alpenkonvention • convention alpine
convenzione delle alpi • alpska konvencija
www.alpconv.org

Facing droughts in the Alpine region

Experiences, approaches and common challenges

Expert Paper by the "Water Management in the Alps" Platform

Imprint

Author

Water Management in the Alps Platform of the Alpine Convention in the mandate period 2017-2018

Presidency of the Platform

Paolo Angelini; Italian Ministry for the Environment, Land and Sea
Luka Stravs; Slovenian Ministry of the Environment and Spatial Planning

Members of the Water Management in the Alps Platform

Austria: Christian Schilling and Karl Schwaiger (Federal Ministry of Sustainability and Tourism)
France: Benoit Terrier (Rhone-Mediterranean and Corsica Water Agency), Martine Lami (MEEM/DGALN/DEB)
Germany: Christian Wanger and Tobias Hafner (Bavarian State Ministry of the Environment and Consumer Protection), Ronja Wolter-Krautblatter (Bavarian Environment Agency)
Italy: Andrea Bianchini (Italian Ministry for the Environment, Land and Sea), Rolando Pozzani (International Institute Ligurian Studies), Raffaele Rocco (Autonomous Region Valle d'Aosta/Vallè d'Aoste), Rudolf Pollinger and Willigis Gallmetzer (Autonomous Province of Bolzano/Bozen)
Liechtenstein: Elija Kind (Office of Environment)
Slovenia: Maja Jelen (Slovenian Ministry of the Environment and Spatial Planning)
Switzerland: Ulrich Sieber (Federal Office for the Environment)
CIPRA International: Serena Arduino, Martha Dunbar
WWF: Elisabeth Sötz, Neza Posnjak
ISCAR: Leopold Füreder, Thomas Scheurer
AEM: Simon Beerens-Bettex
Alpine Space Programme: Primož Skrt
Arge Alp: Sara Verones
Permanent Secretariat of the Alpine Convention: Taja Ferjančič Lakota

Experts that have collaborated to this report

Austria: Christian Schilling (Federal Ministry of Sustainability and Tourism)
Germany: Christian Wanger and Andreas Kolbinger (Bavarian State Ministry of the Environment and Consumer Protection), Hannah Berger, Maria Foltyn, Holger Komischke and Ronja Wolter-Krautblatter (Bavarian Environment Agency)
France: Jerome Crosnier (Direction régionale de l'Environnement, de l'Aménagement et du Logement Auvergne-Rhône-Alpes)
Italy: Andrea Bianchini (Eurac Research, consultant of the Italian Ministry for the Environment, Land and Sea), Paolo Angelini and Nicoletta Diano (Italian Ministry for the Environment, Land and Sea), Giuseppe Fragola (Eastern Alps District Authority)
Monaco: Celine Van Klaveren-Impagliazzo (Focal point to the Alpine Convention)
Slovenia: Luka Stravs, Maja Jelen, Lara Flis and Mateja Ribnikar (Slovenian Ministry of the Environment and Spatial Planning), Andreja Sušnik, Andreja Moderc, Ana Žustar and Gal Oblišar (Slovenian Environment Agency)
CIPRA International: Serena Arduino
WWF: Elisabeth Sötz
Permanent Secretariat of the Alpine Convention: Taja Ferjančič Lakota

Table of contents

Abbreviations and acronyms

CDD index	Maximum number of consecutive days with P< 1 mm/day
CNR	National Council for Research, Italy
DAS	Deutsche Anpassungsstrategie, Germany
DGR	Decision of Regional Government, Italy
DISS	Decadal Index of Drought Stress
DTM	Digital Terrain Model
EUSALP	European Strategy for the Alpine Macroregion
FRMP	Flood Risk Management Plan
GDP	Gross Domestic Products
IED	Industrial Emissions Directive
IMELS	Italian Ministry for the Environment, Land and Sea
IPCC	Intergovernmental Panel on Climate Change
IPPC	Integrated Pollution Prevention and Control
ISAC-CNR	Istituto di Scienze dell'Atmosfera e del Clima, Italy
ISCAR	International Scientific Committee on Research in the Alps
ISPRA	High Institute for Environmental Protection and Research, Italy
JJA	June, July, August
MOU	Memorandum of Understandings
PGRE	Plans de Gestion de la Ressource en Eau
PNACC	Plan National d'Adaptation au Changement Climatique, France
PRTR	Pollutant Release and Transfer Register
RBMP	River Basin Management Plan
RCP	Representative Concentration Pathway
SAO	Sentinel Alpine Observatory
SNACC	Strategia Nazionale di Adattamento ai Cambiamenti Climatici, Italy
SPI index	Measure of "drought" using the Standardised Precipitation Index on time scales of 3, 6, and 12 months
SRACC	Regional Strategy for Adaptation to Climate Change, Italy
SRES	Special Report on Emissions Scenarios
WEI	Water Exploitation Index
WFD	Water Framework Directive
ZAMG	Zentralanstalt für Meteorologie und Geodynamik, Austria

1. Introduction

The Alpine Convention established a Platform on "Water Management in the Alps" at the X Conference of the Parties in 2009 (decision X/B5), after the adoption of the 2nd Report on the State of the Alps on "Water and Water Management Issues". The Platform aims at the implementation of the objectives and recommendations identified in that report.

In the period 2017-2018, one of the two topics addressed in the mandate was how to face drought periods in the Alpine Region: from the analysis of climate data (rain/snow patterns and scenarios) to strategic planning.

The motivation to address this topic in the mandate was that drought periods had been observed regionally as i.e. recently happened in summer 2015 in large parts of Europe. Due to climate change, these events will probably occur even more often in the future, thus resulting in an increased competition for the use of a resource that generally had not created major issues in the past.

Various activities of the Platform were carried out in this respect, including two expert workshops (first one in Ajdovščina, Slovenia, and the second one in Vienna, Austria) on the exchange of experiences and good practices about drought risk management in the Alps, particularly in terms of the impacts of the 2015 drought. The 7th Water Conference organised together with Forum Alpinum 2018 in Breitenwang (Austria) was used to summarize the experiences in different regions of the Alps, to stimulate the exchange and the dissemination of the good practices, and to raise awareness on this specific issue.

Futhermore, a questionnaire for the collection of information in term of droughts has been sent to the Parties of the Alpine Convention. Feedback to this questionnaire was received from Austria, France, Germany, Italy, Slovenia and Monaco, reporting data and information updated to the first half of 2018.

This report summarizes the information provided by the Alpine Countries based on the answers to the questionnaire as well as the main experiences and findings of the two dedicated workshops of the "Water Platform" on drought management in the Alps and the 7th Water Conference.

2. Analyses of the received questionnaire

2.1. Adaptation to climate changes and droughts

Austria, Germany, France, Italy and Monaco adopted a national climate change adaptation strategy, with the last two Countries preparing a related action plan.

Slovenia adopted a Strategic framework for climate change adaptation and a Climate change adaptation strategy for agriculture and forestry.

In Italy, regional adaptation strategies and plans are going to be developed or adopted in almost all the Alpine Regions (each one is at a different stage, with Lombardy being the most advanced). In Germany there are sub-national adaptation strategies: in particular, a special chapter in the Bavarian Climate Adaptation Strategy (updated in 2016) presents an overview on Climate Change in the Alpine Region; the same is found in the Italian National Adaptation Strategy. Climate change adaptation strategies or action plans for the Alpine region have not been approved yet in Slovenia but the Alpine Strategy for adaptation to climate change in the field of natural hazards is used. In France, there is an approved adaptation plan for the Rhône Mediterranean river basin, which covers the whole French Alpine area. In Austria, the national climate change adaptation strategy applies to all regions of Austria and provides an action plan with recommendations for 14 different areas of action.

In general, different climate change scenarios are considered, as well as different climate change models are used and sometimes mixed for ensuring the consideration of a wide range of possible trends. On a regional level the newest generation of EURO-CORDEX models are appreciated by more than one Country. Enhanced datasets and remote sensing technologies help institutions, research centers and private enterprises in building increasingly reliable models, also on a regional and seasonal scale, which start taking into account snow-water-equivalent estimates too.

In general, droughts risk is considered in all the strategies, even if, as for Bavaria, the main focus is on downstream areas outside of the perimeter of the Alpine Convention, and in Monaco concerns resources that anyway are in a large part imported from France. Generally the period of most interest is from April to end of summer-beginning of autumn. Drought return periods are assessed in the Slovenian case based on their impact on the GDP.

In all the investigated Alpine areas climate models show similar regional trends: during the summer months (JJA in particular), extreme drought periods increase considerably; in winter, climate models show regional differences: in areas on the southern Alps drought periods can increase, but not as much as the summer periods, while in the German Alps an increase in winter precipitations is likely.

Generally, the Alpine parts of the basins are not considered to be very vulnerable to hydrological droughts, even if some decrease in the spring runoff is expected.

More vulnerable areas are generally outside of the Alpine areas, from the foothills to the irrigated plains.

2.2. The impacts of the main droughts in the last 15 years

Drought of 2003 was extremely meaningful for all the Alpine Countries with a precipitation deficit for the 8 driest months going from -20% of long-term annual precipitation in Austria to -50/-60% in France, Italy and Slovenia, with losses in agriculture amounting to hundreds million €.

Several other meaningful droughts were recorded, in particular in:

- 2005 in Italy and France;
- 2006 in Slovenia;
- 2007 in Italy and Slovenia;
- 2009 in Slovenia;
- 2011 in Bavaria (particularly severe);
- 2012 and 2013 in Slovenia;
- 2015 in Bavaria (the most significant in the last 40 years), Slovenia, France and Austria (both in summer and in November-December);
- 2016 in France and Italy;
- 2017 in France, Italy (-41% in JJA on national level, -81% in August on national level, both the periods ranging as the 4th driest since 1800), Austria and Slovenia.

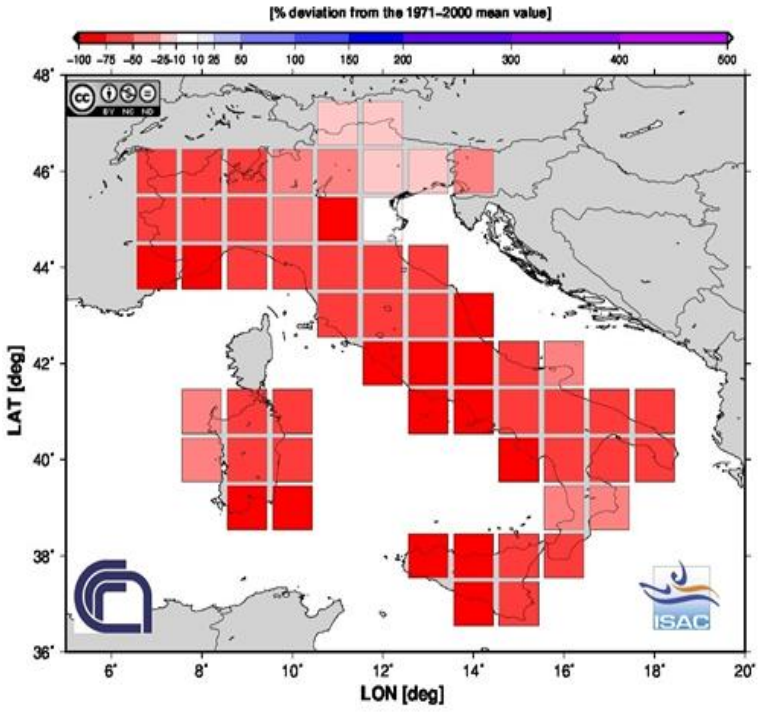


Figure 1 - Deviation of summer 2017 (June, July and August) precipitations in Italy compared to the 1971-2000 mean value (source: National Research Center - CNR)

Droughts periods are recurring with an alarming frequency, particularly affecting summer months with some episodes also of winter droughts.

Austria, Slovenia and Italy registered important losses in agriculture production (up to 128 million € in Slovenia from the 2003 drought, predicted income losses during the 2015 drought in Austria based on precipitation distribution during summer of 175 million €). Less meaningful impacts have been recorded particularly in Austria, Germany and Italy with the hydropower sector, and in France with the tourist sector (i.e. for artificial snow production). In 2003 and 2012, water scarcity situations led to the reduction of drinking water for non-domestic uses in some parts of Slovenia.

During extreme droughts, the drinking water supply to households have been affected locally for few days in Italy (2017, small providers in the lower Adige basin), Bavaria (2003, 2015, few small providers), Austria (2003) and Slovenia (2003) but outside of the Alpine perimeter.

In Austria, particularly small service providers and individual water supplies were close to service limits during 2015 drought, but interconnections among service networks of regional service providers introduced as mitigation measures as a result of the 2003 drought allowed to avoid major problems. In Slovenia, reductions of water use introduced for irrigation, car wash and other activities like filling swimming pools have been introduced.

Austria reported effects on aquatic ecosystems downstream to the Alpine region during summer 2015, particularly because of high water temperatures and low water levels in some lakes and side arm or headwaters of larger rivers in Eastern Austria. Low water levels and dry headwaters occurred in 2003 and 2015 in Bavaria as well.

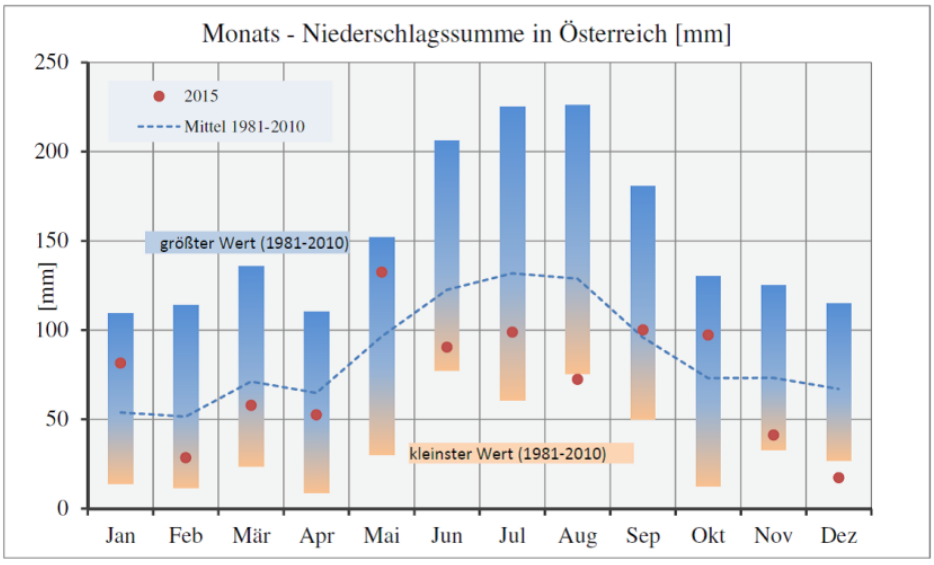


Figure 2 - Monthly accumulated precipitation in Austria, compared to long-term average and its variance (lowest and highest value) for the 1981-2010 period

In Italy, during the severe drought of spring-to-autumn 2017, only special measures including the reduction of concessions' withdrawals and water releases from regulated lakes and reservoirs in the Alps prevented the continuation of the long-lasting missed meeting of the ecological flow of rivers such as Po and Adige in the Po plain.

2.3. Lessons learned and prioritization of uses

2.3.1 Overview

The frequency with which severe and extreme droughts recurred in the last years, also leading to situations of water scarcity, has brought the Alpine Countries to find solutions and to plan the management of these events.

Lessons learned differ from situation to situation but are basically related to six categories of measures:

1. establishing commissions of institutions and stakeholders aiming at agreeing on compromises among sectors and introducing procedures linked to threshold values;
2. increasing the resilience of the water supply systems (investing in alternative sources, pumping from other regions, connecting to other networks);
3. improving irrigation efficiency and/or setting limitations to agricultural withdrawals;
4. advising agricultural producers on how to reduce exposure to drought (diversification of crops, sowing of more drought-tolerant hybrids etc.);
5. helping runoff with planned water releases from reservoirs;
6. increasing natural water retention.

In any case, a prioritization of the water uses is needed in case of severe water scarcity.

In the Alpine Countries there are no known difference in prioritization between summer and winter. The only common and defined priority in case of water scarcity is freshwater supply to households. Secondly, other uses of higher public interest (e.g. fire-fighting) may be prioritized.

For sure the less priority is given to filling domestic swimming pools, private car washing and irrigation of private gardens, which are generally the first activities restricted in case of severe water scarcities.

In Italy, as stated by the "Environmental code", in case of water scarcity, after human consumption, the second priority is agriculture. Furthermore, based on the agreement between two Ministries, the release of water from hydroelectric reservoirs may be ordered, without any compensation to hydropower companies if not the discount of the concession fee. Incidentally, this last measure is not commonly used, as the Government promotes dialogue and cooperation among water users, in particular with the recent solution of the "observatories on water uses" established by the Ministry of the Environment, Land and Sea in each District Authority. The use of reservoirs for improving water discharge for different uses (from agriculture to households water supply – more rare –) is found in all the member States, but seems more consolidated in Italy (i.e. in 2017, as a result of a structured negotiation). In Austria, where drinking water comes almost completely from groundwater or spring water, in regions vulnerable to resource limitations much effort has been dedicated to introducing mitigation

measures to ensure drinking water supply (interconnections of service networks, multiple resource use), which proved their effectiveness in 2015.

The more diffused measures in case of drought and decrease of drinking water levels, as a first reaction of institutions to these events, is the reduction of water uses for private irrigation, car wash and other activities like filling swimming pools.

Italy limited water uses for hydropower based on an agreement among different sectors, while France seems to prefer more binding measures like prefectural orders. During peaks of water consumptions in 2015, a few service providers in Austria had to call for water savings and very few had to limit the supply.

All these measures are planned to be replied in the next drought events.

2.3.2 At the national level

Even if the first implemented measures are similar in all the Alpine Countries, the procedures established in order to face these situations differ quite substantially among the States.

In Austria water scarcity and droughts are addressed in the 2015 river basin management plan. Although Austria is rich in water resources, their spatial distribution is uneven but water scarcity is not an issue in general. Due to the regional and time-limited relevance of droughts, the establishment of Country-wide drought risk management plans is not considered as necessary in general. However, as a result of the drought in 2003, measures to improve the resilience of public water supply were introduced in vulnerable regions (mainly interconnection of supply networks among different regions/operators and the exploitation of additional drinking water resources as back-up). Measures to enhance natural water retention in catchments and strengthen the sustainability of different water uses are promoted by the 2015 river basin management plan.

In France there are water resources management plans (PGRE) at river sub-basin scale. These plans are set up to improve the long-term water resources management of sub-basins that are unbalanced between the water available and the needs in water abstraction. There are also "*arrêté cadre sécheresse*" ("drought framework order") that define how to manage crisis situation. These drought framework orders are designed at the scale of "*département*" and are subdivided in sub-basins. They define threshold values that are associated with restriction levels.
The French plan concerning the Var basin includes also the Principality of Monaco, which, in turn, is working on raising awareness of water uses, with significant results (drinking water consumption has been declining by 1% per year on average in the last decade). Within this drought plan no alert threshold nor crisis flow were defined for the hydrological characteristics of Monaco's supply zone; only the amplitude of the water table fluctuations has to be monitored.

In Slovenia, no specific plans to limit water uses in case of drought events have been established yet. A specific measure from the River basin management plans is being

prepared that will establish indicators for early warning of different levels of intensity and thresholds of droughts in connection with climate changes affecting river basins and surface- and groundwater levels. Since the end of 2017 an upgraded version of mGROWA-SI model has been operating, making modelling of all water balance components possible on a monthly as well as a daily timescale; this will additionally support drought management.

In Germany, in Lower Franconia, a pilot study on the "Development of low water management" is going to be established; outside the Alps a pilot program was started to develop concepts for sustainable irrigation. Within the Bavarian Alps there is no need for that yet.

In Italy, at the end of 2016 the Italian Ministry for the Environment, Land and Sea (IMELS) launched the "Permanent Observatories on Water Uses" at River District level, namely commissions of institutions and stakeholders called to agree on smarter solutions and measures to better manage water resources in case of scarcity. Next than working on these negotiation aspects, these commissions will likely work on the basis of plans with standardized procedures like e.g.: level X of runoff in the section A means quantity Y of water released from reservoirs and quantity Z of reduced withdrawals (tested in 2017 plan licensed by the Adige observatory).

2.4. Monitoring of water uses and trends

In Italy, data on water uses in the different sectors of the river districts are included in the River Basin Management Plan, without any sub-division between the Alpine and the non-Alpine areas. At the same time, Italian public institutions involved in the "Permanent Observatories on Water Uses" are cooperating for collecting weather-climate data and trying to define reliable seasonal models with the aim of helping decision-making processes on water uses on the basis of forecasted runoff and snow-water-equivalent.

In Bavaria, data on public water supply are collected in the frame of RBMPs too. For other economic sectors using water resources, this is foreseen in the future, but not specifically for the Alpine area.

In France, monitoring demonstrates that per capita water consumption is decreasing, but no clear trends are available for the agricultural sector, being seasonally variable.

In Slovenia, the trend of water exploitation (index WEI) is slightly increasing, but it is not statistically significant; the most water-intensive sector in 2004 was energy production, using the large majority of water resources (water mainly returned to the source later), with similar (minor) rates used by public water supply and industries.

In the Principality of Monaco, water uses are monitored and, over the past few years, raising awareness by households, private and public stakeholders has led to a notable diminution of water consumption.

In Austria, sectoral water uses have been quantified during the development of the 2015 river basin management plan. On average, industrial and commercial water uses comprise about two thirds of the total water used; about 25% of water is used for public water supply, and the remaining 7% is used for agricultural purposes.
Due to the introduction of water saving technologies in households as well as improved awareness about the value of water, per capita water uses for public water supply in Austria decreased in the last 15 years (from around 150 liters to about 135 liters per person per day), but this decrease is balanced by population growth. For industrial water uses, water saving technologies have been introduced due to the obligations set by the IPPC and IED Directives as well, and contributed to considerable water savings. Furthermore, in Austria, due to the considerable expansion of artificial snowmaking, the development of water retention reservoirs for snowmaking facilities helped to reduce the pressure on surface waters by limiting water withdrawals in critical low-flow periods in winter. Similar reservoirs are spreading over the entire Alpine Arc, being also a useful private strategy for adaptation to climate change implemented by the ski resorts.

2.5. Pilot projects and forecast of the snow-water-equivalent

In Austria, during the last few years, initiatives have been intensified to improve the knowledge base and data availability on water abstractions, particularly concerning the agricultural sector; follow-up activities are currently carried out.

In France, even if outside of the Alpine perimeter, there are management plans in priority areas to better share available water and leave more water to the good functioning of rivers. Furthermore, there are some projects for improving water efficiency in industry, irrigation, water supply as well as for encouraging water-efficient activities.

Slovenia is particularly active in cooperation and research projects, among which: CRP TRIN project on irrigation, ViVaCCAdapt project on adaptation to climate change (droughts, floods and soil erosion) in the Vipava valley, DriDanube project on adaptation to droughts in the Danube region, GROWA-SI on modelling water flows and quantifying groundwater recharge. Important was also the DMCSEE project on improving drought preparedness and reducing drought impacts. Considering the likely risk of longer and more frequent drought periods in the future, calculating the water available in the ground as well as in the seasonal snow become fundamental in order to better manage the use of the resource.

In France, Meteo France collects and provides data to better manage droughts: water retention capacity, snow-water-equivalent, evapotranspiration, net rainfall etc.

Similarly, in Italy, Eurac Research and the private initiative "MySnowMaps" allow monitoring and estimation of the depth and density of snow cover on the entire Alpine region; these data are mapped on DTMs and can include other meteorological information. These products allow monitoring and calculating snow-water-equivalent in each Alpine river basin, helping the forecast of river basins' runoffs due to snow-melting

- but also from precipitation and ice melting, as well as soil moisture and evapotranspiration - and comparisons on multiannual basis of snow-height and snow-water-equivalent. At the same time, Eurac Research started an activity with Italian hydropower providers to forecast drought impacts on hydropower production (project SECLIFIRM).

In Slovenia, the GROWA project is reaching interesting results on indexes (decadal index of drought stress), monitoring of cumulative water balance, and calculation (products of water balance modelling through GROWA-SI will be the foundation for further work on environmental indicator "VD_15: quantitative retention of groundwater level", which in the next years will also give information on seasonal variability; snow-water-equivalent is calculated too). Water balance calculation and irrigation forecast (5 days in advance) for several different locations with agriculture, vegetable and fruit productions is already undergoing.

3. Outcomes from the drought risk management workshops and the Water Conference, including main messages from the experts

3.1 First expert workshop, Ajdovščina (Slovenia), 14th September 2017

© Alpine Convention

Experts from Austria, Germany (Bavaria), Italy and Slovenia presented their experiences and activities related to drought risk management. Topics of the workshop were the current situation in drought risk management in the Alpine region, past drought events that caused considerable damages, and measures for drought management that have already been implemented in the past and turned out to be effective. Systems for monitoring and modelling of drought events, examples of good practices and experiences which can be used as good basis for future drought risk management activities were presented as well. The discussion indicated that - due to climate change - droughts may occur even more frequently in the future. Main conclusions were that droughts cause consequences that can be calculated in damages of billions Euros, that prevention measures are mostly dispersed in the documents of different sectors (water management, agriculture, nature, water supply, etc.) and that a more comprehensive and focused approach is needed.

© Alpine Convention

Presentations from the workshop are available on the webpage of the Alpine Convention[1].

[1] http://www.alpconv.org/en/organization/groups/WGWater/WSHDrought.html

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

italian delegation alpine convention

REPUBLIC OF SLOVENIA
MINISTRY OF THE ENVIRONMENT AND SPATIAL PLANNING

DROUGHT RISK MANAGEMENT IN THE ALPS EXPERT WORKSHOP & 2ND WATER MANAGEMENT PLATFORM MEETING

September, 14th (Thursday) & 15th (Friday)
Ajdovščina, Slovenia

14.09.2017 (THURSDAY) – EXPERT WORKSHOP AND EXCURSION

Venue: Ajdovščina Municipality, Cesta 5. maja 6a, 5270 Ajdovščina

10:00 – 14:00 Drought Risk Management in the Alps Expert Workshop (moderators: Paolo Angelini & Luka Stravs)

10:00 – 10:15 Christian Schilling (AT- BMLFUW) – Drought management in Austria
10:15 – 10:30 Hannah Berger (DE- BEA & BSMECP) – New challenges in drought management in Northern Bavaria
10:30 – 10:45 Dr. Giuseppe Fragola (IT) – Management of water scarcity in the Adige river basin: the case of 2017 drought
10:45 – 11:00 Lara Flis (SI- MOP) – Drought Risk Management in Slovenia
11:00 – 11:30 Discussion

11:30 – 12:00 *Coffee Break*

12:00 – 12:15 Gregor Gregorič (SI - ARSO) – Drought Monitoring in Slovenia
12:15 – 12:30 Mira Kobold (SI - ARSO) – Hydrological droughts in Alpine regions of Slovenia
12:30 – 12:45 Florjana Ulaga, Peter Frantar (SI - ARSO) – River flow regimes and discharge trends in Slovenian Alps
12:45 – 13:00 Peter Frantar, Urška Pavlič (SI - ARSO) – Possible use of water balance model mGROWA as water scarcity indicator
13:00 – 13:15 Andreja Sušnik (SI - ARSO) – DriDanube (Drought Risk In the Danube Region) project
13:15 – 13:30 Jože Papež, Silvana Batič (SI - Hidrotehnik d.d.) – Life ViVaCCAdapt project - Adapting to the impacts of climate change in the Vipava Valley
13:30 – 14:00 Plenary Discussion

14:00 – 15:00 Quick Lunch (Hotel & Casino Gold Club Ajdovščina)

15:00 – 19:00 Excursion/ Field Trip

15:00 – 17:00 Part 1 - Vogršček Water & Drought Management Reservoir (Silvana Batič, Jože Papež,)
17:00 – 19:00 Part 2 - Good (Small) Hydropower Practices in Slovenia (Alida Rejec)

20:00 – Dinner (Hotel & Casino Gold Club Ajdovščina)

3.2 Second expert workshop, Vienna (Austria), 23rd January 2018

© BMNT

The workshop was part of the discussion and exchange of knowledge which had started in September 2017 with the first expert workshop on Drought Risk Management in the Alps held in Ajdovščina (Slovenia), and after which the Water Platform decided to continue this exchange of knowledge and experiences. The workshop aimed at highlighting experiences with, and identification of droughts events in Alpine Countries and ways of dealing with the associated challenges. Experts from different countries (Czech Republic, Italy, Slovenia) and from different regions (Bavaria in Germany and the Region of Salzburg in Austria) presented their experience with past drought events and existing strategies and approaches to cope with challenges in different sectors of water resources management. Furthermore, approaches for the identification of low flow and streamflow droughts as well as the impact of droughts and climate change on future water resources management were presented. The workshop was very successful in bringing together experts from different regions within the Alps and outside the Alpine area. It has facilitated knowledge exchange in the field of drought management and raised the awareness about the importance of drought management and the existing knowledge to mitigate impacts of droughts events, which are likely to become more frequent in future in the Alpine area.

© Alpine Convention

Presentations from the workshop are available on the webpage of the Alpine Convention[2].

[2] http://www.alpconv.org/en/organization/groups/WGWater/WSHDrought-Vienna.html

ALPINE CONVENTION

www.alpconv.org

23.01.2018

2ND WORKSHOP OF THE WATER PLATFORM OF THE ALPINE CONVENTION ON DROUGHT RISK MANAGEMENT IN THE ALPS

Venue: Bundesministerium für Nachhaltigkeit und Tourismus (BMNT) Vienna
Main Building - Stubenring 1; 1st Floor, Saal 2 (Gobelinsaal)

08:30 – 09:00 Registration

Part I – National and regional experiences and existing strategies

09:00 – 09:15 Welcome and Opening of the Workshop (Austrian Federal Ministry of Sustainability and Tourism)
09:15 – 09:30 Ministry of Environment and Spatial Planning of Slovenia (L. Stravs, M. Jelen - Summary of 1st Expert Workshop on drought risk management in the Alps in Ajdovscina (Sep. 2017))
09:30 – 10:00 Bavarian State Ministry for Environment and Consumer Protection (H. Berger - Low flow management)
10:00 – 10:30 Regional Government of Salzburg (J. Wiesenegger – Strategic water resources management and drought)
10:30 – 11:00 Ministry of Environment of the Czech Republic (V. Matuszná. - National strategy on drought management)

11:00 – 11:30 *Coffee Break*

Part II – Identification of droughts and climate change impacts

11:30 – 12:00 University of Life Sciences Vienna (G. Laaha -Low flows and streamflow droughts - processes, indicators and requirements)
12:00 – 12:30 Italian Ministry of the Environment, Land and Sea (The management of water scarcity in Italy: from hydrological droughts to stakeholder's coordination)
12:30 – 13:00 Vienna University of Technology (G. Blöschl -Droughts and climate change in Austria – implications for water resources management)

13:00 – 14:00 Lunch

Part III – Approaches for drought management

14:00 – 14:30 Slovenia (A. Susnik – New approaches to better drought management in Slovenia and Danube region)
14:30 – 15:00 WWF (E. Sötz - Ecosystem-based solutions in drought risk management)
15:00 – 15:20 Outlook: activities of Alpine Convention Water Platform on Drought Risk Management
15:20 – 15:45 Discussion
15:45 – 16:00 Workshop wrap-up and summary

16:00 – End of workshop

MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE
italian delegation alpine convention
BUNDESMINISTERIUM FÜR NACHHALTIGKEIT UND TOURISMUS
REPUBLIC OF SLOVENIA MINISTRY OF THE ENVIRONMENT AND SPATIAL PLANNING

3.3. 7th Alpine Water Conference, Breitenwang (Austria), 5th June 2018

The 7th Alpine Water Conference was part of the Forum Alpinum 2018 (4th-6th June 2018) and was organized by the Platform Water Management in the Alps together with ISCAR (International Scientific Committee on Alpine Research) and Sub-group 3 "Integrated and sustainable water management" of Action Group 6 of the EU Strategy for the Alpine Region (EUSALP). The objective of the Water Conference was to present the work which has been carried out in 2017-2018 by both the Water Platform of the Alpine Convention and the EUSALP Sub-group 3 of AG 6. The two morning sessions of the Water Conference were dedicated to presentations and discussions on *the impacts of, and response to, droughts in the Alpine region,* and highlighted experiences with, and approaches to, droughts in different Alpine regions of Germany (Bavaria), Austria (Salzburg, Tirol), Italy and Slovenia. Furthermore, the conference was used to present the content and the main conclusions of the 2017-18 activities, which are also included in this synthesis paper (see chapter 2).

The presentations from the Water Conference are available on the webpage of the Alpine Convention[3]. Conference proceedings are available in the publication prepared by ISCAR[4].

© A. Bianchini

© M. Jelen

[3] http://www.alpconv.org/en/organization/groups/WGWater/7waterconf.html
[4] http://forumalpinum.org/en/

7TH WATER CONFERENCE

Water in the Alps – Management of hydrological extremes and sustainable hydropower use

The 7th Water Conference is organized by the Water Platform of the Alpine Convention in dialogue with EUSALP AG 6 Subgroup Water

OFFICIAL GREETINGS OF THE AUTHORITIES

Markus Reiterer (Secretary General of the Alpine Convention)
Stefan Wildt (Regional Government of Tyrol)
Paolo Angelini & Luka Štravs (Co-chairs of the Water Platform of the Alpine Convention)

MODULE 2: THE IMPACTS OF AND RESPONSE TO DROUGHTS IN THE ALPINE REGION (PART I)

Chair: **Hannah Berger** (Bavarian Environment Agency), German delegation to the Water Platform

Andreas Kolbinger (Bavarian State Ministry of the Environment and Consumer Protection, Germany): Current developments and challenges in drought management in Northern Bavaria
Johannes Wiesenegger (Regional Government of Salzburg, Austria): Strategic water resources management and drought
Nicoletta Diano (Italian Ministry for the Environment, Land and Sea)
Debate / interactive section

MODULE 2: THE IMPACTS OF AND RESPONSE TO DROUGHTS IN THE ALPINE REGION (PART II)

Chair: **Christian Schilling** (BMNT, Austria), Austrian delegation to the Water Platform

Andreja Sušnik (ARSO, Slovenia): New tools for better drought risk management
Gunther Heißel (Regional Government of Tyrol, Austria): Security of drinking water in light of climate change
Andrea Bianchini (IMELS Consultant, Italy; Platform Water Management in the Alps): Facing droughts in the Alpine region – Experiences, approaches and common challenges
Debate / interactive section

MODULE 3: GREEN INFRASTRUCTURES FOR AN INTEGRATED AND SUSTAINABLE WATER MANAGEMENT

Chair: **Luka Štravs,** Slovenian delegation to the Water Platform

Elisabeth Sötz (WWF, for EUSALP AG 6): Greener Alpine Rivers? Conclusions and Recommendations of the EUSALAP AG 6 – Subgroup Water
Joze Papež (Hidrotehnik, Slovenia), **Mateja Ribnikar** (MOP, Slovenia),**Maja Jelen** (MOP, Slovenia): 50 Shades of Green Infrastructure- Experiences from Slovenia
Manuela Künzl (Bavarian State Ministry of the Environment and Consumer Protection, Germany): Alpine green infrastructure – joining forces for nature, people and the economy
Debate / interactive section

MODULE 3: COMMON GUIDELINES FOR THE USE OF SMALL HYDROPOWER IN THE ALPINE REGION

Chair: **Pietro Colonna** Italian Delegation to the Alpine Convention

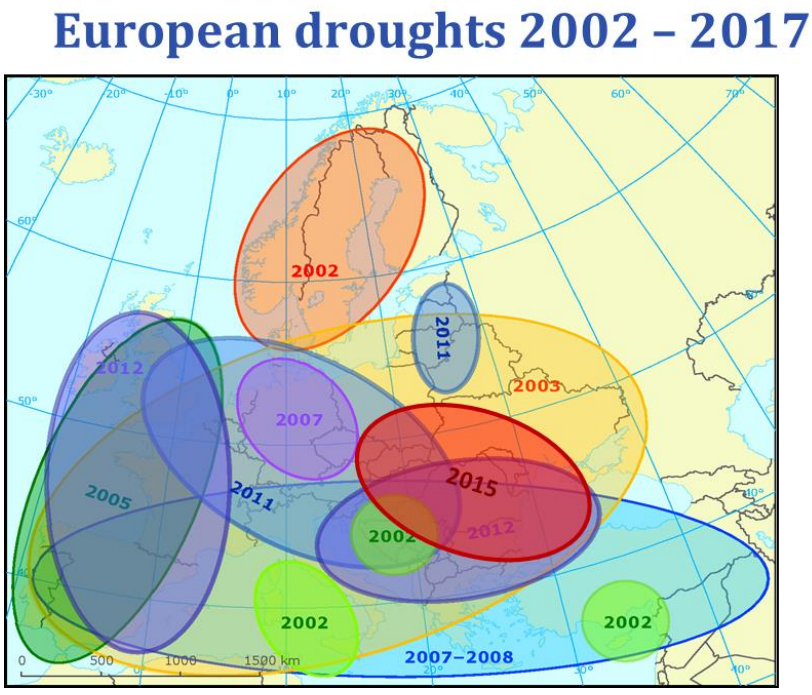
Pietro Colonna (Italian Delegation to the Alpine Convention): Presentation of the elaboration and content of common guidelines
Christian Schilling (BMNT, Austria): Application of the Common Guidelines for the use of Small Hydropower in the Alpine region
Debate / interactive section

3.4. Main messages

Based on the results of the two expert workshops held in Ajdovscina and Vienna, and the 7th Alpine Water Conference held in Breitenwang in the frame of the Forum Alpinum 2018[5], the following messages emerged:

Occurrence of droughts in the Alpine region:

- Drought of 2003 was extremely meaningful for all the Alpine Countries with losses in agriculture for hundreds million €
- While there are areas in the Alps with abundant water resources, there are regions, still within the Alpine perimeter, where droughts have been observed with significant impact, for example those happened in 2015 and 2017 in large parts of Europe
- In the 2002-2017 period, droughts occurred, even in Alpine areas where previously there had not been problems:
    - 2005: Italy, France
    - 2006: Slovenia
    - 2007: Italy, Slovenia
    - 2009: Slovenia
    - 2011: Bavaria
    - 2012, 2013: Slovenia
    - 2015: Bavaria, Slovenia, France and Austria
    - 2016: France, Italy
    - 2017: France, Italy, Austria and Slovenia.



Source: EEA, 2012; EEA, 2017

[5] http://www.alpconv.org/en/organization/groups/WGWater/default.html and http://forumalpinum.org/en/

- Water demand tends to rise without major problems in the Alpine areas with abundant water resources, but in regions with limited precipitation water resources may become, or are already getting, scarce
- Low flows were observed in summer as well as in winter, also in regions with high precipitation; in extraordinary years (when severe droughts occur) this results in a competition for limited water resources among different sectors

Different types of droughts:

- meteorological drought (caused by precipitation deficiency)
- soil moisture drought (caused by low soil moisture)
- hydrological drought (caused by low discharges and low groundwater level)
- ecological drought (water scarcity leads to a weakened functioning of different ecosystems)
- socio-economic drought (caused by impacts of above mentioned types of droughts)

Impacts of droughts:

- Effects of droughts (i.e. in 2015) have been experienced in almost all water-dependent sectors, albeit with different intensity, e.g. agriculture, ecology, hydropower, navigation
- Droughts can become one of the major challenges in water management

Existing approaches for drought management:

- Drought management has to switch from crisis management to preparedness, monitoring and forecasting is essential; management options have to be based on hydrological indicators characterising the impacts, longer forecasting periods are required as for floods
- Existing drought management approaches/systems are in place, but there is still room for improvement (e.g. forecasts based on real data from drinking water providers, assessment of effectiveness of measures)
- Best practice examples include systematic approaches to low flow management, reservoir filling plans for artificial snowmaking, multiple-pillar approach and networking for drinking water provisions, restrictions to water uses, water reuse, negotiation among sectors, crop diversification, monitoring and process understanding
- Existing knowledge, best practices, guidelines and information by research observatories can be used as a good basis for future international cooperation and to support local actions regarding drought management in the Alpine region
- Raising awareness (including the role of media) on drought risk and on direct and indirect water consumption is important; especially communication on measures for preparedness, with effective graphics demonstration

Existing gaps:

- There is a need to find solutions on how to face drought periods in the Alpine region and to switch from analysis of climate data to strategic planning

- Data needs for models and predictions are extensive; in some cases existing monitoring approaches need to be upgraded to improve data collection and documentation of droughts
- Information and experience on how to quantify drought situations is necessary (e.g. common rules for thresholds), monitoring and modelling of drought events and monitoring of water uses is essential
- In general, occurrence of droughts is recognized at a late stage, when the signs become visible and when drought is already underway; forecasts and early warning are therefore highly needed
- There are still gaps in evaluating the impacts (databases missing), indicators are needed and need to be implemented.

Strategic planning:

- Drought issue is mentioned in documents of the EU and regional cooperation, but there is no legal document about drought management on EU level nor are droughts included in the Alpine Convention protocols: legal framework and strategic management of droughts are needed (drought risk management plans etc.),
- Implementation of measures is important
- River Basin Management Plans can be used in normal situations (low-flow) but often fail in case of droughts; thus specific plans are to be suggested
- Emphasis on ecosystems should be placed in the Integrated River Basin Management (IRBM) also in case of droughts
- Work out strategies to make sectors (drinking water supply, agriculture) more resilient against droughts, i.e. by means of:
    a. investing in alternative water sources
    b. investing in smart grids i.e. linking networks of water providers;
    c. enhancing planning of water availability i.e. with reservoirs filling plans
    d. promoting crops diversification and other farming practices more adaptable to extreme situations (taking into account extreme rainfalls)

Effects of climate change on future droughts:

- Due to climate change, drought events and observed low flows are likely to occur more often in future (increased low flows in alpine areas, decreased low flows in lowland areas), but runoff variability is larger than expected changes for coming decades
- Shift from winter droughts to summer droughts is likely, adaptation measures should be tailored to local situations and should be based on experiences from recent droughts
- Changes of quality and quantity of water resources have to be expected, without proper adaptation measures there might be not enough water for all requirements
- Some regions are faced with increasing water needs for irrigation of crops; efficiency of irrigation systems has to be improved.

4. Challenges to be tackled in the future and at a transboundary level

The drought episodes occurred in the last 15 years have demonstrated that even severe droughts recur frequently, and this trend certainly cannot be neglected.

Climate change is very likely influencing this situation; in fact, drought risk is considered in all the Alpine national strategies of adaptation to climate change.
We cannot be optimistic about the recurrence of drought episodes, whereas we should be about the possibilities to adapt to these phenomena. The experience from the last decades has shown that proper adaptation measures can limit - to a certain extent - damages and losses.
Lessons learned from the latest episodes have demonstrated their efficacy. They differ according to different situations, but are basically related to six categories of measures aiming at:

- institutionalising the negotiation on water uses in a basin-wide perspective;
- increasing the resilience of the water supply systems;
- improving the efficient use of water in agriculture, including temporary limitations to agricultural withdrawals during emergency situations;
- reducing the exposure to droughts of the agricultural sector;
- helping runoff with planned water releases from reservoirs;
- increasing natural water retention.

The list is not aiming at suggesting a prioritization, but these measures can be applied either jointly or separately based on the local/regional conditions. These measures should be replicated in the future, both as a response to emergency and a way forward for increasing relisience and adaptation.

In the meantime, a growing awareness has raised on the delay with which droughts are dealt with, being usually managed as emergency situations. Forecasts and early warning are therefore highly needed, such as an extensive effort on the improvement of waters uses' monitoring.
Focussing on these aspects is the key challenge for the future, in order to move from pure emergency management to prevention and preparedness. Drought risk should be therefore considered like a natural hazard, to be dealt with in an integrated cycle of response-recovery-mitigation-preparedness phases.

As a consequence, further efforts are needed for achieving this goal, and international cooperation may help in this sense thanks to the transboundary nature of many Alpine catchments and the demonstrated added value of exchanging experiences in the Alpine region.

Sources

Alpine Convention Webpage, Water Platform - http://www.alpconv.org/en/organization/groups/WGWater/default.html

Alpine Convention Webpage, Water Platform, Workshop on Droughts in Ajdovščina - http://www.alpconv.org/en/organization/groups/WGWater/WSHDrought.html

Alpine Convention Webpage, Water Platform, Workshop on Droughts in Vienna - http://www.alpconv.org/en/organization/groups/WGWater/WSHDrought-Vienna.html

Alpine Convention Webpage, Water Platform, 7th Water Conference - http://www.alpconv.org/en/organization/groups/WGWater/7waterconf.html

Forum Alpinum Webpage - http://forumalpinum.org/en/

http://agromet.mkgp.gov.si/Publikacije/STRATEGIJA%20prilagajanja.pdf

http://annuario.isprambiente.it/entityada/basic/6358/singola#

http://gis.arso.gov.si/related/evode/wfd/2014_I_01_01_9.pdf

http://kazalci.arso.gov.si/?data=indicator&ind_id=20

http://kazalci.arso.gov.si/?data=indicator&ind_id=761

http://kazalci.arso.gov.si/?data=indicator&ind_id=831

http://land.copernicus.eu/global/products/swe

http://meteo.arso.gov.si/uploads/probase/www/agromet/OT/Ocena_tveganja_Susa_KONCNA.pdf

http://mvd20.com/LETO2013/R14.pdf

http://propluvia.developpement-durable.gouv.fr/propluvia/faces/index.jsp

http://sao.eurac.edu/

http://www.alpine-space.org/2007-2013/projects/projects/detail/CLISP/show/index.html#project_outputs

http://www.alpiorientali.it/il-distretto/chi-siamo.html

http://www.arso.gov.si/novice/datoteke/036813-Energie_Umwelt_339.pdf

http://www.bacino-adige.it/sito/index.php/dati-online-web/carenza-idrica-adige-2017

http://www.bestellen.bayern.de/shoplink/lfu_was_00124.htm (Bayerisches Landesamt für Umwelt, 2016: Niedrigwasser in Bayern. Grundlagen, Veränderung und Auswirkung)

http://www.bestellen.bayern.de/shoplink/stmuv_klima_009.htm

http://www.bf.uni-lj.si/index.php?eID=dumpFile&t=f&f=22104&token=38301aed79ea6db7a4be6882178effb8a83d65bf

http://www.bmub.bund.de/themen/klima-energie/klimaschutz/anpassung-an-den-klimawandel/

http://www.climatrentino.it/binary/pat_climatrentino/SIEFF.pdf

http://www.climatrentino.it/chi_siamo/provincia_trento_clima/

http://www.developpement-durable.gouv.fr/adaptation-france-au-changement-climatique

http://www.dmcsee.org/

http://www.eaurmc.fr/climat.html

http://www.eaurmc.fr/fileadmin/grands-dossiers/documents/Changement_climatique/bilan_connaissances_Chgt__Clim_AERMC_couv_def.pdf

http://www.ff.um.si/zalozba-in-knjigarna/ponudba/zbirke-in-revije/revija-za-geografijo/clanki/stevilka-10-1-2015/RG1910-105Hozjan-Vplivpodnebnihspremembnanaravnenesrece.pdf

http://www.interreg-danube.eu/approved-projects/dridanube

http://www.life-vivaccadapt.si/en/

http://www.minambiente.it/comunicati/siccita-osservatorio-po-5-prelievi-da-corsi-dacqua-alpini-e-laghi-prealpini-soluzione

http://www.minambiente.it/notizie/acqua-roma-il-workshop-minambiente-creiamo-pa

http://www.minambiente.it/notizie/emergenza-siccita

http://www.mko.gov.si/fileadmin/mko.gov.si/pageuploads/podrocja/naravne_nesrece/program_ odprave_posledic_skode_v_kmetijstvu_susa2013.pdf

http://www.mop.gov.si/fileadmin/mop.gov.si/pageuploads/podrocja/podnebne_spremembe/porocilo_podnebne_spremembe1_2.pdf

http://www.mop.gov.si/fileadmin/mop.gov.si/pageuploads/podrocja/podnebne_spremembe/SOzP_ang.pdf

http://www.mop.gov.si/fileadmin/mop.gov.si/pageuploads/podrocja/voda/nuv_II/NUV_VOD.pdf

http://www.mop.gov.si/fileadmin/mop.gov.si/pageuploads/podrocja/voda/nuv_II/NUV_VOJM.pdf

http://www.mysnowmaps.com/en/how_does_it_work

http://www.nid.bayern.de/files/docs/LfW_Niedrigwasser_2003.pdf

http://www.ovgw.at/wasser

http://www.provincia.bz.it/agenzia-ambiente/download/PianoClima_Energia_AA2050_Ansicht.pdf

http://www.regione.fvg.it/rafvg/comunicati/comunicato.act?dir=/rafvg/cms/RAFVG/notiziedallagiunta/&nm=20170620172349008

http://www.regione.piemonte.it/pinforma/ambiente/1363-una-strategia-regionale-per-affrontare-il-cambiamento-climatico.html

http://www.rhone-mediterranee.eaufrance.fr/docs/infos-secheresse/2015/AC-en-vigueur/74_AC_10juillet2015.pdf

http://www.rhone-mediterranee.eaufrance.fr/docs/sdage2016/docs-officiels/20151221-SDAGE-RMed-2016-2021.pdf

http://www.sos112.si/slo/tdocs/crp_scenariji.pdf

http://www.sos112.si/slo/tdocs/ujma/2004/susa_2003.pdf

http://www.sos112.si/slo/tdocs/ujma/2007/073.pdf

http://www.dmcsee.org/uploads/file/319_1_ears_disturbed_water_balance_susnik_pogacar.pdf

http://www.sos112.si/slo/tdocs/ujma/2015/85_93.pdf

http://www.stat.si/statweb for 2003, 2006 and 2007 data

http://www.zamg.ac.at/cms/de/klima/news/werden-duerre-perioden-im-alpenraum-haeufiger

https://bur.regione.veneto.it/BurvServices/pubblica/DettaglioDgr.aspx?id=323983

https://ec.europa.eu/clima/policies/adaptation/what_en

https://masteradapt.eu/

https://www.adv-geosci.net/32/99/2012/adgeo-32-99-2012.pdf

https://www.bmlfuw.gv.at/umwelt/klimaschutz/klimapolitik_national/anpassungsstrategie/Fortschrittsbericht.html

https://www.bmlfuw.gv.at/umwelt/klimaschutz/klimapolitik_national/anpassungsstrategie/klimaszenarien.html

https://www.bmlfuw.gv.at/umwelt/klimaschutz/klimapolitik_national/anpassungsstrategie/strategie-kontext.html

https://www.bmlfuw.gv.at/wasser/wasser-oesterreich/herausforderungen/klimawasser.html

https://www.bmlfuw.gv.at/wasser/wasser-oesterreich/wasserkreislauf/hydrograph_charakt_extrema/2015trockenheithydro.html

https://www.bmlfuw.gv.at/wasser/wasser-oesterreich/wasserkreislauf/hydrograph_charakt_extrema/monatscharakteristiken.html

https://www.bmlfuw.gv.at/wasser/wasser-oesterreich/wasserkreislauf/hydrograph_charakt_extrema/Trockenheit2003.html

https://www.bmlfuw.gv.at/wasser/wasser-oesterreich/wasserkreislauf/hydrographie_oesterreich/mitteilungen/Mitteilungsblatt83.html

https://www.bmlfuw.gv.at/wasser/wasser-oesterreich/wasserkreislauf/Wasserbilanz.html

https://www.bmlfuw.gv.at/wasser/wasser-oesterreich/wasserrecht_national/planung/EmRegV-OW.html

https://www.bmlfuw.gv.at/wasser/wisa/fachinformation/ngp/ngp-2015/tabellen/GW/gw_tabellen.html

https://www.bmub.bund.de/publikation/adaptation-to-climate-change-initial-progress-report-by-the-federal-government-on-germanys-adapt/

https://www.eaurmc.fr/fileadmin/grands-dossiers/documents/Changement_climatique/Plan_Bassin_Chgt_Clim-VF30-06-14.pdf

https://www.eaurmc.fr/fileadmin/grands-dossiers/documents/Changement_climatique/Plan_Bassin_Chgt_Clim-VF30-06-14.pdf

https://www.lfu.bayern.de/wasser/klima_wandel/projekte/adaptalp/doc/abflussszenarien_inn.pdf

https://www.ovgw.at/media/medialibrary/2016/04/Studie_Wasserversorgung_2015.pdf

https://www.regierung.oberbayern.bayern.de/imperia/md/content/regob/internet/dokumente/presse/2016-06-28_wasserversorgungsbilanz_oberbayern.pdf

https://www.regierung.schwaben.bayern.de/Aufgaben/Bereich_5/Wasserwirtschaft_und_Wasserbau/WVB2025_Schwaben_2015-01-26_Web.pdf

https://www.schweizerbart.de/papers/metz/detail/prepub/84722/Future_drought_probabilities_in_the_Greater_Alpine_Region_based_on_COSMO_CLM_experiments_spatial_patterns_and_driving_forces?l=DE

https://www.umweltbundesamt.de/monitoringbericht-2015-startseite

https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/climate_change_24_2015_summary_vulnerabilitaet_deutschlands_gegenueber_dem_klimawandel_2.pdf

https://www.vcalc.com/wiki/Titan/Snow+Water+Equivalent+%28SWE%29

https://www.verbund.com/cc/de/investor-relations/finanzpublikationen#tabbed-1

Attachment 1 - National Questionnaires

AUSTRIA

1) Is there an approved climate change adaptation strategy in your Country? Please link any references to the official documents.

The Austrian national climate change adaptation strategy[6] was approved by Austrian Government in October 2012. It consists of two parts: Part 1 (Context) covers strategic principles and explains how the strategy is embedded into the overall context. Part 2 provides an action plan with concrete recommendations in 14 areas of action (e.g. agriculture, forestry and so on).
The government program contains the mandate to implement this strategy and to regularly evaluate the progress of implementation. The last progress report was published in 2015[7].

2) a) Are there approved climate change adaptation strategies as well as action plans in the Alpine Regions/Länder/Districts in your Country?

The national climate change adaptation strategy applies for all regions of Austria and provides recommendations for 14 different areas of action (see also question 1).

b) If yes, what is the reference climate change scenario at regional level? Please briefly describe it.

For the national climate change adaptation strategy (2012) based on the SRES scenario A1B an ensemble of regional climate models (ECHAM5/CCLM; HADCM3/CCLM) was used to predict regional climate change effects until the middle of the twenty-first century.
Regional climate change scenarios have been updated in 2015 based on newest generation regional climate change models (EURO-CORDEX) using the RCP 4.5 and RCP 8.5 emission scenarios. As a result fact sheetshave been produced for every region outlining the climate change effects on air temperature and precipitation until the end of the twentyfirst century[8].

c) Are drought periods assessed as a likely risk? What are the most interested periods of the year?

In 2012 the Federal Ministry of Agriculture, Forestry, Environment and Water Management commissioned in cooperation with the regional governments a scientific study[9] on the impacts of climate change on water resources management. This study highlighted possible impacts on 10 fields of water management and gave recommendations for possible actions. The respect to drought periods, low flow periods of rivers as well as the quantitative availability of groundwater have been considered as possible fields of water management.
Based on a recent study published in 2015 by the ZAMG[10] mainly during the summer months drought periods are likely to increase in the whole Alpine area. For the considerable drying trends, precipitation was found as the relevant driver for the North of the Alps, whereas temperature was detected the main driver for southern and eastern areas[11].

3) a) What are the river basins most exposed to the risk of droughts in the future? And what based on the historical data and experiences?

[6] https://www.bmlfuw.gv.at/umwelt/klimaschutz/klimapolitik_national/anpassungsstrategie/strategie-kontext.html
[7] https://www.bmlfuw.gv.at/umwelt/klimaschutz/klimapolitik_national/anpassungsstrategie/Fortschrittsbericht.html
[8] https://www.bmlfuw.gv.at/umwelt/klimaschutz/klimapolitik_national/anpassungsstrategie/klimaszenarien.html
[9] https://www.bmlfuw.gv.at/wasser/wasser-oesterreich/herausforderungen/klimawasser.html
[10] http://www.zamg.ac.at/cms/de/klima/news/werden-duerre-perioden-im-alpenraum-haeufiger
[11] https://www.schweizerbart.de/papers/metz/detail/prepub/84722/Future_drought_probabilities_in_the_Greater_Alpine_Region_based_on_COSMO_CLM_experiments_spatial_patterns_and_driving_forces?l=DE

Based on the ZAMG study 2015, in all investigated Alpine areas (ranging from southern Germany to northern Italy and from eastern France to western Hungary) climate models show similar regional trends: during the summer months June, July and August extreme drought periods will increase considerably. For winter periods, climate models show regional differences: in areas south of the Alps drought periods could increase also in winter periods, but not that strong as compared to the summer periods.
For Austria, in Alpine areas no big changes are likely within the next decades in terms of drought periods. In northern, eastern and southern regions of Austria, drought periods are likely to increase.

4) a) What have been the more significant events in the last 15 years? Describe the events, also including data on precipitations, runoff, dry days in the reference areas. Please include links to reports of the events.

In the last 15 years, in Austria two significant drought periods have been observed in 2003 and in 2015.
In 2003, the annual precipitation was about 80% of long term annual precipitation, regionally in eastern and south eastern parts down to less than 70%. These deficits were intensified by very high summer temperatures (the summer was one of the hottest since the beginning of records). The resulting high evaporation strongly affected the groundwater due to precipitation deficits.[12,13]
In 2015, the situation was comparable: Austria received about 80% of the longterm average annual precipitation (1981-2010) with regional variations in deficits of up to -30%[14]. Except some regions in the south of Austria in July, all other regions of Austria suffered from monthly precipitation deficits with regional variations in June, July and August (up to -70%) as well as in November and December (-50% to -90% - highest relative deficits compared to longterm average)[15].
Accumulated river discharges showed for whole Austria a deficit of -14% compared to the longterm average (1981-2010) with regional differences up to -60% (see also table 2).
Groundwater levels in the second half of 2015 were mostly near or below the average (see also table 1). In some parts of Austria groundwater levels fell below the lowest (monthly) observed groundwater levels.

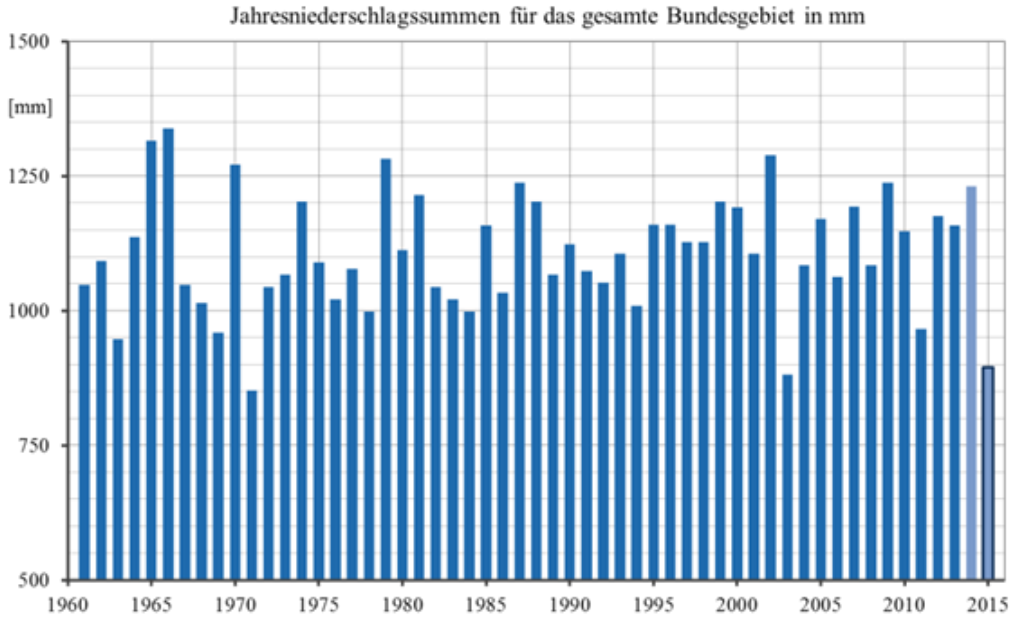


Figure 1: Accumulated annual precipitation in Austria 2015

[12] https://www.bmlfuw.gv.at/wasser/wasser-oesterreich/wasserkreislauf/hydrograph_charakt_extrema/Trockenheit2003.html
[13] https://www.bmlfuw.gv.at/wasser/wasser-oesterreich/wasserkreislauf/hydrographie_oesterreich/mitteilungen/Mitteilungsblatt83.html
[14] https://www.bmlfuw.gv.at/wasser/wasser-oesterreich/wasserkreislauf/hydrograph_charakt_extrema/monatscharakteristiken.html
[15] https://www.bmlfuw.gv.at/wasser/wasser-oesterreich/wasserkreislauf/hydrograph_charakt_extrema/2015trockenheithydro.html

Monitoring station	River	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dez
Innsbruck	Inn	127	127	92	103	114	114	89	85	100	116	105	88
Salzburg	Salzach	159	100	85	104	115	108	77	82	89	109	76	94
Federaun	Gail	133	121	88	56	64	62	60	89	113	102	52	63
Krottendorf	Lavant	175	152	110	79	82	80	79	84	89	162	101	94
Gumisch	Gurk	136	123	93	62	60	74	69	80	82	125	78	67
Mureck	Mur	146	114	75	89	86	74	69	78	70	136	75	65
Wels-Lichtenegg	Traun	151	59	59	94	96	77	48	39	49	85	47	80
Admont	Enns	187	125	86	120	108	93	69	77	78	114	78	93
Opponitz-Mirenau	Ybbs	164	75	74	91	99	61	47	39	45	98	56	116
Lilienfeld	Traisen	136	74	69	73	112	95	73	60	59	100	73	78
Raabs an der Thaya	Thaya	185	62	34	40	49	30	18	14	16	46	61	93
Angern	March	139	98	61	79	56	39	28	42	41	48	55	60
Deutsch Haslau	Leitha	175	124	86	76	98	66	46	30	31	77	51	46
Neumarkt	Raab	106	112	43	37	158	50	87	33	33	172	34	25
Kienstock	Danube	133	79	71	93	120	99	66	62	65	78	63	73
Korneuburg	Danube	133	82	72	92	117	95	65	61	64	80	64	73

Table1: Monthly discharge volumes of major rivers in Austrian Danube river basin 2015 compared to long-term average discharge volumes (1981-2010) (Red >175%, Blue: >75%-175%, brown: <75%)

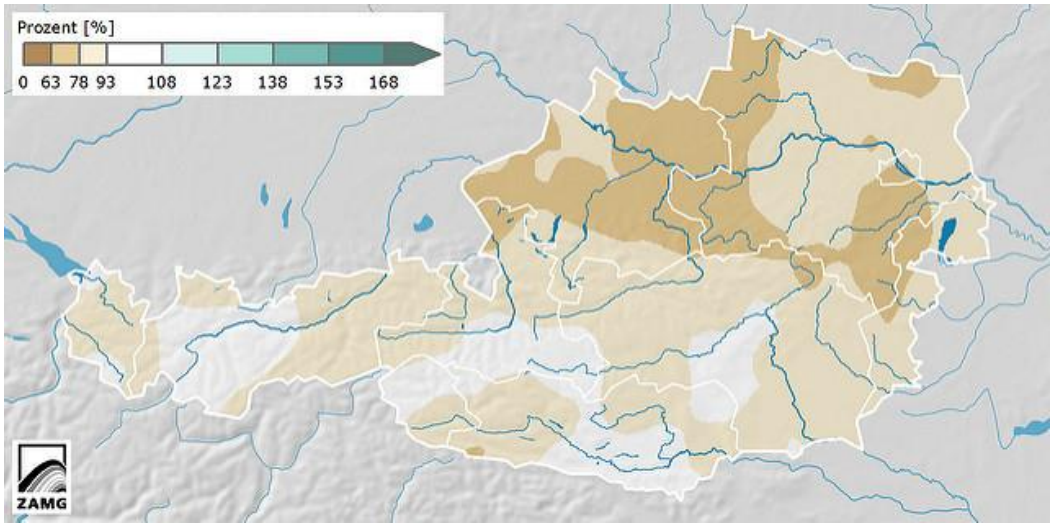


Figure 2: Spatial distribution of annual precipitation 2015 – deviation from average annual precipitation (1981-2010)

However, drought conditions (water tables in groundwater and surface waters below long-term annual mean values (partly considerably below long-term means)) could be observed due to low snow fall in winter and observed precipitation deficits in eastern parts (low land areas) of Austria as of end of June 2017, although data are so far very uncertain.

b) Have the drought events caused situations of water scarcity to specific sectors? What have been the economic losses in each sector (e.g. reduced production of hydro-electricity, harvest losses, ecc.).

Effects of the drought in 2015 have been experienced in almost all water-dependent sectors with different intensity.
In terms of **Agriculture**, the Austrian hail insurance company ("Österreichische Hagelversicherung") estimated total income losses due to losses in crop yields based on data of precipitation distribution (until the end of August) of about 175 Mio. €. Reduced income losses can partly be supported by crop yield statistics, since these statistics reflect an average situation (irrigated areas may provide normal yields and losses in crop yields at non-irrigated areas will be significantly higher than reflected by the statistics).
Water demand increased significantly in areas with periodical irrigation due to significant deficits in precipitation. In the Marchfeld region, the water demand for agricultural irrigation was significantly above (between +30% and +100%) the long-term average.
A lower **hydropower**[16] output for electricity generation (run-of-river) (-9,9%) was registered compared to 2014, but there were no restrictions to supply security with electricity from hydropower.

c) Was the water supply for domestic uses always ensured or have you registered some problems?

Resources availability was not affected at the beginning of the dry conditions in summer 2015[17]. Only little limitations in water supply were detected for 2015 (capacity of network was sufficient also during peaks of water consumption for about 90% of observed service provider). During peaks of water consumption particularly small service provider or individual water supplies were close to service limits (calls for savings of water at 10% and limitations in supply at 5% of observed providers). Introduced mitigation measures as a result of the drought in 2003 (interconnections between service networks between regional service providers; multiple resource use as basis for supply security) in regions vulnerable to resource limitations have proved their effectiveness in 2015.

d) Have these events caused problems and damages also downstream in sections of the basins far from the Alps?

In the most affected regions of Austria (eastern parts (low land areas) of Austria) some side arms of larger rivers or headwater of some small streams suffered from extremely low water tables or even fell dry (see also Table 2), e.g. the side arms of the free flowing section of the Danube river east of Vienna (Lobau) as well as the headwaters of the some small streams in the Vienna Forest. Assessments of water quality of the respective waters were not carried out in 2015.
Several extraordinary fish kills have been reported from region Lower Austria (north-eastern part of Austria). For some lakes extraordinary water temperatures of around 30°C and water levels minus 50 cm below the average have been reported. For some fish ponds in Lower Austria additional aerations measures were needed to sustain the oxygen supply of aquacultures. However, the reports from the public concerning increased fish kills could not be confirmed in general from regional river authorities.
Elevated water temperatures were observed in almost all rivers in July and August 2015. From 232 stations with continuous recording of e.g. data on water temperature, at 69 stations in 2015 the observed water temperatures exceeded the fish-region specific maximum water temperatures in July and August (see figures 4 and 5; the Austrian Quality Objective Ordinance - Ecological Status of Surface Waters laysdown values, inter alia for general physico-chemical conditions, one of these the thermal conditions expressed as maximum water temperatures for each fish region in Austria which is associated with the good ecological status), whereas 125 stations showed no exceedance (38 stations were excluded from evaluations due to different reasons). Stations with observed water temperatures above the fish region-specific maximum water temperature were located in central and northern parts of Upper Austria (Innviertel, Mühlviertel), downstream (outflows) of great lakes (Salzburg, Upper Austria, Carinthia, Tyrol) and in lowland regions in eastern parts of Austria with considerably lower river discharges (see Figure 5), whereas stations within the Alpine regions or at large Alpine-fed rivers like Inn, Salzach or Danube did not show observed water temperatures above the maximum water temperatures.

[16] Investoren-Präsentation Quartale 1-4/2015 (https://www.verbund.com/cc/de/investor-relations/finanzpublikationen#tabbed-1)
[17] https://www.ovgw.at/media/medialibrary/2016/04/Studie_Wasserversorgung_2015.pdf

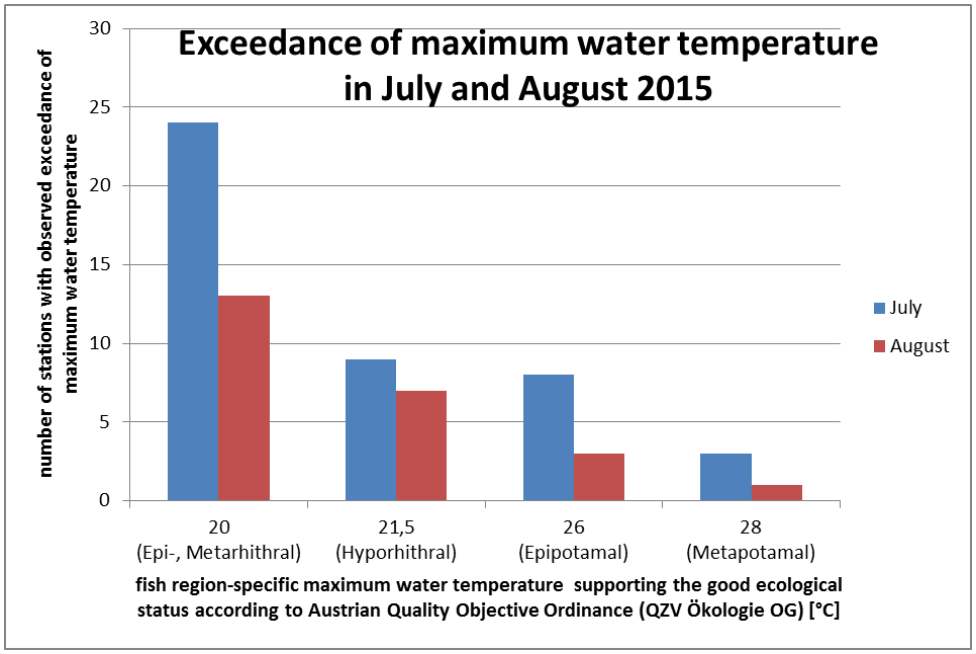


Figure 4: Number of continuously recording water quality stations where observed water temperatures in July and August 2015 exceeded the fish region-specific maximum water temperatures associated with good ecological status according to Austrian Quality Objective Ordinance (QZV Ökologie OG)

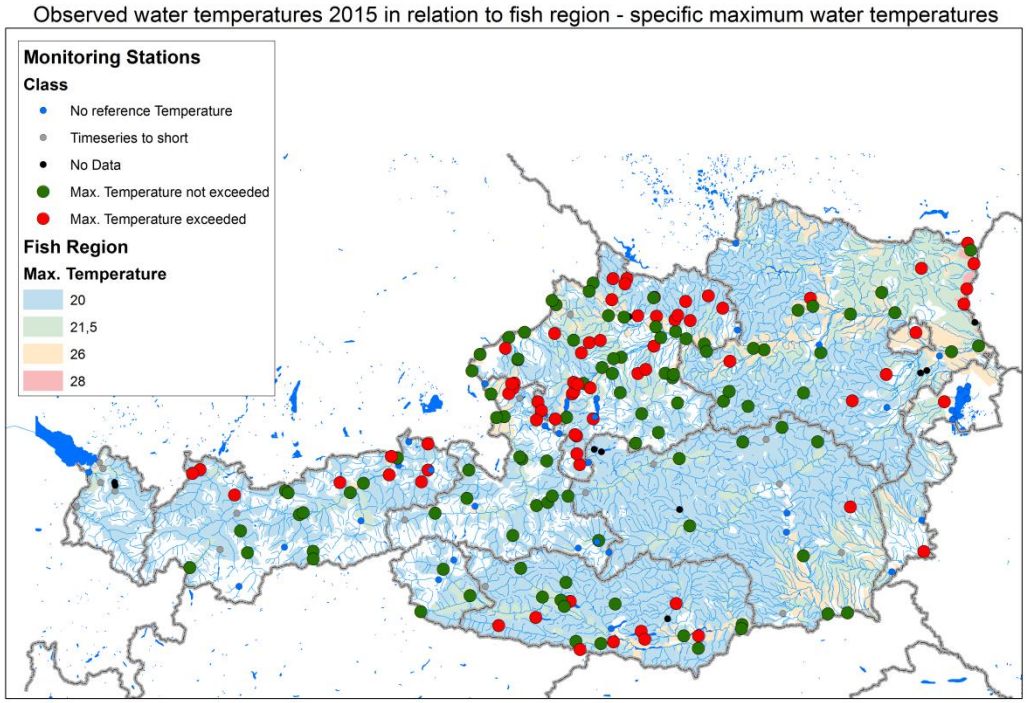


Figure 5: Regional distribution of water quality stations where observed water temperatures in July and August 2015 exceeded the fish region-specific maximum water temperatures associated with good ecological status according to Austrian Quality Objective Ordinance (QZV Ökologie OG)

5) a) What are the main lessons learned after the major droughts of the last years?

Droughts appear regionally and periodically in future. The situations in 2003 and 2015 seemed to be a good blue print to shape action for the adaptation to climate change, as conditions of these 2003 and 2015 droughts seemed to be quite close to situations, which are forecasted for the future.
Actions taken as a consequence of the drought in 2003 to make water supply more resilient against effects of droughts have proven their effectiveness in 2015.

Based on the ZAMG study 2015, drought periods as observed in northern and eastern parts of Austria during 2015 are likely to become the normal case in 2100.

b) Was there any planned prioritization of sectoral uses in case of water scarcity situations? Do there is a prioritization for future events? Is the prioritization different from summer to winter?

All water uses going beyond insignificance have to be permitted by the competent authorities. Permissions are limited in the extent of water uses and have to respect the resource availability (natural regeneration) as well as existing water uses. Furthermore, water uses are limited in time. Reapplications for permissions are subject to detailed analyses in terms of changes resource availability of water uses of the respective resource.
However, permitted water uses may not impede other water uses, particularly those of higher interests (e.g. public water supply, other public water uses or water uses for firefighting, etc.).
In case of limitations of resource availability due to drought conditions which result in restrictions of existing water uses, the competent authorities have to regulate water uses in order satisfy all existing water uses appropriately.
Within the last 10 years, there was no planned prioritization of sectoral water uses. Some restrictions of water uses have been reported on community level in some cases for periods of stressed water availability e.g. for filling swimming pool, car washing or irrigation of private gardens.

c) Was it possible contrasting the drought situation through an improved management of storing capacity of regulated lakes and reservoirs in the basin?

As indicated in point 4c, as a consequence of the drought in 2003, in regions vulnerable to resource limitations much effort has been put to introduction of mitigation in order to ensure the supply security for drinking water, e.g. by interconnections between service networks between regional service providers; multiple resource use as basis for supply security. These mitigation measures have proved their effectiveness in 2015.

d) Were any limitations established to water withdrawals and uses during the drought period? What about future events?

During peaks of water consumption in 2015, particularly small drinking water provider or individual water supplies were close to service limits. There were calls for savings of water at 10% and limitations in supply at 5% of observed providers (n=47).

6) Are there in your Country special plan(s) at basin/sub basin level for severe droughts? Are any standard procedures planned?

Water scarcity and droughts are addressed in the river basin management plan 2015. Although Austria is rich in water resources, its spatial distribution is unevenly distributed. In average, only 3% of the available water resources are used for domestic, industrial or agricultural purposes. Water scarcity is not relevant for Austria. Droughts is a natural phenomenon which can occur regionally and seasonally also in a water-abundant country like Austria. Due to its regional and time-limited relevance, the establishment of country-wide drought risk management plans is not considered as necessary in general.
However, as a result of the drought in 2003 measures to improve the resilience of public water supply were introduced in vulnerable regions (mainly interconnections of supply network between different regions/operators and the exploitation of additional drinking water resources as back-up). They have proven their effectiveness since no major restrictions/limitations in public water supply have been observed during the drought in 2015. Additionally, much effort is put on the awareness raising of general public in terms of the efficient use of water.
The river basin management plan 2015 specifies some further options for actions considered in the light of climate change mitigation to enhance the natural water retention in catchments and to strengthen the sustainability of different water uses (efficiency in agricultural irrigation, artificial groundwater recharge, preparation of separate management plans, etc.) which support also the resilience against future droughts. Additional measures as the consequence of the drought in 2015 are planned, e.g. the elaboration of an emergency plan to avoid fish kills due to future droughts has started in the region of Lower Austria.

7) Are water uses of different sectors quantified and monitored? How are the trends? Please provide some data if possible.

In average, only 3% of the available water resources are used for domestic, industrial or agricultural purposes in Austria.
Sectoral water uses have been quantified within the process of establishment of the river basin management plan 2015[18] in order to assess the risk of groundwater bodies to fail the good quantitative status.
In average, industrial and commercial water uses comprise about two third of total water uses. About 35% of water is used for public water supply, and the remaining 7% is used for agricultural purposes (irrigation)[19]. Evaluations about industrial and agricultural water uses are based on statistical data which have been collected in the late 1990s and updated in regular intervals (e.g. Agriculture in 2010). Data about industrial water uses from facilities under the scope of PRTR are stored in a central database (emission register[20]) since 2010. Figures for drinking water supply are based on data of regular and representative surveys which are conducted by ÖVGW[21] (roof organization of drinking water suppliers).
Due to the introduction of water saving technologies in households as well as improved awareness about the value of water, per capita water uses for public water supply tended to decrease in the last 15 years (from around 150 l to about 135 l per person per day), but this decrease is balanced by population growth. For industrial water uses, water saving technologies have been introduced due to obligations of IPPC and IED Directives as well and contributed to considerable water savings. However, reliable trends about industrial water uses cannot be given.

8) Are there some relevant projects addressing priority areas in your Country? Please briefly describe the main outcomes of those projects relevant for the areas of your interest and link the useful documents.

Data availability for water abstractions by industry, public water supply and agriculture is different for the individual sectors, but in general very limited. For industrial facilities (PRTR facilities) data are stored in the emission register since 2010.
During the last years initiatives have been started at federal level to improve data base and data availability, particularly for the agricultural sector, which is of importance on the regional level. Although the success of these initiatives was limited so far, follow-up studies and activities are currently carried out to improve the knowledge base.

9) Is there any good practice in your Country relevant for planning water uses like e.g. calculating water retention capacity in the basin or snow-water-equivalent in each moment[22]?

Artificial snow making has considerably developed in the Alpine area in winter season over the last years. In the meantime, nearly every bigger ski resort is equipped with artificial snow making equipment which is used to secure appropriate snow conditions throughout the winter season. Artificial snow making considerably influences the water management and water availability at regional level.
Initially water was abstracted directly from surface waters which significantly affected the discharges of respective surface waters during low flow periods and frequently caused problems with ecological discharges.
As a consequence, a series of reservoirs for water retention have been built for artificial snow making, which are (have to be) filled up prior to the winter period and which help to reduce the pressure on surface waters during periods of low flow in winter. Since water uses for artificial snow making need to be permitted, details how many water is allowed to be abstracted at which discharges/periods are (should be) specified within the permissions itself and take into account minimum requirements for ecological discharges.

[18] https://www.bmlfuw.gv.at/wasser/wisa/fachinformation/ngp/ngp-2015/tabellen/GW/gw_tabellen.html
[19] https://www.bmlfuw.gv.at/wasser/wasser-oesterreich/wasserkreislauf/Wasserbilanz.html
[20] https://www.bmlfuw.gv.at/wasser/wasser-oesterreich/wasserrecht_national/planung/EmRegV-OW.html
[21] http://www.ovgw.at/wasser
[22] For more information read i.e. http://land.copernicus.eu/global/products/swe and https://www.vcalc.com/wiki/Titan/Snow+Water+Equivalent+%28SWE%29

FRANCE

1) Is there an approved climate change adaptation strategy in your Country? Please link any references to the official documents.

There is a national adaptation plan to climate change (PNACC).
References can be found at the following link: http://www.developpement-durable.gouv.fr/adaptation-france-au-changement-climatique.

2) a) Are there approved climate change adaptation strategies as well as action plans in the Alpine Regions/Länder/Districts in your Country?

There is an approved adaptation plan for the Rhône Mediterranean river basin and it covers the whole of French alpine area.
Here are the internet links for:

- the plan: https://www.eaurmc.fr/fileadmin/grands-dossiers/documents/Changement_climatique/Plan_Bassin_Chgt_Clim-VF30-06-14.pdf;
- the scientific literature review that was used to design the plan: http://www.eaurmc.fr/fileadmin/grands-dossiers/documents/Changement_climatique/bilan_connaissances_Chgt_Clim_AERMC_couv_def.pdf. This scientific literature review is being revised and should be updated in the coming weeks;
- the Rhone-Mediterranean river basin management plan, chapter 0F-0: http://www.rhone-mediterranee.eaufrance.fr/docs/sdage2016/docs-officiels/20151221-SDAGE-RMed-2016-2021.pdf;
- other documents can be found at the following link: http://www.eaurmc.fr/climat.html.

The drought prefectoral orders taken over the past years are listed in the following link: http://propluvia.developpement-durable.gouv.fr/propluvia/faces/index.jsp.

b) If yes, what is the reference climate change scenario at regional level? Please briefly describe it.

A range of climate change scenarios indicated in the scientific literature review was considered.

c) Are drought periods assessed as a likely risk? What are the most interested periods of the year?

Yes, drought periods are assessed as a likely risk.
In the Alpine area, the periods at risk of droughts have extended over the past few years (see example and consequences further in 5a).

3) a) What are the river basins most exposed to the risk of droughts in the future? And what based on the historical data and experiences?

Currently, the Alpine area is not the most exposed area in terms of droughts in the Rhône Mediterranean river basin. However, the risk of droughts in the Alpine area is very likely to increase. For example, the low flows are likely to decrease by 30% on the Rhone river and on the Durance river.
The Prealpine area seems to be more exposed to the risk of droughts in the future.

b) Inside of these basins, please describe the more vulnerable areas.

The vulnerability maps produced in the river basin management plan illustrate that within the alpine area, sub-catchments are likely to be affected in different ways. Please refer to the plan for more details: https://www.eaurmc.fr/fileadmin/grands-dossiers/documents/Changement_climatique/Plan_Bassin_Chgt_Clim-VF30-06-14.pdf.

4) a) What have been the more significant events in the last 15 years? Describe the events, also including data on precipitations, runoff, dry days in the reference areas. Please include links to reports of the events.

2003 was the worst year in terms of drought in the past 15 years (the reference for the worst drought is 1976). In 2005, 2015 and 2016 (Southern Alps) there were also significant events.
2017 is currently one of the worst years on record in terms of drought.
In 2003, the cumulated rainfall deficit in the first 8 months was over 50%.

b) Have the drought events caused situations of water scarcity to specific sectors? What have been the economic losses in each sector (e.g. reduced production of hydro-electricity, harvest losses, ecc.).

Yes. For example, in winter 2016/2017 there was a high demand for water consumption (touristic season) and for artificial snow for skiing.
Hydropower companies must also comply with the minimum flow rate in rivers (10% of module in France).

c) Was the water supply for domestic uses always ensured or have you registered some problems?

No problem has been registered yet but in Savoie for example, locally, there could potentially be some problems for water supply (when water supply depends on small streams).

d) Have these events caused problems and damages also downstream in sections of the basins far from the Alps?

No, these problems have remained local so far.

5) a) What are the main lessons learned after the major droughts of the last years?

Following some severe droughts, some "arrêtés cadre sécheresse" ("drought framework orders") that define how to manage crisis situation have been modified. Some of them now include threshold levels (for river flow and groundwater level) for the whole year (see for example in Haute Savoie http://www.rhone-mediterranee.eaufrance.fr/docs/infos-secheresse/2015/AC-en-vigueur/74_AC_10juillet2015.pdf).

b) Was there any planned prioritization of sectoral uses in case of water scarcity situations? Do there is a prioritization for future events? Is the prioritization different from summer to winter?

Priority is given to water consumption: when a drought prefectoral order is taken, when a crisis level is reached, all abstraction is forbidden except water consumption.
The first restrictions affect swimming pools and car wash by private owners (it remains authorized at garages for examples), watering of gardens etc.
Then at a more severe crisis level water for irrigation is restricted.
There is no known difference in prioritization between summer and winter.

c) Was it possible contrasting the drought situation through an improved management of storing capacity of regulated lakes and reservoirs in the basin?

It has been possible in some cases (river Ain, river Durance), but it is not so common across the river basins.

d) Were any limitations established to water withdrawals and uses during the drought period? What about future events?

Yes in both cases. It has happened and it will happen. So far in the French Alpine area it has happened more frequently in the Southern Alps, less in the Northern Alps.
The drought prefectoral orders taken over the past years with the limitations enforced are listed in the following link: http://propluvia.developpement-durable.gouv.fr/propluvia/faces/index.jsp.

6) Are there in your Country special plan(s) at basin/sub basin level for severe droughts? Are any standard procedures planned?

There are water resources management plans (PGRE) at river sub-basin scale. These plans are set up to improve the long term water resources management of sub-basins that are unbalanced between the water available and the needs in water abstraction.
There are also "arrêté cadre sécheresse" ("drought framework order") that define how to manage crisis situation. These drought framework orders are designed at the scale of "département" and there are subdivided in sub-basins. They define threshold values that are associated with restriction levels.

7) Are water uses of different sectors quantified and monitored? How are the trends? Please provide some data if possible.

Yes it is monitored.
Water consumption per inhabitant tends to decrease.
For irrigation it depends on the hydrology. There is no obvious general trend.

8) Are there some relevant projects addressing priority areas in your Country? Please briefly describe the main outcomes of those projects relevant for the areas of your interest and link the useful documents.

There are some projects but not in the Alpine area.
There are for examples management plans in priority areas to better share available water and leave more water to the good functioning of rivers.
There are actions put in place to save water (in the industry, to repair leakages, to provide more efficient material for irrigation etc.) or to encourage the substitution of activities when the measures taken to save water is not enough.

9) Is there any good practice in your Country relevant for planning water uses like e.g. calculating water retention capacity in the basin or snow-water-equivalent in each moment[23]?

Hydrological data is available on the Internet. Meteo France provides data to better manage droughts: water retention capacity, snow-water-equivalent, evapotranspiration, net rainfall etc.

GERMANY

1) Is there an approved climate change adaptation strategy in your Country? Please link any references to the official documents.

In Germany, adaptation to climate change is a permanent task established along an agreed and politically adopted institutional and methodological framework. Scientific research programmes, participation and consultation processes as well as the establishment of ongoing reporting systems are set up. On the national level nearly all federal ministries are represented in the "Interministerial Working Group on Adaptation to Climate Change" (IWG Adaptation), lead by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety. To coordinate adaptation activities with the federal states the Conference of Environmental Ministers established in June 2009 a standing committee for the adaptation to climate change impacts. Both the interministerial and national-federal cooperation are crucial to bring together expertise in the manifold tasks of climate change adaptation.
The Federal Cabinet, under the lead responsibility of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), adopted the German Strategy for Adaptation to Climate Change (Deutsche Anpassungsstrategie, DAS) at the end of 2008 (cf.: http://www.bmub.bund.de/themen/klima-energie/klimaschutz/anpassung-an-den-klimawandel/). The overarching goal of the DAS is to reduce Germany's vulnerability vis-à-vis the impact of climate change and to enhance Germany's ability to adapt to climate change. This is to ensure wherever possible that the existing goals of the various policy spheres can also be achieved despite advancing climate change.
In order to flesh out the DAS, this was followed by the Adaptation Action Plan (Aktionsplan Anpassung, APA), which was adopted by the Federal Cabinet on 31 August 2011. The APA supports the DAS with

[23] For more information read i.e. http://land.copernicus.eu/global/products/swe and https://www.vcalc.com/wiki/Titan/Snow+Water+Equivalent+%28SWE%29

specific activities of the Federation, and specifies links with other national strategy processes (including the National Strategy on Biodiversity, National Forest Strategy, High-Tech Strategy 2020).
In 2015, the Federal Government of Germany adopted the initial progress report on the German Strategy for Adaptation to Climate Change (DAS) www.bmub.bund.de/N52706/ (see also brochure: https://www.bmub.bund.de/publikation/adaptation-to-climate-change-initial-progress-report-by-the-federal-government-on-germanys-adapt/). This report gives an overview of the federal activities since the adoption of the DAS in 2008 and the Action Plan I (Aktionsplan Anpassung, APA I in 2011) and outlines future measures and activities to combat the impacts of climate change in an Action Plan II (APA II). The Federal Government decided to report periodically: monitoring report (see: https://www.umweltbundesamt.de/monitoringbericht-2015-startseite) every 4 years, vulnerability assessment (see: https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/climate_change_24_2015_summary_vulnerabilitaet_deutschlands_gegenueber_dem_klimawandel_2.pdf) every 6 years, Adaptation Actions Plans as well as the Progress Reports every 4 years. Furthermore, it was decided to evaluate the adaptation process in Germany on a regular basis. The first report is scheduled for 2019. In Germany all mayor resolutions with regard to the adaptation process are enforced by cabinet decision.

2) a) Are there approved climate change adaptation strategies as well as action plans in the Alpine Regions/Länder/Districts in your Country?

The Bavarian State Government has updated the Bavarian Climate Adaptation Strategy in 2016 (http://www.bestellen.bayern.de/shoplink/stmuv_klima_009.htm). The goal is to make Bavaria safe against the risks of climate change in the long term. For 2019 a handbook for the implementation of adaptation to climate change is planned.

c) Are drought periods assessed as a likely risk? What are the most interested periods of the year?

A special chapter in the Bavarian Climate Adaptation Strategy presents an overview to Climate Change in the Alpine Region. It is assumed that the mountain precipitation will increase more strongly than at low levels, which means that mountain regions are less affected by drought. Future climate changes are currently being updated for the whole region of Bavaria with an ensemble of climate scenarios based on several climate models.

3) a) What are the river basins most exposed to the risk of droughts in the future? And what based on the historical data and experiences?

Historically:
Along the upper Partnach and Loisach (near Garmisch-Partenkirchen) and the Vils some gauges register that annual minimum flow during the 20. century shows decreasing trends that are intensified during recent years. (source: unpublished report dealing with low water trends in Bavaria until 2015).
Future:
No results for whole Bavarian Alpine area, therefore difficult to assess which catchments are most at risk.
Results from Adapt Alp project (only the Inn river area!) should be seen only as tendency as only some gauges are interpreted:
- Gauge Passau-Ingling: representative for whole Inn-area: near future (2021-2050) no to minor changes, in distant future changes expected- validated through analyses with other ensemble of discharge projections (Low Water report Bavaria; also: https://www.adv-geosci.net/32/99/2012/adgeo-32-99-2012.pdf);
- Gauge Oberaudorf (Inn near Austrian border): in the near future in winter no changes to increase possible, in summer not changes to decrease possible, increase of signal in summer foreseen for distant future (https://www.lfu.bayern.de/wasser/klima_wandel/projekte/adaptalp/doc/abflussszenarien_inn.pdf, S.94 ff.);
- results for Alpine Rhine: see summary in attached document ("Final_WP4_SUM_REP_update250711.pdf").
Results from pilot study Mangfall/Attel "future development of spring discharge in Upper Bavaria" results show that it is projected that spring discharge is being reduced by up to 10% until 2025 (Wasserversorgungsbilanz Oberbayern;

https://www.regierung.oberbayern.bayern.de/imperia/md/content/regob/internet/dokumente/presse/2016-06-28_wasserversorgungsbilanz_oberbayern.pdf).
Same in Swabia: pilot study Allgäu, in the Alpine region reduction of spring discharge by 5% until 2025 (Wasserversorgungsbilanz Schwaben: https://www.regierung.schwaben.bayern.de/Aufgaben/Bereich_5/Wasserwirtschaft_und_Wasserbau/WVB2025_Schwaben_2015-01-26_Web.pdf).
In addition, first Bavarian wide results for the future change of low discharges have been modeled, including some alpine gauges. They show in the near future in summer no changes to decrease possible, in winter no decrease. No further risk assessment has been made with these results so far.[24]

4) a) What have been the more significant events in the last 15 years? Describe the events, also including data on precipitations, runoff, dry days in the reference areas. Please include links to reports of the events.

The most significant events in the last 15 years occurred in 2003, 2011 and 2015.
The year 2003 was characterized by 8 dry months between February and September 2003. Temperatures between March and September were up to 0,8°C higher than the average (1961-90).
In Bavaria as a whole around 30% less precipitation was measured compared to the reference period from 1951- 2010.
The year 2011 was characterized by two drought periods. Between February and May below average precipitation rates were measured across Bavaria. This lead to significant low waters. In autumn of the same year there was a 35- to 49-days drought period. South of the Danube the precipitation rate was 53% to 82% below the average (1961-90)
The event 2015 was the most significant in the last 40 years in Bavaria. The year already started with a precipitation deficit. Between November 2014 and April 2015 367mm precipitation was measured south of the Danube which equals 82 % of the average. The significant drought period began in April. Between February and November 9 of 10 months were to dry. The most precipitation was measured in the Bavarian Alps with 440mm. The warm summer 2014 and low precipitation during winter 2014/2015 led also to significant lows at ground water monitoring stations. At some measuring stations in the Alps a new minimum value was reached.
Link/Reference (only in German) Bayerisches Landesamt für Umwelt(2016): Niedrigwasser in Bayern. Grundlagen, Veränderung und Auswirkung. Downloadable: http://www.bestellen.bayern.de/shoplink/lfu_was_00124.htm
Bayerisches Landesamt für Wasserwirtschaft (2005): Wasserwirtschaftlicher Bericht – Niedrigwasserperiode 2003. Downloadable: http://www.nid.bayern.de/files/docs/LfW_Niedrigwasser_2003.pdf.

b) Have the drought events caused situations of water scarcity to specific sectors? What have been the economic losses in each sector (e.g. reduced production of hydro-electricity, harvest losses, ecc.).

In 2003 the low water chamber (Niedrigwasserraum, used to keep the level of the Isar at stable conditions) of the Sylvenstein Reservoir (upper Isar) was only filled by 24 % at the end of September.

c) Was the water supply for domestic uses always ensured or have you registered some problems?

In 2003 some problems in smaller communes in the low mountain range in Bavaria occurred. But not in the Alpine area.
In 2015 some alpine pastures faced significant problems due to only freshwater source being natural springs.

d) Have these events caused problems and damages also downstream in sections of the basins far from the Alps?

[24] Bayerisches Landesamt für Umwelt (2016): Niedrigwasser in Bayern. Grundlagen, Veränderung und Auswirkung. Download: http://www.bestellen.bayern.de/shoplink/lfu_was_00124.htm

As far as we know: no.

5) a) What are the main lessons learned after the major droughts of the last years?

Some communal water suppliers invested in alternative sources/measures for freshwater supply, e.g. pumping from other regions. It is foreseen that all communes have to cater for alternative water sources/independent systems.
There are adaptation strategies but not specifically for the Alpine area.
A evaluation about supply reliability and recommended action on administrative district level can be found in water supply balances for Upper Bavaria and Swabia (https://www.regierung.oberbayern.bayern.de/imperia/md/content/regob/internet/dokumente/presse/2016-06-28_wasserversorgungsbilanz_oberbayern.pdf; https://www.regierung.schwaben.bayern.de/Aufgaben/Bereich_5/Wasserwirtschaft_und_Wasserbau/WVB2025_Schwaben_2015-01-26_Web.pdf).

c) Was it possible contrasting the drought situation through an improved management of storing capacity of regulated lakes and reservoirs in the basin?

In summer 2015 the Sylvenstein reservoir had to top up low waters in the Isar to stabilize the Isar discharge, see also Low water report.

d) Were any limitations established to water withdrawals and uses during the drought period? What about future events?

Not in the Bavarian Alps, but in other regions of Bavaria.

6) Are there in your Country special plan(s) at basin/sub basin level for severe droughts? Are any standard procedures planned?

Not in the Bavarian Alps, in Lower Franconia a pilot study on "Development of low water management" is established.
Outside the Alps a pilot programme was started to develop concepts for sustainable irrigation. Inside the Bavarian Alps there is no need for that yet.

7) Are water uses of different sectors quantified and monitored? How are the trends? Please provide some data if possible.

For the public water supply: yes. For other sectors this is foreseen in the future, but not specifically for the Alpine area (see question 6 project on irrigation).

ITALY

1) Is there an approved climate change adaptation strategy in your Country? Please link any references to the official documents.

The National Strategy of Adaptation to Climate Changes (SNACC) has been adopted in June 2015 by the Italian Ministry of the Environment, Land and Sea (IMELS) thanks to a Director's Decree, also in coherence with the EU Adaptation Strategy (April 2013, https://ec.europa.eu/clima/policies/adaptation/what_en).
The National Plan of Adaptation to Climate Changes is still under preparation after a public consultation phase ended in March 2017 (http://www.minambiente.it/notizie/strategia-nazionale-di-adattamento-ai-cambiamenti-climatici-0). The Plan is aimed to be a practical tool devoted to Regional and local authorities and it is shared with the authorities themselves in the context of the "Conferenza Stato-Regioni" meetings (official meeting of Government's representatives with Regional Governments).
Specific sections of the document are devoted to water management (quantity and quality), risk of desertification, soil conservation and droughts, as well as specific pilot studies on the Po river basin and on the mountain areas have been prepared.

2) a) Are there approved climate change adaptation strategies as well as action plans in the Alpine Regions/Länder/Districts in your Country?[25]

Region Friuli Venezia Giulia: Start-up phase of a Regional Strategy: a process is underway for the preparation of a Regional Climate Change Adaptation Strategy which is currently (July 2017) in the start-up phase[26]. The process of setting up a Regional Strategy for Adaptation to Climate Change will make possible to evaluate the opportunity to prepare a Regional Plan for Adapting to Climate Change too, or to adopt other instruments and tools for the implementation of the Strategy.

Region Lombardia: In 2013 and 2014, in collaboration with the Lombardy Foundation for the Environment, the Regional Strategy for Adaptation to Climate Change (SRACC) has been drawn up in line with the recommendations of the European institutions and in line with the Italian National Strategy approved with directorial decree n. 86/2015.

The strategy has defined the role of regional institutional stakeholders through specific internal consultation mechanisms, has deepened and updated the climatic bases (past and current climate changes, climate variability and future climate change) at the regional level, has conducted a quantitative evaluation on the sectoral impacts (meta-analysis of scientific bibliography) and the analysis of vulnerability to climate change in the eight key sectors considered. Furthermore, the strategy has established for each of the sectors affected by the effects of climate change the functional relationship between impacts, general adaptation targets and specific measures, taking into account the overall framework of sectoral and inter-sectoral policies and interventions already under way or planned by the regional administration.

Starting from the Strategy - which traces the guidelines to "adapt" to the impacts of climate change in the regional territory - in 2015 has been started the work for the elaboration of the "Regional Action-Document on Adaptation to Climate Change" in order to identify the priority areas in which to intervene by responding to the needs of sector planning.

The Action-Document represents an important governance tool that recognizes and defines the priority areas with respect to the effects produced by the climate on the regional territory, and on the other hand identifies the actions to minimize risks and impacts on the population, on materials and natural resources and to increase the resilience of society, economy and environment.

With all the General Directions concerned by the relevant policies and with the main regional stakeholders, has been carried out an important joint work aimed at identifying shared adaptation measures based on the programs already in place following the principle of the so-called mainstreaming of economic and instrumental resources for the implementation of the interventions. Is important to recall the importance of the principle of mainstreaming, which means the integration of the adaptation in the various sectoral policies, both in terms of interventions and resources.

There have been identified approximately 30 measures for the identified priority areas of human health and air quality, soil and land protection, water management and quality, agriculture and biodiversity, tourism and sport.

Region Piemonte: Region Piemonte is working to implement the European guidelines and the National Strategy for the adaptation to climate change, consistently with the contents of the Paris Climate Agreement, and aims to adopt a Regional Strategy document in the framework of a path aimed at tackling the identification of coordinated actions aimed at reducing the vulnerability of natural and socio-economic systems and increasing their resilience, incorporating these objectives within the programs and plans of the sectors that are most vulnerable to the negative effects of such changes.

The process of defining a comprehensive strategy to face with climate change, which includes both mitigation and adaptation, has already been launched on the signing of the Under 2 MOU protocol in November 2015. The work of drafting the Regional Strategy is being concretized through the preparation of a DGR (Decision of Regional Government) that provides for the establishment of a Control Room / interdepartmental working group to which entrusting the tasks of: 1) coordinating the internal connection for the drafting of the document, 2) identifying and starting a path of involvement of stakeholders and civil society in sharing and implementing the Strategy itself[27].

A preliminary action for the preparation of the Strategy is the work already started with the Regional Agency for Environmental Protection of Piemonte for the definition of scenarios and pressure indicators related to

[25] Main source: ISPRA, http://annuario.isprambiente.it/entityada/basic/6358/singola#, last update December 5th 2016 - 12:12.
[26] http://www.regione.fvg.it/rafvg/comunicati/comunicato.act?dir=/rafvg/cms/RAFVG/notiziedallagiunta/&nm=20170620172349008
[27] http://www.regione.piemonte.it/pinforma/ambiente/1363-una-strategia-regionale-per-affrontare-il-cambiamento-climatico.html

climate change, useful to outline the cognitive framework and the future impacts, trying to highlight the expected impacts at regional and local level.
The objective is to prepare, in a short time, an Address-Document for the preparation of the Regional Strategy for adaptation to climate change.
The first working hypotheses of the Region Piemonte (which will be finalized in the Address Document) do not foresee the drafting of a specific Adaptation Plan, but rather a Strategy-document containing elements capable of addressing the mainstreaming of adaptation towards sectoral planning according to criteria and priorities that will be recognized in relation to the different degree of vulnerability and risk of the territories and sectors of action, taking care to enhance synergies and avoid maladaptions. It is intended to stimulate an action to update regional sectoral planning with specific measures to mitigate and adapt to climate change, as well as the assessment of the climate impact of the measures defined in the plans and how climate change can affect the effectiveness of some of these.
It is also envisaged to combine the application of the Strategy-document with an important coordination action to ensure the concrete downstream of the adaptation in planning not in different thematic areas (e.g. health, agriculture, protected areas, energy, transport...) but also in different levels of territorial government (provincial, municipal).
Autonomous Province of Trento: The Autonomous Province of Trento has not yet approved a Local Strategy of Adaptation to Climate Change, however, to appropriately orientate and regulate actions to tackle climate change, it has adopted a specific law, "Trentino for the protection of the climate" (Provincial Law March 9th, 2010, No. 5), subsequently replaced by the Environmental Impact Assessment Law, currently in force (Provincial Law 17 September 2013, n.19), which has kept the contents unmodified.
Point 1 of article 23rd of this Law states that "the Province promotes an overall strategy to tackle climate change, adopting appropriate adaptation and mitigation measures within the province planning and planning tools, both in general and sectoral, in compliance with the objectives established by the State, the European Union and at international level, ensuring adequate forms of participation of citizens and stakeholders ".
The general strategy adopted by the Province of Trento to tackle the consequences of climate change includes until now a complex series of initiatives that refer to the adoption of regulatory and organizational instruments, monitoring and research, mitigation measures, adaptation, information and awareness of citizenship.
However, has emerged the need to give greater coherence to these interventions and therefore to start a process for defining a Climate Change Adaptation Strategy at the provincial level and a related Climate Action Plan to identify priorities for action in the coming years according to the most vulnerable sectors.
The Strategy definition process is currently in its start-up phase, with the updating of the state of the art, which has as its initial reference point the analysis carried out in 2008, summarized in the publication "Forecast and consequences of climate change in Trentino", on the impact of climate change in Trentino and the identification of the most vulnerable sectors.
In addition, several climate change impact studies are under development based on various future climate scenarios; they have already allowed the use of the acquired information for regulatory measures on individual sectors[28].
Autonomous Province of Bolzano/Bozen: No strategies or plans to adapt to climate change are being developed, but the Autonomous Province of Bolzano is very active with regard to climate change mitigation[29].
Autonomous Region Valle d'Aosta/Vallèe d'Aoste: A specific strategic document has been prepared, but not formally approved, in the technical field, also thanks to the studies developed in the context of various cooperation projects[30]. The competent political body is now assessing the Strategy. Similarly, a Plan that is now being assessed by the competent political body has been prepared in the technical field, but not yet formally approved.
Region Veneto: Veneto Region is not developing an adaptation strategy or a related plan, but has worked on the definition of individual sectoral plans linked to climate change-related aspects (protection of the atmosphere, transport, rural development). Furthermore has to be reported the adhesion of the Region to the Under2MoU Protocol in June 2016[31].

[28] http://www.climatrentino.it/chi_siamo/provincia_trento_clima/ and http://www.climatrentino.it/binary/pat_climatrentino/SIEFF.pdf
[29] http://www.provincia.bz.it/agenzia-ambiente/download/PianoClima_Energia_AA2050_Ansicht.pdf
[30] http://www.provincia.bz.it/agenzia-ambiente/download/PianoClima_Energia_AA2050_Ansicht.pdf
[31] https://bur.regione.veneto.it/BurvServices/pubblica/DettaglioDgr.aspx?id=323983

Limited to coastal area, with the DGR n. 762 of 27/05/2016, the Regional Council approved the ratification of the "Memorandum of Understanding for the drafting of national guidelines on the defense of coastlines from erosion and from the effects of climate change, between the Ministry of the Environment, Land and Sea and the riparian Regions", in order to frame the issue in its overall context in reference to the structural alteration and degradation factors and to favor actions to reduce the causes that generate the phenomena, as well as all actions to protect and enhance the coasts valorization.

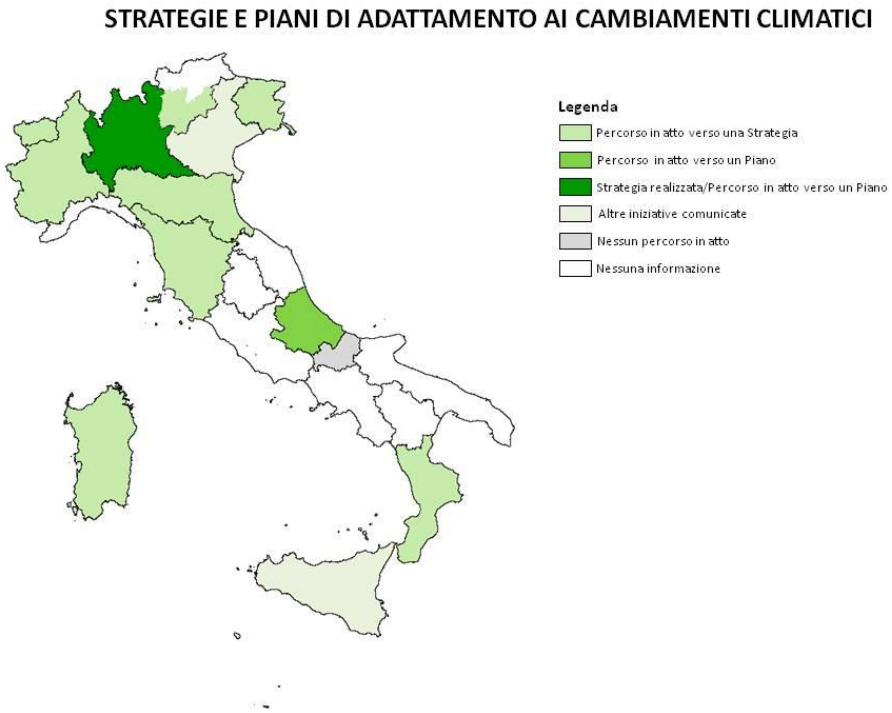


Figure 2- Regions according to their process towards a strategy and a plan for the adaptation to climate changes (ISPRA, 2016 - http://annuario.isprambiente.it/entityada/basic/6358/singola#)

b) If yes, what is the reference climate change scenario at regional level? Please briefly describe it.

Region Lombardia: The regional territory is particularly complex from a climate point of view and includes 4 out of 6 climatic macro-regions identified by the national plan.

Most of the Italian Alpine arc has been classified as the macro-region 4: in this macroregion there is the minimum value of average temperature (5.7 ° C) and the maximum number of frost days; winter rainfall is less abundant (143 mm) than in the climatic macroregion 5, which is the wettest, but by far there is a medium-high value, while summer rainfall is the most significant (286 mm) compared to all other macro-regions[32].

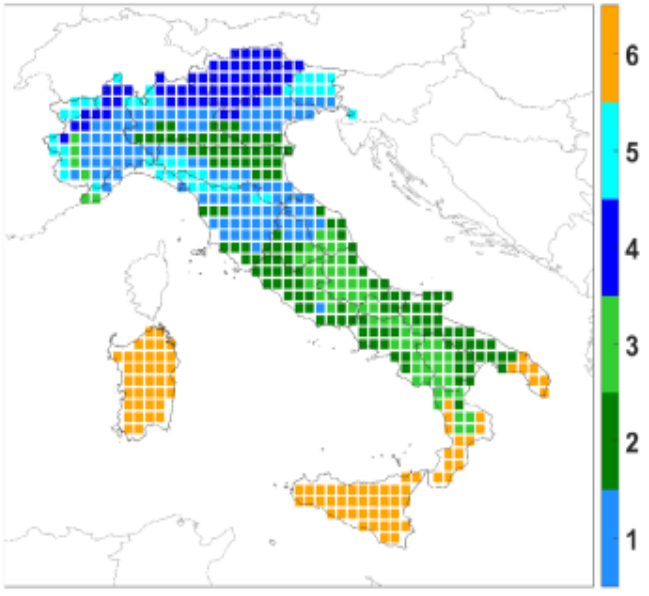


Figure 3 - Climate zoning at a national level in the reference period 1981-2010

[32] PNACC – National Plan of Adaptation to Climate Change.

Below there are the seasonal climate projections for temperatures and precipitation, presented in the PNACC:

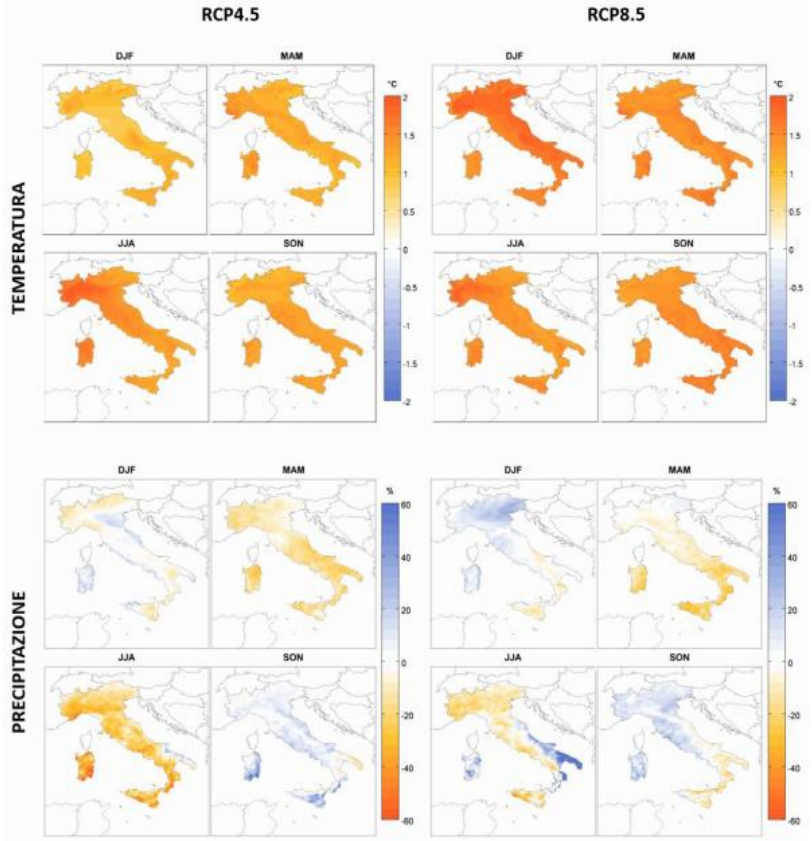


Figure 1 - seasonal climate projections: temperature and rainfall anomalies for the period 2021-2050 compared to the period 1981-2010, according to scenarios RCP4.5 and RCP8.5

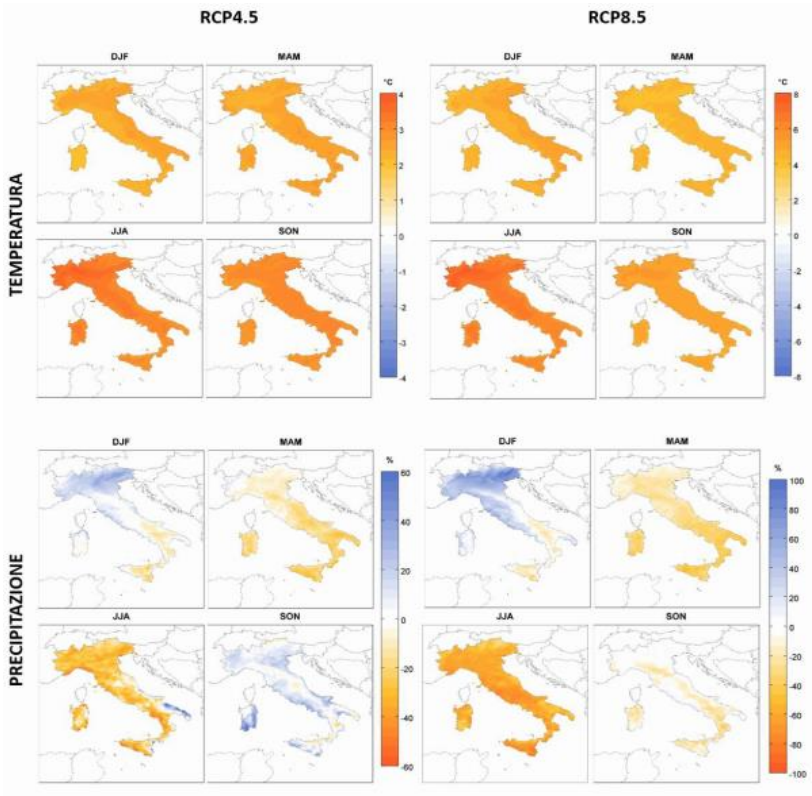


Figure 2 - seasonal climate projections: temperature and rainfall anomalies for the period 2071-2100 compared to the period 1981-2010, according to scenarios RCP4.5 and RCP8.5

The scenarios that have been used for the Document of Action of Region Lombardia is the same used in the Regional Strategy and is based on a review of scientific literature, including the outcomes of the project ENSEMBLES (2009) and the climate analysis carried on thanks the action A1 of the LIFE project MasterAdapt (https://masteradapt.eu/).

c) Are drought periods assessed as a likely risk? What are the most interested periods of the year?

District of Eastern Alps: drought is a likely risk in particular from the beginning of April to the end of August.

Region Lombardia: As indicated in the Lombardy Region's Climate Change Adaptation Strategy, the main climate models forecasts for Northern Italy a general decline in summer season rainfalls, which, together with the increase in average and maximum seasonal temperatures, likely increase the frequency of hot and dry summers at the end of the century. Based on the understanding of the physical processes of the atmosphere and the integration of numerical climate models, it has been estimated that the frequency and duration of drought events is likely increasing by the end of the century (Gao and Giorgi 2008; Dai 2011; CH2011, 2012). Especially during the summer, the greater inter-annual variability and the reduction of seasonal precipitation, combined with the higher evapotranspiration rates induced by higher temperatures and the increase in solar irradiation (Gobiet et al. 2013), could further amplify the loss of soil moisture, exacerbating potential problems of agronomic drought.

As for frequency, some studies predict that in Italy drought events of a certain intensity that today have 100-year return periods could increase their recurrence up to return periods of 70-40 years for 2050 and equal to 40-10 years for 2070, with some differences depending on the climate models considered (Giannakopoulos et al., 2009, Coppola and Giorgi, 2010). Further than becoming more frequent, the dry periods could become even longer. Most regional and global climate models agree to predict an increase in the CDD index (indicator of maximum drought length) across the Mediterranean basin. For Lombardy, the increase in the CCD index by the end of the century could range from 40 ± 5% in the lowland areas to 30 ± 5 in hilly and mountain areas. However, the uncertainties are considerable and may vary substantially depending on the model used.

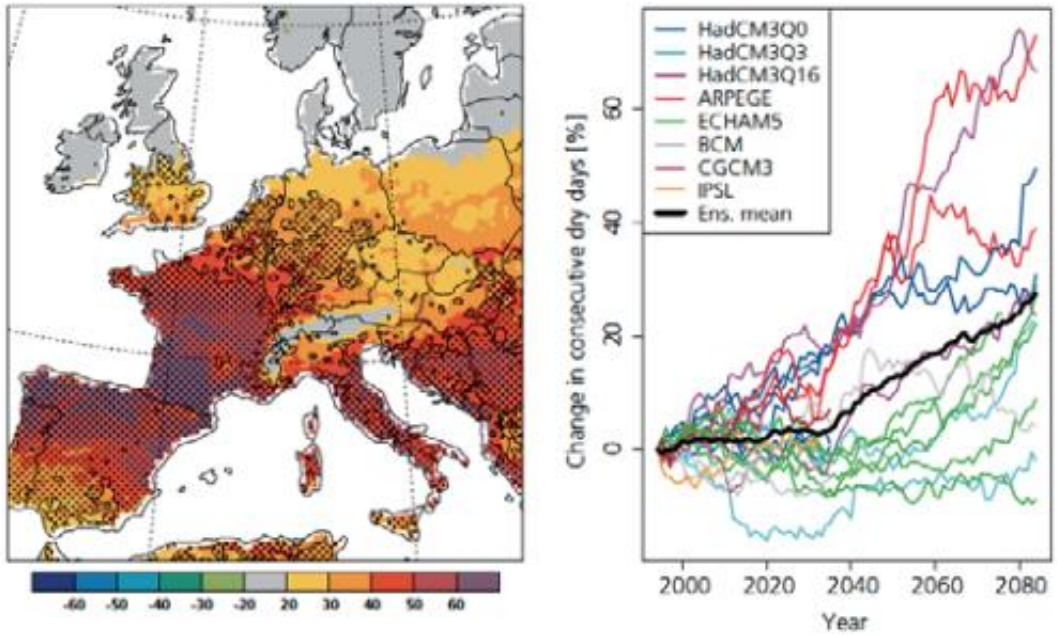


Figure 4 - estimate of the increase of drought days in the period 2071-2100 (average of 8 models) compared to the period 1981-2009, considering the emission scenario SREAS A1B, and trend of dry days along the whole period according to the different models.

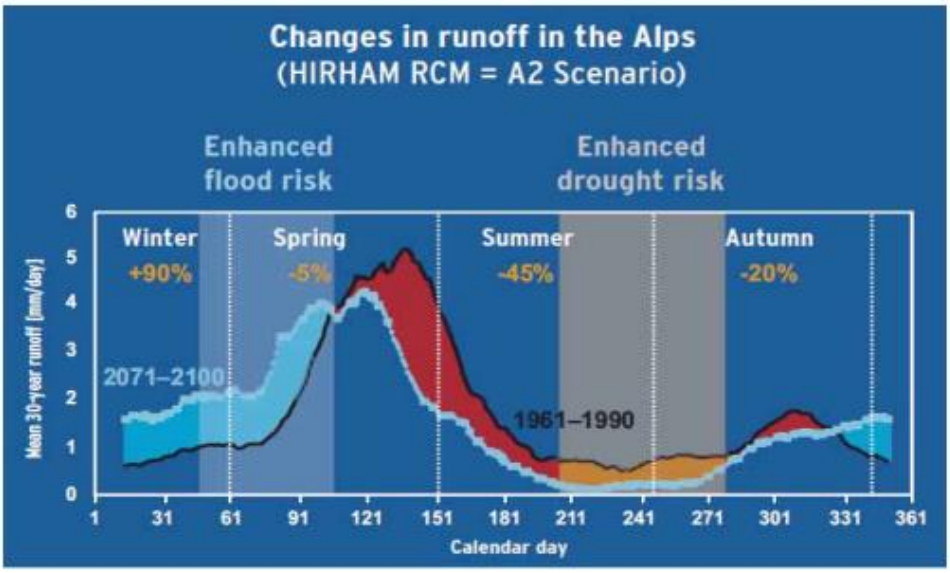


Figure 5 - The chart shows the expected trend of the runoff or central Alps' rivers in the period 2071-2100 compared to the period 1961-1990 (Beniston, 2006).

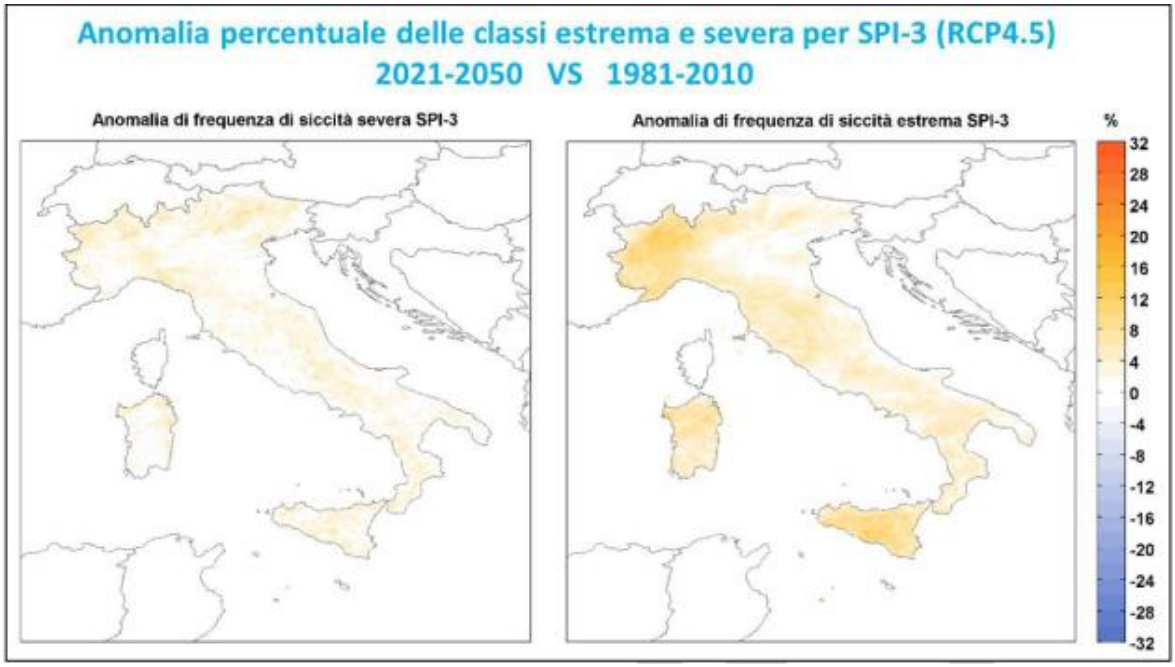


Figure 6 - Drought index (SPI) on severe (left) and extreme (right) droughts of 3 months based on the scenario RCP4.5 (source: PNACC).

The maps here above show that the number of events of severe and extreme droughts of the duration of 3 months will increase on the entire national territory. Based on the climate zones as classified by the SNACC (and reported in the figure no.2) the most interested climatic macro-regions are 1, 2 and 6.

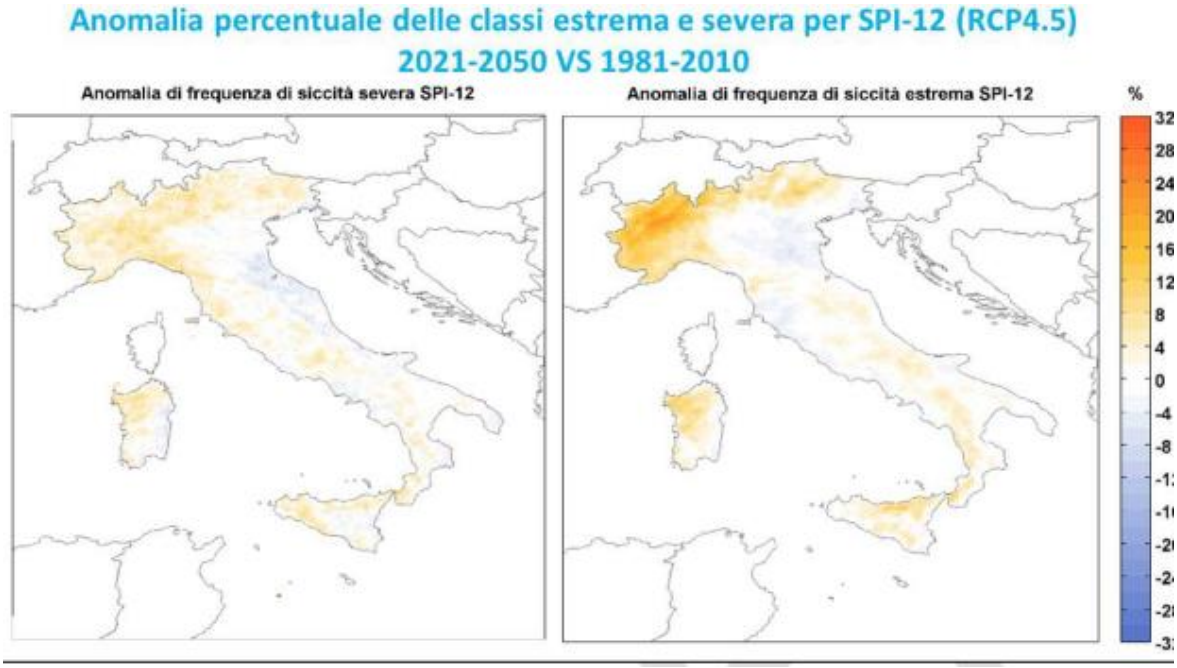


Figura 7 - Drought index (SPI) on severe (left) and extreme (right) droughts of 12 months based on the scenario RCP4.5 (source: PNACC).

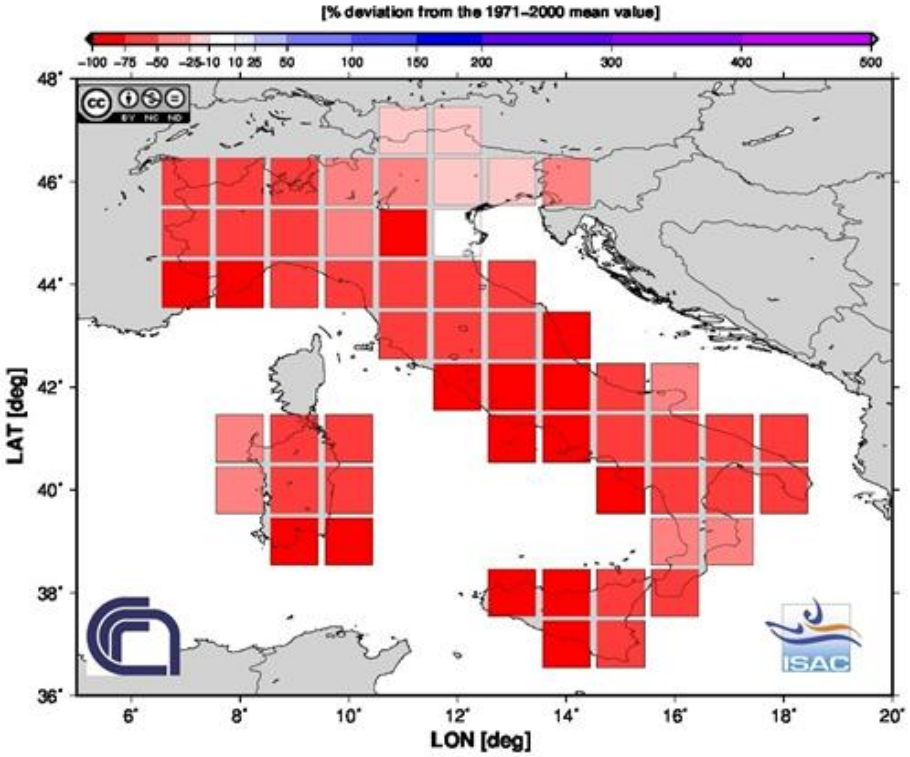
3) a) What are the river basins most exposed to the risk of droughts in the future? And what based on the historical data and experiences?

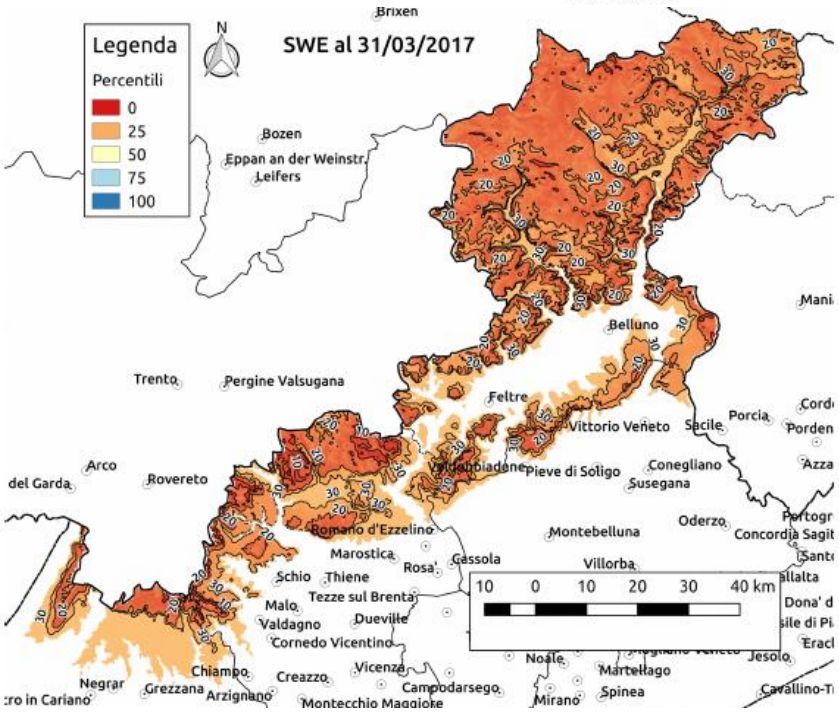
Yes they are, as explained in the answer before and particularly for the summer and early autumn months. In the District of Eastern Alps (http://www.alpiorientali.it/il-distretto/chi-siamo.html), the most exposed seems to be the river basin of Adige.

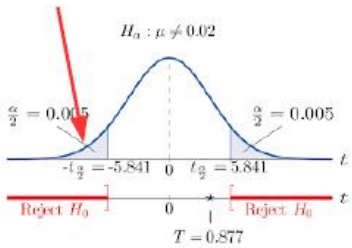
b) Inside of these basins, please describe the more vulnerable areas.

In the District of Eastern Alps, the irrigated plans of Adige River, which are the wider irrigated area in the District, are the more vulnerable area. Water levels of 2017 drought are here: http://www.bacino-adige.it/sito/index.php/dati-online-web/carenza-idrica-adige-2017.

4) a) What have been the more significant events in the last 15 years? Describe the events, also including data on precipitations, runoff, dry days in the reference areas. Please include links to reports of the events.







Drought

Summer 2017, on a national basis, is ranked as the 4th driest since 1800 according to ISAC-CNR. Relatively to the 1971-2000 mean precipitations, anomaly of summer 2017 average precipitations is -41% on the national level, -82% in the month of August. Eleven of Italy's 21 regions has asked for the state of emergency in order to help tackle the drought.
The dry summer 2017 immediately follow an extremely dry winter, as shown by the map of the snow anomaly in Veneto Region on March 31st 2017.
District of Eastern Alps: In the last 15 years, the most severe droughts have been recorded in 2003, 2005, 2007 and 2017.

b) Have the drought events caused situations of water scarcity to specific sectors? What have been the economic losses in each sector (e.g. reduced production of hydro-electricity, harvest losses, ecc.).

District of Eastern Alps: the sector most exposed to droughts is the agricultural sector, while freshwater distribution can be affected at local level and for short periods only in extreme situations.
An economic analysis of the costs per sector of past events is under elaboration with the first data being produced on Eastern Alps.
On the national level, the Italian Ministry for the Environment, Land and Sea, together with the High Institute for Environmental Research (ISPRA), is producing an economic assessment of droughts costs, including scenarios around the economic impact of choices to possibly take in case of future severe droughts.
On these basis, standardized data on potential economic losses per sector based on different choices of water uses in case of water scarcity are under study.

c) Was the water supply for domestic uses always ensured or have you registered some problems?

District of Eastern Alps: for short periods, low water flows in the Adige River have not prevented the rise of the salt wedge from the sea, stopping the drinking-water treatment plants.

d) Have these events caused problems and damages also downstream in sections of the basins far from the Alps?

District of Eastern Alps: this problem happened in the Adige Basin more than one hundred kilometers outside of the Alpine perimeter.

5) a) What are the main lessons learned after the major droughts of the last years?

The IMELS (Ministry of the Environment, Land and Sea) launched on July 2016 the "Permanent Observatories on Water Uses" at River District level in order to implement, within the various territories, a new governance system, able to favor the optimal management of water resources and to address shortage crises in the name of cooperation, dialogue between the parties and attention to territorial specificities. These commissions of institutions and stakeholders are called, in particular, to operate as a "governing body" in case of droughts helping to find the smarter solutions and compromises in order to better manage water resources in case of scarcity.[33]
Ministerial Decree 294 of October 25th, 2016, officially established the Permanent Observatories, as a specific measure of the District Management Plans. Based on the concept of "water shortage" (water demand is higher than availability of sustainable water resources) and according to the tool of the "water budget" (according with the Ministerial Decree July 28th, 2004), 4 levels of criticality level for droughts management are established: 1. not critical; 2. low water criticality (the water demand is still satisfied but indicators shows a negative trend and weather forecast do not foresee sufficient rains; the observatory assume the role of governing body for the management of water crisis); 3. medium water criticality (there are the conditions for the declaration of prolonged drought pursuant to art.4.6 of WFD and the declaration of state of emergency); 4. severe water criticality (all the measures have been taken but remains a critical state that is not finishing soon). After the declaration of the state of emergency by the President of the Council of Ministers (4th level), Civil Protection (which is member of the Permanent Observatories) is allowed

[33] http://www.minambiente.it/notizie/emergenza-siccita

to intervene for practically managing the situation and the Observatories serve as an informative/operative support.
District of Eastern Alps: the need to optimize the use of water in agriculture has emerged, together with the possibility to sustain river runoff with water from the reservoirs, even if realized only for hydroelectric production.

b) Was there any planned prioritization of sectoral uses in case of water scarcity situations? Do there is a prioritization for future events? Is the prioritization different from summer to winter?

Italy: as stated by the "Environmental code" (Law by Decree no.152 of April 8th 2006), in case of water scarcity, after the human consumption, the second priority have to be given to agriculture; furthermore, based on the agreement between two Ministries, could be also decided the release of water from hydroelectric reservoirs, without any compensation to hydropower companies if not the discount of the concession fee[34]. By the way, this last measure is not commonly used, while the Government promotes a dialogue among water users, in particular with the recent solution of the "Permanent Observatories on Water Uses" (also called "drought observatories" on the news) established in 2016 by the Ministry of the Environment, Land and Sea in each District Authority.[35]
There are no differences in prioritization based on the season.
District of Eastern Alps: the first level of priority is always given to domestic uses and, secondarily, to agriculture. During winter, water scarcity situations could particularly affect drinking water, considering that agricultural water uses are reduced.

c) Was it possible contrasting the drought situation through an improved management of storing capacity of regulated lakes and reservoirs in the basin?

The use of reservoirs for improving water discharge for different uses has been experienced in Italy (e.g. in 2017 - as a result of a structured negotiation, even if a public forced right on releases is planned by law).
District of (the Italian) Eastern Alps: the Permanent Observatory for Water Uses of Eastern Alps has prepared a plan to face water scarcity during the season of irrigation 2017. That plan had foreseen to face water scarcity situations with the release of water from hydroelectric reservoirs, and the extremely dry spring and summer have brought to test the effectiveness of the plan after a work of coordination between all the involved stakeholders.

d) Were any limitations established to water withdrawals and uses during the drought period? What about future events?

In the Po River District, the Permanent Observatory on Water Uses, during the severe drought of spring and autumn 2017, on August 3rd established i.e. the reduction of 5% compared to the concessions of water

[34] **COURTESY TRANSLATION**
Article 167
Agricultural uses of water
1. In periods of drought and in any case of scarcity of water resources, during which the allowed derivations are regulated, after the human consumption must be ensured the priority for the agricultural use including the aquaculture activity referred to the law of 5 February 1992, n. 102.
2. In the event that, pursuant to Article 145, paragraph 3, derivations will be regulated, the competent administration, having heard the holders of the derivation concessions, shall take the relevant measures.
3. The collection of rainwater in reservoirs and tanks serving agricultural lands or individual buildings is free.
4. The collection as to the paragraph no. 3 does not require a license or concession to derive water; the laws concerning building, construction in earthquake zones, dikes and dams and other special laws regulate the realization of the relative structures.
5. The use of groundwater for domestic purposes, as defined in the second paragraph of Article 93 of the Consolidated Law on electrical systems, approved by the Royal Decree of 11 December 1933, n. 1775, remains governed by the same provision, provided that it does not compromise the water balance referred to the Article 145 of this Decree.
Article 168
Use of water addressed to hydroelectric use
1. Taking into account the principles set out in the third part of this decree and the national energy plan, as well as the guidelines for multiple uses of water resources, the Minister for the Environment, Land and Sea, in agreement with the Minister of Production, having heard the Basin Authorities, as well as the Regions and the Autonomous Provinces, discipline - without this giving rise to the payment of compensation by the public administration and only generating the corresponding reduction in the concession fee:
a) production for sale of desalinated water obtained in the production cycles of coastal power plants;
b) the use of the water collected in reservoirs for hydroelectric purposes to cope with emergency situations of water scarcity;
c) the defense and the cleaning for the protection of water quantity and quality of hydroelectric reservoirs.
[35] http://www.minambiente.it/comunicati/siccita-da-po-sardegna-ai-primi-sei-osservatori-galletti-passo-la-nuova-governance

withdrawals from irrigation utilities fed by Alpine watercourses. Also pre-Alpine Regulated lakes, excepted for Lake Idro, have released water in measure to ensure an increase of 5% of the flow rate downstream as established by the Observatory, in order to ensure the ecological flow of the river in a situation of severe scarcity.[36]
In the District of Eastern Alps, the Permanent Observatory specifically planned the water uses for the dry season of 2017 including both the release of water from reservoirs and the limitation of water withdrawals for irrigation.

6) Are there in your Country special plan(s) at basin/sub basin level for severe droughts? Are any standard procedures planned?

Next than working on negotiation aspects, these commissions (the Permanent Observatories on Water Uses) will likely work on the basis of plans with standardized procedures like e.g.: level X of runoff in the section A it means quantity Y of water releases from reservoirs and quantity Z of reduced withdrawals.
The plan prepared in 2017 by the Adige Observatory has been immediately "tested" with good results. By the way, considering the complexity of the procedures and the competition for water uses, at least in the starting phase, standardized procedures have not been introduced.

7) Are water uses of different sectors quantified and monitored? How are the trends? Please provide some data if possible.

Data about the main water uses are included in the River Basin Management Plan according to the Water Framework Directive.
The High Institute for Environmental Research (ISPRA) and the National Council for Research (CNR) –as members of the Permanent Observatories on Water Uses - are collecting weather-climate data and trying to define reliable seasonal models with the aim of helping decision-making processes on water uses on the basis of forecasted runoff and snow-water-equivalent. On June 28th 2018, they have published a handbook on weather-climate and specific droughts indicators[37].

8) Is there any good practice in your Country relevant for planning water uses like e.g. calculating water retention capacity in the basin or snow-water-equivalent in each moment[38]?

Next than the work under development by ISPRA and CNR in the context of the Permanent Observatories, at least two further examples deserve to be mentioned.
Eurac Research is using Earth Observation (by remote sensing) and modelling techniques to monitor water scarcity, in particular the relationship between snow cover in the Alps and run-off in Alpine rivers as well as drought aspects such as soil moisture anomalies, evapotranspiration losses or impact on vegetation. An operational snow cover monitoring service with full Alpine coverage is in place as well as activities with Italian hydropower providers to forecast drought impacts on hydropower production (H2020 climate service project SECLIFIRM). The Sentinel Alpine Observatory (SAO) is used to develop innovative methodologies with the aim of creating multi-temporal datasets of biophysical and descriptive variables that cover the entire Alpine range. In order to guarantee quick access and processing of the big amount of Sentinel data acquired over the Alps, the SAO computational infrastructure is federated with the Earth Observation Data Centre for Water Resources Monitoring (EODC Water) infrastructure. SAO aims at becoming a networking platform for users of Earth Observation data in the Alpine region. Monitoring snow coverage and, in general, the use of remote sensing data, allow calculating and even predicting – thanks to physically-based hydrological models and statistical models – runoff from snow-water-equivalent, ice melting and precipitations, as well as soil moisture and evapotranspiration, thus contributing to build a complete and reliable water budget that can help the proactive management of water-resources.[39]
The private initiative "MySnowMaps" allows monitoring and estimating height and density of snow cover on the entire Alpine region; these data are mapped on a DTM and include also other meteorological information. This open source product allows to monitor and calculate snow-water-equivalent in each Alpine

[36] http://www.minambiente.it/comunicati/siccita-osservatorio-po-5-prelievi-da-corsi-dacqua-alpini-e-laghi-prealpini-soluzione
[37] http://www.minambiente.it/notizie/acqua-roma-il-workshop-minambiente-creiamo-pa
[38] For more information read i.e. http://land.copernicus.eu/global/products/swe and https://www.vcalc.com/wiki/Titan/Snow+Water+Equivalent+%28SWE%29
[39] http://sao.eurac.edu/

river basin, allowing the forecast of river basins' runoffs due to snow-melting and comparisons on multiannual basis of snow-height and snow-water-equivalent.[40]

MONACO

Monaco has no hydropower installation and gets its water supply from France.
Regarding **adaptation to climate change**, a **global strategy has been prepared**, including vulnerability assessment and sectorial impacts. However this strategy isn't public yet and the establishment of the **action plans** linked to adaptation is integrated in the implementation of the "Air-Energy-Climate Plan", currently being updated.
The Principality's policy in terms of water management responds to objectives of environmental efficacy, linked to resources preservation and wastewater treatment.
Rationalising and reducing water usage remain among the main challenges for the sustainable management of the water resource. Over the past few years, raising awareness by households, private and public stakeholders in the Principality lead to a notable diminution of **water consumption** in Monaco.
Since about ten years, thanks to the actions carried out by the State, the private sector and individuals, drinking water consumption has been declining by 1% per year on average.
Regarding **supply**, the Principality of Monaco uses its local resources (Alice, Marie, Testimonio, Fontdivina and Ingram sources) which supply, depending on the year, between 30 and 50% of the public drinking water network.
However, the water used in the Principality mostly comes from France. This importation represents on average 75% of the drinking water consumed, especially during the low-flow period of the local resource.
The main supply watershed, i.e. the Var hydrologic basin, benefits from an advantageous climatologic situation, combining the effect of the Alps, the sea and several important natural karstic reservoirs (Mercantour) and the Var's water table which functions as a buffer.
Waterworks already carried out from the end of the XIX century (Vésubie canal) made it possible to insure in a satisfying way the supply of the littoral zone despite a constantly growing population.
Furthermore, global water need tends to be confounded with the extraction due to drinking water production, representing 90% of the volume produced.
To summarize, this area has got a good water supply and shows **no conflicts of use**, while not excluding significant piezometric variations.
Since the 90s however, **dry years** showed that the resource may be largely mobilised (used up) despite the advantageous storage and supply situation.
In 2007 a French **drought plan** was approved for the supplying watershed, setting for each zone the situations for vigilance, alert, crisis and reinforced crisis, as well as the corresponding water use restriction measures.
Within this drought plan **no alert threshold nor crisis flow were defined** for the hydrological characteristics of Monaco's supply zone, only the amplitude of the water table fluctuations has to be monitored.
Thus, the Principality's supply basin currently benefits from a very peculiar situation in terms of production capacity and volume distribution which protects it, for now, from the most restrictive situations in case of drought.
Regarding identified **challenges and vulnerabilities** in Monaco, the following can be listed:

- Reliability of the available local drinking water resource;
- Degradation of the quality of local sources in times of rain;
- Degradation of the bacteriological balance due to heat waves and slow-flow periods;
- Salinization of underground waters especially in the summer (intensive exploitation of the water tables and sea-level elevation);
- Availability of imported surface water;
- Diffuse pollution, from sources outside of the area, due to industrial waste (important concentration of pollutants in the summer when the flows are reduced and the pressure strongest).

[40] http://www.mysnowmaps.com/en/how_does_it_work

SLOVENIA

1) Is there an approved climate change adaptation strategy in your Country? Please link any references to the official documents.

Slovenia does not have approved climate change adaptation strategy, but has approved strategic framework for climate change adaptation[41], and adopted climate change adaptation strategy for agriculture and forestry[42].

2) a) Are there approved climate change adaptation strategies as well as action plans in the Alpine Regions/Länder/Districts in your Country?

Climate change adaptation strategies or action plans for Alpine region are not approved yet in Slovenia. But we use Alpine Strategy for adaptation to climate change in the field of natural hazards.

b) If yes, what is the reference climate change scenario at regional level? Please briefly describe it.

There is no chosen reference climate scenario. In previous studies, four different SRES emission scenarios (A1, B1, A2, B2) were modelled for north-western region of Slovenia[43]. According to A1 scenario, a raise of air temperature for about 4 °C and a negative change in precipitation for about 1% are expected for that region by the end of 21st century. According to B1 scenario, air temperature will rise for about 2.9 °C and there will be no significant change in precipitation amount. According to A2 scenario, a raise of air temperature for about 4.8 °C and a negative change of precipitation for about 1% are expected. According to B2 scenario, air temperature will rise for about 3.6 °C and there will be no significant change in precipitation amount for that region in 21st century.
Currently, more recent RCP scenarios are being adopted for Slovenia[44].
Slovenia took part in the project CLISP – Alpine Space programme 2007-2013 in which the study of regional vulnerability has been elaborated on the basis of climate change scenarios and other input data. Although demanding, regional vulnerability studies are important because they could show differences in vulnerabilities due to regional specifities which should be taken into account in the climate adaptation measures.[45]

c) Are drought periods assessed as a likely risk? What are the most interested periods of the year?

Most interesting period is vegetation period (April – October) since most damages comes from agriculture sector due to drought stress of rain-fed crops. Drought return periods are assessed in five levels according to degree of impacts. Droughts with light impacts (around 0.1% GDP) are assessed as very likely, with return period of few years. Severe droughts, causing impacts close to 1% GDP are much less likely, with return period of 20 to 50 years.[46]

3) a) What are the river basins most exposed to the risk of droughts in the future? And what based on the historical data and experiences?

The past data shows that the East and Southwest parts of Slovenia are more exposed to dry events, especially the river basins in North-Eastern and South-Western Slovenia. The most vulnerable areas due to droughts are not in the Alpine Region.

b) Inside of these basins, please describe the more vulnerable areas.

[41] http://www.mop.gov.si/fileadmin/mop.gov.si/pageuploads/podrocja/podnebne_spremembe/SOzP_ang.pdf
[42] http://agromet.mkgp.gov.si/Publikacije/STRATEGIJA%20prilagajanja.pdf
[43] http://www.sos112.si/slo/tdocs/crp_scenariji.pdf
[44] http://www.mop.gov.si/fileadmin/mop.gov.si/pageuploads/podrocja/podnebne_spremembe/porocilo_podnebne_spremembe1_2.pdf
[45] http://www.alpine-space.org/2007-2013/projects/projects/detail/CLISP/show/index.html#project_outputs
[46] http://meteo.arso.gov.si/uploads/probase/www/agromet/OT/Ocena_tveganja_Susa_KONCNA.pdf

Looking at the whole territory of Slovenia the most vulnerable to drought events are Vipava, Dragonja, Mura and Rižana rivers and aquifers in Dravsko polje, Ptujsko polje, Krško polje and Brežiško polje. The most vulnerable river basins due to droughts are therefore mainly not in the Alpine Region.

4) a) What have been the more significant events in the last 15 years? Describe the events, also including data on precipitations, runoff, dry days in the reference areas. Please include links to reports of the events.

2003: Slovenia recorded the most severe drought after 2nd World War. Drought began in early spring and lasted till the end of summer. Only 40-70% of the normal amount of precipitation was recorded in the major part of Slovenia. In this period, cumulative water deficit for grass increased to 500 mm in the Littoral region, ranged from 400 to 450 mm in north-eastern and south-western regions, and was above 300 mm in central Slovenia. Damage due to drought was recorded for more than 60% of agricultural land in Slovenia. The first estimations of losses in crop yield in 2003 exceeded 103 million EUR.[47]
2006: drought in 2006 affected less than 25% of the area of Slovenia and lasted only slightly less than two months but was very intensive in the affected areas. Most of the damage was recorded in Littoral region, where cumulative water deficit rise to 400mm.
2007: dry period began in May in Littoral region and in June in north-eastern part of Slovenia and lasted till August. The severity of the drought differed per various regions as did the consequences visible on crops. The drought affected a total of 27,875 ha of agricultural area and the damage exceeded 16.5 million EUR. Cumulative water deficit in many parts of Slovenia ranged between 130 and 300 mm and rise to 500mm in Slovenian Istria. [48]
2009: drought appeared in Littoral region in May and, with interruptions, lasted till the end of September.
2012: drought affected several economic and social sectors. From autumn 2011 till the end of September 2012 we recorded low precipitation amount. In Littoral region only 30% of normal amount of precipitation fell from June to August 2012. Most significant damage in agriculture was in NE and SW parts of Slovenia. Hydrological drought was longer than in 2003 but less intensive.[49]
2013: dry period began in first decade of June in Littoral region and in second half of June in NE part of Slovenia. Drought was most intensive in July and lasted till the end of August. Cumulative water deficit in summer was more than 400mm in SW part and around 300 mm in eastern part of Slovenia. In 2013 three heath waves were recorded which caused heat stress, especially to less tolerant plants.[50]
2015; Four intense, however relatively short heat waves hit Slovenia in summer 2015 (one in June, two in July and one in August). The main impact on agriculture was caused by heat stress. Hot and dry periods were discontinued with precipitation episodes, therefore cumulative surface water balance values were close to long term average (except in south-western Slovenia near Adriatic coast where surface water balance reached extremely low levels). Also spring (April-May) and late winter period were very dry.[51]

b) Have the drought events caused situations of water scarcity to specific sectors? What have been the economic losses in each sector (e.g. reduced production of hydro-electricity, harvest losses, ecc.).

2003, 2006, 2007, 2012, 2013, 2015 and 2017 droughts hits dimensions of natural disaster or exceeded 0.3 promille of planned state budget revenues. In 2003 and 2012, wider reduction of drinking water for non-domestic use especially in Littoral region was recorded. The most affected sector was agriculture; highest financial losses are listed below:

- 128 mil EUR 2003
- 50 mil EUR 2006
- 16 mil EUR 2007[52]
- 57 mil EUR 2012[53]

[47] http://www.sos112.si/slo/tdocs/ujma/2004/susa_2003.pdf
[48] http://www.sos112.si/slo/tdocs/ujma/2007/073.pdf
[49] http://www.dmcsee.org/uploads/file/319_1_ears_disturbed_water_balance_susnik_pogacar.pdf
[50] http://mvd20.com/LETO2013/R14.pdf
[51] http://www.sos112.si/slo/tdocs/ujma/2015/85_93.pdf
[52] http://www.stat.si/statweb for 2003, 2006 and 2007 data
[53] http://www.ff.um.si/zalozba-in-knjigarna/ponudba/zbirke-in-revije/revija-za-geografijo/clanki/stevilka-10-1-2015/RG1910-105Hozjan-Vplivpodnebnihspremembnanaravnenesrece.pdf

- 106 mil EUR 2013[54]
- 65 mil EUR 2017[55]

c) Was the water supply for domestic uses always ensured or have you registered some problems?

Water supply from public system is always ensured for domestic uses. In case of drought and decrease of drinking water, there were reductions of water use introduced for irrigation, car wash and other activities like filling swimming pools. Some problems occurred in summer 2003 when drinking water had to be delivered to 47.396 people under the coordination of the administration for civil protection and disaster relief.

d) Have these events caused problems and damages also downstream in sections of the basins far from the Alps?

No.

5) a) What are the main lessons learned after the major droughts of the last years?

Mainly after intense droughts in 2012 and 2013, general awareness of vulnerability to drought was very high. More investments were dedicated to effective irrigation systems and projects on improvement of irrigation efficiency were launched. Advices on how to reduced exposure to drought (diversification of crops, sowing of more drought-tolerant hybrids etc.) are being forwarded to farmers.

b) Was there any planned prioritization of sectoral uses in case of water scarcity situations? Do there is a prioritization for future events? Is the prioritization different from summer to winter?

There is no planned prioritization of sectoral uses in case of water scarcity situation set up yet. The only priority set in legislation is provision of fresh water to households. There are Indicators of drought in aquifers in Slovenia in use that are currently based on frequency statistics of groundwater level (percentile classes of <5%, 10%, 25%, 75% and >75%) while Standardized Groundwater level index (SGI) in in process of preparation and establishment.

c) Was it possible contrasting the drought situation through an improved management of storing capacity of regulated lakes and reservoirs in the basin?

Some of it – yes. By effective and appropriate water management of reservoirs. But regarding the household water supply – we mainly use groundwater resources for water supply.

d) Were any limitations established to water withdrawals and uses during the drought period? What about future events?

In case of drought and decrease of drinking water levels, there were reductions of water use introduced for irrigation, car wash and other activities like filling swimming pools.

6) Are there in your Country special plan(s) at basin/sub basin level for severe droughts? Are any standard procedures planned?

Slovenia does not have any specific plans to limit water use in case of drought events established yet.
A certain measure no. OS3.2b8 from the River basin management plans for the Danube and for the Adriatic river basin districts is in progress of preparation that will establish indicators for early warning of different levels of intensity and thresholds of droughts in connection with climate changes affecting river basins and surface- and groundwater levels. [56,57]

[54] http://www.mko.gov.si/fileadmin/mko.gov.si/pageuploads/podrocja/naravne_nesrece/program_odprave_posledic_skode_v_kmetijstvu_susa2013.pdf
[55] http://www.mkgp.gov.si/fileadmin/mkgp.gov.si/pageuploads/podrocja/Kmetijstvo/Podnebne_spremembe_v_kmetijstvu/Analiza_stanja_naravnih_nesrec_NN_4.pdf
[56] http://www.mop.gov.si/fileadmin/mop.gov.si/pageuploads/podrocja/voda/nuv_II/NUV_VOD.pdf
[57] http://www.mop.gov.si/fileadmin/mop.gov.si/pageuploads/podrocja/voda/nuv_II/NUV_VOJM.pdf

At Slovenian Environmental Agency, a regional water balance model GROWA-SI of 100m x 100m resolution is currently operating. By the end of the year 2017 an upgraded version of GROWA-SI called mGROWA-SI model system[58] will be operating, making modelling of all water balance components possible on monthly as well as daily timescale. This way its products/outcomes will be additionally supporting drought management.

7) Are water uses of different sectors quantified and monitored? How are the trends? Please provide some data if possible.

Overall water use in 1996-2004 period:

- 1997: 790 million m^3
- 1998: 794 million m^3
- 1999: 788 million m^3
- 2000: 804 million m^3
- 2001: 793 million m^3
- 2002: 792 million m^3
- 2003: 829 million m^3
- 2004: 966 million m^3

Water use by sectors in 2003 in units of 1000 m^3:

- Households: 164183.239
- Agriculture: 606.089
- Industry, mining industry: 81048.892
- Services: 26756.082
- Energy production: 595130.405
- Fishery: N/A
- Tourism, health service: 3252.419

Percentage of water use by sectors in 2004:[59]

- Energy production: 77.3%
- Public water supply: 10.5%
- Industry: 11.7%
- Agriculture: 0.5%

The water exploitation index WEI in Slovenia was about 2% in 2014, with reference WEI value in the period (2012-2014) being about 3%. Trend of WEI is slightly increasing, but is not statistically significant.[60,61]

8) Are there some relevant projects addressing priority areas in your Country? Please briefly describe the main outcomes of those projects relevant for the areas of your interest and link the useful documents.

CRP TRIN project (on-going)[62]

It targets accuracy of irrigation water demand forecasting. Project's objectives are 1) legislation of united ground-data collecting system, 2) preparation of irrigation forecasting model for each of the main cultures, 3) evaluation of impacts of optimal irrigation, 4) evaluation of impacts of deficit irrigation at professional level, 5) evaluation of impacts of deficit irrigation at economic level and 6) preparation of reports on optimal and correct process of irrigation.

LIFE project VivaCCAdapt (on-going)[63]

Adapting to the impacts of climate change in the Vipava valley Project aims developing measures for avoiding economic effects of climate change. Anticipated project result is development of a climate change adaptation strategy, piloting and assessment of irrigation decision support system and establishment and evaluation of green windbreaks.

DriDanube project (on-going)[64]

[58] http://www.arso.gov.si/novice/datoteke/036813-Energie_Umwelt_339.pdf
[59] http://kazalci.arso.gov.si/?data=indicator&ind_id=20 for all the data on water use.
[60] http://kazalci.arso.gov.si/?data=indicator&ind_id=761
[61] http://gis.arso.gov.si/related/evode/wfd/2014_I_01_01_9.pdf
[62] http://www.bf.uni-lj.si/index.php?eID=dumpFile&t=f&f=22104&token=38301aed79ea6db7a4be6882178effb8a83d65bf
[63] http://www.life-vivaccadapt.si/en/
[64] http://www.interreg-danube.eu/approved-projects/dridanube

The main objective of DriDanube project is to increase the capacity of the Danube region to manage drought related risks. The project aims at helping all stakeholders involved in drought management become more efficient during drought emergency response and prepare better for the next drought.

GROWA-SI (on-going)[65]

It is a cooperation project between the Slovenian Environmental Agency and Research Centre Jülich to quantify groundwater recharge for the whole territory of Slovenia using GROWA model. To reach this goal, this project is carried out in five tasks: 1) to set-up a uniform and consistent nationwide GIS input data base consisting of climate, soil, geology, topography, land use data etc., 2) to carry out a nationwide water balance study with the aim to quantify the renewable water resources (total runoff), 3) to separate total runoff into the runoff components: direct runoff and groundwater recharge, 4) to calibrate the model and validate the model results by using national data base of measured runoff from gauging stations, and 5) to assess options for further model development.

DMCSEE (closed project)[66]

The mission of the proposed DMCSEE was to coordinate and facilitate the development, assessment, and application of drought risk management tools and policies in South-Eastern Europe with the goal of improving drought preparedness and reducing drought impacts. Therefore, DMCSEE focused its work on monitoring and assessing drought and assessing risks and vulnerability connected to drought.

9) Is there any good practice in your Country relevant for planning water uses like e.g. calculating water retention capacity in the basin or snow-water-equivalent in each moment[67]?
   - Water balance calculation and irrigation forecast (5 days in advance) for several different locations with agriculture, vegetable and fruit growing production;
   - GROWA – ETP calculation (products of water balance modelling through GROWA-SI will be the foundation for further work on environmental indicator "VD_15: quantitative retention of groundwater level"[68] which in the next year will also give information on seasonal variability as well);
   - Establishing of new drought index: decadal index of drought stress (DISS)
   - Monitoring of cumulative water balance for vegetation season (April-September) and off-season (October-March).

[65] http://www.arso.gov.si/novice/datoteke/036813-Energie_Umwelt_339.pdf
[66] http://www.dmcsee.org/
[67] For more information read i.e. http://land.copernicus.eu/global/products/swe and https://www.vcalc.com/wiki/Titan/Snow+Water+Equivalent+%28SWE%29
[68] http://kazalci.arso.gov.si/?data=indicator&ind_id=831