Water resources management in Valle d'Aosta (Northwest of Italy)

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Abstract: In recent years there have emerged signs of possible water use conflict in the northwestern Italian region of Valle d'Aosta. Pollution and development have highlighted conflicting needs, and the resources no longer appear sufficient to meet demand. Conservation of water as a fundamental resource for life and development in the region must therefore represent a priority objective in the region.

Intervention measures and initiatives have thus been drawn up for effective public action to protect and improve the quality and quantity of water resources, safeguard public health and protect the sources of water supply as strategic resources within the broader objective of environmental conservation.

Programming organic interventions, integrated within the various water use sectors for the additional purpose of avoiding issues of resource scarcity or poor quality, would allow such objectives to be achieved over the coming decade.

Keywords: Glacier, water availability, irrigation canal, drinking water, consumption sector

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Riassunto: *La Regione Valle d'Aosta è caratterizzata da abbondanza d'acqua, seppure non equamente distribuita sull'intero territorio, che ha consentito per lungo tempo di considerare i fabbisogni come variabili indipendenti sia tra loro sia rispetto alle disponibilità. La storia valdostana descrive una realtà dove la crescita della domanda di acqua, che naturalmente si accompagna allo sviluppo economico e sociale di una comunità, si è tradotta in un aumento e in una stratificazione nel tempo di punti di captazione e di scarico dei reflui, provocando un depauperamento quali-quantitativo della risorsa. Le condizioni sono ora radicalmente mutate e lo sviluppo antropico ha fatto emergere nuove necessità spesso contrastanti di loro. Le risorse non sembrano più sufficienti per i fabbisogni, tutti gli usi delle acque appaiono collegati ed interdipendenti e l'inquinamento li condiziona e ne è a sua volta condizionato. Diventano sempre più evidenti i segnali di possibili conflitti tra utilizzatori diversi, il sovradimensionamento di alcuni prelievi, non più giustificati dagli attuali meccanismi produttivi, e il ricorso in alcune aree alle risorse idriche sotterranee. L'uso di ingenti quantitativi di acque a scopo irriguo o idroelettrico ha modificato i regimi idraulici dei corsi d'acqua e con essi gli habitat fluviali: al depauperamento quantitativo è seguito, quindi, il degrado biologico e naturalistico dell'ecosistema fluviale con ripercussioni sulla qualità delle acque superficiali. Lo sviluppo urbanistico ha infine inciso nelle fasce fluviali con costruzioni di varia natura, incrementando ulteriormente il degrado dell'ecosistema fluviale. Tali conseguenze sono rese particolarmente evidenti oggi che la domanda di usi ambientali dei corsi d'acqua regionali diventa sempre maggiore e che iniziano a manifestarsi limitazioni di uso in relazione al non raggiungimento dei livelli qualitativi prescritti dalla normativa per quell'uso specifico. Sono state pertanto approvate azioni di governo delle risorse idriche volte a garantire il giusto equilibrio tra il soddisfacimento del fabbisogno idrico per lo sviluppo economico e sociale e la tutela dello stato ecologico naturale, operando in tre settori:*

1. *tutela della qualità della risorsa acqua per renderla idonea ai diversi utilizzi e per sostenere un ecosistema vario e differenziato, nel caso di acque superficiali;*
2. *tutela e riqualificazione dell'ecosistema fluviale;*
3. *riequilibrio dei regimi idraulici e il razionale utilizzo della risorsa idrica.*

Geographical characteristics

The autonomous region of Valle d'Aosta has an area of about 3270 km^2, about 90% of which is mountainous. Glacial areas occupy a total 237 km^2. The watershed is almost always higher than 3000 m a.s.l. with appreciable sections over 4000 m a.s.l. and a mean altitude of about 2100 m a.s.l.

The high altitude of the region has meant that much of Valle d'Aosta has been conserved in its natural state despite the intense occupation at the valley bottom of the Dora Baltea and several side valleys. Valley bottom areas generally have a high degree of human

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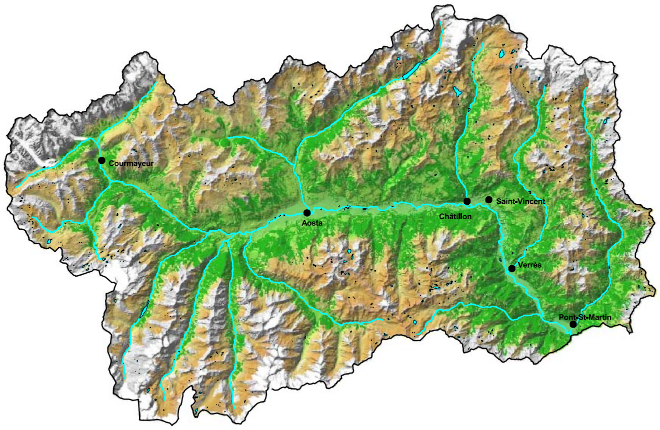

Fig. 1: *Valle d'Aosta map.*

impact: this is where most of the population, the main traffic arteries and business activity are concentrated.

The main water course is the Dora Baltea which originates with its two branches, the Veny Dora and the Ferret Dora, from the glaciers on Mont Blanc. From the confluence of the two Doras to the regional boundary the river is about 100 km long. The Dora Baltea has a fairly complex basin with a large number of major tributaries and typical montane features. Along its Valle d'Aosta stretch, many tributaries drain into the Dora on both sides. The river flows with a wavy pattern – in stretches sub-rectlinear – in an incised valley bottom, with steep rocky slopes.

The presence of glaciers greatly affects the flow regime, with minimum discharges in winter and maximum in summer in accordance with the period of maximum glacial melt. The mountain chains offer direct protection from moist air from the Atlantic, resulting in fairly low absolute rainfall and low intensity.

In the river catchment area mean rainfall varies from 600 mm/year in the lowlands to over 1800 mm/year in upland areas. Rainfall is concentrated in the watershed zones where it reaches as high as 2000 mm/year. The valley bottom has less rainfall, with a minimum at Aosta of less than 600 mm/year. As regards the rainfall regime, the more eastern sector has two peaks, with the springtime maximum far exceeding that of the Po Valley. This is therefore a pre-Alpine regime. The more western stations have a fairly homogeneous rainfall pattern during the year, hence not referable to classic schemes, probably due to the considerable effect of the Alpine chain. The Courmayeur station even shows a winter maximum with a similar regime to that of Mediterranean stations.

A little history

The historical settlements in the area are sited on the edge of terraces, leaving the original deep-cut river channel unbuilt-up. This ancient settlement pattern, with towns and roads some way from the river course and a very small number of connections between the two banks, also characterised the farming system in the land in between. Indeed, the signs of ancient Roman centuriation are still visible. This has resulted in widespread hydraulic infrastructures in the area with numerous canals, still in operation, the most ancient of which date back to the 15th century.

From the 13th century onwards, the stabilisation of the rural population entailed the building of irrigation channels along the slopes of whole valleys, dug with rudimentary tools by Aostan peasants after obtaining concessions to harness the water courses from the holders of feudal rights: the Duke of Savoy, the Challands, the bishop, the Collegiate, the Lords of Nus, and the Vallaises.

At the end of the 18th century the Valle D'Aosta municipalities, completing the process of release from feudal rights, acquired the ownership of water and forests, paying the overall sum of 800,000 gold francs, paid in part to the feudal lords, in part to the Royal Treasury of the Kingdom of Savoy. What was proclaimed was thus not the simple right to full use of the waters concerned, but that of property by regular law of purchase (deeds of affranchisement). With the approval of the unified water law of 1933 to aid the emerging hydroelectric industry, such rights were progressively eroded until they were totally extinguished.

The Regional Statute has restored to the Regional Authority the property of water for drinking and irrigation purposes, but not that for other uses. The latter rights are granted free of charge on a 99-year lease to the Regional Authority, which is entitled to grant subleases.

Fig. 2: *Dora Baltea River in the Saint-Marcel's moist area.*

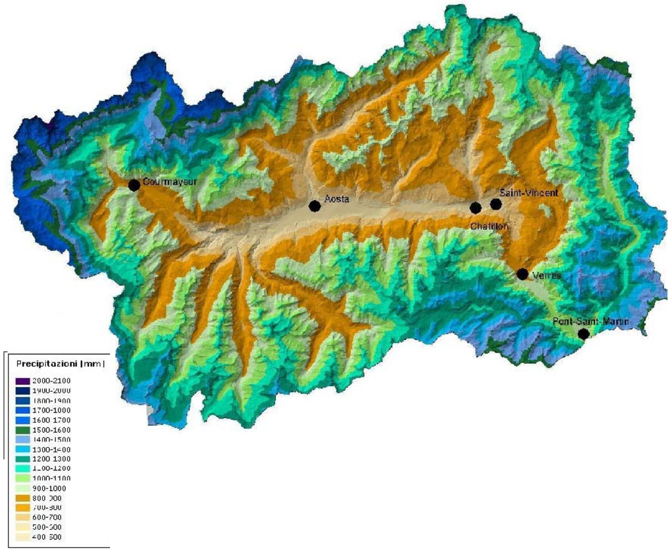

Fig. 3: *Map of the average annual rainfall.*

In 1998, all the water courses and the relative structures used for irrigation and drinking water were transferred to the Regional Authority, as well as the administration of the entire state water resources in the region. It was also clarified that the 99-year lease extends to river channels and relative structures.

Fig. 4: *Ru Vernier, irrigation canal (Quart).*

Fig. 5: *Ru Neuf, irrigation canal, near the bed of Grand Eyvia river (Aymavilles).*

Water resource uses

The regional administration has the task of ensuring that water in the Valle d'Aosta is protected and used fairly for the needs of the local population, according to criteria of solidarity, safeguarding the rights of future generations, renewal, re-use and resource saving, also with a view to ensuring the priority of meeting the population's drinking water needs.

The Valle d'Aosta has an abundance of water, albeit not equitably distributed throughout the region, which has nevertheless meant that water requirements have long been considered as independent variables both amongst one another and with regard to availability. These conditions have allowed water demands to be regulated administratively sector by sector, as they arose, without the need of global water balances.

In the Valle d'Aosta, there is a situation where the growth in water demand, which naturally accompanies the economic and social development of a community, has been translated into an increase and stratification in time of the water extraction and wastewater discharge points, leading to degradation of resource quality and quantity.

The overall number of censused extractions from surface water bodies, boreholes and springs is 8316. Such extractions are for hydroelectric purposes (about 10%), irrigation (80%) and the remaining 10% for livestock, drinking water, domestic or industrial use. Importantly, about 10% of the extractions have multiple uses.

As regards drinking water uses, all the municipalities in the region are able to guarantee an adequate supply of drinking water, even though in periods of greater tourist flow and in the summer there are local water deficits in terms of both quantity and quality.

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Fig. 6: *Ru de Chené , irrigation canal, (Valsavarenche).*

The coverage of the aqueduct service amounts to 99.8%, with a mean daily water endowment per inhabitant of 222 l (according to the annual report to Parliament on the state of water services - 2004). The total annual volume extracted is about 24 million m^3 and network losses are estimated at 20-25%. The main supply source consists in springs (about 78% of water extracted), while the remaining volume is taken from boreholes. The regional network of drinking water extraction and distribution is particularly fragmented among numerous networks which are often not interconnected and which often use water from surface springs of limited capacity. Indeed, today in the region there are about 270 municipal aqueducts that distribute water from over 500 springs and 20 boreholes, to which should be added 100 so-called fractional aqueducts.

The situation of drinking water supply in some of the region's larger towns, namely Aosta and Verrès, is very different. In such cases the main source of drinking water is the aquifer of the alluvial plains on which the two towns have been built. The number of users served by each aqueduct ranges from about 30,000 users for Aosta to a few dozen or less served by most of the municipal and sub-municipal aqueducts.

In summer, the daily volume of water extracted and used for irrigation is estimated at 3.5 million m^3, while industry (excluding HEP production) accounts for a daily water volume of about 250,000 m^3.

In all, there are 116 diversions for hydroelectric purposes, accounting for a daily water use ranging from an average 10 million m^3 to a peak of 30 million m^3. The river basin contains a large number of seasonal or weekly reservoirs that regulate flows for the production of hydroelectric energy.

Conditions have now radically changed and economic development has often made conflicting water needs emerge. Resources no longer seem sufficient to cover requirements, all uses appear connected and interdependent, and pollution and water uses condition one another. Signs of possible conflict between different water users are becoming evident, as is overextraction of water resources, no longer justified by current production mechanisms, and recourse in some areas to groundwater resources.

Everyone remembers the summer of 2003, when particular weather conditions led to a sharp reduction in precipitation (rain and snow) and high summer temperatures led to a considerable increase in water demand for various uses. There was widespread talk of drought, that is, of the occurrence of a temporary and/or periodic climate phenomenon. In other cases, there are water shortages either due to supply failure due to pollution arising from various sources, or because water availability fails to meet all requirements.

Water shortages are thus caused by various factors that can generally be linked to human action and water resource management, or to the environment, in the case of phenomena arising from climate change. A significant change is currently under way both in water resource availability and perception which shows that the system in Valle d'Aosta is struggling to meet requirements. Such steps are necessary since water is becoming increasing scarce precisely when demand is greater, and the demand for water resources has changed.

The consumption sector is, due to its importance and specific nature, is the sector with the most detailed, binding laws on quality, besides being in constant evolution towards increasingly rigorous limits. Besides recording a constant increase in terms of quantity, domestic demand is becoming increasing demanding in terms of quality, with ever greater difficulty in meeting requirements.

In the agricultural sector, water demand is strictly related to crop type and especially to the surge or sprinkler irrigation system adopted. Current changes in irrigation systems, resulting especially from economic and technological evolution under way in the sector, are oriented towards saving water, and hence should be supported and incentivised. However, there remain unresolved cultural issues concerning the need to review the administration of water diversion rights, recognised for amounts of water which today exceed those required, but which are instead deemed as inalienable acquired rights.

Among the other uses, electric energy production undoubtedly represents the greatest impact on water resources due to the changes introduced into the hydrographic network. Yet it is also the sector with the highest economic return, thus being strategic for the economy in the Valle d'Aosta.

Finally, in rapid growth are demands for planned snow sprinkling

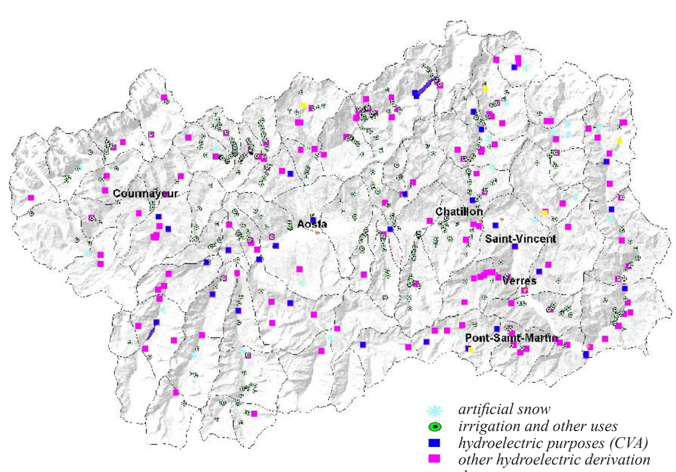

Fig. 7: *Map of the water extraction from a river for irrigation, for hydroelectric purposes (by CVA) and for snowmaking.*

of ski slopes. Constituting another important sector in the regional economy, winter sports are practised in the period of lowest water availability, namely in winter.

Evolution of water availability

Water resource availability at the regional level is theoretically sufficient to cover any demand through specific infrastructural networks, which make such resources accessible in almost all the region. In recent years the Regional Authority has committed substantial financial and human resources to establishing a meteorological and hydrological network. The regional hydrographic office was founded in the late 1980s to manage the concessions for water diversion, with its first six remotely-sensed weather stations. In 2002 it also took over the duties of the former National Hydrographic and Mareographic Service. The remote-sensing network currently consists of 66 stations with over 300 sensors measuring hydro-meteorological parameters. Thus every hour about 2000 data are acquired from 46 pluviometers, 53 thermometers, 24 hydrometers, 24 snow samplers, 8 barometers, 84 snow thermometers, 7 radiometers, 6 hygrometers and 12 anemometers.

In 2002 the Foundation for the Safe Mountain of Courmayeur was established. In connection with the Regional Authority, it supplies a complete picture of the trend in Valle d'Aosta glaciers which has been made available to all those in the Glacier Observatory. Those who participate in the Glacier Observatory, besides the Authority's technical staff, are the heads of the Valle d'Aosta Alpine Rescue and the high mountain guides to identify initiatives to monitor glaciers in Valle d'Aosta, plan interventions to protect them, and disseminate the scientific knowledge acquired and the interventions implemented, also by improving the regional glaciological data base. Year by year thousands of new records are being acquired, compared amongst themselves and with available historic data. They are beginning to provide an overview of the consequences of the change under way in regional climate upon water resources.

Data on rainfall distribution and the state of the glaciers (mountain and polar) are creating increasing cause for concern year after year as they indicate a trend which can only aggravate water resource availability. Rainfall distribution during the year is undergoing a variation: rainfall events are becoming more intense and lasting less, and are interspersed with long periods of precipitation scarcity. Due to the general increase in mean temperatures, snowfalls appreciably affect the higher altitudes on Italy's mountains, with a tendency towards a general shift towards 1800-2000 metres a.s.l., and snowmelt occurs earlier than before. The glaciers are progressively retreating, and the most pessimistic scenarios predict their complete disappearance from the Alpine Arc by the year 2035. These are all factors of a change under way which, if confirmed, will also have considerable repercussions upon water resource availability. Watercourse flows in the Valle d'Aosta have undergone appreciable variations in recent years: some assessments, albeit preliminary, give for example a 10-15% reduction in average flows measured at some hydroelectric diversions, compared with historic means from ten or so years ago. A greater number of flow peaks may be noted during intense rains, which are followed by long periods of reduced flow much lower than the historic mean. Overall water volumes do not appear to have undergone, at least for the time being, significant variations, despite the awareness that the contribution of glacier melt is fundamental to ensure this result.

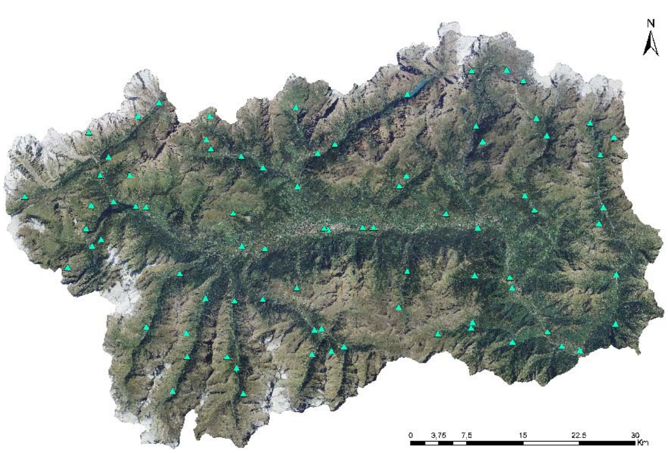

Fig. 8: *Weather stations map.*

From preliminary conclusions on the trends in climate data over the last 20 years compared with the historic data available and the few climate trend scenarios for the Alpine Arc, for Valle d'Aosta we may thus hypothesise that, by the end of the century:

- snow-covered areas in winter will retreat above 1800 m;
- winters should be milder, although one cannot rule out phenomena of intense cold and snow even at low altitude, hence of lower duration;
- summers will be hotter especially at night-time, with significant droughts and the possibility of serious water shortages due to the drying-out of more superficial sources of water supply with lower capacity;
- the seasons of spring and autumn will be subject to considerable variability in weather conditions, with a large number of intense rainfall events with storms that will cause an increase in the frequency of landslides and detritus flows;
- the Valle d'Aosta glaciers will have fully melted by 2035 and the permafrost at high altitude will also melt, thus leading to typical hydrogeological degradation such as rockfalls, rock and ice avalanches, and detritus flows during intense rains.

However, the information is still very partial and needs to include further detail for the various areas of the Alpine Arc. Such uncertainties are translated into a general indeterminacy which does not yet allow us to gain precise quantitative data on which to base appropriate interventions, but only indications of trends in changes.

In Valle d'Aosta there is under way a general extension of monitoring of meteo-climatic data and an enhancement in the capacity to predict the effects on soil of specific weather conditions: the Regional Authority is developing its predictive capacity in the sectors of meteorology, hydrogeological risk and water resources so as to be able to predetermine regional effects of particular weather conditions or interventions entailing soil use changes. The weather report is becoming increasingly precise for individual areas in the region and more reliable in its forecasts; the avalanche forecast in winter provides information on the avalanche risk based on an increasingly extensive information gathering system on snow conditions, involving various operators, such as Alpine guides, the army and the police; the hydrogeology and hydraulic bulletin provides daily information on possible effects on soil related to the hydrogeological risks of the weather conditions predicted; the hydrological bulletin, released monthly during the winter and every 10 days during the late-spring and summer months, provides a series of indications regarding the current state of available water resources in the region of Valle d'Aosta, as well as a summary of the weather and climate for the previous period.

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The prospective scenario in the medium term is thus that of growing difficulty in gaining access to the water resources required, if the water supply and distribution systems are not re-organised. Indeed, water should be stored when it is made available, in the event of rainfall or snow-melt, to be then distributed to all users when necessary for domestic use, irrigation and industrial purposes. Such resources will then have to be used efficiently, employing the quantities strictly required and when required, and without needless waste.

Such lines of action for the sectors already defined above point to the need to make substantial changes in both resource and land use which necessarily conflict with consolidated uses in the production sectors and in forms of urban settlement. Urbanisation of the land must, in turn, take account of the need to review the systems of water supply, using sources that are safer both in terms of location and availability, and of the increase in some types of hydrogeological risk, which are currently also those where there are greater difficulties predicting triggering mechanisms and hence the development of phenomena.

The hydroelectric industry may still count for a few years to come upon water supplies from melting glaciers, but already recurrent drought in winter and summer are forcing a review of production plans. The farm sector must increasingly rationalise the use of irrigation, which peaks precisely when there are greater water shortages. Creation of water basins to be fed in the event of greater flows, to be made available in periods of water shortage, is an option to be assessed, given that such basins could also be used both for irrigation purposes and for scheduled snow-sprinkling, hence in two periods of the year which do not conflict with one another.

Water extraction has caused a serious impact on the environment, and only recently has awareness been raised on this issue. Indeed, until a few years ago projects to extract and use water solely targeted economic objectives and there was little interest in the effects induced on the water course regime and in impacts generated on the land. Few thought that the indiscriminate use of water would entail severe environmental degradation and that it was necessary to ensure the minimum biological flow for a water course.

Impact of water uses

Today the problem of water extraction is viewed as one of the main environmental problems also in Valle d'Aosta. There is great concern as to the very quality of the resource. Indeed, the use of water, indispensable in our civilised lives, leads inexorably to the degradation of its original quality. The surplus of organic matter and pollutants discharged into water courses limits their natural self-cleansing capacity, creating the need to use expensive technologies to recover their initial characteristics.

Intensive exploitation of water resources in the recent past, supporting a development policy that followed the classic economic model, has changed the natural regime of regional water courses, leading to a clear reduction. The use of huge water volumes for irrigation or hydro-electricity has changed the hydraulic regimes of water courses and, along with them, river habitats: quantitative impoverishment has been followed by biological degradation of the river ecosystem, with repercussions on the quality of surface waters.

The main water diversions that may affect the hydrometric regime in the Valle d'Aosta are for hydroelectric power. There are a large number of irrigation channels but usually, given the small acreage of farmland, they have little influence upon the regime of the main water courses. If one excludes the westernmost sector (uphill of Morgex), all the valleys of the main tributaries have hydroelectric plants that remove considerable flows from water courses. There are also several reservoirs used for the same purpose sited in Valpelline, Valtournanche and the Gressoney valley.

The main valley itself is affected by a continuous series of gronde starting from Morgex as far as Pont Saint Martin. Such water diversions, though affecting flows, do not result in the presence of temporarily dry sections except for the easternmost tributaries in the sections immediately uphill of the confluence into the Dora Baltea. Of these, the most serious case is probably that of the River Lys at Pont Saint Martin. However, we are dealing with phenomena to be linked, at least in part, to natural infiltration into the conoid deposits formed at the outlet of the main valley bottom. Finally, urban development has lastly carved into the fluvial belts with constructions of various types, thereby further increasing degradation of the river ecosystem.

Such consequences have been made especially evident now that there is an ever-increasing demand for environmental uses of regional water courses and use restrictions are starting to occur due to the failure to reach legal quality standards prescribed for that specific use. Water resource extraction for irrigation and energy uses will be increasingly in conflict with environmental uses of water courses, thus calling for a review of systems of water storage and distribution.

The term "environmental uses" is used to cover uses that are different from "classic" uses (domestic, irrigation, industry, energy), such as the maintenance of water quality, landscape conservation and enhancement, ecosystem and biodiversity conservation, and recreation (tourists stays, fishing, canoeing).

There emerges a picture of the current state that is represented in the map of so-called "synthetic pressure", in the map representing the ecosystem value of the water courses in question and the map summarising quantities being extracted from surface water courses. Assessment of the pressure, together with quality evaluation, was finally used to detect critical situations. In this case, a situation is defined as critical when it is far removed from optimisation for various reasons, such as the seriousness of the state of degradation or concurrent causes of disturbance and situations of vulnerability.

Elaboration of the indicator showed the geographical reference units in which high-value conditions combine with such situations of significant pressure as to compromise the maintenance of the good conditions encountered, i.e. situations in which degradation is such as to require restoration.

The following general considerations may be made:

- the level of naturalness of water courses and banks is conditioned by the presence of a large number of transversal works that may interrupt the river continuum at several points along the same water course and by the considerable broadening of bankside works;
- the riparian ecosystem is extremely fragmentary, with relict riparian forests and wetlands, with problematic chances of recovery;
- use of the water courses is thus fairly limited, with the exception of fishing, although the demand for sports and recreational uses (rafting, canoeing, cycling, etc.) is on the rise;
- there are still several districts where the level of wastewater treatment is far from optimal;
- the extent of water extraction for the various uses is such that there are many stretches where the mean residual volume in the channel bed is below 30%.

Water resource management action

Regional action in the water sector aims to ensure constant, balanced use in the various sectors (drinking water and domestic, industrial, agricultural, hydroelectric). It seeks to go beyond intervention approaches that are sectoral and situational, frequently conditioned

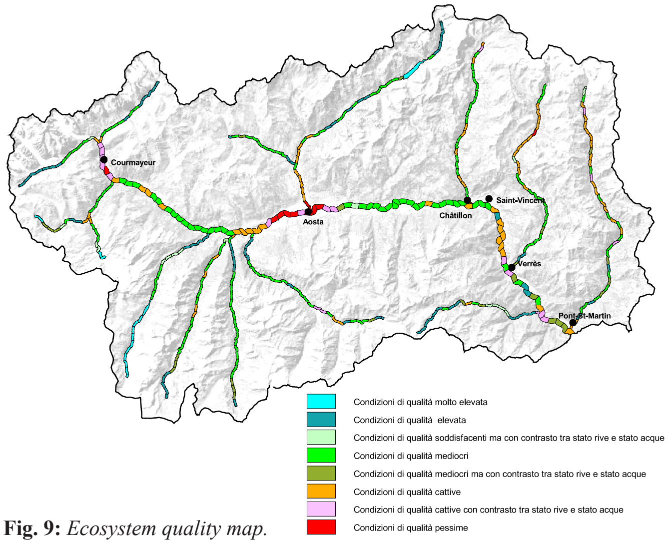

Fig. 9: *Ecosystem quality map.*

by the outbreak of problems that, in turn, lead to emergency solutions.

The programming of organic interventions, integrated in the various resource use sectors partly to prevent problems of resource availability or quality, seeks to achieve optimisation of uses, equitable distribution and savings by the various parties concerned.

Thus water policy is one of the elements that contribute to implement a sustainable and balanced regional economy, meeting different environmental conditions and needs in the region while ensuring an adequate supply of water resources required for the life and development of the region.

The regional Water Protection Plan, approved in February 2006, laid down water resource management measures to ensure the right balance between satisfying water requirements for economic and social development and protection of the natural ecological status. The plan's objective is to reconcile the supply of water quantity, of the quality required, to meet the demands of the domestic sector, industry, energy and agriculture, with landscape protection, ecosystem and biodiversity conservation.

With this in mind, three specific objectives have been identified:

1. protection of water quality to make it suitable for the various uses and support a various, differentiated ecosystem, in the case of surface waters;
2. protection and improvement of the river ecosystem;
3. re-equilibrium of hydraulic regimes and rational water resource use.

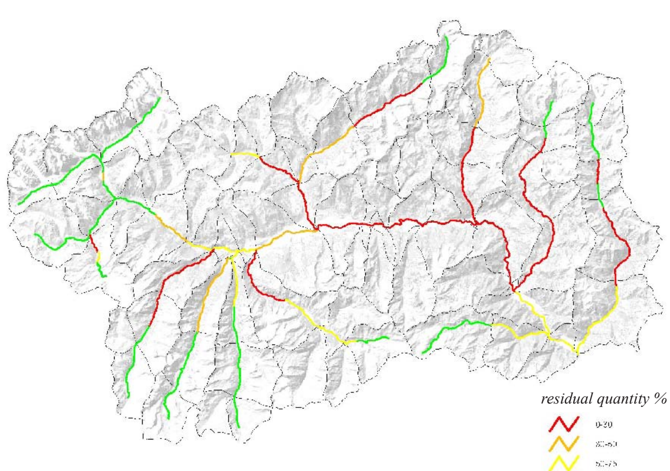

Fig. 10 – *Water supply map.*

The choice of the three categories of objectives responds to an operative need for clarity and definition of aims rather than a need to identify individual sources of benefit for water bodies.

In the case of surface water courses this is particularly evident: improvement of the environmental quality of water bodies also entails an improvement in the state of the overall river ecosystem (banks, channel and micro- and macrofauna). By the same token, improvement in river habitats has positive effects on the self-cleansing capacity of the water course and hence on water quality. Similarly, the re-equilibrium of the water balance, that is, the improvement in water flow conditions, brings about positive effects upon water quality and river habitat.

Achieving quality objectives is pursued by integrated action on several levels: wastewater treatment, reduction in polluting sources, protection of important habitats, re-naturalisation of degraded environments, and so forth.

While the notion of restoring the river system entails the shift from a situation of degradation to an improved state, it does not necessarily mean that a past situation is recovered. Indeed, without ruling out the latter possibility, restoration may both recover some historical qualities of the water course, and design new qualities.

Restoration may thus be restricted to bringing water quality up to an acceptable level but also re-establish missing vegetation or replace inappropriate vegetation, tackle problems of bank or channel bed instability, or, further, enhance the use value of the water course (fishing amenities, riverside trails, picnic areas close to streams, rafting, etc.) or the historical and architectural heritage of the surrounding area.

Naturally, restoration also includes all those measures that aim to conserve contexts and river sections that have retained high environmental value, which is generally what is meant by protection. Renaturalisation does not only mean bringing the water course to its pre-existing (or pre-human) natural state, since this approach would be absurd and misleading, especially in regions subject to high human impact such as Valle d'Aosta where it is indispensable to interact with water courses according to the more sustainable approach.

Improvement and restoration may consist in landscape enhancement/restoration and natural enhancement/restoration, being distinguished only at the level of compromissione and hence of the importance of the measures to be implemented. In the first case, to tackle a situation compromised from the natural standpoint, interventions are planned to enhance insertion of the water course into the landscape; in the second case, restoration aims to re-establish riverine habitat conditions most responding to the needs of riparial vegetation and of fluvial and riparial micro- and macrofauna.

As regards the conservation or restoration of natural flow conditions, we must identify the hydrological regime that can ensure long-term protection of the geomorphological structures of the water course and the presence of a biological community corresponding to natural conditions. It is not just a matter of defining a discharge for the hydrological characteristics of the water course (such as low-flow conditions), but it must be connected to the minimum conditions which allow the existence of a high-quality natural ecosystem.

For water extraction to be compatible with the environmental state of the water body and to conserve or restore natural flow conditions we need to determine:

- the flow to be left downhill of existing water diversions so that minimal conditions of naturalness are restored (which might also not coincide with the original conditions that have been definitively compromised) as well as the environmental quality, or so that the current conditions are guaranteed, should these be in line

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with the set objectives;
- the minimum impact on channel bed and bank conditions;
- any morphological restoration of the channel, altered either by existing water extraction or by hydraulic engineering interventions.

Action to ensure suitable water availability, that is in such quantities as to meet human and ecosytem requirements, envisages the following priority measures:

- reduction in requirements, understood as the demand for the extraction of water resources from surface and groundwater bodies that may be directly related to actual, indispensable needs for that particular use; modulation of the extraction and immediate determination of quantities diverted not only allows the extracted flow to be controlled with respect to legal concessions, but also ensures the reduction in extraction to what is actually necessary, thereby limiting waste;
- rational resource use, understood as the use of only quantities actually necessary with the quality characteristics strictly required for that particular use; for this purpose, maintenance, modernisation, completion and the construction of new works for water extraction and distribution for the various uses involved and for wastewater treatment all serve to reduce the losses in supply-storage-distribution systems and to assign the right quantity of water where it is actually needed;
- multiple resource use by recycling water in production cycles and recovery of the resources used, but still suitable in terms of quality for various uses, and the subsequent employment for various, yet compatible, uses, of the same quantities diverted (such as energy and farming).

So as to ensure the operational achievement of the objectives established, a series of intervention programmes are being implemented. The most important are as follows:

1. at the end of 2009 a multi-year programme of interventions providing for an investment of 180 million euro in seven years to complete the system of domestic wastewater treatment and build three compensoriali aqueducts able to rationalise and make drinking water supply more secure for about 50% of the resident population in the region, including the capital Aosta;
2. in 2008 an experimental programme was approved to determine the minimum biological flow with regard to the main regional producer of hydro-electric energy, the Compagnia Valdostana delle Acque (CVA). The other concessionaries of hydroelectric power have launched procedures to comply with the Protection Plan, using calculation methods set by the same plan;
3. an intervention programme is currently being set up for the system of water courses and the Dora Baltea, especially to launch, where possible, initiatives to achieve natural and landscape restoration and improvement to make the main river of Valle d'Aosta become the axis of a new regional tourist and recreational system;
4. specific guidelines have been defined to assess the demand to divert water for hydroelectric purposes;
5. in 2009 a programme to enhance knowledge of groundwater and possible geothermal uses was approved.

These initiatives will operate alongside the planned measure illustrated above to assess water availability.

Conclusions

A small Alpine region like Valle d'Aosta has to tackle the great challenge of water resource management in a scenario of new environmental needs and climate change. This challenge must be faced with pragmatism and commitment. Only in this way will it be possible to guarantee, in such a difficult upland terrain, a sound future for a society in harmony with its own natural resources and the environment.

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