drier than today. It seems likely that Alpine climate change will lead to changes in the timing and amount of run-off in European river basins and that floods and droughts will become more frequent. Initially, glacier retreat is projected to enhance the summer flow in the rivers in the Alps. However, when glaciers shrink, summer flow is projected to be reduced (Hock et al., 2005) by up to 50% (Zierl and Bugmann, 2005) in catchments which are strongly glacierised today. The summer discharge of Alpine catchments may decrease significantly, will, however, still be dominated by snow melt. Winter floods may become more frequent in the lower parts of the Alps. However, these winter floods in the Alps belong in general to the class of small to middle events but not to the class of extreme events. Due to the fact that the Alps are the primary source for such major rivers as the Rhine, Rhone, Po, and Danube, the impact of reduced mountain discharge would be felt far beyond the mountainous regions themselves.
In particular further research will be necessary to quantify the impacts of climate change on the water cycle at a regional levels in more detail and to translate the findings of climate models into hydrological parameters (such as water table, discharge, etc.).
Climate change requires adaptation and mitigation. At different administrative levels manifold measures and activities may be necessary.

Water management adaptation and mitigation measures in terms of Climate Change will be worked out within the framework of the Climate Action Plan of the Alpine Convention and in the forthcoming River Basin Management Plans in line with the CIS Policy Paper on Climate Change of the EU water directors and the European Commission dated June 2008.

[105] IPCC, 2008, page 15
[106] (IPCC, 2001b) from IPCC, 2008, page 95

Case Study from Slovenia

Climate Change in the Triglav National Park

Introduction

The Triglav National Park (TNP) is situated in the very north-western corner of Slovenia. It is on the territory of the Eastern Julian Alps, being at the south-eastern rim of the Alpine arch.

The TNP was founded in the year 1924 as the Alpine Conservation Park. Since 1981, the present area of the park, 838 square kilometres, has been protected by law. Human activities in the park are severely restricted, mainly to agriculture with pastoral economy, crafts with wood and woollen products and to environmentally friendly tourism, predominantly to hiking and mountain climbing.

Two thirds of the park territory is covered by forest, mainly in a karst area which is desolate at high altitudes. This is the headwater region of major rivers, the source of the River Sava which drains into the Black Sea Basin and that of the River Soča which flows into the Adriatic Sea. Due to the high amount of precipitation the territory of the park has a high abundance of water.

Having very little local anthropogenic pressure, the territory of the TNP is an ideal natural laboratory to study the impact of global climate change.

Fig. D-3: The Triglav National Park area with two river sources, the River Sava draining into the Black Sea, and the source of the River Soča draining into the Adriatic Sea.

Climate

The major climate system in the area covered by the TNP is Alpine, however, there is a strong sub-Mediterranean climate influence in the south-western part, especially in the valleys. Complex terrain and interaction between climate systems contribute to variable climate conditions with a very high variability in spatial and temporal precipitation.

There are regions in the south-western part of the Julian Alps, where total mean annual precipitation exceeds 3.500mm, while it hardly reaches 2.000 mm per year in the northern part of the TNP. In the Soča valley the mean annual precipitation is almost twice as high as in the Sava Dolinka valley although they are not far apart. The same high variability is well expressed in temperature conditions. The south-western valleys are more temperate and the northern and eastern parts are colder. Altitude is the main factor that influences mean annual temperature with a lapse rate of – 5.3°C per 1km. In the highest mountain regions temperature conditions are very close to that of the open atmosphere. The lowest temperature occurs on the high Alpine plateaus in the presence of snow cover when a strong temperature inversion forms cold air pools in shallow karst basins in still weather. High variability in altitude, from 180m up to 2.864m, also makes Alpine climate systems more variable and more sensitive. This variety is also reflected in climate variability over time and is an important factor in determining the impact of global climate change. Precipitation regime, describing the average annual variation of total monthly precipita-

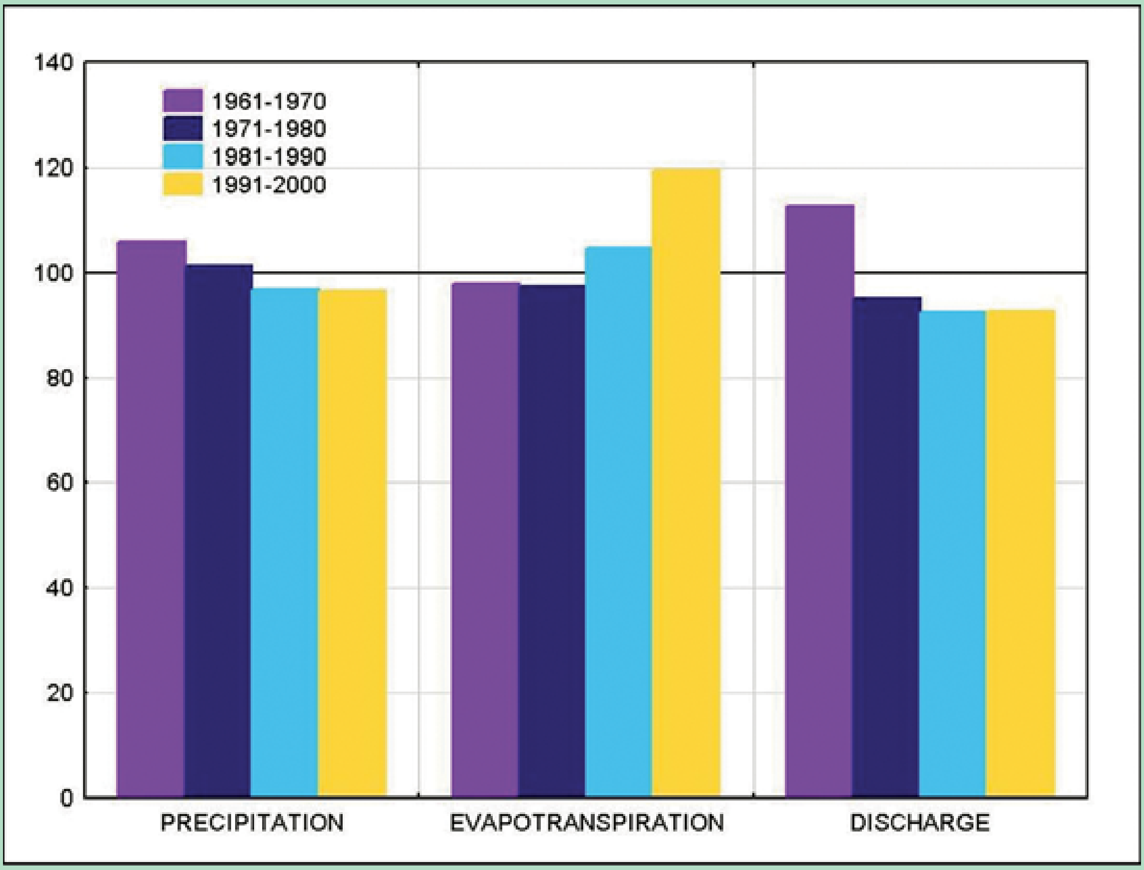


Fig. D-4: Decadal distribution of the coefficient of precipitation, evapotranspiration and river flow. Index 100 is a 1961-1990 reference period mean.

tion, is very specific but uniform across the whole region of the TNP. It has a very pronounced maximum in the autumn months of October and November, a weak maximum in the late spring months of April, May and June, and a minimum in the winter months of December, January and February.

Present trends in annual precipitation totals are not very significant, showing a decrease of around 8% in the central TNP region (Fig. 3). However, the changes are obvious on monthly and seasonal bases. The precipitation regime has changed significantly, especially in the last 10 years. Throughout the TNP a significant increase in autumn precipitation totals has been observed. On the other hand, winter and spring precipitation totals have decreased during the observed period.

Evapotranspiration (ET), which is the sum of evaporation and the moisture that plants are releasing into the atmosphere, has significantly increased - especially in last decade of 1990-2000. In the central part of the TNP the annual ET total increased by up to one quarter. The main factors that influence the ET increase are changes in temperature and solar radiation, which have both increased, especially during the last decade. What is most significant is the ET increase during the summertime, when it has been always most intensive. Only in November and December was there less ET than on average in the last decade.

Accumulated snow is very important for discharges of rivers whose headwaters are in the Alps and has a significant influence on river flow regime, especially in the late spring months. In the higher region of the TNP the snow cover is usually highest in the late spring months, at the high mountain meteorological station, Kredarica, it is on average around 4,4m. Although there are isolated extremes, such as snow cover depth of 7m in 2001, snow cover has generally diminished in recent years. In the last 50 years the average maximum seasonal snow cover at Kredarica has decreased by almost 2m. The main reason for this significant decrease in snow cover is the rise in air temperature in the cold period of the year. Noticeable warming started in the late 1980s and the last decade was already 0,8°C warmer than the mean air

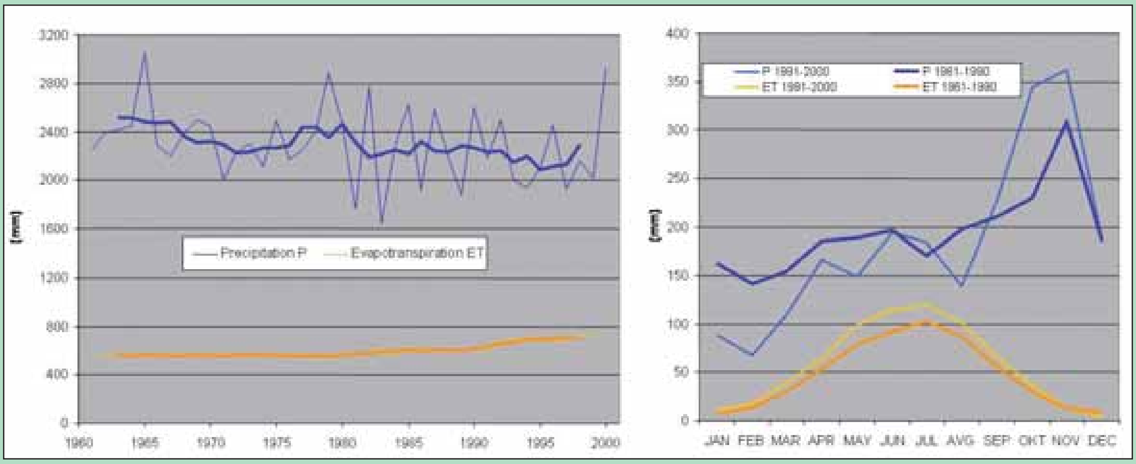


Fig. D-5: Annual precipitation totals and evapotranspiration with a 5–year moving average (left). Monthly precipitation totals and evapotranspiration distribution in the decade 1991-2000 compared to the 1961-1990 reference period (right).

temperature –1,6°C of the reference period 1961-1990. In the TNP region a significant increase in temperature was observed in all seasons but autumn. In the last 50 years the most significant temperature rise was observed in the summer months at 3,3°C, just a little less in winter at 2,9°C and in spring at 2,5°C. Another cause for the reduction in snow cover has been the fall in winter precipitation.

Water Regime

The trends of characteristic discharges in the TNP are similar to other mountainous regions in Slovenia. The declining trends of all characteristic discharges - low, average and high - were observed in most rivers. Both in the Black Sea Basin (Fig. 4) and the Adriatic River Basin the low, average and high flows are decreasing.
The only exceptions are two rivers in south-western part of the TNP with no significant change in flow.

River flow regime describes the average annual variation of the river discharge over the year. The changes in the climatic elements, especially with regard to precipitation, temperature and snow cover are the factors which influence the regime most.

The influence of climate change on river regimes was most pronounced in the last decade of 1991-2000.

The following elements of river regimes of the 1990s changed most markedly compared with river regimes of the multiannual reference period 1961-1990:

- the flow in spring decreased, mostly due to the decrease of the snow cover,
- the flow in autumn increased due to an increase in precipitation, but also due to the rise in temperature that diminished snow retention in high mountains,
- the flow in summer decreased due to water loss via higher evapotranspiration.

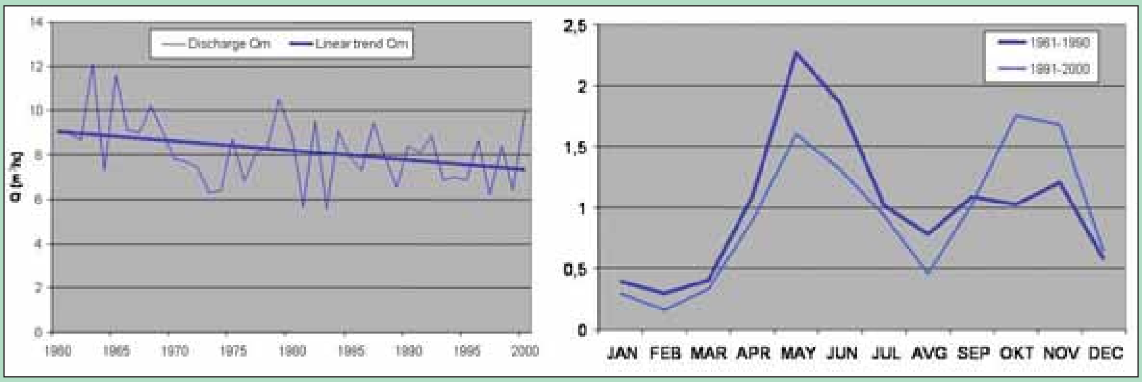


Fig. D-6: Annual river discharge with linear trend (left). Monthly discharge coefficients of decade 1991-2000 compared to monthly discharge coefficients of the 1961-1990 reference period (right). Coefficient value 1 represents average annual discharge.

The most significant change in the river regime is the shift of the highest flow from the spring to the autumn months (Fig. D-6).

Triglav Glacier

Glaciers in the Alps are very sensitive to variations in climate, which has been documented by numerous historical records of the progress of glacier areas in cold periods and their recession in warm periods. More recently, receding glaciers have been one of the most visible indicators of global climate change in the Alps.

There are only two glaciers, below the peaks of Triglav (2864m) and Skuta (2532m), which are left in the Slovenian Alps. Both are at a relatively low elevation, at just about the lowest threshold altitude of permanent ice in the Alps. The Triglav glacier lies in the Julian Alps on the northern side of Mt. Triglav at an altitude of between 2.400 and 2.500 meters. This low altitude is the cause of the glacier's high sensitivity to climate change and of dramatic glacier reduction in recent years (Fig. D-7). Its present surface is less than one hectare, thus we can speak only about a glacier patch (Fig. D-8). Due to its small size and location in an area which is highly frequented by mountain trekkers, the slow disappearance of the Triglav glacier is very present in the minds of and well-known among the general public in Slovenia.

In the early 20th century the glacier extended to the edge of the vertical northern face of Mt. Triglav. At that time it measured about 32 hectares, and the earliest photographs of the glacier show typical transversal fissures on it. A century later, it only measures 0,7 ha and is only about 3 meters thick on average. In the last 15 years alone, more than 300.000 m³ of ice have melted. That means that in 15 years, 15 times

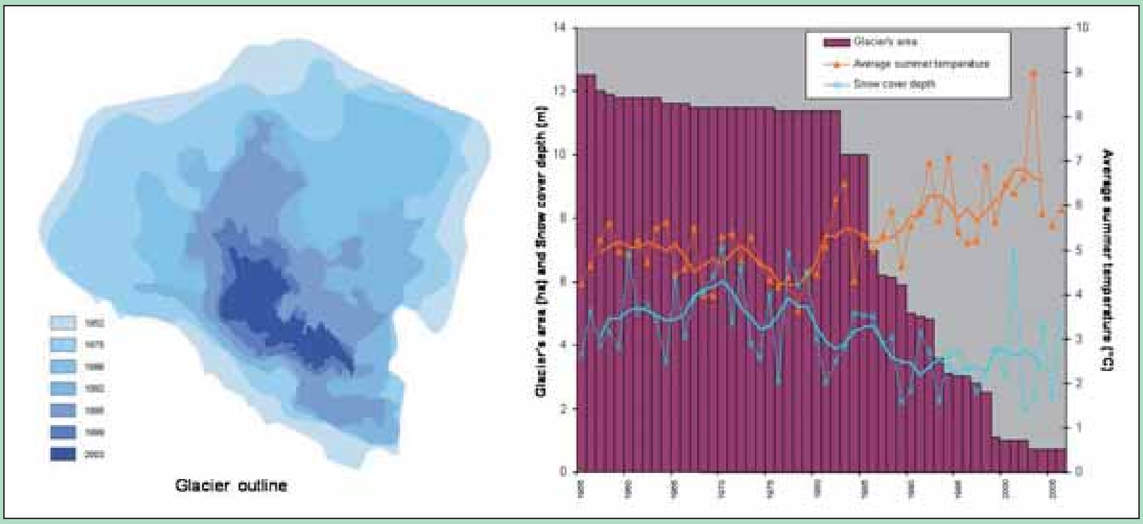


Fig. D-7: The outline (left) and glacier area of the Triglav glacier decrease in relation to the rise in temperature and decrease in the depth of the snow cover (right).

Photo D-1: Impacts of Climate Change in the Alpine region can most obviously be observed at glaciers. It is predicted that Climate Change will also have an influence on the water cycle and water availability. Disappearing glacier on the Mount Triglav, Slovenia more ice has melted than its total volume today. In the last 50 years the glacier has become narrower at certain places by more than 35m, and its volume has decreased by two million m^3.

The melting of the glacier is very well documented by time series of data for more than 50 years. The data concerning glacier measurements and the climate data from the high mountain meteorological station, Kredarica, at an altitude of 2.515 m, just about 300m away from the glacier, provide material for a qualitative analysis of climate impact on glacier development. Both the rise in air temperature and the amount of winter precipitation have been decisive for the decline in the size of the glacier. The glacier's dramatic reduction process coincided with the start of rises in summer temperatures and the decrease of snow cover depth in the 1980s (Fig. D-7). The shrinking of the glacier stopped temporarily only in the years when the snow cover was 3 meters deep or even deeper. However, such conditions which occur approximately twice in a decade will not reverse the shrinkage of the glacier area. If the process of decline continues at the rate of the last decade, the glacier will vanish completely in the course of ten years.

Future Scenario

The Alpine ecosystem is very sensitive to minor changes in climate, as snow is a major factor that influences climate and has a very sharp altitude threshold with regard to temperature conditions. This is the reason that changes in temperature could lead to abrupt changes both to the Alpine climate and to the ecosystem. In dealing with future climate scenarios, one must be aware of a high degree of uncertainty, especially at a local scale, due to uncertainties in the social-economic development of the world, in population growth and also in simplified physical processes used in climate models. The temperature rise in the Slovenian Alpine region, including the region of the TNP, is expected to be from 3,9 to 7,4°C in summer and from 3,4 to 6,1°C in winter, depending on different emission scenarios by the end of the 21st century. The precipitation regime is also expected to change. However, precipitation scenarios are far less reliable than temperature scenarios. Summer time is expected to be drier, while more precipitation is to be expected in winter time. The frequency of heavy precipitation is also expected to rise.

In the case of the climate scenario described above, the flows of the rivers in the TNP are expected to continue decreasing and summer droughts will be more pronounced with the lower flows. More river bed sections are expected to be dry and many small watercourses to be completely dry in summer. On the other hand, due to increased incidents of heavy precipitation events, more extreme and frequent torrential floods could be expected. The water abundance in the different seasons of the year is also is expected to change. It appears most likely that the shift of high flows from the spring time to the autumn, which has already been recorded, will become predominant in the river regime in the future.

As a result of this predicted temperature rise, the Triglav glacier will very soon be history, and the Triglav slopes will be barren, free from snow and ice in the summer. This will not only be a great loss to the wealth of natural scenery in the Alps, but it will also permanently change the flow regime of the watercourses in the TNP which are dependent on melting snow and ice and thus water dependent ecosystems will be affected.

National Contributions
Regarding Information on Climate Change

Austria

The impact of climate change on water resources is a critical issue which has to be elaborated and taken into account in a serious manner. Since the Alps react particularly sensitively to changes in climatic conditions, the effects on them could be examined e.g. the variations in glaciers from 1969 to 1999 illustrate this point clearly and are also alarming. In this period of 30 years, the glaciated area in Austria decreased from 567 to 471 km^2 – a reduction of 17%. Maximum discharge due to the melting of ice can be expected to occur in another 40 years with an upward shift in the snow line by an estimated 500 to 600 meters in the long term.
With regard to precipitation, climate models currently predict no distinct changes in the annual average for the whole country, whereas forecasts identify a spatial separation along the main ridge of the Austrian Alps, with a slight increase in the annual amount of rainfall in the north and a decrease in the south.
The situation concerning the discharge of rivers corresponds to changes in precipitation in combination with temperature. Therefore, significantly lower discharges in summer and increases in the winter period are expected.
Consequences regarding the frequency and magnitude of flood events are difficult to examine due to their overlapping with anthropogenic interferences, however, disastrous weather events have been registered more frequently in the last decade.
Apart from potential changes to precipitation and run-off patterns, further impacts are to be expected with regard to river and lake ecology due to the constant increase of the mean annual temperature observed in surface waters.

A number of research projects in Austria are devoted to climate change issues. The major starting point was the “StartClim” programme, initiated by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management and implemented in 2002 following the extensive floods in the country. StartClim supported different research projects on new topics concerning climate and climate change, analysed from different points of view and by different scientific disciplines. A large number of participants, approximately 80 Austrian scientists and more than 30 Austrian institutions took part in the programme. StartClim focused on issues regarding extreme meteorological events and related impacts, heat waves and droughts, health, tourism, energy, biodiversity and economic effects.

In addition to StartClim, the international ClimChAlp Interreg III B Alpine Space project aims at supporting the political decisions regarding the protection from and prevention of natural disasters due to climate change in the Alps, since natural hazards are expected to become an even more critical issue in Austria. The projects “Flood Risk” and “Flood Risk II” also aim at developing a new understanding in order to further develop the national strategies for flood prevention. The key-question in this regard is the effect of possible changes in the shares of precipitation in the form of snow and of rain on the discharge of rivers in relation to the dynamics of calculation parameters for flood risk management and their related consequences. By way of the participation of many institutions, of many findings and recommendations with respect to meteorology/hydrology, geomorphology, economic aspects and spatial planning, flood control measures and disaster protection have been established. The recommendations have already been partly implemented and will be further implemented, for example in guidelines (for regional planning, etc.) and with respect to public awareness.

Within the next ten years a special effort will be made to identify inundation areas and to speed up hazard-zone mapping, contributing to the implementation of the EU Floods Directive 2007/60/EC. Simulation models for the hazard assessment of torrential flows, debris flows, snow avalanches and rock fall have been developed. Considerable portions of the budget are spent on avalanche, erosion and torrent control measures. In 2005 for example, federal funds in the amount of EUR 69 million were invested in protective measures. Total investments including the contributions by federal provinces, municipalities etc. amounted to EUR 122 million.

Furthermore, a task force comprising representatives from Universities, from administration and from the Austrian Water and Waste Management Association are currently working on an assessment of expected impacts of climate change on water management in Austria. The aim is to develop appropriate adaptation measures and guidelines for planners, public authorities, communities and policy makers. The topics flood risk, groundwater, hydro power generation, water supply and sanitation, bathing waters, glaciers and implications on the implementation of the EU Water Framework Directive should be addressed in particular.

With regard to measures for mitigation, the Austrian Climate and Energy Fund was allocated EUR 500 million for the years 2007 – 2010. In addition, the fund can be provided with third-party funds.

France

In the basin of the River Rhône, over the past century, the average temperature rise was +0,7°C in the north, +1,1°C in the south; high level temperatures rose by +1,1°C; the temperature of lakes rose by 2°C. Various simulations developed during the past fifty years, even when viewed independently from one another confirm an increase in winter precipitation and a reduction in summer and autumn rainfall, which is more accentuated in the southern part of France. The country is therefore expected to have to face a global reduction in the flow in rivers. In mountainous regions, most of the projections forecast a decrease in the volume stored in glaciers and a reduction of the snow cap causing earlier spring floods (which are already one month earlier in the Durance valley), an increase in winter currents and a more severe low flow in summer in every region presently characterized by a nival regime. Some fish species, such as artic char in mountainous lakes could be endangered.

The evolution of underground storage is more difficult to foresee. As is the case for surface water, reserves of water stored underground are recharged with rainfall and melted snow and should obviously be facing the same trends. Nevertheless, its evolution remains strongly related to the permeability level of soils, to evaporation and sublimation rates, and also to the modification of soil use according to forestry and agriculture practices. The reduction in the storage of glaciers has been confirmed; according to recent studies, in 1800 the total water storage volume for glaciers in the European Alps as a whole used to be about 200 km^3; in 1973 this volume was reduced by half, and in 2006, only one third was left. No recent figures for France were available to update the estimated volume of 15,5 km^3 for glaciers in the 1990s.

The water intake for various uses relies on both underground and surface resources. In France, 81% of total abstractions throughout the country (31 billion m^3/yr) rely on surface water mainly because of cooling towers using high volumes. Although conflicts arise in some regions in summer (during recent droughts) between the needs of refrigeration, agriculture, domestic needs and also the preservation of life in river beds, it has not, until now, seemed to be a strong issue in the Alpine region. Cooling requirements in this region are less than 9% of water abstraction; domestic needs account for 43% and irrigation for 37% (out of 1.245 million m^3/year 2006).

National programmes for saving water are being encouraged and implemented. Maize culture seems to be slowly falling and irrigation efficiency is being improved with new devices for adjustment to plant needs (even if some regions experience problems in safeguarding production). Faced with local conflicts during low flow periods, water users cooperate to decide on a share of the resources available. As soon as the recharge of the water table is considered to be insufficient during drought episodes, Prefects impose strong restrictions (e.g. refilling pools, watering golf courses, etc.).

Impact on the water supply and on tourism is difficult to foresee within the Alpine region, as water resources are more or less abundant and locally, are sufficient for drinking supplies. The most obvious phenomenon is the development of artificial snow making: recent figures (2006) for the French Alpine perimeter give a consumption of 8 millions m^3/a (with 24% coming from groundwater; see also the case study). Even if it is still less than 1% of the total needs of the region, this phenomenon remains an issue as it is affecting the high reaches of the Alpine torrents during the low flow winter season. As a result of unpredictable snow fall –possibly related to climate change - this should be mentioned as a first sign of an impact on climate in the Alpine region.

France has started implementing the Kyoto Protocol, reducing greenhouse gases by 1,8% compared to 1990, aiming at 20% less before 2020 and a fourfold reduction in gas by 2050.

Germany

During the past 50 years the mean temperatures in the Alps have already increased twice as much as the global average. Due to this fact, climate change has a particularly strong impact on the Alps as a sensitive natural space. The German states of Bavaria and Baden-Württemberg, as well as the German Meteorological Office, have been running a joint research project since 2001 called ClimChAlp which studies climate change and its consequences. The project is supported by the EU within the framework of the INTERREG III B Alpine Space Programme. According to this, scenario calculations within the scope of the ClimChAlp and KLIWA projects predict the following climate changes for the future: Reduced number of frost days (lowest temperature is below freezing) and ice days (highest temperature is below freezing)

- By the year 2050 the monitoring stations close to the Alps will reveal a decline in the ice days from 10 to 60% and in frost days from 10 to 30%
- Rising temperatures in the summer and winter six month periods
- In the Alpine region an estimated temperature increase of approx. 2K is expected in winter and up to 4K in the summer by the year 2100. An increase in temperatures in winter leads to more rain instead of snow.
- A reduction in the amount of precipitation in the summer and an increase in the winter
- By 2100 models show an increased precipitation of approx. 20% for the Alpine region, whereas there will be approx. 30% less rain in summer
- Earlier snow melting with a shift of the occurring maximum runoff from spring to winter
- At higher elevations snow melting is expected to occur approx. 10 days earlier by the year 2050
- Greater variability, both in temperature as well as in precipitation, with a growing risk of extreme weather conditions.

As a result, the dramatic glacier decline, that is already being registered today, for example, will persist. The consequences will not only have an impact on the population living in the Alpine region (water supply), but also on those living outside this area (low levels of the rivers Iller, Lech, and Rhine in the summer).

These changes in climate parameters for the Alpine Region demand joint and consistent action by all affected parties. Besides reducing CO_2 emissions, increased research activities are required, especially with regard to the regionalisation of future climate forecasts for the Alpine region. Simultaneously, local/regional adjustment strategies and measures have to be prepared. The following tasks are of particular importance:

- Research: further development of global/regional climate models for the Alpine region for the forecast of future climate parameters at a local level
- Flood control/flood prevention: Alignment of the assessment basis to account for climate change (e.g. accounting for “climate change” factors in the dimensioning of dykes (HQ100 +15%) in Bavaria), further optimisation of flood warning systems
- Aquatic ecology: Observing the impact of increasing water temperatures / low runoff on the quality of water,
- Setting up a low-water warning system,
- Water supply: Securing a sustained supply of (drinking) water (public use having priority over irrigation of agricultural land, for example)
- Reservoir management: Adjustment of reservoir management in the light of changed water regime parameters and an increase of extreme occurrences (snow melting and heavy rain occurring at the same time)
- Georisks: advancing the development of forecast models and hazard maps indicating georisks (landslides, mountain slides)
- Water regime/flood prevention: adjustment of agricultural and forest farming, especially of the mountain forest
- Setting up an integral cross-border risk management system
- Planning requirements: implementation of adjustment strategies/measures in regional development, regional and land use plans
- Conversion of the winter tourist trade programme to deliver an all-year concept

A general shortage of water in the Bavarian Alpine Region is not expected. Regional or local adjustment measures may be necessary. The costs for these measures are not quantifiable at present. They will have to be financed by municipal and state budgets in compliance with the specified detail measures.

Italy

Predictable general future trends (water & climate change)

In most cases, it is not possible to find a single trend for the whole Alpine area as far as climate change is concerned.

Observations converge on a strong and general increase of the temperature in the Alps with different magnitudes, depending primarily on the emission scenarios and models used to predict the future climate and the country being examined. Model results show a trend of continuous warming: the mean Alpine temperature might increase by 3 to 5°C in summer and by 4 to 6°C in winter by the end of the 21st century (ClimChAlp, 2008). Difficult and complex as future climate forecasting may be, especially at a reduced spatial scale such as the regional Italian one, the assessment of its impacts on the hydrological cycle such as precipitation regime, river discharge or groundwater flow is even more difficult. The climate-change induced modifications on the Alpine water cycle regime have shown their main impacts on the whole Po and Adige river basin area, the Alps being the major contributor to the river regime and to the whole catchment economy.

Precipitation

General trends concerning observed mean precipitation in the whole of the Alps have not been found: relevant differences exist between regions (ClimChAlp, 2008). Although models have difficulty in calculating precipitation patterns in mountain areas, most projections up to 2100 tend to decrease in summer and to increase in winter. For the period 1901-90, an increase in winter precipitation by 20-30% per 100 years in the western part of the Alps and a decrease of autumn precipitation by 20-40% to the south of the main ridge have been detected and confirmed according to recent studies (ClimChAlp, 2008), as well. In some Alpine regions in Italy (e.g. in Valle d'Aosta) precipitation has been decreasing since 1940. Drier years have been increasing in Valle d'Aosta (Cambiamenti climatici in Valle d'Aosta, 2007). In general, the trends mentioned above are not clearly recognizable as was also noticed for the Alpine region as a whole; in general and for Italy, in particular, an increase in the intensity of the single rainfall events, but an overall decrease in the total number of rainfall events have been observed (ClimChAlp, 2008[107]). As a result, a decrease in the annual mean precipitation of about 20% has been observed in the last thirty years, (the decrease is more evident during the spring and summer seasons); in addition to the inter-annual variability increases. In the Po river basin, climate projections for this century confirm the present trend, with an increase in temperature of a few degrees at the end of the century, and a decrease in precipitation, accompanied by an increase of the inter-annual and inter-monthly variability (Arpa Emilia Romagna, 2007).

River discharge patterns

Annual river discharge patterns have changed over the past 10 years in Europe. In some regions an increase has been observed, in others - mainly located in Southern Europe - there has been a decrease. The combined effect of temperature increase and significant changes in precipitation patterns is likely to impact on the annual discharge patterns of European rivers, with a particularly negative impact on the rivers in the southern part of the Alps, inducing a long-term decrease in available water resources after a temporary increase in the upcoming decades characterised by heavy melting rates (ClimChAlp, 2008). In the Italian Alps the anticipated snow melting is likely to bring forward the spate usually expected in late spring-early summer. Then, the decrease in precipitation patterns and the reduced ice availability is likely to produce more severe water scarcity phenomena in the warmer season (Cambiamenti climatici in Valle d'Aosta, 2007). An increase of the annual mean temperature of about 2°C has been observed from 1960 to the present, with a relevant increase in the linear trend which leads to a forecast increase of the annual mean temperature of close to 3-4°C at the end of the century (ARPA Emilia Romagna, 2007). The reduced availability of the water resources induced by the new climatic regime could increase competition among users and cause a critical situation for sectors depending on water resources: drinking water, agriculture (both with regard to reduced quantity and a phase shift in the growing season with respect to natural availability), energy (hydroelectric plants, increasing energy demand for water withdrawal/abstraction and distribution, cooling of thermoelectric plants), tourism (decreased snow precipitation, deterioration of the water status), industry, water infrastructure.

Agriculture & water availability

Agriculture is one of the main sectors likely to be impacted by climate change in the Alps. Both negative and positive effects are expected. Higher temperatures can bring positive effects to the Alps as well, and crop growing is likely to expand to areas where it has not been possible to set up farming activities (e.g. vineyards). Water scarcity phenomena could influence agriculture and harvests in the Alps, as already happened during the 2003 heat wave - e.g. when a loss of 23% of the total grass harvest in Valle

[107] "ClimChAlp - Climate change, impacts and adaptation strategies in the Alpine Space", Interreg IIIB Alpine Space Project, 2008

d'Aosta was calculated (Cambiamenti Climatici in Valle d'Aosta, 2007). Agricultural methods should be adapted to changing climate and territorial conditions, using different plant species, applying new irrigation methods and avoiding extensive seeding cultures in alpine and peri-alpine areas (ClimChAlp, 2008).

5Snow cover & Tourism

Climate change is likely to have an impact on snow precipitation and snow cover in mountain areas worldwide. Snow cover in the continental area of the Northern Hemisphere decreased by 5,7% (NOAA, 2007) at a global level between 1972 and 2005. A general decrease in snow cover has been observed both in height and duration especially at low and medium altitudes throughout the Alps, coupled with the warming of air temperature (ClimChAlp, 2008). This decreasing trend is very likely to continue throughout the 21st century for all Alpine countries. A generalized negative trend is expected throughout the 21st century with less frequent snow falls and faster snow melting due to higher and more variable temperatures (IPCC, 2007; OECD, 2007; NOAA). A significant decrease in the amount of fresh snow (from December to February: -44% between the mean of the period 1983-1996 and the period 1996-2007 in Sestrière –TO– source: ARPA Piemonte) and in the volume of the Alpine glaciers has been observed. The snow coverage, which is an integrated response to variations in temperature and in precipitation, results in reductions in spring and between autumn and winter, since the snow accumulation season has been postponed and the snow–melting season anticipated. Due to the negative correlation between the snow coverage and the air temperature, a constant shrinkage of the Alpine glaciers is expected (which has been almost homogeneous since 1860). From a quantitative point of view, melting is the cause of a loss of about 40% of the glacier surface (ARPA Piemonte, 2007). During the period 1975-2006, precipitation in the Po river basin decreased by 20% on yearly basis and by 35% for the months from January to August. A similar trend can be found in the River Po discharge series referring to the river delta, with an annual 20% decrease which varies to 40% during the summer season (ARPA Emilia Romagna, Arpa Piemonte, 2007). Areas more likely to be affected by such a change in the following years are the ones located at lower altitudes. These are rather common in the Italian Alps, namely in regions such as Friuli Venezia-Giulia, Lombardia, Veneto and Piemonte (Ministero dell'Ambiente-EURAC, 2007).

Measures

Climate change is already having a significant effect on water availability and contributing to the further deterioration of water status. The impacts on water resources are likely to heavily affect the status of natural and anthropic systems. Therefore, both mitigation and consistent adaptation strategies are needed in order to avoid negative consequences on the resilience of hydraulic systems. Adaptation strategies, in particular could be integrated into already existing policies for the protection and management of water resources (Water Framework Directive, groundwater directive, flood directive, water scarcity and drought strategy) in coordination with the adaptation strategies of other sectors (energy, land use, agriculture, etc.) and in line with a national plan on sustainable development, which is currently being carried out as an implementation of the European sustainable development strategy (ESDS).

7. National programs concerning water use

Currently, the impact of climate change on water resources is taken into account in the plans of several sectors (National Irrigation Plan, Renewable Energy incentives, etc.). Italy has also supported and prepared specific actions for protecting surface and groundwater bodies, signing framework, supplementary and sector agreements with the regions. According to national law 267/98 "Urgent Measures for the Prevention of Hydro.geological Risk", Plans for Hydrogeological Planning are being drafted and adopted including a detailed delimitation of areas in danger and at risk of floods and landslides, and regulations on land use which prevent the setting up of new human activities in high risk areas. The Plans have a dual goal: to encourage safe territorial development and to reduce hydro-geological risks.

Slovenia

Slovenia recently experienced several severe droughts. The drought of 2003 was the worst, as well as severe floods, of which flash floods in autumn 2007 caused the highest number of human casualties for decades. These weather extremes have already been perceived as a consequence of climate change both by scientists and by the general public. Moreover, some scientists warn that the temperature rise in Slovenia in this century will be twice the global mean and that precipitation might decrease by as much as thirty percent in the most critical time in summer.
General strategies have been discussed to tackle climate change, but no national programmes or action plans have been developed yet. Most recently, in the field of agriculture, a process has been initiated that should lead to a programme in this sector.

At a national level, the elements comprising adaptation strategies for climate change are much in line with the Green Paper of the EC on adapting to climate change in Europe. However, due to some specifics of the country, national strategies emphasise following priorities:

- sustainable integrated water management of water resources for hydropower production, flood prevention and maintaining ecological functions, as well as for other uses,
- adapt sustainable forestry to climate change adapted in order to maintain its ecological functions, as a source of biomass and as a drain for carbon dioxide,
- spatial planning instruments for avoiding flood risk, loss of agricultural land etc,
- sustainable use of natural resources and safeguarding biodiversity, together with the relevant policies to build healthy ecosystems resistant to climate change,
- informing the general public on climate change impacts and actions to adapt to it.

These strategies are very much based on water management and forestry, since more than three quarters of Slovenia's territory is composed of river headwaters and more than half of the territory is forested.

It is to be expected that in due time, the general strategy will be upgraded into sectoral and cross-sectoral strategies and then later on, into national programmes. The first official action in this direction was taken in March 2008 by the Ministry for Agriculture Forestry and Food which prepared a draft of the strategy of adapting to climate change. This strategy has to be approved by the Government and by Parliament. The strategy has five pillars: education, information and counselling targeted at the general public and farmers; research of climate change at a national level; building up capacity for adapting to climate change in agriculture and forestry; government measures and changes in legislation; building international cooperation and solidarity. It has been estimated that the annual cost of implementing the strategy will be about 70 million Euros.

When the strategy was presented to the media it was proposed in public that, a national centre for adapting to climate change should be established as soon as possible. Such a centre should be cross-sectoral.

The slow pace of response to climate change in Slovenia is due to the relative abundance of water. There are no major conflicts of interest regarding water use. But there should be changes in this field. Between 2000 and 2006 the Government paid about 86 million Euros to farmers affected by droughts and invested only 3 million Euros in irrigation systems to prevent these events. Due to the climate change it is expected that increasing damage to the national economy will prompt the introduction of policies to adapt to climate change, rather than coping with the consequences of it.

In the future the Alps will be of strategic importance to the country, since even a decline of water resources in this area will leave it with a relative abundance of water. At present, available groundwater resources alone, can more than cover the current per capita water consumption of the entire country.

Switzerland

In order to achieve the requirements of the Kyoto Protocol, legislation on CO_2 reduction was adopted by the Swiss parliament. A long term national programme concerning Climate Change which will also replace the CO_2 law after 2012 has not yet been formally adopted, but preparation is under way. For this, the Swiss Department (Ministry) of the Environment, Transport, Energy and Communications has published a road map to the future Swiss climate policy aiming at a "Climate Framework Law".

Regarding the increasing risk of natural disasters
- the Swiss government decided – as adaptation measures - to improve warning (including forecasts) and alert systems for floods and other natural hazards (programme OWARNA: Optimierung von Warnung und Alarmierung bei Naturgefahren). In this context the system GIN (Gemeinsame Informationsplattform Naturgefahren), a common platform with data and information concerning natural hazards will be established. This project brings together the data and competences of the Meteorological Institute, the Federal Office for the Environment and the Swiss Federal Institute for Forest, Snow and Landscape Research.
- In a national position paper on flood control and climate change[108] general recommendations and policy guidelines are set out by KOHLS (national commission for flood protection).
- PLANAT (national platform for natural hazards, www.planat.ch) has been established in order to set out strategies to improve protection against natural hazards.

The Swiss government appointed the Advisory Body on Climate Change (OcCC: Organe consultatif sur les changements climatiques, www.occc.ch). Its role is to formulate recommendations on questions regarding climate and global change for politicians and for the federal administration (see e.g. the last report on the expected impacts of climate change on Switzerland in the year 2050 with a special chapter on water resources management: www.occc.ch/products/ch2050/CH2050-bericht_d.html).

In 2008, the Federal Office for the Environment (FOEN) launched a four-year project called CC-Hydro to study the impacts of climate change on the water resources and water bodies in Switzerland. Based on the most up-to-date climate scenarios, this projects aims at quantifying and providing information on the changes in the hydrological cycle and river discharges with high spatial and temporal resolution, differentiated according to climatic regions, altitude zones and geomorphologic characteristics.

A further ongoing project initiated by an organisation of Swiss electricity companies focuses on investigating the impact of climate change on the hydroelectric power production[109].
The Federal Government approved a four-year national research programme entitled "NRP 61 Sustainable Water Supply"[110]. The overall aim is to determine the capacity of natural systems to absorb the effects of changes in environmental conditions (climatic conditions) in order to develop intelligent and forward-looking strategies for sustainable and integral water resources management.

CHR, the International Commission for the Hydrology of the River Rhine initiated a scientific project "Development of joint climate and discharge projections for the international Rhine river catchments" in 2007.

With respect to the future water supply, a pre-study[111] (called "water supply 2025") of the Swiss Federal Institute of Aquatic Science and Technology shed light on the question of the effects of climate change on water resources, drinking water quality and on water consumption. It comes to the conclusion that – while currently around 5% of the renewable water resources are used by Swiss water suppliers - no acute water scarcity will occur at a national level under climate change scenarios, either. However, local and temporal effects on quantity and quality cannot be excluded. In the subsequent main project these questions will be dealt with in more detail, and will go beyond drinking water supply.

In this chapter the relevant existing legislation concerning water management is presented. The first part relates to the provisions of the Alpine Convention and its Protocols, while the second part focuses on EU legislation and similar measures in application in non-EU States.

[108] http://www.swv.ch/media/downloads/Klima_und_Hochwasser.pdf

[109] http://www.mountain-water-net.ch/FILES/pdf/Projekt_Klimaaenderung_Wasserkraft_Hauptstudie_Kurzportrait_V2_070906.pdf
[110] http://www.snf.ch/E/targetedresearch/researchprogrammes/newNRP/Pages/_xc_nfp61.aspx
[111] http://www.eawag.ch/organisation/abteilungen/ing/schwerpunkte/wasserinfra/wasserversorgung_2025/index_EN

E EXISTING LEGAL FRAMEWORK CONCERNING WATER MANAGEMENT

E1. THE ALPINE CONVENTION

The Alpine Convention is a multilateral framework treaty signed in 1991 by the 8 states of the Alpine arc as well as the European Community. Water management is one of the topics in relation to which the Parties of the Alpine Convention committed to take adequate measures (Article 2.2 of the Convention, listing the fields in relation to which the Parties agreed to take measures; Article 2.3 states that the parties will adopt Protocols defining the specific aspects of implementation of the Convention), with the objective of preserving or re-establishing healthy water systems, in particular by keeping lakes and rivers free from pollution. Natural hydraulic engineering techniques should be applied and the use of water power should serve the interests of both the indigenous population and the environment alike (Article 2.2.e) of the Convention).

Eight implementation Protocols have been adopted and are now in force in the countries of the Contracting Parties which have ratified them. Each of these eight Protocols has some bearing or influence on water management in the Alps. As water is one of the essential environmental media, it is normal that it becomes relevant whenever the natural environment, considered in all its aspects, is at stake. In the following the provisions of the existing Protocols relevant to water are briefly described.

Not surprisingly, the Protocol which most directly and frequently refers to water issues, in particular in relation to hydropower production, is the **"Energy"** Protocol. As a general objective, the production, distribution and use of energy must be made compatible by adopting framework conditions and measures, which are adequate to the Alpine region's specific tolerance limits. One of the specific measures to be taken is a prior environmental impact assessment before large new infrastructures are constructed or existing ones are upgraded.

The issue of hydropower production as a renewable source of energy is mentioned in several articles. On the one hand, it is an established fact that the use of renewable sources of energy, including the rational use of water resources, is to be promoted. On the other hand, it is specified that this must not be to the detriment of landscapes or river functions. To this end, several measures need to be taken such as establishing minimum flows, implementing standards for the reduction of artificial fluctuations in water levels and guaranteeing migration of aquatic species.

The Contracting Parties also committed themselves to protecting water resources in areas reserved for drinking water, in protected areas and their buffer zones, in quiet zones as well as in areas of unspoilt nature and countryside. The reopening of disused hydroelectric power stations is preferential to building new ones. The issues of prices for the use of water resources and of compensation for services provided to the local population in the public interest should be examined.

Under the Protocol on **"Spatial planning and sustainable development"** spatial planning and sustainable development policies aim at balancing economic interests with environmental protection. Specific reference is made to the sensible use of natural resources, including water. In practice, this objective is to be achieved by drafting territorial plans and programmes for sustainable development and by subjecting projects, which are likely to have a negative impact on the environment, to environmental impact assessment procedures in the early stage of the decision-making process leading up to the granting of the authorisation. In addition, users of "Alpine resources" (including water) should be charged market prices which reflect the real cost of the supply and use of these resources.

The Protocol on **"Nature Conservation and Landscape Protection"** aims at protecting, preserving and, where necessary, restoring the natural environment, including the natural landscape. Specific reference is made, inter alia, to glaciers and waters in the Alpine territory, the latter being a habitat for fauna and flora which are rich in species. Nature protection is to be achieved, in particular, by the Contracting Parties producing, at regular intervals, inventories on the state of protection in their territories as well as models, programmes and/or plans laying down needs and measures required in order to achieve the objectives of the Protocol.

In the Protocol on **"Mountain Forestry"** it is stated that forests are indispensable, among other things, for the hydrological equilibrium. In addition, forests have a protective function against natural hazards (in particular related to erosion, floods, landslides and avalanches). A sound management of forests therefore contributes in an essential way to the water balance, and vice-versa.

The Protocol on **"Tourism"** requires measures leading to sustainable tourism, which preserves the natural environment. Guidelines, development plans and sectoral plans have to be adopted at the appropriate territorial level in order to enable the impact of tourism development on, inter alia, water to be assessed. This extends to ski slope developments as well. Artificial snow production, in particular may be authorised only if the location's hydrological, climatic and ecological conditions allow it.

Pursuant to the **"Soil Protection"** Protocol, the Alpine soil should be preserved in a sustainable manner in order to allow it to perform its natural functions as it is, inter alia, an integral part of the ecological balance, especially with regard to its waters and nutrient cycles. High moors and lowland moors must be preserved and to this end the use of peat is to be discontinued completely in the medium term; drainage schemes in wetlands and moors shall, in principle, be limited to the upkeep of existing networks; the impact of existing drainage systems shall be remedied. Moor soils shall, in principle, not be used, or used only for agricultural purposes but by leaving their characteristic features intact.
Registers of areas subject to natural risk, such as hydro-geological and hydrological risks as well as maps of areas subject to erosion, have to be established; soil erosion should be limited to the inevitable minimum, and adequate measures (hydraulic, engineering and silvicultural techniques with minimal environmental impact) to prevent erosion shall be implemented. Finally, measures limiting the input of harmful substances into the soil shall be taken, preferably by limiting emissions at source.

As regards the Protocols on **"transport"** and **"mountain farming"**, which do not directly refer to water, it should nevertheless be mentioned that the correct implementation of these Protocols has consequences on the state of waters in the Alps. New transport infrastructures have to be subjected to environmental impact assessment and, in this framework, water-related relevant aspects have to be taken into consideration. Mountain farming, as a general principle, must also be developed in a way which is fully compatible with the environment, including its water compartment as mentioned in the preamble to the respective Protocol.

Finally, all Protocols contain a similar article, requesting that the specific needs highlighted in the individual Protocols are duly taken into account in other policies. This means, therefore, not only that water is an individual concern of the Alpine Convention, but also that water management can impact negatively on the achievement of other goals of the Convention and therefore water management should also take other concerns of the Convention into account, in an integrated way. This "clause of integration" is formulated in different ways in the various Protocols and in some of them it makes specific reference to water. In some of the Alpine Convention Protocols, the reference to water is made explicitly: policies related to the water supply have to take into account the requirements laid out in the Protocols on spatial planning and sustainable development and on tourism; policies on the safeguard of the water balance and of water quality shall take the requirements of the Protocols on nature and landscape protection into consideration; policies on water management shall take account of the requirements of the Protocol on soil protection.

In order to achieve the objectives referred to in Article 2 of the Alpine Convention "the contracting parties should take appropriate measures inter alia in water management; the objective is to preserve or reestablish healthy water systems in particular by keeping lakes and rivers free from pollution by applying natural hydraulic engineering techniques and by using water power, which serves the interests of both the indigenous population and the environment alike"; CIPRA forwarded a proposal for a potential Water Protocol in 2003.

E2. EUROPEAN UNION LEGISLATION

Water policy and management in the area of the Alpine Convention is, to a considerable extent, influenced by the legislation of the European Union (EU) on water. The most important parts of this legislation are the following:

The Water Framework Directive 2000/60/EC

Directive 2000/60[112] was adopted in 2000 and entered into force in 2003. It intends to create a legal framework for water management within the EU and beyond. Its objectives are

- to achieve/maintain good status for all waters, as a rule by 2015, to prevent the further deterioration of water, and protect and enhance the aquatic and terrestrial ecosystems;
- to ensure coordination and cooperation in shared river basins across administrative and political borders;
- to promote the sustainable use of water, based on long-term protection of the available water resources;
- to enhance the protection and improvement of the aquatic environment thorough the progressive reduction of discharges and the phasing-out of discharges, emissions and losses of particularly hazardous substances;
- to progressively reduce groundwater pollution, and
- to contribute to the mitigation of the effects of floods and droughts and
- to ensure widespread information and consultation of the public when developing and reviewing the river basin management plants.

[112] Directive 2000/60 establishing a framework for the Community measures in the field of water policy, OJ EU 2000, L 327 p.1

The Directive applies to surface and groundwater, as well as to coastal waters. It requests the EU Member States to identify the river basins within their territory and to designate river basin districts. Where a river basin concerns more than one country (international river basin districts), coordination and cooperation in developing the river basin management plans is mandatory for and within EU Member States, and endeavours have to be taken to extend such cooperation to countries which are not members of the European Union. For each river basin district, a competent authority shall be identified.
By the end of 2004, the EU Member States had to provide, for each river basin district on their territory or for the part of an international river basin district which is situated on their territory, an analysis of the characteristics of the district, an analysis of the impact of human activities on the state of surface water and of groundwater, an economic analysis of the use of water, a register of the areas which require special protection and all those water bodies which were used for the abstraction of drinking water. These national reports were sent to the European Commission which published an implementation report in 2007[113].

By the same date, Member States had to establish a list of all areas which required special protection. This concerned areas from which drinking water is abstracted including areas intended for the abstraction of drinking water in the future, bathing water areas which came under the field of application of Directive 2006/7, zones vulnerable to nitrates (Directive 91/676/EEC), nutrient sensitive areas (Directive 91/271/EEC) and areas in which fauna and flora are protected (Directives 79/409/EEC and 92/43/EEC).
By the end of 2006, the EU Member States had to establish programmes for monitoring the status of the surface waters and groundwater of each river basin district, in particular the volume, the ecological and chemical status of surface waters and the chemical and quantitative status of groundwater.
On the basis of the analyses and the findings of the monitoring measures, EU Member States will have to develop, by the end of 2009, a programme of measures for each river basin district. The Directive indicates not less than twelve basic measures which must be inserted in such programmes; these include measures to implement EU water legislation, measures to realise the polluter-pays principle in the cost of water, to prevent and mitigate pollution from point and from diffuse sources, to reduce direct discharges of pollutants, to prevent accidental pollution and to introduce effective control measures. Member States are further obliged to fix complementary measures in their programmes if the basic measures do not achieve the environmental objective; the Directive gives a list of possible measures.
Such programme of measures shall be reviewed and, if necessary, updated in 2015 and every six years thereafter.
Furthermore, EU Member States shall develop, for each river basin, a River Basin Management Plan which shall contain the monitoring and control details as well as a number of other steps taken or to be taken, in order to reach the objectives of Directive 2000/60. These management plans shall also be established by 2009; they will be reviewed and updated in 2015 and every six years thereafter.
All plans and programmes must address all human impacts on surface waters and on groundwater as well as being elaborated with intensive public participation, in order to ensure that the balancing of diverging interests in the different stages of implementing Directive 2000/60/EC takes into consideration all the interests at stake and, furthermore, to ensure that the different plans, programmes and measures are subsequently effectively put into operation. The Commission which receives the national plans and programmes, is to assist in coordinating them, publish implementation reports, organise conferences on the Community water policy and shall otherwise promote the integrated approach to water management within the European Union and beyond. Implementation of the Directive is complemented and guided at European level by an unprecedented cooperation of Commission, Member States, EFTA countries, NGOs and stakeholders, the Common Implementation Strategy[114].
The overall aim of the Directive is to reach a good ecological and chemical status of all waters within the European Union as a rule by 2015.
Because aquatic ecosystems vary widely across Europe, experts set up 14 different Geographical Intercalibration Groups (GIGs). Intercalibration, as described in Annex V of the EU Water Framework Directive, ensures that different national systems for the assessment of the status of waters achieve comparable results. For the implementation of the WFD, experts from Italy, France, Germany, Austria and Slovenia collaborated in the Alpine GIG. The results of the expert groups were published in the draft Commission Decision CMT(2008) 343/3 in June 2008.

In articles 16 and 17, the Water Framework Directive leaves two specific elements to ‘Daughter Directives’: establishing environmental quality standards for ‘priority substances’ of EU-wide relevance for surface waters, and defining ‘good chemical status’ for pollutants of EU-wide relevance for groundwater, and defining the criteria for the reversion of upward pollution trends.

[113] Commission Staff Working Document: First report on the implementation of the Water Framework Directive 2000/60/EC, SEC(2007) 362 of 22 March 2007.

[114] http://ec.europa.eu/environment/water/water-framework/objectives/implementation_en.htm

Directive 2006/118/EC on Groundwater

The key objectives and obligations related to groundwater protection are enshrined in the Water Framework Directive

- defining good status in terms of chemistry and quantity (no over-abstraction),
- achieving/maintaining good status, non-deterioration and the reversal of upward pollution trends.

As foreseen in article 17 of the Water Framework Directive, as the Water Framework Directive also applies to groundwater, most of what is said also refers to groundwater:

- Member States had to identify and define groundwater bodies and analyse the pressures and impacts of human activities on their quality, with a view to identifying those groundwater bodies that present a risk of not achieving the good quantitative or chemical status which the Water Framework Directive requires to be reached by 2015.
- Furthermore, Member States had to establish, by 2004, registers of protected areas within each river basin district for those groundwater areas, habitats and species that were directly dependent on water, as well as for those bodies of groundwater which were used for the abstraction of drinking water.
- Member States had to establish, by the end of 2005, networks for monitoring groundwater, in order to obtain an overview of the quantitative status and chemical status of groundwater.
- A programme of measures (clean-up programmes) will have to be established by 2009 which will include, among others, controls on the extraction of groundwater and on artificial recharges of groundwater bodies, regulation of measures with regard to pollution from point and diffuse sources, and prevent direct discharges of pollutants into groundwater. Such programmes must be operational by the end of 2012. They shall be reviewed and updated at least every six years
- The River Basin Management Plan which will also have to be established by 2009, must include a summary of the pressures of human activity on the status of groundwater , a summary of the economic analysis of groundwater use and of protection, monitoring and remediation measures.

Pursuant to Art. 17. of the WFD, the EU adopted a Directive on the protection of groundwater[115] at the end of 2006 which complements the Water Framework Directive by containing more specific measures with regard to groundwater. This Directive will have to be transposed into the law of the EU Member States by early 2009. It establishes criteria and procedures for the assessment of a good chemical status of groundwater (in a first step for nitrates and pesticides, with quality standards identical to those for drinking water) and lays down criteria for the identification and reversal of increasing trends in pollution concentrations in groundwater. The Directive also determines that the programmes of measures, mentioned in Directive 2000/60/EC, shall include measures to prevent or limit the indirect entry of hazardous or other pollutants into groundwater (the direct discharge of pollutants into groundwater is already prohibited under the Water Framework Directive).

Directive on Environmental Quality Standards for Surface waters (adopted, about to be published)

As foreseen in article 16 of the Water Framework Directive, the EU adopted a Directive on environmental quality standards for surface waters[116] in 2008.
It establishes environmental quality standards for 33 substances of EU-wide relevance, as well as an inventory by Member States of emissions, discharges and losses of priority substances and pollutants. The list has to be reviewed regularly.

Directive 91/271/EEC on Urban Wastewater Treatment

The Directive on urban wastewater[117] aims to reduce pollution from urban wastewater at source. It requires EU Member States to

- ensure the collection, in a canalisation system, and treatment of wastewater in all settlement areas ('agglomerations') of more than 2.000 persons[118];
- ensure the secondary (biological) treatment, before discharge, of all wastewater in agglomerations of more than 2.000 persons; a more advanced treatment is required for all agglomerations of more than 10.000 persons located in the catchment of a so-called 'sensitive area' (such areas are largely those suffering from eutrophication or in danger of becoming eutrophic),
- provide for a pre-authorisation of all discharges of industrial wastewater (and where necessary pre-treatment) into the urban wastewater collection systems;
- ensure that wastewater from the food processing industries which is discharged other than into the urban wastewater collection system, respects certain conditions with regard to the protection of the environment;
- monitor the performance of the wastewater treatment plants;
- monitor the quality of the receiving waters;
- control the disposal of sewage sludge and its possible re-use.

[115] Directive 2006/118/EC on the protection of groundwater against pollution and deterioration, OJ EU 2006, L 372 p.19. This Directive, together with Directive 2000/60/EC, substitutes Directive 80/68, OJ EU 1980, L 20 p.43 which will cease to exist in 2013.

[116] http://ec.europa.eu/environment/water/water-dangersub/surface_water.htm

[117] Directive 91/271/EEC concerning urban wastewater treatment, OJ EU 1991, L 135 p.40

[118] The Directive refers to "population equivalents" which "means the organic biodegradable load having a five-day biochemical oxygen demand (BOD5) of 60 g of oxygen demand per day"

Sensitive areas are to be designated by the Member States; they concern in particular, areas, where the water is found to be eutrophic, or where it is used for the production of drinking water. Linked to the Alpine region, such impact may extend well beyond the region itself: the Northern Adriatic, the North Sea, inter alia, adjacent to the estuaries of the River Rhine and the River Elbe, and the north-west part of the Black Sea adjacent to the estuary of the River Danube, are sensitive areas. In high mountainous regions – over 1.500 m above sea level – where low temperatures make effective biological treatment difficult, a less stringent type of treatment than a secondary treatment may be established, provided that detailed studies indicate that such discharges do not adversely affect the environment.
The Directive prohibits the discharge of sewage sludge into surface waters. It provides for a re-use of the treated wastewater and of the sewage sludge, if possible.

Member States had to establish programmes for the implementation of the Directive, regularly update them and have to report to the European Commission on the programmes and on their implementation. The Commission has to regularly elaborate and publish an implementation report[119].

Member States which have joined the European Union since 2004, have received specific transition periods agreed in the different Accession Treaties.

Directive 91/676/EEC on Nitrates in Water pollution from Agricultural Sources

Directive 91/676/EEC aims to protect waters against pollution by nitrates from agricultural sources and thereby to combat the eutrophication of surface waters as well as the pollution of groundwater[120].
The Directive establishes two levels of obligations

- in so-called nitrate vulnerable zones (where either the nitrate content in surface waters or groundwater exceeds or is a risk of exceeding the drinking water quality standard of 50 mg per litre, or where waters are eutrophic), legally binding measures have to be applied via so-called action programmes.
  These entail prohibitions and limitations of manure application in terms of time and location, and, in general, manure application is limited to a maximum of 170 kg nitrogen per hectare and year.
- in other areas, the elaboration and promotion of codes of good agricultural practice is required, which farmers are to apply on a voluntary basis.

[119] See last Commission Staff Working Document: 4th Report on the implementation of the Urban Waste Water Treatment Directive, SEC(2007) 363 of 22 March 2007. This Report covers the period until the end of 2003 and reports on 15 EU Member States only. See also, for a detailed Report on each of the 15 Member States: Commission: Informal Background Document on implementation of the Urban Waste Water Treatment Directive, http://circa.europa.eu/Public/irc/env/ wfd/library?l=/framework_directive/treatment_directive/4th_uwwtd_report/final-circa-

[120] Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources, OJ EU 1991, L 377, p.1.

Limited derogations are possible by Decision of the European Commission. Furthermore, EU Member States have to designate vulnerable zones in their territories according to common EU criteria or apply action programmes throughout their national territory. The decisive criterion for such designation is, whether the nitrate content in the surface waters or in the groundwater of a zone exceeds or is at risk of exceeding 50 mg per litre, or whether the waters are eutrophic. Member States then have to elaborate action programmes for these vulnerable zones. The action programmes shall, in particular, ensure that the amount of livestock manure which is applied to the land each year does not exceed 170 kg of nitrogen (N) per hectare; furthermore, the programmes shall, inter alia, determine periods, where the land application of certain fertilisers is generally prohibited.
If requested, the European Commission, may grant a derogation, not, however with regard to the environmental objective of the Directive (no eutrophication and/or no nitrate concentration above drinking water standards), but only concerning the permitted maximum manure application of 170 kg per hectare and year. Amongst the countries in the Alpine region, Austria obtained a derogation of this nature for the period from 2006 until 2007 which permitted, under certain circumstances, an application of 230 kg of nitrogen per hectare on land. However, fewer than 10 farms made use of this[121].
Member States have to report to the Commission regularly on the implementation of the Directive and on the state of the surface waters and groundwater in vulnerable zones as well as on the results of the monitoring and on the effects of the action programmes. The Commission publishes an EU report at regular intervals. The most recent one concerned the period from 2000 until 2003; it covered the fifteen States which were, at that time, Member States of the European Union[122].

Directive 2006/7/EC on Bathing Waters

Bathing waters have been the subject of EU legislation since 1975[123]. In 2006, the existing legislation was replaced by the new Directive 2006/7[124] which entered into force in March 2008. The previous Directive 76/160 will not completely disappear until 2014; however, as soon as a Member State has adopted all the necessary legal, administrative and practical measures with regard to Directive 2006/7, the new provisions will apply.
Bathing waters are waters where the competent authorities of Member States expect a large number of bathers and have not prohibited or permanently advised against bathing; swimming pools and spa pools are not included in this definition. Member States shall identify bathing waters every year. During the bathing

[121] Decision 2006/189, OJ EU 2006, L 66 p.44.

[122] Commission: Report on implementation of Directive 91/676/EEC (period 2000-2003), COM(2007)120 of 19 March 2007.

[123] Directive 76/160 on the quality of bathing waters, OJ EU 1976, L 31 p.1.

[124] Directive 2006/7 concerning the quality of bathing waters, OJ EU 2006, L 64 p.37.

season, they shall normally take four samples, in order to test the quality of the bathing water. The Directive determines two microbiological indicators of faecal contamination as parameters for the quality, Escherichia coli and intestinal Enterococci, for which maximum concentrations are laid down in the Directive; samples taken during a short-term pollution period – up to three days - shall not be taken into consideration.
At the end of each bathing season, an assessment of the bathing water quality is carried out. This normally takes into consideration the results of the sampling during the current and the preceding three bathing seasons. The bathing water is then classified as excellent, good, sufficient, or poor; for each of these categories, classification criteria are laid down in the Directive. The first classification of bathing waters is to be made by 2015; by then, all bathing waters shall be at least of "sufficient" quality.
These provisions constitute a considerable change with regard to the requirements of Directive 76/160 which is likely to remain in force for a number of years. Directive 76/160 requires the monitoring of 19 pollutants or other parameters during the bathing season, and requires that samples of the bathing water be taken every fortnight during the bathing season. The results are to be collated at the end of each bathing season and sent to the European Commission. An EU-wide annual report on the quality of bathing waters is to be published before the start of the bathing season in the following year[125]. From 2008 on, this data on the quality of bathing water will be available in an interactive format on the server of the European Environment Agency[126].

Directive 98/83/EC on Drinking Water

The objective of this Directive[127] is to protect human health from the adverse effects of any contamination of water that is intended for human consumption. It lays down

- maximum admissible concentrations for 48 microbiological and chemical substances, such as nitrate, lead, iron, manganese or other heavy metals, pesticides or coliforms; limited derogation is possible, subject to a series of conditions;
- an obligation for Member States to regularly monitor drinking water supplied to consumers or used by the food production industry. The quality of the drinking water is normally assessed at the point where the water emerges from the tap.
- an obligation to inform consumers regularly about the quality of their drinking water, and
- an obligation to report every three years on the quality of drinking water. The European Commission shall publish, every three years, a synthesis report on the quality of drinking water in the European Union[128].

Directive 2007/60/EC on Flood Risks

At the end of 2007, the European Union adopted a directive on the assessment and management of flood risks[129]. EU Member States have to transpose this Directive into their national legislation by November 2009.

The provisions of the Directive will have to be progressively implemented. By 2011, EU Member States will have to undertake a preliminary flood risk assessment of their river basins and coastal zones, with the aim of identifying those areas where a potential flood risk exists. In those zones, Member State will then have to elaborate flood hazard maps and flood risk maps by 2013. These maps shall identify areas which could be flooded, differentiating between a low, medium and high probability of such flooding. They shall also show the extent of the likely flood, the potential adverse effect on humans and on the environment, the number of people living in the zone, economic activities in the zone and other relevant information.

By the end of 2015, Member States will then have to draw up flood risk management plans for the identified zones. These plans have to include measures which reduce the probability of floods and their adverse consequences. They shall pay particular attention to flood prevention measures, to measures to mitigate their adverse effects and prepare the public in the identified zones for flood events and advise them of the appropriate behaviour in such a case. Flood risk management plans shall not include measures which significantly increase flood risks in a neighbouring country of the same river basin, unless such measures have been agreed upon by the States concerned previously. Coordination of the flood risk management plans shall take place among the States belonging to the same river basin, with the European Commission assisting, where necessary, in such coordination.

Directive 2008/1/EC on Integrated prevention and Reduction of Pollution (IPPC Directive)

This Directive (originally adopted as Directive 96/61/EC) addresses key industrial plants from a range of sectors, such as energy industries, production and processing of metals, mineral industry, chemical industry, waste management, pulp and paper industries and larger animal husbandry (pigs and poultry). For certain industrial sec-

[125] Commission: Quality of bathing waters. 2007 bathing season. Summary reports. Luxembourg 2008. The summary is available in 22 languages, the reports of the different Member State in English only. http://ec.europa.eu/environment/water/water-bathing/report_2008.html
[126] http://www.eea.europa.eu/themes/water/mapviewers/bathing
[127] Directive 98/83 on the quality of water intended for human consumption, OJ EU 1998, L 330 p.32.
[128] See the most recent report: Commission: Synthesis report on the quality of drinking waters in the Member States of the European Union in the period 1996-1998 (2002)
http://ec.europa.eu/environment/water/water-drink/pdf/report96_98.pdf.
[129] Directive 2007/60 on the assessment and management of flood risks, OJ EU 2007, L 288 p.27.

tors, thresholds are set above which the Directive applies.
All such plants are subject to a permit procedure, where the permit must be based on best available techniques. As far as existing plants are concerned, there was a transition period until 31/10/2007 to enable them to comply with the provisions.
Best available techniques are developed and published in so-called BREF documents for the industrial sectors covered[130].

Other Directives

Depending on specific circumstances, other Directives or Regulations not primarily addressing water issues may become relevant for water management. This is the case with regard to projects or plans and programmes falling under the province, of Directive 85/337/EEC on environmental impact assessments of certain private and public projects or of Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment, respectively. In addition, programmes or activities impacting directly or indirectly on the water values of Special Areas of Conservation or Special Protection Areas (Natura 2000 sites) may require an assessment of the implications pursuant to Article 6 (2 to 4) of Directive 92/437EC on the conservation of natural habitats and of wild fauna and flora.

E3. OTHER INTERNATIONAL CONVENTIONS AND WATER MANAGEMENT IN THE ALPINE REGION

UN-ECE Convention of the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention)[131]

Before the adoption of the EU-Water framework directive (WFD), the UN-ECE (United Nations Economic Commission for Europe) Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) already set a milestone for transboundary water management in the European region. This convention, ratified by all Alpine Convention member states (apart from Monaco) and the European Union, intends to strengthen national measures for the protection and ecologically sound management of transboundary surface waters and groundwater. With respect to its strong transboundary river basin perspective it can be regarded as a precursor of the WFD.
The Convention obliges Parties to prevent, control and reduce water pollution from point and non-point sources. The Convention also includes provisions for monitoring, research and development, consultation, warning and alarm systems, mutual assistance, institutional arrangements, and the exchange and protection of information, as well as public access to information.

Under the Convention, the Protocol on Water and Health was adopted in London on 17 June 1999, and the Protocol on Civil Liability was adopted in Kiev on 21 May 2003. The Protocols have, however, not yet been ratified by all countries.

Protocol on Water and Health

The main aim of the Protocol is to protect human health and well-being by better water management, including the protection of water ecosystems, and by preventing, controlling and reducing water-related diseases. The Protocol is the first international agreement of its kind adopted specifically to attain an adequate supply of safe drinking water and adequate sanitation for everyone, and effectively protect water which is used as a source of drinking water.
To meet these goals, its Parties are required to establish national and local targets for the quality of drinking water and the quality of discharges, as well as for the performance of the water-supply and wastewater treatment systems. They are also required to reduce outbreaks of and the incidence of water-related diseases.
This Protocol introduces a social component into cooperation on water management. Water resources management should link social and economic development to the protection of natural ecosystems. Moreover, improving the water supply and sanitation is fundamental in breaking the vicious cycle of poverty.

Protocol on Civil Liability

The Protocol on Civil Liability and Compensation for Damage Caused by the Transboundary Effects of Industrial Accidents on Transboundary Waters will give individuals affected by the transboundary impact of industrial accidents on international watercourses (e.g. fishermen or operators of downstream waterworks) a legal claim to adequate and prompt compensation.

Companies will be liable for accidents at industrial plants, including tailing dams, as well as during transport via pipelines. Physical damage, damage to property, loss of income, the cost of reinstatement and response measures will be covered by the Protocol. The Protocol sets limits on financial liability depending on the risk of the activity, i.e. the quantities of the hazardous substances that are or may be present and their toxicity or the risk they pose to the environment. To cover this liability, companies will have to establish financial collateral, such as insurance policies or other guarantees. The Protocol will ensure the non-discrimination of victims: victims of the transboundary effects cannot be

[130] http://eippcb.jrc.ec.europa.eu/pages/FActivities.htm
[131] http://www.unece.org/env/water/

treated less favourably than victims from countries in which the accidents occurred. The Protocol fills one of the major gaps in international environmental legislation and solves the problem of uncompensated damage in neighbouring countries.

Moreover, by encouraging companies to take measures to prevent damage for which they will henceforth be liable, the Protocol will help to prevent accidents from happening in the first place and limit their adverse effects on people and on the environment. The limits on financial liability and the minimum amount of financial collateral have been agreed by all the parties to the negotiations, including the insurance sector, and are therefore realistic and appropriate. Furthermore, the negotiators have drafted the agreement in such a way as to reduce the obstacles to ratification, taking into account the experience with other international civil liability instruments which failed to be implemented.

E.4 WATER MANAGEMENT LEGISLATION IN SWITZERLAND AND LIECHTENSTEIN

A comparison between the Swiss water legislation and the EU-Water Framework Directive[132] came to the conclusion that as far as water protection matters are concerned, both are based on similar principles and follow the same general approaches, enabling coordinated cooperation where necessary. This statement is underpinned by water protection programmes between Switzerland and its neighbouring countries, both programmes which have already been realised and ongoing ones.
The same applies with respect to flood protection policy.

Liechtenstein implements the EU legislation on water, following the integration of key elements of EU water legislation into the European Economic Area Agreement[133].

Concluding Remarks

(1) A comprehensive set of legislation in the framework of the European Union, the Alpine Convention but also within Switzerland as well as transboundary agreements are in place.

(2) Water management with regard to EU legislation is largely based on EU directives. While it is binding as regards the results to be achieved, it leaves EU Member States the necessary discretion in approaching the different water management and environmental challenges. A particularly good example thereof is the EU Water Framework Directive, which obliges Member States to tailor objectives related to the quality of surface water bodies according to their special characteristics.

(3) This framework character is underlined and strengthened by the fact that all water legislation is based on Article 175(1) EC Treaty which provides for majority decisions, but which allows Member States to maintain or introduce more stringent measures to protect their aquatic environment.

(4) All directives follow the pattern of
- identifying the environmental and other problems with regard to the water;
- adopting clean-up and management plans and programmes to address the identified problems;
- monitor the different water bodies in order to prevent new pollution or other problems. Transition periods and limited derogation possibilities allow for specific local or unforeseen circumstances to be taken into account;

(5) The implementation of the EU provisions is the task of the EU Member States. The European Commission has to ensure that the provisions are actually applied and has, in this regard, a surveillance function as well as the right to submit applications to the European Court of Justice under article 226 of the Treaty. The participation of the public in decisions regarding plans, programmes and projects, as well as the publication of implementation reports ensure transparency in decision-making and application of the water management measures.

(6) In EU states the implementation of the Water Framework Directive and the establishment of River Basin Management Plans are under way in order to achieve good status by 2015.

(7) The daily practical enforcement and implementation is a particular challenge.

(8) Commissions specific to individual rivers are in place for all transboundary river catchments.

(9) The EU legislation is in compliance with the provisions of Article 2 (2) of the Alpine Convention. The latter mentions the objective of preserving and reestablishing healthy water systems.

[132] EG-Wasserrahmenrichtlinie und Schweizer Wasser- und Gewässerschutzgesetzgebung - eine Gegenüberstellung: Peter Rey, Edwin Müller , Bern, 2007; see also http://www.bafu.admin.ch/wasser/01444/01995/index.html?lang=de (available only in german)
[133] http://www.efta.int/content/legal-texts/eea/annexes/annex20.pdf

F MAJOR WATER MANAGEMENT ISSUES AND THE MAIN CHALLENGES FOR THE FUTURE

The Alps contribute a disproportionately high share of water compared to the catchment area, which is fed into large European river systems. This is the reason why water from the Alps is of vital importance for the surrounding extra-Alpine regions and also for large parts of Europe. Furthermore, the Alps are still one of the largest continuous areas on the continent with outstanding unique and diverse natural habitats. Ever growing pressures caused by man are increasingly threatening this heritage and the ecological functioning of watercourses.
Sound water management is one of the objectives of the Alpine Convention laid down in its Article 2(2). A number of Protocols in force already address water-related issues. Water is also mentioned as one of the topics in the multiannual work programme of the Alpine Conference. A specific initiative was initiated in 2006 in the form of international conferences ("the Water Balance in the Alps", Innsbruck October 2006, Munich October 2008). Finally, water as a cross-cutting issue is of relevance in relation to the Action Plan of the Alpine Convention on climate change. In this plan that was adopted at the Ministers' Conference in March 2009 in Evian, several measures on water were defined, such as reducing water consumption, improving the use of water and reducing the impact of hydro-electric plants on the environment. With these priorities, the objectives (reinforce the implementation of the Water Frame Directive, prevent water shortage, develop plants according to the ecology of water streams) must be implemented specifically in the Alps in the coming years.
It has clearly been demonstrated in the previous chapters that a broad range of water management issues have to be tackled in the Alpine region in order to address the pressures. Nature and the extent of challenges concerning water management are quite diverse within the Alpine perimeter due to differences in climate, geology, topography, land use, the intensity of settlement areas, history, or the socio-economic background. Pressures and impacts which are considered to be a major challenge at local or at regional level do not necessarily emerge in other regions, nor are they necessarily a major issue for the whole Alpine space.
Concrete examples for this broad range of issues, whose relevance varies according to local and regional conditions, include

- the chemical quality of water, where the national contributions based on the results of the dense monitoring network already in place show a low level of pollution due to (comparatively) low(er) pressures for most surface waters and for groundwater. Additionally, mitigation measures were taken in the past and low concentrations of pollutants can also be explained by the high dilution of chemical substances due to high precipitation and river discharges. Nevertheless, some problems were reported, mainly localised on the outskirts of the Alpine region in areas with industry, intensive land use and agriculture.
- problems with regard to the availability of water. The overall picture provides a real abundance of water due to high precipitation in the entire region, which as a consequence, is characterised as "The Water Tower of Europe". Nevertheless, the national reports, case studies and scientific studies cited clearly reveal the existence of problems occurring at a local level in the Alpine region, leading to conflicts among water users and to negative ecological impacts. The reasons for this may be quite diverse, covering the full range of water abstraction - for irrigation purposes, the production of artificial snow, for the drinking water supply during the peak tourist season together with natural low water availability in winter or periods of occasional droughts in summer. This is particularly relevant in the southern part of the Alps and is also a consequence of climate change.

Major water management issues

Looking at the entire Alpine region, the assessment of the national contributions in the previous chapters provides a clear picture of the major water management issues and efforts which are shared by all Alpine countries or at least by most of them. In particular they include the overriding need

- to provide **integrated risk management against natural hazards**, as the high sums spent each year on this particular field indicate,
- for EU Member States to implement and update river basin management plans according to the time schedule of the EU Water Framework Directive including coordination with non-EU countries
- to find ways and approaches of using hydropower without impairing river ecology and river hydro-morphology to an excessive extent, with a particular focus on preserving the remaining rivers and river stretches which are still unspoilt,
- **to remediate the hydromorphological impacts of the past** due to flood protection measures and hydropower plants and here, in particular, to restore river continuity, to improve the lateral connectivity of rivers with their surrounding terrestrial habitats and groundwater bodies, to provide an ecologically sound quantity of residual water, to reduce the negative effects of hydro-peaking and last but certainly not least

- to **adapt to the consequences of climate change** in spite of all efforts to mitigate the causes of the ongoing change. Based on modelling results, it is predicted – depending on the contemplated region – that more or less pronounced changes will occur in temperature and precipitation which will result in impacts on the water balance. Forecasted changes may therefore
  - increase the risk and impact of natural hazards, including, in particular, flooding and, where relevant, rock falls due to the warming up of permafrost, and therefore require enhanced efforts for integrated risk management beyond the high level of efforts already being undertaken
  - increase periodical problems with droughts and water scarcity - in particular in the southern and south-eastern parts of the Alpine range - which may require enhanced efforts in the management of water quantity also involving paying attention to downstream needs,
  - impact water availability due to changing runoff from glaciers and snow cover,
  - impact the already exploited amount of hydropower generation via changes in the water balance as well as efforts to increase hydropower generation in line with the EU target of increasing energy efficiency, reducing greenhouse gas emissions and increasing the share of renewable energy each by 20%, thus potentially endangering those river stretches which are still close to natural conditions,
  - have an impact by increased pressures (like artificial lakes and related skiing infrastructures), including increased water and energy requirements for artificial snow production.

Main challenges for the future

In order to assess the need for action, it is necessary to take note of the current situation in terms of policy response to the main issues which have been identified.
With regard to natural hazards, as demonstrated in the report, technical approaches and solutions have been in place for some time to find a sound balance between the ecological needs of rivers and new flood protection measures. The concept of providing more “space for the river” is state-of-the-art and has been put into place with the exception of cases where a lack of space imposes clear limits.
The same applies to the hydropower sector. As shown in the report, viable approaches can lessen impacts on river ecology and are already in place or on the way for the hydropower sector and can be taken as inspiring examples for other hydropower plants which were built in the past. Sound ecological residual water requirements and fish passes, tailor-made for the local situation, have gradually become standard and state-of-the-art for the authorisation of new water-use grants and plants or for renewals of existing permits.
Overall, the review of the legal framework in chapter E has revealed that a broad range of key water legislation has been put in place since the adoption of the Alpine Convention in 1991. The new framework is largely based on EU water legislation for EU member states. The approach followed by Switzerland also takes the vision of “Integrated Water Resource Management” into account, as is the case for EU countries as well. Key acts include legislative instruments for targeting point as well as diffuse sources of pollution in addition to EU legislation on Environmental Impact Assessment.
According to the EU Water Framework Directive, clear ecologically oriented targets, tailor-made to the specific type of surface waters have to be met within an ambitious timeframe. Its objective of no deterioration of the status of surface waters and groundwater and its broad legal framework for water management are already in place or in the course of being implemented. The hydrological basin, to which the Water Framework Directive pays attention as a management unit, is considered to be an ideal spatial reference and also a milestone for modern water management. Furthermore, the explicitly type-specific approach differentiates the special conditions in Alpine countries to a sufficient extent.
Furthermore – complementary to this new legal framework - a comprehensive set of bi- and multilateral agreements ensures transboundary as well as basin-wide multilateral coordination of approaches and solutions to water management issues.
Last but not least, an additional set of provisions already enshrined within the framework of the Protocols to the Alpine Convention also target specific water issues (e.g. hydropower production in the energy Protocol; artificial snow production in the tourism Protocol).
The assessment of the existing legal framework (EU legislation, bilateral and multilateral Conventions such as the Alpine Convention) shows that, overall, a comprehensive set of provisions and instruments is in place.
Against the background of this set of legislation, which is in place, and taking ongoing work on river basin management in line with the provisions of the EU water framework Directive into account, it emerges that the challenges identified can be tackled by making use of existing instruments.
Rather than producing a new water-specific piece of legislation for the Alpine region at this stage in order to overcome potential gaps resulting from a lack of ratification of Protocols or from a lack of implementation of EU legislation, it is of major importance to ensure that efforts to implement the existing rules are continued and intensified in order to reflect properly the variety and intensity of issues at stake in the different Alpine regions.

By way of conclusion, the following can be recommended:

- To ensure the proper implementation and reinforce the ways of implementing existing legislation (including, inter alia, socio-economic aspects resulting from Article 7 of the Energy Protocol, Article 11 of the Protocol on Spatial Planning and recovery of costs for water services - Article 9 Water Framework Directive),

- to follow up the implementation of the EU Water Framework Directive with the focus on hydro-morphology, river continuity and achieving synergies in relation to the need to provide more space for rivers; but equally taking into account, when setting up the River Basin Management Plans, the need to adapt to the impacts of climate change as recommended in the CIS policy paper on climate change of the EU water directors and the European Commission from June 2008,
- to assess the ongoing developments in the hydropower sector and the benefits resulting from further exploitation of hydropower generation against its impact on nature and hydro-morphology. In doing this, particular attention should be paid to the assessment of small hydropower plants and their relative contribution to meet targets of renewable energy production,
- to consider knowledge which is already available on the effects of climate change when designing new plants with a long service life such as hydropower plants or flood control works in order to make them "climate proof",
- to quantify the effects of climate change on water management issues in more detail, to adapt interregional models due to the high diversity of conditions in the different regions within the Alpine perimeter and in particular to translate forecasted changes of temperature and precipitation into hydrological parameters (e.g. river flows) for the entire network of surface waters and finally
- cooperation between the various parties in the scientific community with regard to ongoing efforts and the involvement of the whole water management sector should be further enhanced with a view to finding viable approaches on how to deal with Alpine research in the future, as well.

An idea emerging from the conference in Munich and considered worthwhile to be pursued was the setting up of a platform for water management, similar to PLANALP, which could inter alia serve for the exchange of best practice examples or for a proper follow-up of recommendations listed above. The official decision for the creation of the platform was adopted in March 2009 at the Xth Alpine Conference.

A broad range of additional potential issues which could be addressed by this platform was put forward at the Munich conference and in the comments received afterwards, respectively. Such proposals cover, inter alia, the elaboration of guidelines for ecological and economical aspects of hydropower generation, guidelines for residual water, an enhanced involvement and closer cooperation between the research communities and administration in water issues with regard to climate change and biodiversity, a review of forthcoming River Basin Management Plans with regard to whether specific Alpine issues have been taken into account appropriately or not or the extension of monitoring networks.

The platform will comprise of the representants of the Parties of the Alpine Convention as well as relevant active stakeholders in science, economy and NGOs.

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Photo F-1: Pristine waters of the Alps are the treasury of the Europe for coming climate change water shortages. Alpine water treasure. Dvojno jezero, Triglav National Park, Slovenia.

EXISTING LEGAL FRAMEWORK CONCERNING WATER MANAGEMENT			
Category	**Topic**	**EU Legislation in Place for Austria, France/Monaco, Germany, Italy, Liechtenstein and Slovenia**	**Similar National Legislation in Switzerland**
General Framework	Framework in the Field of Water Policy	- Directive 2000/60/EC - Water Framework Directive	- Article 76 of the Swiss Federal Constitution of 18.04.1999 (SR 101) - Federal Law on Water Protection of 24.01.1991 (SR 814.20)
	Assessment and Management of Floods	- Proposal for a Directive on the Assessment and Management of Floods	- Federal Law on Hydraulic Engineering of 21.06.1991 (SR 721.100) - Ordinance on Hydraulic Engineering of 2.11.1994 (SR 721.100.1)
	Nature Protection and Conservation	- Directive 85/337/EEC - Assessment of the Effects of Certain Projects on the Environment - Directive 92/43/EEC - Habitats Directive Directive 79/409/EEC - Birds Directive - Directive 2001/42/EC (SEA Directive)	- Federal Law relating to the Protection of the Environment of 7.10.1983 (SR 814.01) - Ordinance on Environmental Impact Assessment of 19.10.1988 (SR 814.011) - Federal Law on the Protection of Natural and Cultural Heritage of 1.07.1966 (SR 451) - Federal Law on Hunting of 20.06.1986 (SR 922.0) - Ordinance on Hunting of 29.02.1988 (SR 922.01) - Federal Law on the Protection of Natural and Cultural Heritage of 1.07.1966 (SR 451)
Specific Uses of Water	Drinking Water	- Directive 98/93/EC on the Quality of Water Intended for Human Consumption	- Annex 2 letter 2 of the Water Protection Ordinance of 28.10.1998 (SR 814.201) - Law on Foodstuffs of 9.10.1992 (SR 817.0) - Federal Department of the Interior Ordinance on Drinking Water, Water from Sources and Mineral Water of 23.11.2005 (SR 817.022.102) - Ordinance on Foreign Substances and Content Substances of 26.06.1995 (SR 817.021.23)
	Bathing Water	- Directive 2006/7/EC - Management of Bathing Water Quality and Repealing Directive 76/160/EEC	- Water Protection Ordinance of 28.10.1998 (SR 814.201)
	Water Suitable for Fish-Breeding	- Directive 2006/44/EC - Fish-Breeding Directive	- Federal Law on Fisheries of 21.06.1991 (SR 923.0) - Ordinance concerning the Federal Law on Fisheries, of 24.11.1993 (SR 923.01)
Release of Substances	Quality of Surface Water	- Proposal for a Directive on Environmental Quality Standards Decision 2455/2001/EC - List of Priority Substances	- Federal Law on Water Protection of 24.01.1991 (SR 814.20) - Water Protection Ordinance of 28.10.1998 (SR 814.201)
	Protection of Groundwater	- Directive 2006/118/EC - Groundwater Directive Directive 80/68/EEC - Protection of Groundwater Against Pollution Caused by Certain Dangerous Substances	- Federal Law on Water Protection of 24.01.1991 (SR 814.20) - Water Protection Ordinance of 28.10.1998 (SR 814.201)
	Urban Waste Water	- Directive 91/271/EC - Urban Waste Water Treatment Directive	- Federal Law on Water Protection of 24.01.1991 (SR 814.20); - Water Protection Ordinance of 28.10.1998 (SR 814.201)
	Pollution from Agricultural Sources	- Directive 91/676/EEC - Nitrates Directive - Directive 86/278/EEC - Sewage Sludge Directive - Directive 91/414/EEC - Plant Protection Products	- Federal Law on Water Protection of 24.01.1991 (SR 814.20) - Water Protection Ordinance of 28.10.1998 (SR 814.201) - Annexes 2.5 and 2.6 of the Ordinance on Chemical Risk Reduction of 18.05.2005 (SR 814.81)
	Others	- Directive 96/61/EC - IPPC Directive - Directive 2006/11/EC - Dangerous Substances - Directive 96/82/EC and Amending Directive - Seveso Directive - Directive 2006/507/EC - Persistent Organic Pollutants	- Federal Law relating to the Protection of the Environment of 7.10.1983 (SR 814.01) - Ordinance on Chemical Risk Reduction of 18.05.2005 (SR 814.81) - Ordinance on Protection against Major Accidents of 27.02.1991 (SR 814.012) - Ordinance on Chemical Risk Reduction of 18.05.2005 (SR 814.81)

Annex 1: Existing Legal Framework concerning Water Management

Bi- and Multilateral Agreements for Trans-Boundary and Basin-Wide Water Management in the Alpine Area

#	Contracting States (of AC-Countries)	Waters	Year	Title of agreement	Commission
1	A, CH, D, FL	Lake Constance	1960	Übereinkommen über den Schutz des Bodensees gegen Verunreinigungen (Agreement for the protection of Lake Constance against pollution)	Internationale Gewässerschutzkommission für den Bodensee http://www.igkb.de/ (International commission for the protection of Lake Constance)
2	A, CH	River Inn	2003	Abkommen zwischen der Republik Österreich und der Schweizerischen Eidgenossenschaft über die Nutzbarmachung des Inn und seiner Zuflüsse im Grenzgebiet (Agreement between the Federal Republic of Austria and the Swiss Confederation on the utilisation of the river Inn and its tributaries in the border region)	Österreich-Schweizerische Kommission für die gemeinsame Nutzung des Oberen Inn (Austrian-Swiss commission for the common use of the upper Inn)
3	A, CH	River Alpenrhein	1892	Staatsvertrag zwischen der Schweiz und Österreich-Ungarn über die Regulierung des Rheines von der Illmündung stromabwärts bis zur Ausmündung desselben in den Bodensee (Treaty between Switzerland and Austria-Hungary on the regulation of the river Rhine from the estuary of the river Ill downstream to Lake Constance)	Internationale Rheinregulierung http://www.rheinregulierung.at/ (International regulation of the river Rhine)
4	A, I, D, SL (CH*) *cooperation	River Danube	1998	Übereinkommen über die Zusammenarbeit zum Schutz und zur verträglichen Nutzung der Donau (Donauschutzübereinkommen) (Agreement on the co-operation for the protection and the reconcilable utilisation of the River Danube)	Internationale Kommission zum Schutz der Donau http://www.icpdr.org/ (International commission for the protection of the Danube river)
5	A, D	Danube Catchment	1991	Vertrag zwischen der Republik Österreich einerseits und der Bundesrepublik Deutschland und der Europäischen Wirtschaftsgemeinschaft andererseits über die wasserwirtschaftliche Zusammenarbeit im Einzugsgebiet der Donau (Treaty between the Federal Republic of Austria on the one hand and the Federal Republic of Germany and the European Economic Community on the other hand concerning the co-operation in the field of water management regarding the river Danube catchment area)	Ständige Gewässerkommission nach dem Regensburger Vertrag (Standing commission for water protection according to the treaty of Regensburg)
6	A, SL	River Drau	1954	und der Regierung der Föderativen Volksrepublik Jugoslawien über wasserwirtschaftliche Fragen an der Drau vom 25. Mai 1954, welches am 15.01.1955 in Kraft getreten ist (Agreement between the Federal Republic of Austria and the Federal Government of the People's Republic of Yugoslavia on water management questions at the Drava river from 25th May 1954, coming into force on 15th January 1955)	Österreichisch-Slowenische Kommission für die Drau (Austrian-Slovenian commission for the Drava river)

Annex 2: Bi and Multilateral Agreements for Trans-Boundary and Basin-Wide Water Management in the Alpine area

Bi- and Multilateral Agreements for Trans-Boundary and Basin-Wide Water Management in the Alpine Area

#	Contracting States (of AC-Countries)	Waters	Year	Title of agreement	Commission
	A, SL	River Drau	1993	Notenwechsel zwischen der Österreichischen Bundesregierung und der Regierung der Republik Slowenien betreffend die Weiteranwendung bestimmter österreichisch-jugoslawischer Staatsverträge (Exchange of notes between the Federal Republic of Austria and the Government of the Republic of Slovenia on the ongoing appliance regarding certain Austrian-Yugoslavian treaties)	
7	A, SL	River Mur	1956	Abkommen zwischen der Republik Österreich und der Föderativen Volksrepublik Jugoslawien über wasserwirtschaftliche Fragen der Mur-Grenzstrecke und der Mur-Grenzgewässer (Mur-Abkommen) (Agreement between the Federal Republic of Austria and the Federal People's Republic of Yugoslavia on water management questions regarding the river Mur borderline and the river Mur border-watercourses (Mur agreement)	Österreichisch-Slowenische Kommission für die Mur Austrian-Slovenian commission for the river Mur
8	F, CH	Lake Geneva	1963	Abkommen zwischen dem Schweizerischen Bundesrat und der Regierung der Französischen Republik betreffend den Schutz der Gewässer des Genfersees gegen Verunreinigung (Agreement between the Swiss Federal Council and the French Republic on the protection of Lake Geneva against pollution)	CIPEL : Commission internationale pour la protection des eaux du Léman (http://www.cipel.org) (International Commission for the Protection of Lake Geneva)
9	I, CH	Italian-Swiss-Waters	1972	Abkommen zwischen der Schweiz und Italien über den Schutz der schweizerisch-italienischen Gewässer gegen Verunreinigung (Agreement between the Swiss Confederation and the Italian Republic on the protection of the Swiss-Italian Waters against pollution)	CIPAIS: Commissione Internazionale per la Protezione delle Acque Italo-Svizzere (http://www.cipais.org/) (International Commission for the Protection of the Italian-Swiss Waters)
10	CH, F, D, L, NL	River Rhine	1999	Übereinkommen zum Schutz des Rheins (Convention on the Protection of the Rhine)	IKSR - Internationale Kommission zum Schutz des Rheins http://www.iksr.org/ (International Commission for the Protection of the Rhine)
11	CH, F	River Doubs	1993	Abkommen zwischen dem Schweizerischen Bundesrat und der Regierung der Französischen Republik über die Ausübung der Fischerei und den Schutz des aquatischen Lebensraumes im Grenzabschnitt des Doubs (Agreement between the Swiss Federal Council and the French Republic on the exercise of fishery and the protection of aquatic environment in the border section of the River Doubs)	Commission internationale pour la pêche dans le Doubs (International Commission on the fishery in the River Doubs)
12	CH, A, FL	River Alpenrhein	1998	Kooperationsvereinbarung Alpenrhein (Cooperation agreement Alpenrhein)	nternationale Regierungskommission Alpenrhein http://www.alpenrhein.net/ (International governmental commission for the Alpenrhein)

Annex 2: Bi and Multilateral Agreements for Trans-Boundary and Basin-Wide Water Management in the Alpine area

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