Groundwater in the Southern Member States of the European Union:

an assessment of current knowledge and future prospects

Country report for Italy

Contents

M.V. Civita [(o)], A. Massarutto [(oo)] and G. Seminara [(ooo)]

[(o)] *Polytechnic of Turin, Italy*
Former Head of the National Research Project "Assessment of Aquifers Vulnerability"
of GNDCI-CNR (*e*-mail: massimo.civita@polito.it)

[(oo)]*Dipartimento di Scienze economiche, University of Udine, Italy*
e-mail: antonio.massarutto@uniud.it
and
Iefe, Università Bocconi, Milan (Italy)

[(ooo)]*Accademia dei Lincei, Italy*
and
Department of Civil, Environmental and Architectural Engineering
University of Genova, Italy
e-mail: giovanni.seminara@unige.it

Groundwater in Italy:
A Review

Contents.

Foreword.

This paper has been written as the contribution of Accademia dei Lincei to the preparation of the EASAC Report on Ground Waters in Southern European Mediterranean Countries.

1. Water Governance in Italy.

1.1. Water institutions: property rights, administration and policy.

1.1.1. Institutional framework of water management: the legacy of the past.

The historical development of water rights in Italy, as in other EU countries, can be summarized as a progressive establishment of public power over a free-access common property. As soon as issues of general interest came out, the state has assumed the power to regulate private behaviour, allocate public money for infrastructures and plan the allocation of resources in order to meet social demands.

This statement helps understanding some of the key characteristics of the Italian water institutions, namely:

- *Sectoriality*: in fact, until recently, water legislation has not dealt with water but with specific water uses, and has mostly been concerned with providing the means for satisfying demands.
- *Fragmentation*: a large number of different administrations and territorial levels have competences in the water domain, often overlapping or contrasting.
- Add-on and *lack of coherence*
- *Emergency driven*: typically, advances in the setting up of a state power to regulate water arise when emergencies exert pressure on the policymaker
- Dominated by supply-side and *public-work approaches*

Therefore, even the introduction of a system based on river-basins and integrated management (law 183/1989) cannot be understood without keeping in mind past legacies and constraints arising from history. In particular, it should be kept in mind that the inheritance of existing uses (abstractions and discharges) often makes the room for decision very restrict; the decision power of basin institutions, though apparently unlimited, is in fact severely constrained by the lack of instruments and the need to rely ultimately on political commitment of decision-makers. Although the state has the power to withdraw licenses or to assign them to different users after expiration, this happens in fact only with difficulty.

As a result, despite the rhetorics spent by legislation and official documents about the need of a long-term oriented strategy and integrated planning, water policy continues to be dominated by short-run problem solving, if not by emergency management. Just to provide a figure, until recently the public expenditure for water-related policies has been dominated by emergency management (90% of the total) with only limited resources remaining available for ordinary management, maintenance and structural actions. Water shortage, seasonal droughts, groundwater pollution, urban rainwater management (just to cite some emerging issues) and other similar events are still managed as emergencies (ex-post remediation) rather than by preventive actions and integrated strategies.

The most distinctive state power concerns *licensing* of all water uses. Licenses for abstractions have been required for surface waters since the end of the XIX century, while groundwater use has remained more or less free until 1994. Discharges have required authorization starting from the 70s (L.319/76). Other activities, such as building and land use in the river domain, also require licenses. The procedure for releasing abstraction licenses has traditionally allowed for a discretional power of the state. The 1933 law, fundamentally still in use, states that the guiding principle should be the recognition of the public interest: in case of competing applications or oppositions to a request, the competent authority should choose the solution that best represents, in its judgment, the public interest. This discretional power has been somewhat tempered in recent times. Requirements for minimum flows have been introduced, and a sort of a priority ladder for allocating water in periods of absolute shortage has been made explicit (human consumption first, agriculture next, then all other uses).

Legislation concerning *water quality* has been initiated much later, with law 319/76 establishing for the first time emission standards for all discharges into watercourses and public sewers. A licensing system has also been introduced. The main difference with respect to the water abstraction policy lies in the fact that the discretional power of the public administration is much more limited here, since the respect of the emission standard is the only requirement. The traditional case-by-case approach has then been gradually replaced by a planned approach: licenses are released within a set of general principles and targets that the competent authority sets through regional plans. Planning involves in particular:

- Household supply (each aqueduct has a legal provision of water assigned by the Waterworks Master Plan);

• Water quality, through the Water Protection Plan introduced by Dlgs 152/99 (discussed in the next section) and anticipating philosophy and contents of the WFD;
• Land use in the river corridors
Regions are the competent authorities for water policy and planning. Law 183/89 has introduced a system of master plans based on river basins. The *basin plan* was conceived as a framework water plan providing directives and guidelines for sectorial plans. The entire national territory was divided into a number of river basins: for each of them a *Basin Authority*, which is responsible for the basin plan, was set. River basins were divided into three categories. In large river basins that involve more than one Region (basins of national interest, presently 6) a new institution was created with the participation of all concerned Regions and the Central State. For basins that involve two Regions, the Basin authority was created by both of them; for minor basins Regions had a direct responsibility. This scheme, which was somehow already consistent with the requirements of the WFD art. 3, has been recently modified by DLgs 152/06 discussed in sect. 1.1.4.

1.1.2. Anticipating the WFD.

In 1999 the Italian government approved a law (the DLgs 152/99) motivated by the need to transpose the European Directives (91/271/CEE 'Treatment of urban sewage' and 91/676/CEE 'Water protection from nitrate pollution') into the Italian Legislation. It is fair to say that the main principles inspiring the latter law anticipated the philosophy of the (yet to be approved) Water Framework Directive. In fact, the main goals of the law were:

a) *preventing and reducing pollution as well as restoring polluted water bodies ;*
b) *achieving improvement of the status of natural waters and adequate protection of water bodies, after defining objectives for their environmental quality accounting for their specific use;*
c) *promoting long term sustainable water use, with special attention to drinking waters, integrating protection of both quantity and quality of water resources in each hydrographic basin, and devising an appropriate system of controls and penalties;*
d) *preserving the natural capacity of auto depuration of water bodies, as well as their capacity to host wide communities of diverse animals and vegetal species*.

The ultimate aim of the law was to achieve, within 2016, a status of 'good environmental quality' for all the significant water bodies, namely sufficiently large rivers, lakes, transitional waters, artificial reservoirs, aquifers and water bodies with specific use (water for drinking use, waters suitable for fish and mussel life). Good environmental quality was meant as a status in which "the biological parameters exhibit weak alterations relative to those normally associated with the same ecotype under unperturbed conditions'. Moreover, ground waters may experience ' moderate conditions of disequilibrium of the water balance provided they do not generate overexploitation and non sustainable uses in the long term'. In order to pursue these goals the law imposed respect of *emission limit* values set by the State such to achieve environmental quality standards for the receiving water bodies: in other words, the level of treatment (defined as 'appropriate treatment ') required for waste waters was defined on the basis of the need to insure that *the receiving water body meets minimum quality requirements*. Environmental quality of surface waters was defined in terms of their chemical as well as ecologic status while environmental quality of ground waters was defined in terms of their quantitative and chemical status. Environmental quality objectives were specified for all significant water bodies.

The Basin Authorities of national and interregional relevance were asked to define, before December 31st 2001 and after consultation with local Authorities, appropriate environmental objectives to be implemented in the Water Protection Plan as well as priorities among the measures to be undertaken. Before December 31st 2003, the Regions, after consultation with Provinces, were expected to formulate their Water Protection Plans, which was to be finally approved before December 31st 2004 once the competent Basin Authority had checked conformity of the Plan to objectives.

1.1.3. Groundwater regulation in Italy before the WFD.

The use of groundwater has remained free or unregulated for a long time. The relative abundance of aquifers and springs has favoured in many areas of the country a model based on self-supply on individual, collective or small community base. Once extracted from the underground, water could be reserved to public uses: this is the instrument through which Water Supply Plans (started by 1961 legislation) allocated certain resources to public uses. Nonetheless, private abstraction from wells, ponds and small sources has remained substantially free until the 90s. The number of private wells and small abstractions (mostly for agricultural and industrial use) are countless, and can be estimated in several hundred thousands throughout the country.
The Law 36/94 posed for the first time all water resources, including groundwater, under the *control of the state*. This means in practice that all water uses need to be licensed. For existing groundwater abstractions, the law obliged owners to declare their existence and characteristics in order to make an overall census possible. Most Regions (though not all of them) have completed this task. After the above declaration, the previous free use has been converted into an abstraction license for a limited period of time (usually 30 years). New licences or renewal of those that will expire require the same procedure as abstractions from surface water.
The law also introduced *compulsory metering* for all wells, though implementing and enforcing this measure properly has proved very difficult, given the enormous number of boreholes. Individual abstractions can therefore be assimilated to non-point sources of pollution, in the sense that their proper control is in many respects impossible or extremely costly.

A similar problem concerns *control of pollution*, either arising from agriculture (pesticides, fertilizers, management of livestock waste) or from industry and landfilling.
In principle, *industrial contamination* should exist only as an inheritance from the past, since the law has long banned any direct discharge underground as well as uncontrolled disposal of waste in the soil. The legacy of the past is however again of fundamental importance. Contaminated sites are countless and only recently some Regions have started an exhaustive monitoring of critical situations. The diffused presence of SME and the tradition of weak control lend support to the suspicion that the number of critical situations is much larger than what emerges from the official figures presented in sect. 5.
Agricultural contamination has been gradually contrasted, although agriculture has long benefited from weaker rules and more benevolent enforcement. Most Regions, and especially those characterized by the diffused presence of intensive agriculture have produced legislation aimed at controlling the use of harmful substances, limit the use of fertilizers and introduce duties of care and environment- friendly practices. It is also important to note that the CAP reform has driven most of Italian agriculture out of the market of commodities and much more concerned on quality products and territorial specialties. Emphasis on quantitative production has been reduced, while organic farming and biologic production have rapidly been expanding. Probably the most critical areas are those in which intensive livestock breeding, particularly pigs and poultry, takes place. Farming in these areas is more or less regulated and constrained to respect adequate land/livestock ratios and adopt livestock waste management plans that have to be approved and validated by the regulator. The control of pesticide trade is one of the few tasks remained under the responsibility of the Central State. DLgs 152/99 put special emphasis on groundwater protection through the provision of a zoning system. In particular, two instruments were foreseen: i) *sensitive areas*, namely water bodies subject to or liable to eutrophication unless convenient measures are undertaken; surface waters used to produce drinking waters, which might contain nitrate concentrations larger than 50

mg/l if convenient measures are not taken; areas requiring special wastewater treatment to prevent pollution.; ii) *vulnerable zones* concerning pollution arising from pesticides. In sensitive areas and vulnerable zones standards are more strict and special duties of care and technological prescriptions are adopted (e.g. compulsory adoption of Codes of good agricultural practices).
The law also stated that Regions should develop *monitoring programs* of both surface and ground waters in order to establish a coherent and comprehensive overview of their physical, chemical, biological and hydro geological status within each river basin district. Data, collected into Annual Reports, should be made available to the public through multimedia networks.
The first National Census of Water Bodies belonging to different typologies, due on 2001 according to DLgs 152/99, was postponed to 2003 by DLgs 258/2000. It is yet to be completed, though some steps forward have been made by several Basin Authorities.

1.1.4 Transposition of the WFD into the Italian Legislation: DLgs 152/06 and DLgs 4/08 .

As discussed above, some features of the water policy envisaged by the Directive 2000/60/EC had somehow been anticipated in the Italian Legislation (Law 183/89 and DLgs 152/99). However, a full transposition of the WFD has been enforced in Italy through DLgs 152/06 and its most recent modifications (DLgs 4/08), which provide a comprehensive treatment of the whole subject concerning the legislation on environmental matters.
A major modification enforced by this law is the definition of 14 *water districts*, in which all minor basins are merged. *District Authorities* replace the previous Basin Authorities and are responsible for the application of the principles of the WFD within each district. The idea underlying this reorganization is an attempt to establish for each district a governing Institution of equal relevance, with similar organs employing the same procedure to form, approve and adopt planning actions. National supervision is insured through the presence of the Minister for the Environment in the composition of each *Permanent Institutional Conference*, namely the organ assigned the task to release appropriate directives to guide the planning acts of the district authority. Moreover, institutional cooperation is established among Regions belonging to each district and the State, through a central body, the *Committee of Ministers*. All the requirements foreseen by the Directive, namely defining and enumerating surface and groundwater bodies, assessing the pressures on each of them and impacts on their ecological status as well as the definition of measures required to recover good ecological status must be included in the *District Plan*. This will consist of two *Sectorial Plans* for each basin belonging to the district: a *Hydrogeological Plan*, concerning soil protection and hydrogeological risk; a *Management Plan*, concerning environmental protection of water bodies and rational exploitation of water resources. Following art. 14 of the Directive, district authorities are also required to establish appropriate *Consultation Bodies* whereby the programs of measures to be implemented for each groundwater body can be debated with stakeholders, thus allowing their participation to the process of decision making.
The *environmental protection of water bodies* is regulated in the law by first setting appropriate *quality objectives*, conform to WFD, for both surface and ground water and classifying water bodies into quality classes, depending on data collected through appropriate monitoring campaigns. The quality objectives for each water body are to be met before December 22nd 2015, with intermediate less stringent objectives foreseen before December 31st 2010 though d*elays are allowed* under exceptional conditions. Quality is pursued by implementing a set of measures adopted by Regional Authorities through *Environmental Plans* to be issued every 6 years: these plans must conform to the general directives of the district authority, contained in a *Master Plan* and must be approved by the district authority. The district *Management Plan* integrates measures foreseen by the various Regional Environmental Plans.
The framework described above admittedly attempts to overcome the traditional *sectorial* approach of the Italian legislation. However, it is seen to involve the tight interaction of a number of institutional actors (at ministerial, district and regional levels), the timely and effective cooperation

of which will be crucial for the whole system to work: the traditional Italian tendency to *fragment* competences and responsibilities still prevails. In fact, fragmentation characterizes also the procedure envisaged for the process of data collection and *monitoring*: a number of different local Institutions (Regions, District Authorities, Regional Environmental Protection agencies, ATO's agencies, Drainage and Irrigation Boards) are given this task, while the National Environmental Protection Agency (APAT) is expected to construct a continuously updated National Environment Information System (SINA). In order for data to be actually made available to SINA a complicated procedure of mutual agreements between Regions, further local Institutions entitled to perform monitoring campaigns and APAT will have to be set.

1.2. Management of water services.

1.2.1. Urban water services: background.

During the XX century, following urbanization and economic growth, centralized supplies have rapidly been expanding towards the majority of population. Public planning (at national and later regional level) was introduced in order to ensure that each supply system had access to resources of adequate quantity and quality. Water supply plans single out communities and relative water requirements; associate each water supply system with one or more sources, and eventually foresee that an infrastructure has to be put in place in case actual needs are not matched by existing supplies. In practical terms, this has led to a sort of "dual approach" (Massarutto, 2002), with local authorities holding responsibility for service provision and Regions (or in extreme cases the State) being responsible for providing the required infrastructure. The whole system evolved towards a heavily subsidized one: while municipalities used their own budget (complemented by tariffs) for building and operating urban networks, the most substantial new investment (storage, transport, drinking water production plants, sewage treatment, large interconnections) arose from Regional planning or from special programmes managed by the Central State for macroeconomic purposes or for facilitating the development of Southern territories.
Around 13.000 water or sewerage undertakings were estimated in the early 90's; this figure probably overestimates the degree of fragmentation (since most small undertakings were in fact located in rural or mountain areas). Nearly 55% of the population was served by few hundreds largest systems. Anyway, fragmentation, poor level of cost recovery and especially lack of financial and industrial autonomy were the key characteristics of the Italian water industry in the early 90's. This structure could perhaps be justified by hydrology and orography, but it was increasingly under pressure because of its vulnerability to pollution – especially affecting groundwater, the key strategic resource for most supplies. The result could be summarized in poor quality records, inability to provide adequate and continuous supply to the most critical zones (especially Southern Italy and Sicily), vulnerability to pollution events (especially contamination by toxic substances), radically insufficient records of connection to sewerage and sewage treatment, financial collapse.

1.2.2. Urban water services: the 1994 reform and its slow implementation.

In the search to remediate to this critical situation, law 36/1994 aimed at a comprehensive reform tackling these problems. Its basic principles were (Massarutto, 1993):

• *Full inter-municipal responsibility* for public supply and sewerage within suitable geographical areas (ATO[1]) set by Regions with the following aims: increasing the size of management areas in order to redistribute water resources and costs, minimize the need of inter-area transfers and make economies of scale achievable.

[1] ATO is the acronym of "ambito territoriale ottimale", meaning "optimal territorial units".

• *Vertical integration* of responsibility on the whole urban water cycle under the same authority (inter-municipal agency for each ATO). Basic quality requirements are provided by legislation and regional environmental planning and external regulation.
• *Clear separation of roles* between political responsibility and need to guarantee service provision and management, the former being assigned to local authorities through the ATO agency, and the latter to be delegated to a professional water company.
• Making *professional operation* compulsory through the elimination of direct labour organizations and the obligation for the ATO to delegate a single operator for the management of the whole UWS. Alternative allowed models range from publicly-owned companies to delegation via competitive tender; mixed-venture solutions and PPP s are also allowed. In all cases, including public undertakings, a contractual approach is required in order to formalize obligations.
• *Full-cost recovery* through charges (although some margin remains for the state to subsidize large projects judged to be of general interest); the state fixes rules for water prices concerning tariff structure, maximum increase rates, benchmarks to be respected.

More in detail (fig. 1.1) the regulatory system devises a model in which investment choices are made by the ATO (through the asset management and development plan – AMDP - representing the base for the contract with the operator). Assets are provided as a free loan for use, while the plan foresees future tariff dynamics in order to allow the operator finance the investment levels to which it is committed by the AMDP. There are margins for the operator to renegotiate the AMDP, in the first place through the tendering process, and secondarily through subsequent voluntary agreements during the contract.

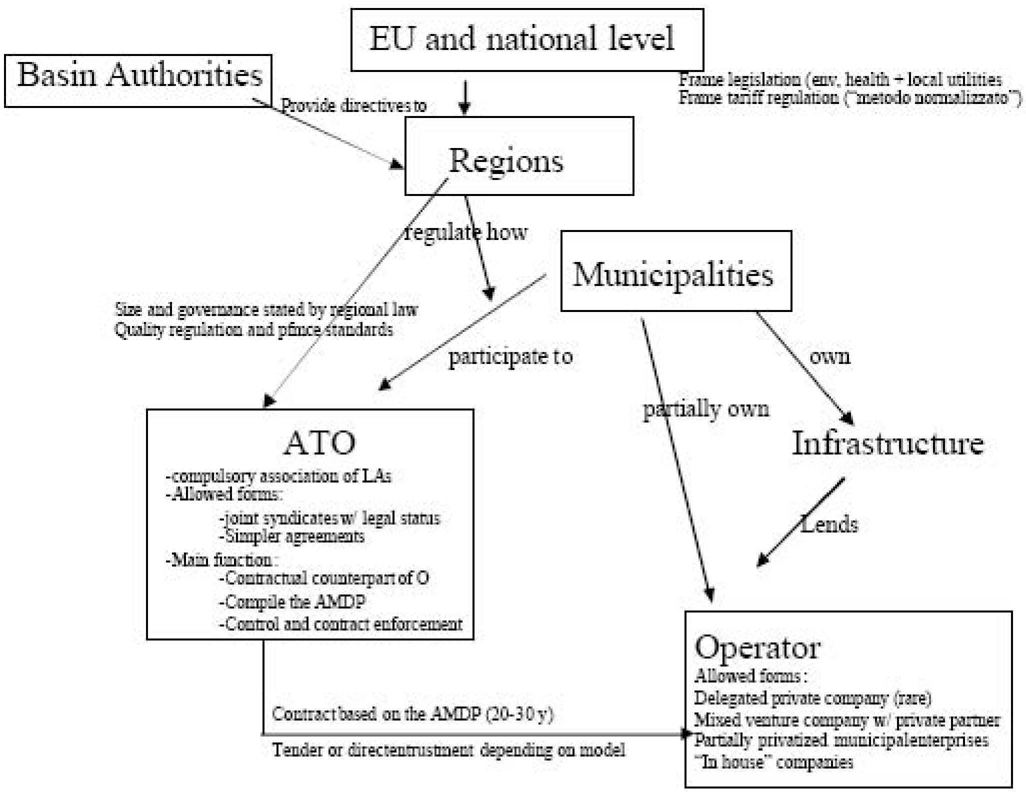


Figure 1.1 – Organization of urban water services after L..36/1994.

Larger scale UWS management and full responsibility over asset planning and operation has the aim of creating self-sufficient management units that can have a better oversight over available resources and feel more responsible for their appropriate management. Regions and Basin authorities have the responsibility of guaranteeing that each ATO has an adequate endowment of drinking water sources; individuation of “reserve zones” – water resources that are suitable to be used in the future for drinking water purposes and should be managed according to precautionary principles – is also required.
The ATO system is also conceived such to allow market-based financial mechanisms, leveraged by water tariffs, to carry on the burden of investment. Regional planning, following this design, would concentrate on environmental regulation and framing of long-term investment strategies. Larger scale is also conceived in order to alleviate the impact of water prices by keeping together areas with different marginal costs of supply (especially urban and rural areas, assuming that the main explanatory factor for cost differentials is urban density).
Self-sustainability should also guarantee industry viability and allow investment to restart – both new investment required by the EU and renewal of ageing infrastructure. Privatization and transformation of water companies into corporations is expected to foster efficiency gains and favour an economic rationality in the setting up of asset management and development plans.
In the following years, however, the reform had to face many problems and difficulties. After 13 years its implementation is still on a leopard-skin base, although the institutional transformations are consolidating (Muraro, 2004). All Regions have finally transposed the national framework legislation, but this required many years. The number of ATOs that have completed the necessary steps (constitution of the agency, check-up of existing systems, issue of the AMDP, choice of the operator, contract) is currently around 50% of the total. Many plans have revealed inconsistencies among targets, programmes and financial resources, and will need substantial modifications.
In the meanwhile, UWS reform was also affected by liberalization policies affecting public utilities (in general) and local utilities in particular. The reform of gas and electricity industry, in particular, created the opportunity for many municipal companies – as we said, in many cases they were organized as multi- utilities – to act as players in the new liberalized industries. Either forced by legislation or building on their own business capacity and assets, the most dynamic companies started a repositioning process, that is still taking place. Transformation into private-law establishments, mergers (mostly on a territorial basis), quotation in the stock exchange, vertical integration (e. g. through the acquisition of power generation facilities or bulk gas import contracts), diversification (e. g. towards telecommunications and other market activities) are some of the most distinguished trends (Vaccà, 2003). At the same time, the national government – also pressed by the EU – has engaged in a reform of local utilities that was clearly oriented by a liberalization design. Project laws on compulsory competitive tendering for all utilities – including water as well as waste management as the most likely candidate - were nearly passed, and finally blocked or weakened due to fierce resistance of local powers. Three legislative reforms have been passed between 2000 and 2003 (Robotti, 2002; De Vincenti and Vigneri, 2006). In the present legislation – still exposed to pressures to change in the direction of further liberalization – municipality maintains the possibility to directly entrust own undertakings only by following the strict criteria of in-house provision[2]; otherwise, a competitive tendering process must take place, even if the company is participated by the local authority. Tenders may regard delegation, as well as the choice of private partners in municipally-owned companies. This latter mechanism was used for example in the first ever tender implementing law 36/94, in the ATO of Arezzo in Tuscany, where the French multinational Suez (with some local partners) finally won the tender and became co-owner of the company.

[2] The definition of “in house provision” comes from EU legislation and especially from some judgments of the European Court of Justice. It identifies undertakings of any legal form, provided that municipalities have on them the same degree of control that they would have on their own offices; and provided that the concerned undertaking is delivering the substantial part of its activity on behalf of the owner local authority.

1.2.3. Water services for industry and irrigation.

Irrigation is by far the largest water user in Italy. Most of it (estimated 75%) is supplied through farmers' associations *Drainage and Irrigation Boards***.** Once established in a certain territory recognized by law, they acquire legal status and public profile, allowing them to charge associates a compulsory fee and to decide on a majority base. Their activity is not limited to irrigation, but also covers land drainage and improvement of rural facilities. Sometimes, they do also provide land drainage services to urban areas (e.g. rainwater retention, disposal of treated effluents). These associations are diffused throughout the country especially in plain areas.
Water services to industry are very rare in the case of water supply, that is for the most part self-managed via individual boreholes and abstractions. Collective systems have been established in some cases, in areas needing long distance supply (especially in the South) or where intensive industrial use was causing environmental problems (such as in the case of the textile district of Carpi, in Emilia-Romagna, where intensive abstractions generated lowering of water table and subsidence, and a collective system has been created in order to centralize water supply systems and boost reuse of treated effluents). Collective sewerage systems and treatment facilities are more diffused. These collective entities are normally managed by entities managing facilities in zones that are equipped for industrial development, together with other services (e.g. waste management, parking). Normally they operate on a full-cost recovery base, even if public intervention has often contributed at least to initial investment. Entities that manage industrial zones are typically established with the participation of firms located in the area, local authorities and other public subjects (e.g. Chambers of Commerce).

2. Groundwater resources in the water cycle of Italy and comparison with surface waters.

2.1. Climate and renewable water resources.

Italy extends through more than 10 degrees of latitude. Based on historical series it is found that the climate varies from the *semiarid* type[(o)] in the South, to the *sub-humid* type in the northern plains, to the *humid* type in the Alps and Apennines (Fig. 2.1). Italy has a fairly fortunate condition among southern European countries as regards the availability of renewable and exploitable water resources. The last two investigations, performed in 1970 and in 1989 by the Italian National Conference of Waters (CNA) based on hydrologic data available for the period 1921-1950, suggest that the total volume of yearly precipitation can be roughly estimated at 296 Gm^3, i.e. 990 mm/year. As shown in Table 2.1 (see also fig. 2.1) precipitations are not uniformly distributed throughout the Italian territory: roughly 41% (1120 mm/year) being located in the North, 26 % (980 mm/year) in the Centre, 20% (950 mm/year) in the South and 13% (750 mm/year) being equally distributed between the two main islands. The yearly volume of water returning to the atmosphere through *evapotranspiration* was estimated at 132 Gm^3 (442 mm/year). Hence, the *total renewable resource* according to CNA, is about 164 Gm^3/year (while EUROSTAT, 1997, estimated 175 Gm^3/year). In order to appreciate the significance of the latter figure, it may be useful to note that the corresponding values for Spain, Greece and Portugal are smaller by factors of 1.5; 3 and 67 respectively.

[(o)] Denoting by P the yearly average precipitation and by T the yearly average temperature, the different climates are defined as follows: *semiarid* type P = 450 – 600 mm/year, T = 18 °C; *sub-humid* type P = 500 - 900 mm/year, T =15 °C; *humid* type P = 800 – 1500 mm/year, T = 13 °C or less

Macro region	Precipitations (g m^3)	Renewable / exploitable Surface waters (g m^3)	Renewable / exploitable Ground water (g m^3)	Renewable /exploitable Total resources (g m^3)
North	121 (40,9%)	27,5 (69,3 %)	6,5 (53,7 %)	33.9 (65,4 %)
Centre	77,6 (26,2%)	5,4 (13,6 %)	2,4 (19,8 %)	7,8 (15,1 %)
South	60,4 (20,4%)	4,3 (10,8 %)	1,9 (15,7 %)	6,1 (11,8 %)
Sardinia	18,3 (6,2 %)	1,8 (4,5 %)	0,2 (1,7 %)	2,1 (4,1 %)
Sicily	18,8 (6,3 %)	0,74 (1,9 %)	1,2 (9,9 %)	1,9 (3,7 %)
Italy	296,1 (100 %)	39,7 (100 %)	12,1 (100 %)	51.8 (100%)

Table 2.1 – An estimate of the distribution of renewable and exploitable resources (in G m^3) among different Regions. Source: ANPA, CNA (1971, 1979) and CNR-IRSA (1999).

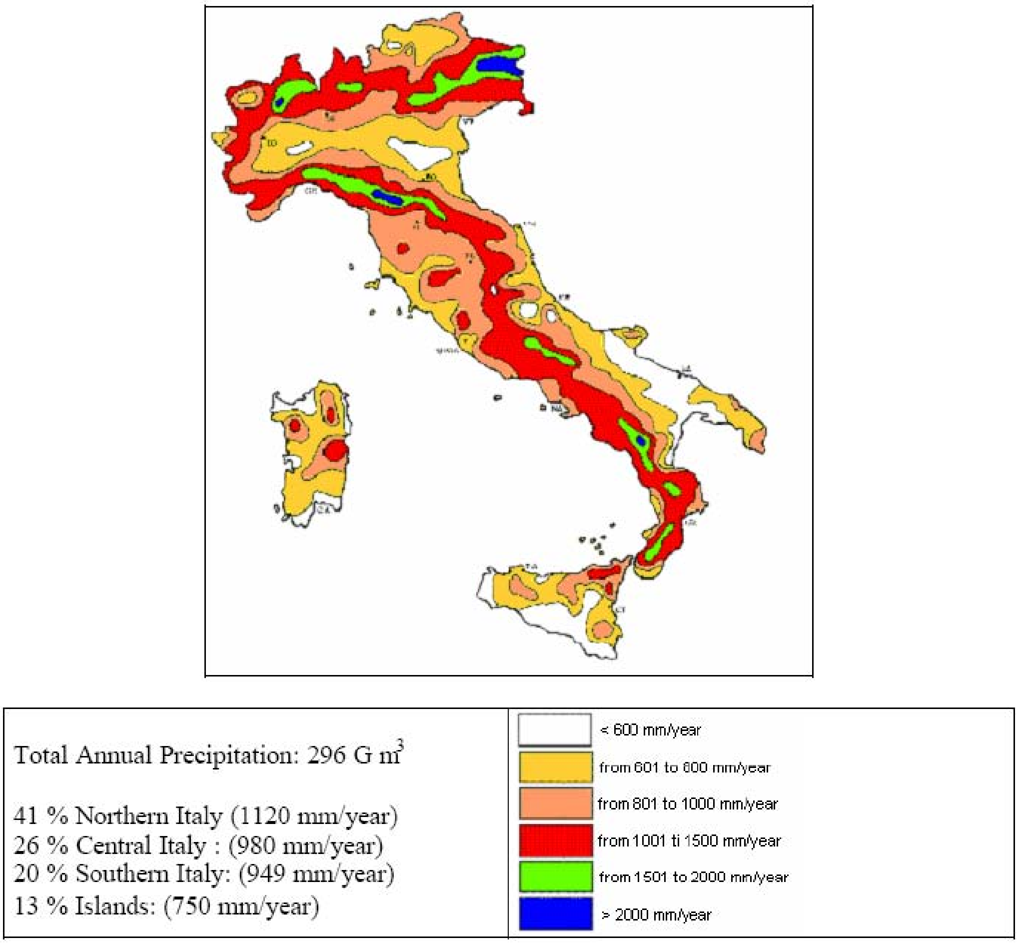


Fig. 2.1 – The yearly average precipitation over the Italian territory.

Taking into account the various constraints which limit exploitability of water resources, it turns out that the volume of *renewable resource* which is *actually exploitable* reduces to 52 Gm^3/year (56 Gm^3/year according to EUROSTAT, 1997) (Figure 2.2).

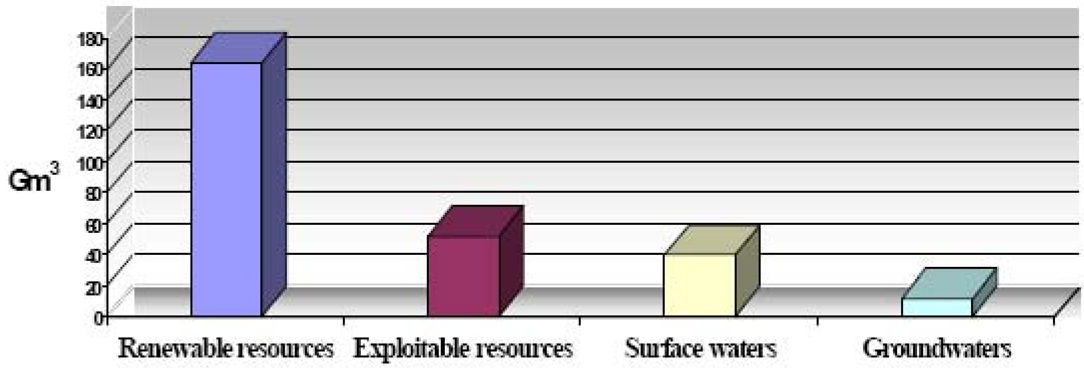


Figure 2.2 – An estimate of the total renewable and exploitable resources of Italy (in G m^3*).Source: ANPA, CNA (1971, 1979) and IRSA -CNR (1999).*

The spatial distribution of the total renewable and exploitable water resources is also fairly non uniform, with a high percentage (65%) located in the North, a smaller fraction (15%) located in the central regions, and even smaller fractions (12% and 4%) in the South and in the major islands respectively. The total volume of Italian *renewable and exploitable ground water* is not quite certain, the highest estimate ranging about 12-13 Gm^3, as opposed to an estimate of roughly 40 Gm^3 for *renewable and exploitable surface waters* (Table 2.1), part of which (roughly 10 Gm^3) are stored in natural or artificial reservoirs. Hence, roughly 23% of the total renewable and exploitable water resource of Italy is stored in aquifers (as opposed to an European average of roughly 13%).

2.2. Aquifers of Italy .

The morphological and hydrogeological characteristics of the Italian territory favour storage of large amounts of groundwater in aquifers. Moreover, their distribution is quite heterogeneous being strongly influenced by the nature and hydrology of hydrogeological complexes (fig. 2.3).

2.2.1. The Alps.

Moving from NW, the Maritime Alps are characterized by a highly permeable, fractured and carsick, carbonate series, lying over a virtually impermeable crystalline basement. Several springs are found, usually characterized by a high degree of variability as carbonate formations are strongly immersed, with deep wells and extended networks of channels. More than 40 springs have been censed, with average flow rates ranging from 0.02 to 2.00 m^3/s and annual average available resource (*AAR*) of the order of 175 Mm^3/year (fig. 2.4).
The Alps of Piedmont and part of Lombardia (Cozie, Graie and Pennine) are mainly composed of metamorphic and crystalline weakly fractured and weakly permeable complexes. As shown by some large underground excavations, only in strongly tectonic areas and in moraine complexes, aquifers of some value exist. They are, however, of limited size and strongly segmented. Beyond the River Sesia, highly permeable carbonate series superimpose upon crystalline-metamorphic complexes. The former complexes then prevail in the Orobic and Brescian Prealps: water supplied to various important urban centres, e.g. Brescia itself, is spring water. Important springs from carbonate aquifers are also located in the Adda basin, Upper Tellina Valley as well as in the Nossena basin (Q = 2 m^3/s), north of Bergamo. The central-northern zones of Trentino, Veneto and Friuli (Lepontine, Retic and Carnic Alps) are also characterized by the presence of weakly pemeable crystalline-metamorphic complexes, with limited carbonate aquifers feeding a few important springs: the Spino spring, which supplies water to the city of Rovereto, the Ri Bianco spring (Stenico), the Acqua Santa spring (Sporminore) and some further 20 springs with Q ranging about 0.5 m^3/s (total *AAR* of about 350 Mm^3/year).

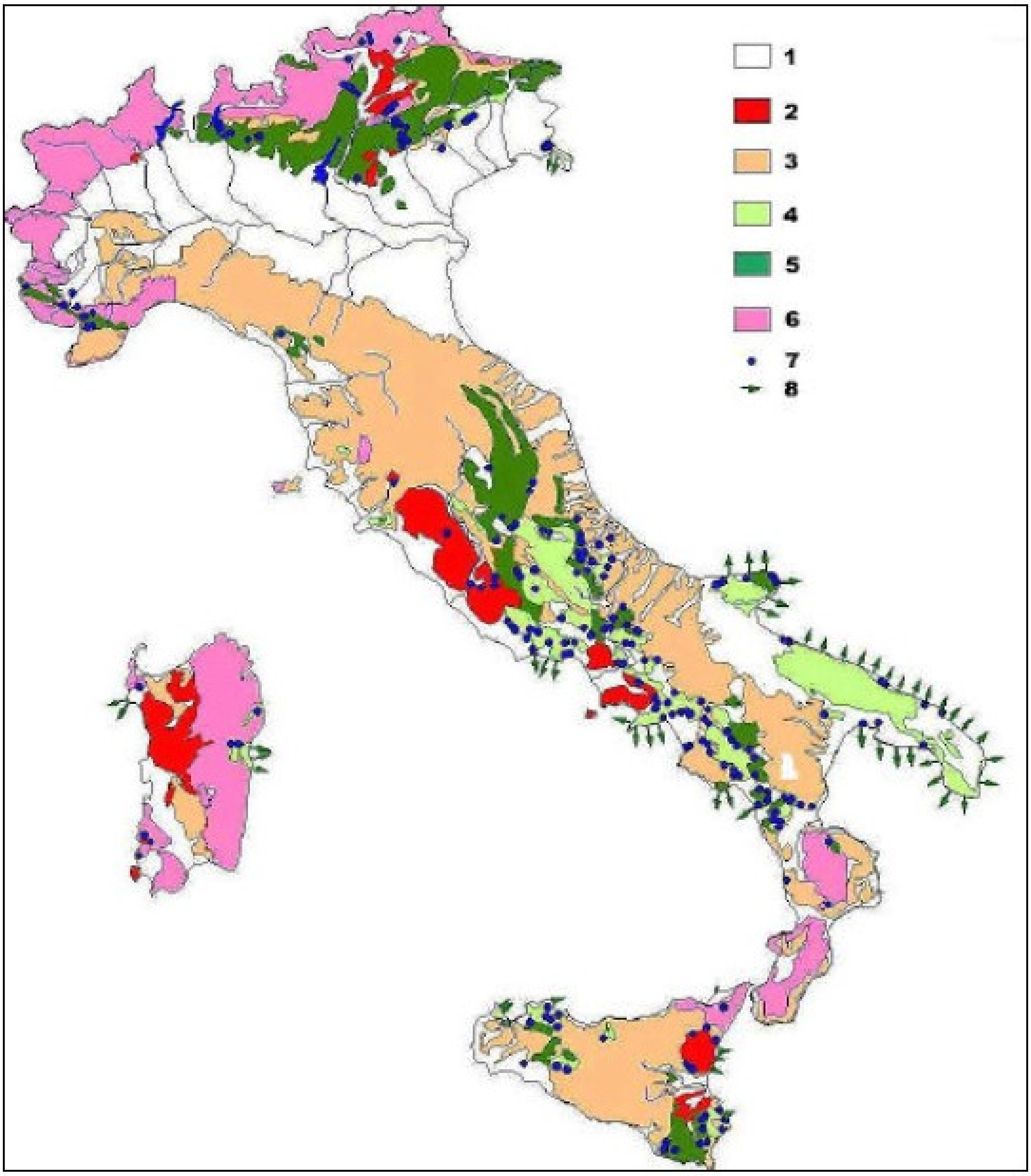
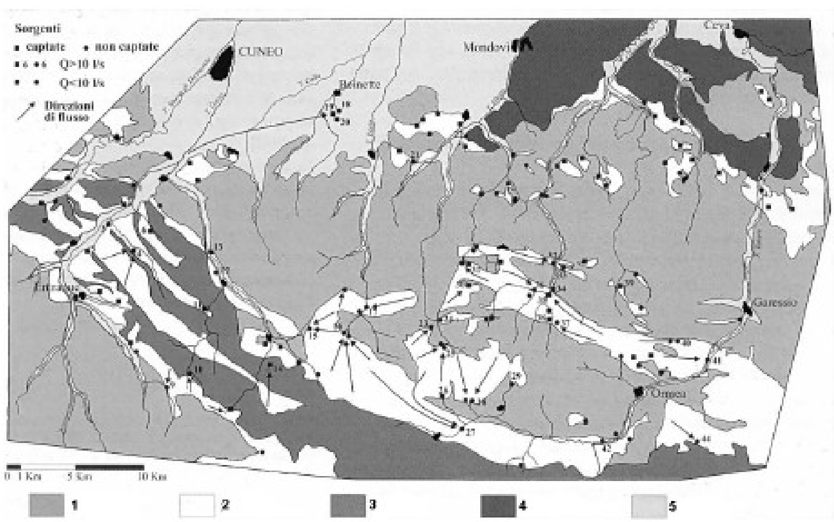


Fig. 2.3 – Schematic hydrogeological chart of Italy: 1 = Recent hydrogeological sequences of sedimentary nature; 2 = Vulcanite and pyroclastic hydrogeological sequences; 4 = Mostly terrigen cenozoic hydrogeological sequences; 5 = continue carbonate hydrogeological sequences; 6 = Vertically segmented hydrogeological sequences; 7 = Metamorphic and magmatic hydrogeological sequences; a = main springs; b = main outlets and/or aquifer losses to the sea (SGWD). (Source: Civita, M.V., 2005).

In the S and SE portions of the chain, close to the edge of the flood plain, several large springs arise from the carsick-carbonated complexes, for a total *AAR* of the order of 1.2 Gm^3/year. The largest springs are those of the middle Brenta, among which most prominent are the Oliero springs (fig. 2.4, Q = 11 m^3/s). Further important springs are those of Montorio Veronese (Q = 4.5 m^3/s), Meschio (North to Vittorio Veneto) and Cornino lake on the right bank of the Tagliamento river (Q = 2 m^3/s).

The springs of the Livenza river (Gorgazzo, Santissima e Molinetto, total Q = 11.4 m^3/s.), located in a neighbourhood of Polcenigo (Friuli), deserve a distinct treatment. This important complex is fed by the vast carbonate structure of Cansiglio, which is highly permeable and strongly recharged by

intense precipitations. The springs, located in a side valley, can be easily exploited and will likely represent, in the near future, a strategic resource for the flood plains of Veneto and Friuli.
The carbonate aquifers located in the southern Alps thus represent an abundant ground water resource, as yet fairly weakly exploited in spite of their good quality. The latter also feed the aquifers in loose rocks located in the flood plain. At the NE end of the chain, close to the border with Slovenia and Croatia, the carbonate complex of Carso is located. This includes a number of dolins and is characterized by underground rivers extending through tens of km, the best known being the Timavo river. The latter debouches into the sea through the spring complex of S. Giovanni di Duino with an *AAR* of the order of 1.5 Gm^3/year, most of which (1.3 Gm^3/year) is hardly exploitable due to its poor quality. In fact, the Timavo river is fed by the total losses from the Reka river, in Slovenia, which is highly polluted due to several civil and industrial untreated wastes.



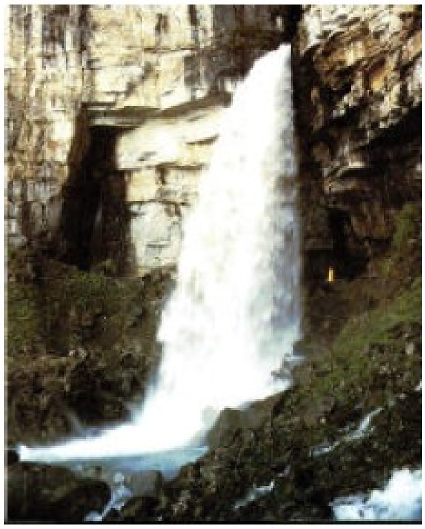


Fig. 2.4 – Left: Hydro-geological scheme of maritime Alps. 1 = Weakly permeable basal crystalline complex; 2 = Carbonate aquifer; 3 = Flysch impermeable complex ; 4 = Weakly permeable limestone-sandstone complex; 5 = Alluvial aquifer. Right: The important Pis spring of river Pesio. (Source: Civita M. V. et al, 2000).

Fig. 2.5 – Left: The springs of Oliero (Valstagna); right: the Santissima spring, Livenza cape (Polcenigo) (Source: M.V. Civita).

2.2.2. The Po flood plain: Veneto and Friuli.

A large plain, which is drained by the Po river and its tributaries, as well as by the Adige river and rivers of the Veneto – Friuli regions, lies between the Alps and the Apennines.

From the hydrogeological viewpoint, one may distinguish an upper plain, bordering the mountain chains (both Alps and Apennines), consisting of the system of highly permeable alluvial fans formed by the rivers which, debouching into the floodplain, feed the underlying aquifer intensely. Part of the waters infiltrating at the edge of the alluvial fans emerge along a strip of springs called *linea delle risorgive* (or *fontanili)*. Part of them flows down valley through a complex artesian multilayered aquifer. This pattern is found throughout a valley strip located at the foot of mountains, from Piedmont to Veneto, Friuli and Emilia Romagna (fig. 2.6).

Fig. 2.6 – Left: chart showing the strip of the valley where the strip of risorgive is located; Right: a “risorgiva” in the eastern part of Piedmont.

The plain of Veneto-Friuli is the result of erosion, transport and settling of sediments (gravel, sand, silt, clay and peat of different origins, fluvial, eolic, marine, lacustrine) which have filled the pre-existing gulf. As a result, the plain can be roughly divided into three main strips: i) an *upper plain*, the foot of Alps where the coarsest highly permeable sediments deposited, ii) a *middle plain*, where gravel and sand strata alternate with finer impermeable strata; iii) a *lower plain*, where low permeability fine sediments (silt and clay) prevail. The aquifer is phreatic in the upper strip, with depth of the water table decreasing downstream: this aquifer is fed by water dispersed by rivers (Adige, Astico, Leogra, Brenta, Piave). The total yearly water supply ranges about 50 m^3/s, roughly 70% of the total water supplied to the hydro-geological complex of Veneto. The middle plain consists of various superimposed artesian aquifers under high pressure. The lower plain contains less water, mainly in sand aquifers (paleo-rivers or sand dunes) alternating to impermeable layers of finer silt and clay. These aquifers are fed by infiltration of precipitations, river dispersion and infiltration of irrigation waters. The groundwater resource associated with “risorgive” is quite important. It is strictly connected to the water loss from rivers flowing through alluvial fans, forming a virtually continuous aquifer which emerges as the water table reaches the ground or the ground water flowing into the lower valley experiences a sharp reduction of soil permeability. The quality of this resource is fairly poor due to pollution from urban centres. Hence, it requires expensive treatment to be exploited for drinking purposes. This notwithstanding, the aquifers of this valley are of crucial importance as, in this area, the largest urban and industrial settlements of the whole country as well as a large fraction of agricultural and livestock production are located.

2.2.3. The Northern Apennine.

The northern Apennine is located between an important tectonic alignment along the NE boundary and the upper Arno and Tevere valleys lying along the S boundary. From the hydrogeological viewpoint, these areas (from Monferrato to Perugia) consist mostly of weakly permeable complexes: aquifers are generally limited, springs are few and characterized by small discharge, supplying water only to local communities. Alpi Apuane (*AAR* ≈ 66 Mm^3/year), the carbonate aquifers of the Caldana mountains and the volcanic aquifer of the Amiata mountain (*AAR* ≈ 57 Mm^3/year) are significant exceptions.

2.2.4. The upper valleys and the coastal plain of Toscana.

An aquifer of great socioeconomic relevance lies in the plain of Firenze– Prato – Pistoia. The hydrogeological pattern of this complex plain is similar to that discussed for the Po-Veneto valleys, though the sizes of the two are quite different. This plain is a part of the *Arno Basin*. The Arno Basin Authority has estimated at 14 m^3/s the unbalance between summer withdrawals and restitutions throughout the Basin. This notwithstanding, various estimates (see the wide documentation provided by the Basin Authority) suggest that most aquifers of the basin are not over exploited. An exception is the aquifer located at the highly industrialized area of Prato (roughly 80 Mm^3 stored) which underwent a strong decline of the water table in 1988. This trend reversed in the years 1991 – 1994 also thanks to various measures implemented, namely the construction of an industrial aqueduct and the artificial recharge of the aquifer through the weir constructed in the Bisenzio torrent feeding the aquifer. More recently, decline of the water table is once again being experienced.
Further open hydrogeological complexes are located in the plain of Pisa (lower Arno), Lucca (middle and lower Serchio), Grosseto (lower Ombrone), the Maremma plain and the plain of the Cornia river. In these terminal plains of rivers the pattern is fairly similar: a free aquifer in coarse sediments lies in contact with the rivers and the sea. It consists of an artesian multilayered aquifer, providing sufficient water resources, specially in the Pisa plain.

2.2.5. The Central-Southern Apennine.

The second major basin of Central Italy is the *Tiber Basin.* Based on a classification of outcropping lithology, it is estimated that roughly 25% of this basin, located in the eastern sector, is highly permeable (mainly carbonate rocks and some gravel-conglomerate); 38%, located in the western-southern sector, is moderately permeable (mainly vulcanite, fans, alluvium non consolidated sediments, sand-limestone); 37%, located in the northern sector, is weakly permeable (Flysch, clay-silt deposits). The Tiber basin is fed by the northern part of the central Apennines, where the main carbonate hydrogeological series is widely compartmented by less permeable terrains. The spring discharge is scarce down to Orte, where the river receives the Nera- Velino tributary, rich of spring water in the upper (Rieti Springs - Q = 5.5 m^3/s) and lower (Montoro Spring group - Q = 15 m^3/s) parts (Data from CasMez (1983)).
The above springs are, hydrogeologically speaking, part of the centre-south Apennine units, which consists of large, fractured and carsick, carbonate sequences, bounded by impermeable layers.. Many springs are characterized by discharges of several m^3/s (e.g. Peschiera, 18 m^3/s; Gari, 17.7 m^3/s; Fibrieno, 9.4 m^3/s; Capo Pescara, 7.5 m^3/s; Acqua Marcia, 5.0 m^3/s; Sorgenti del Sarno , 8.6 m^3/s; Biferno, 4.6 m^3/s; Sanità di Caposele, 4.1 m^3/s) and represent some of the most significant springs of the Mediterranean basin. As many as 43 different supply areas of the springs have been identified, with a total *AAR* of 9.3 Gm^3/year. These must be added to those pertaining to the various alluvial plains of Campania and Lucania, as well as to the volcanic areas of Lazio and Campania with an estimated total *AAR* of 2.1 Gm^3/year. Particularly rich of ground water is the upper Agri valley, while little resource is available in the remaining basins debouching into the Ionio sea, namely Bradano, Basento and smaller basins. Below the northern border of the *Calabria* region

(along the Crati river), the weakly permeable crystalline – metamorphic complexes of the Sila and Aspromonte mountains contain little groundwater which is only locally exploited. This makes the situation of the *Calabria* region quite worrying. In fact, anthropogenic factors (mainly irrigation) coupled with a substantially uncontrolled management of ground water has led to significant local overexploitation of the resource. In particular, in some areas, irrigation is mostly provided through abstractions from private wells belonging to single farms. In the Sibari plain alone, it is estimated that the number of boreholes has increased from 500-1000 (beginning of '70 s) to 5000-6000 (present). The situation is worst for the aquifer serving the city of Reggio Calabria, a densely populated area with only one alluvial aquifer and little surface water. It was estimated (Italpros, 1989) that about 30 Mm^3/year were abstracted (with 300 l/s supplied to the aqueduct of Reggio Calabria). Little knowledge on natural recharge is available and monitoring is scarce.

2.2.6. The coastal plains of the Adriatic side.

Ground water resource on the Adriatic side of the central-southern section of the Appennine, between Cesena and Gargano, is fairly scarce: the hydrogeological complexes consisting of clay-limestone formations in the lower basins and sandstone- limestone in the upper- middle parts of the basins. A number of quasi straight rivers cross the coastal plain in the SW-NE direction. The upper portions of many of them are fed by large springs (see Sect. 2.2.5.), while the lower portions are most often not rich of ground water. In fact, alluvial plains have been formed by deposition of weakly permeable and highly erodible formations subject to intense erosion upstream. As a result, aquifers have limited extension as well as limited productivity. Available data concerning alluvial plains of rivers of the regions Romagna, Marche, Abruzzo and Molise are summarized in Table 2.2.

RIVER	*RIS* (Mm^3/year)	RIVER	*RIS* (Mm^3/year)
Marecchia	20	Saline	15
Musone	20	Pescara	20
Conca	5	Foro	5
Tesino	5	Sangro	20
Tronto	15	Sinello	5
Aterno	20	Trigno	10
Vibrata	15	Biferno	10
Salinello	5	Vomano	20
Tordino	10	Pescara	20

Table 2.2 – Average annual water resource available in aquifers of the main Adriatic rivers (Sources: ARPAER, 2005 a; CasMez, 1983).

2.2.7. The coastal plains of the Tyrrhenian side.

The hydrogeological complexes of the Tyrrhenian side consist of wide coastal plains located at the foot of Apennines as well as of a few volcanoes (Roccamonfina, Campi Flegrei and Vesuvio). These areas have progressively been filled with alluvial deposits, vulcanites and pyroclastites, forming a sequence of superimposed aquifers, the most significant of them being located at the downstream end. In Table 2.3 estimates of the ground water resource available in the coastal plains are reported.

The *AAR* pertaining to the Gargano aquifer are estimated at 380 Mm^3/year, but the corresponding *SGWD* (the Submarine Ground Water Discharge lost to the sea) reaches a value of at least 220 M m^3/year. Much smaller losses (5 Mm^3/year) are estimated for the Murgia aquifer. The most important springs of the Puglia region (Tara, 3.5 m^3/s; Chidro, 2.4 m^3/s; Idume, 1.1 m^3/s) are located along the coast of Salento: with the contribution of smaller springs the total *AAR* of this area reach 240 Mm^3/year, though the associated *SGWD* is not known.

HYDROGEOLOGICAL COMPLEX	*RIS* (Mm^3/year)
Piana Pontina	190
Piana di Fondi	25
Pina del Garigliano	40
Piana della Solofrana – Sarno	160
Piana del Volturno – Regi Lagni	300
Piana del Sele	95

Table 2.3 – Average annual water resource available in aquifers of the main Tyrrhenian coastal plains including the associated spring discharges (Sources: CasMez, 1983).

Fig. 2.7 – Main spring areas of Gargano, Murgia and Salento (Satellite basis from Google Earth)

2.2.9. The two major Islands: Sicily and Sardinia.

Sicily can rely on some relatively good aquifers on the eastern side, in particular those located in the vulcanite of the Etna mountain and in the carbonate complexes of the Iblei. Fairly important, though overexploited, aquifers are also present in the Madonie chain as well as in the Palermo area. The central part of the island has quite scarce ground water resource and surface waters of low quality due to the presence of saline and chalk rocks. The Region of Sicily, being Autonomous, has established an independent *Regional Agency for wastes and waters*, with the aim to insure an efficient and coordinated management of wastes and water. Some progress, at least in the direction of an assessment of the state of surface and ground water, has been made through a Report (May 2006) prepared by the Office of the so called *State Commissioner for Waste Emergency and Water Protection*, in compliance with the requirements of WFD. In this Report, it is estimated that about 10 aquifers (14% of the total number of Sicilian aquifers) are at risk of overexploitation. Six of them appear under threat of significant salt intrusion. The Report is mainly qualitative and as yet incomplete. Though it reveals a significant deficit of monitoring and control activities, however it appears that the beneficial effects of the WFD is starting to be felt even in Sicily.

The island of *Sardinia* also suffers from severe deficit of water supply, as it cannot rely on significant aquifers. The island consists mostly of crystalline rocks and vulcanite, but for a few restricted areas along the eastern coast and the southern-western region, where carbonate aquifers feed a few springs of modest discharge, with low quality waters due to the effect of interaction of aquifers with rocky environments containing mixed sulphides.

The situation of Sardinia is deteriorated in spite of the fact that ground water has traditionally played a relatively minor role, providing for irrigation only in areas where surface waters were unavailable. However, in all the alluvial zones, a dense network of wells is present. Little information is available on them: even the depth of wells is often unknown. However, a few studies suggest that most coastal aquifers suffer from salt water intrusion. This appears to be due not only to ground water overexploitation but also to the exploitation of coastal lagoons for fish breeding (Ardau et al., 2000), which makes lagoons unavailable for the natural recharge associated with river flooding (e.g. Flumendosa estuary, Campidano plain). Salt intrusion in the Capoterra aquifer has further causes: sea-spray and wind carried salt originating from salt mines are deposited on the ground and dissolved into the soil by winter precipitations. Investigations on the Oristano aquifer (Barrocu et al., 1995) compared data available for surface as well as deep aquifers referring to 1979, 1990 and 1995, finding general lowering of the water table and high salinity, mainly in the surface aquifer but also in deep aquifers adjacent to the coast. Similar results were obtained in the drainage area of Arborea, where water is used for cattle breeding. On the contrary, the aquifer of Turritana plain, Gulf of Asinara, is still in good state. A positive effect on natural recharge arises from the use of water stored into reservoirs for irrigation purposes (e.g. Maccheronis dam).

3. Exploitation of ground water and comparison with the use of surface water.

3.1. Total water withdrawal.

The *total water withdrawal* in Italy increased in the years 1975-87 by 35%. This tendency has consolidated in the following years. In 1999 the average yearly water withdrawal per capita ranged about 740 m^3/cap•year (2000 litres/ cap •day – Source IRSA-CNR, 1999), the highest value among the European countries (where the average value ranges about 612 m^3/ cap •year – 1677 litres/ cap • day). *Groundwater withdrawal* amounts to 23% of the above volume, a percentage value much larger than the European average (13%).
The exploitation of water resources is strongly non uniform over the Italian territory: in the North 78% of the renewable and exploitable water resources (65% of the total national budget) is actually exploited; the pressure increases to 96% in the South and in the Islands, (where 21% of the total budget is located). The centre is closer to sustainability, with exploitation set at 52% of the available resources.
The main uses of water resources are agriculture, industry, energy production, domestic uses and, to a lesser extent, tourism. Total withdrawal is maximum in the North for each typology of use (Fig. 3.1). *Irrigation absorbs nearly 50% of the total water withdrawal*. Per capita withdrawals can be calculated from macro regional data, though with some approximation as the boundaries of water districts are not readily reducible to administrative boundaries. The table 3.1 reports values of per capita withdrawals for macro regions, based on data for the population from the last census of 1991.

3.2. Water withdrawal for various uses.

Data concerning water withdrawal from aquifers and surface bodies for domestic uses from 1993 to 1998 have been collected by the Italian Ministry for Health in each Italian Region. This allows an estimate of total withdrawal for domestic use as well as some comparison between use of groundwater and use of surface waters (Fig. 3.2, where note that data concerning the period 1999-2001, refer to 10 regions only).

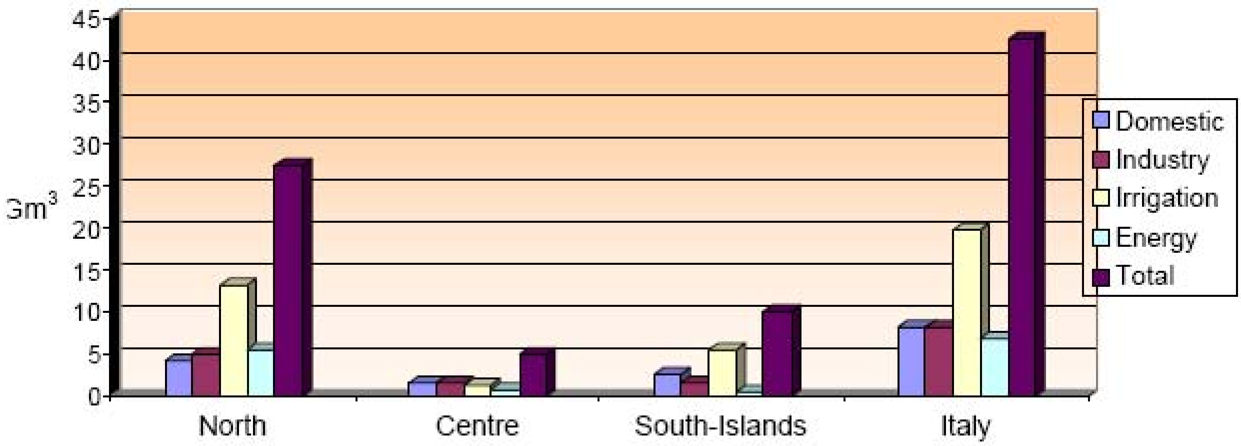


Figure 3.1 – Annual withdrawal of water for various uses (in G m^3). Source: ANPA, data from IRSA-CNR, 1999).

Macro-Region	Domestic (m^3/cap•year)	Irrigation (m^3/cap•year)	Industry (m^3/cap•year)	Energy (m^3/cap•year)	Total (m^3/cap•year)
North	147	532	204	174	1057
Centre	148	89	136	7	380
South	127	277	65	21	471
Islands	140	355	141	79	715

Table 3.1 – Annual water withdrawal per capita for different uses (in m^3/ cap •year) in different macro-regions. Source: ANPA, data from IRSA -CNR (1999) and ISTAT (1991).

It turns out that domestic uses in Italy rely mainly on groundwater due to the generally higher quality of this resource, requiring less treatment to be exploited: more precisely, *85% of the total water withdrawal for domestic use in Italy comes from aquifers*, more so in the North (90%) than in the South, where 15-20% of the total water withdrawal comes from storage basins. The fig. 3.2 shows that groundwater withdrawal for domestic use has constantly increased in the period 1993-1998, while withdrawal from surface waters has kept fairly constant.

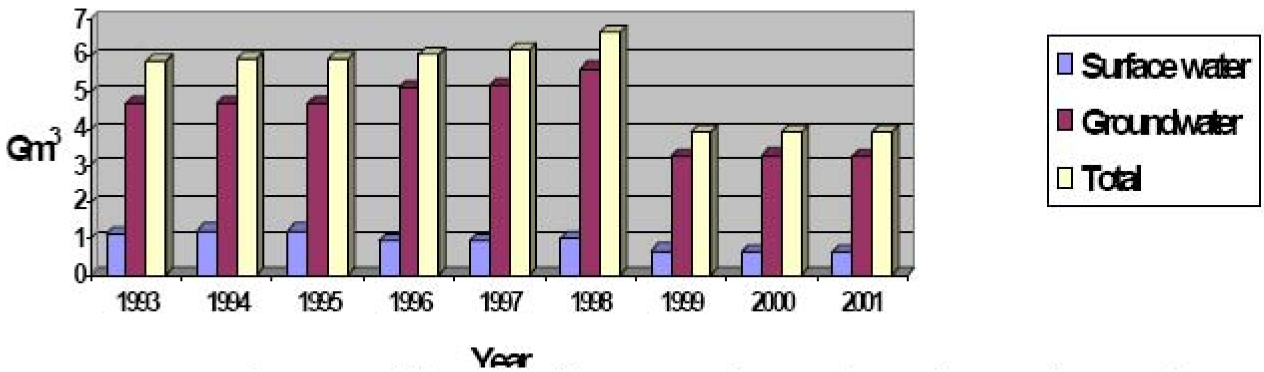


Figure 3.2 – Annual water withdrawal for domestic use from surface and ground waters. (Source: APAT , data from the Ministry of Health).

Comparison pursued for the ten regions for which data were available between the water withdrawal for domestic use in the periods 1996-1998 and 1999-2001 reinforces the above picture: in some regions, like Umbria, Lazio and Friuli, virtually all the water employed for domestic uses originates from aquifers.

However, note that the latter statement cannot be reversed: *roughly 60% of groundwater withdrawal in Italy is used for irrigation*, with only 40% employed for domestic use. In other words, groundwater is extensively employed in many Italian regions for uses other than domestic. In particular, in the largest Italian basin, the Po, 47% of groundwater is employed for irrigation, 20% for industrial use and only 33% for domestic use (data from the Italian Authority for Water Resources and Waste Disposal). The strong pressure thus exerted on groundwater is the cause of the significant environmental impact on aquifers discussed in section 6.

4. Economic value and price of water.

4.1. Economic value of water.

4.1.1. Economic value of water for domestic use.

Empirical studies on domestic water demand have concentrated mostly on the assessment of demand elasticity to price and income, in order to evaluate the potential for the introduction of economic instruments. In most cases they reveal a limited responsiveness of water demand to prices, with some greater effect in the case of high marginal rates (Musolesi and Nosvelli, 2004; Mazzanti and Montini, 2004). Another interesting field of application of econometric techniques, although still experimental, concerns the WTP of water users for service quality improvements.

4.1.2. Economic value of water used for irrigation.

Assessment of water value for agriculture has been carried on in a more widespread manner, even though still in the context of scholarly work. In the literature we can find both works trying to capture an overall macroeconomic dimension of irrigation over vast areas (using indicators such as the differential land value of irrigated and non irrigated farms, or the marginal per-ha income due to irrigation) and works using optimization models in order to derive water demand curves.

Among the most recent surveys we can cite here Massarutto (2003). In three case studies, referring to different regions (Table 4.1) the latter investigation has evaluated the "exit price" – namely the water price above which irrigation is no longer convenient - and assessed the impact of full-cost recovery both on water demand and individual income. As shown in Table 4.1, elasticity is significantly high only when price is higher than the exit threshold; on the other hand, this threshold is likely to be trespassed in case FCR is adopted in a rigid manner. The impact on water demand, in turn, is ambiguous: price increase has an effect on irrigation in the sense that irrigation will stop in case the final price will be higher than the exit price; however, if this does not occur, demand might be even higher since there is an incentive for farmers to maximise their productivity.

Another important result arising from this investigation concerns the trade-off between collectively regulated irrigation and uncontrolled individual abstractions. With a higher water price, the incentive for farmers to engage in self-managed systems grows higher, especially in areas characterized by high added value crops and intensive production. Therefore, an unwelcome effect of pricing could be to encourage farmers to adopt these environmentally unfriendly solutions (Massarutto, 2007).

In an interesting recent study performed within the EU-funded WADI project (Berbel Vecino and Gutierrez Martin, 2004) a linear programming model was applied to some typical irrigated field in Northern Italy. Figure 4.1 illustrates the main results obtained in this study: most cereal production entails a value in the range of 0,20 – 0,30 €/ m^3, with higher figures only in the case of crops that are introduced in the value chain of high-value products such as DOC cheese. The value – and therefore the WTP for water and its shadow price – is significantly higher for fruit production and horticulture, and especially for greenhouses.

	Irrigated surface (he)	Actual water price (€/m³)	Dominant farming systems	Water-related governance issues	Trends/options	Actual recovery of costs(*)
1	27,800	0,015	Continental (maize)	Excess abstraction from watercourse Absolute scarcity in dry years	Transform gravity to spray irrigation Set aside / reforestation	Nearly achieved (70-80%)
2	8,200	0,04 – 0,1	Mediterranean (horticulture)	Excess abstraction from watercourse Conflict with PWS in the summer	Introduce drip irrigation Eliminate continental crops	Substantially achieved (60-70%)
3	180,000	0,08 – 0,1	Mediterranean (fruit, vegetables, durum wheat)	Severe scarcity in case of droughts; need to avoid individual abstractions	Invest for improving productivity of water; use recycled /brackish water	Achieved for operational cost only (50%)

	Scenario	Irrigated surface (he)	Water demand (hm^3)	Changes in water and land use	Exit price (€/m³)	Exit price / FCR	Elasticity below exit price	Absolute Margin (€/ha)	Margin elasticity to water price
1	"before"	27.800	162	No major change	0,17 - 0,40	11 - 26	Insignificant	470 - 1300	0
	"after"	27.800	162		0,12 - 0,30	8 - 20	Insignificant	370 - 900	0,20 - 0,30
2	"before"	8.200	9	Concentration on high value crops More specialization	>0,5 (MED)	>3	- 0,320	1.703	0,11
	"after"	8.200	10		>0,5 (MED)	>3	- 0,170	1.522	-
3	"before"	86.000	109	Concentration on high value crops More specialization	>0,5 (MED)	>3	Insignificant	2.120	0,11
	"after"	86.000	118		>0,5 (MED)	>3	Insignificant	2.023	0,08
	"after"	High reduction of COP area							

Table 4.1 – Scenarios and evaluation of the impact of pricing and FCR on Italian irrigation.(from Massarutto, 2003)

4.1.3. Economic value of water for industrial use.

Economic studies concerning the value of water for industrial use are even more scarce than in the case of agriculture and domestic supply. In a recent study (Massarutto, 2007) the social cost induced when a firm is forced to suspend its production due to the interruption of water supply, was evaluated. Of course, this is not a proper measure of the value of water, but rather a short-term estimate that concerns already established uses in case of emergencies. From the same study, we show in Table 4.3 similar figures calculated for hydropower production under the assumption that demand for electricity can be satisfied in some other way rather than leading to service interruptions.

4.2. The price of Water in Italy.

4.2.1. Structure of water prices.

As already mentioned Sect. 1.2, Italy is moving from a system based on public expenditure towards the full recovery of costs through tariffs; at the same time, the law sets the basis for establishing an economic regulation of prices aimed at guaranteeing cost recovery, efficiency and affordability.
The structure of the water service value chain is described in Fig. 4.2, where we can identify four levels (resource ownership, bulk supply, retail supply and final demand); only the first and the last one are always present, depending on national and regional specificities. The final cost paid by the user includes fees and taxes paid to the resource owner (normally the state), tariffs and prices paid to retail and bulk supply operators and finally direct costs that are borne by the user itself (e.g. for installing and operating its own water abstraction or treatment systems).
Abstraction and discharge fees are considered as environmental taxes and thus set by competent authorities; their level is intended as a compensation for administrative costs related to the licensing and control process. In the economy of water services they play only a negligible role. Bulk supply

systems operate in a few cases for household supply (e.g. Sicily, Sardinia, Romagna) and more frequently for irrigation, under the regime of state-driven water resources policies.

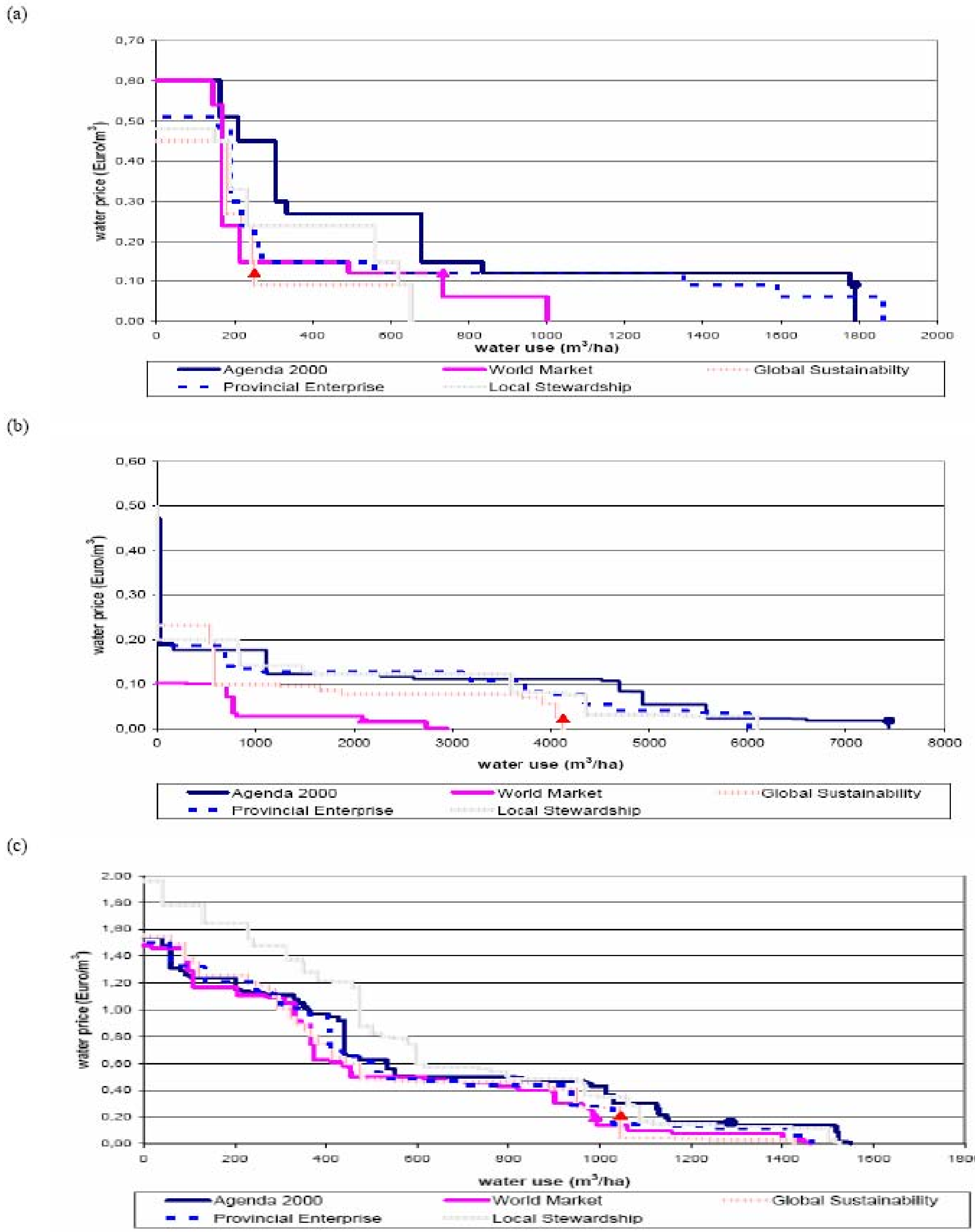


Figure 4.1 – WTP of farmers for irrigation: (a) = cereals; (b) = rice; (c) = fruit (Source: Berbel Vecino and Gutierrez Martin, 2004).

Industrial sectors	Value €/m^3/day
Food, beverages and tabacco	27,67
Textile	38,64
Tanning, manufacturing of leather goods	18,82
Paper	43,77
Chemistry and petrolchemical	73,58
Non-metal minerals	72,43
Metal	55,02
Mechanics	465,80
Wood, plastics, rubber	83,88

Table 4.2 – Added value of water in some industrial sectors of the Po basin (Source: Massarutto, 2007).

Name	Basin	Typology	K_{en}	Valore(*)
			(kWh/m3)	(€/m^3)
Campo Moro	Adda N	Pumping	0,32	0,025
Edolo	Oglio N	Pumping	2,91	0,230
Sardegnana	Brembo	Basin	0,45	0,040
Lanzada	Adda N	Basin	2,15	0,190
Mallero 1	Adda N	Fluent (mountain)	1	0,065
Ardenno	Adda N	Fluent (mountain	1,6	0,103
S.Zenone	Lambro	Fluent	0,04	0,003
S.Pietro d'Orzio	Serio	Fluent	0,09	0,006

Table 4.3 – Value of water for hydroelectric production in the Po basin (Source: Massarutto, 2007).

They sometimes entail a meaningful price charged to the retailers (e.g. the company running the system of Romagna charges a bulk price in the reach of 0,50 €/ m^3), although only exceptionally this entails full cost recovery. Pricing is often used at this level in order to provide incentives to users and cream-skim uses in order to ensure that water is allocated to the most valuable ones.

Retail prices are either set by ATOs following the guidelines provided by national and regional regulations (see below). Water prices are usually set to cover the operation and maintenance costs and sometimes also the investment costs of water supply.

Industrial users are normally charged according to a tariff structure similar to that applied to domestic users provided they are connected to the same systems; dedicated water services for industry are charged in the same way, although they might sometimes adopt different charging schemes aimed at providing incentives and price signals to water users.

Irrigation, when not managed by individual farmers, is usually supplied by farmers' associations, often organized under a public law regime. Irrigation boards – sometimes also supplying industrial uses associated with the consortium – operate on a cost recovery base that normally includes operational costs only, capital costs being nearly 100% subsidized. Water prices are charged on the basis of irrigated surface or (increasingly) on a volumetric base. When water prices are compared, the object of comparison must be carefully considered, since tariff structures vary widely. In fact, tariffs for water supply are sometimes combined with other services, such as wastewater services, electricity supply or solid waste disposal.

Moreover, the quality of the supplied water may vary, and sometimes requires further on-site treatment for industrial use.

Transactions along the value chain of the water sector

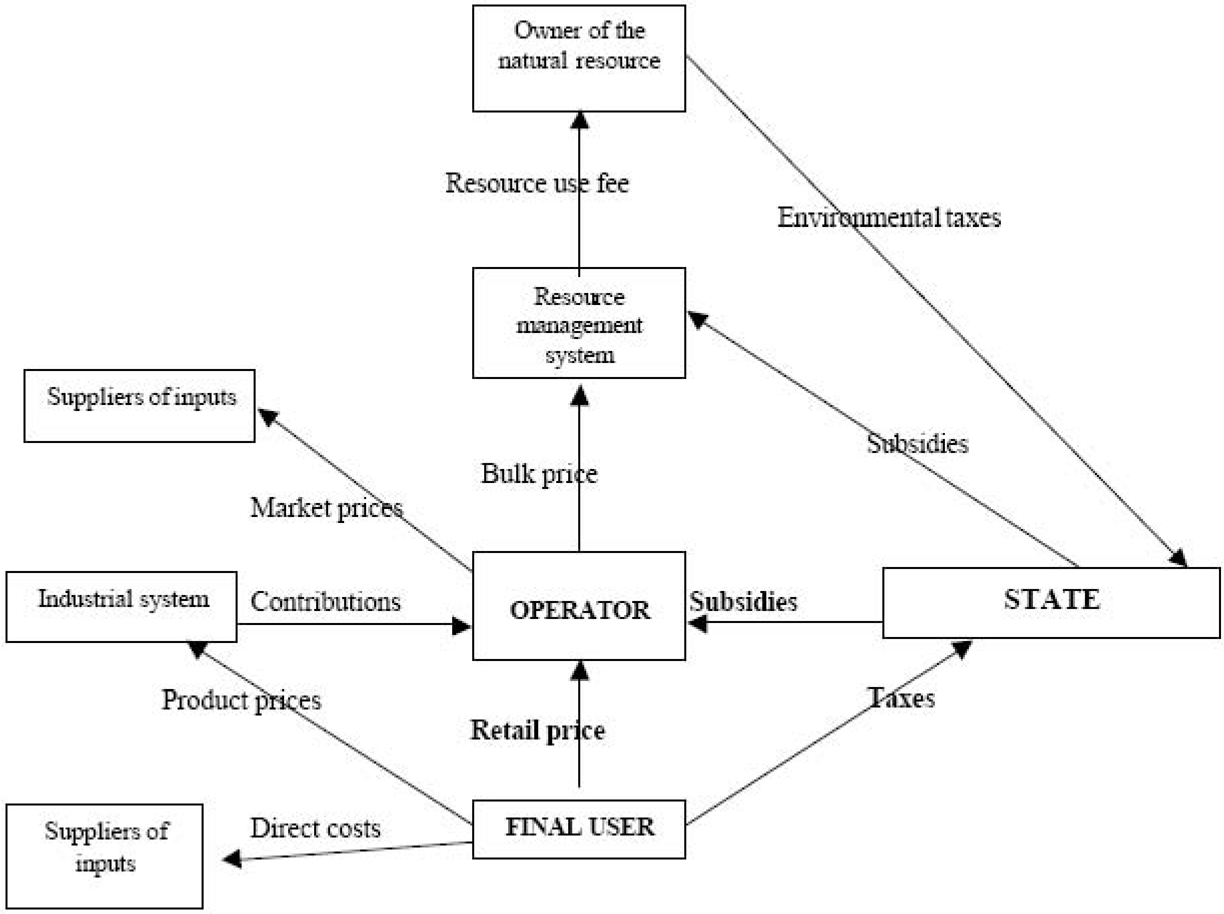


Figure 4.2 – A scheme of financial flows along the value chain of water services

Focus on the integrated water service (urban water supply and sanitation)

Prices for water and for sewerage disposal are set by municipalities or by public bodies through which municipal duties are fulfilled (consortia, etc). This freedom is exercised within a general framework of rules set up at the national level, concerning tariff structures, pricing criteria, obligations and, above all, maximum increase rates.
The main pillars are:
i) obligation to reach *full cost recovery*, definition of cost including the cost of capital and the remuneration of investment ;
ii) price increases should be determined according to a *price-cap mechanism*.
Once the "integrated water service" will be reorganized according to the reform, a new price regulation system will be introduced. The structure of the regulation system is still evolving. Yet the Supervising Committee created by the law has issued in 1996 guidelines for the future price regulation. The charging method concerns the whole "vertically integrated water cycle". Charges are set by the ATO agency on a *cost-plus* basis; eligible costs as well as capital and financial costs are specified in detail. A 7% rate of return on risk capital is also foreseen.
This model, based on the classical "rate of return" regulatory system, is tempered in many ways. *First* of all, a benchmarking system for a part of operational costs is foreseen, through a complex

econometric formula. If true costs exceed the range of ±30% above or below the standard, the municipality should get a formal permission from the Ministry to charge that much, subject to a plan entailing efficiency gains. The benchmarking applies in particular to personnel cost, while other costs (like energy and interests on borrowed capital) are not included and can be added to the total.
Second, the dynamics of charges is regulated by a "price limit": in practice, price increases cannot be higher than a certain limit, calculated as a function of the starting level.
Third, and possibly more important: capital expenditure results from an infrastructural and financial plan that must be agreed upon between the operator and the OMA agency. It means that the local authorities have the chance of exercising a preventive control over future price dynamics, through the asset management plan. Waiting for the new organization to be created, the central government has created a temporary price regulation system that fixes annual maximum allowed price increases, with a mechanism that is similar to the one used in the past but with a philosophy oriented at increasing the degree of cost recovery. Some substantial increases have taken place in the second half of the 90s but, after 2002, the policy has changed: water price cannot be increased any more until the reform will be implemented. Meanwhile, the "standard model" has been subject to a strong criticism and there are pressures for its radical reform.

The tariff structure.
The charge for water supply is structured as a two- or three-part tariff with an incremental block structure, according to the OECD definition. That is, the charge contains:
- a *fixed part*, corresponding to the rental of the meter;
- a *variable part*, depending on metered water consumption;
- in many cases, a *free allowance* for the first units of consumption .

The fixed part is very low, and practically insignificant. However, many municipalities charge for a definite first amount of water independently of actual consumption (free allowance). This amount therefore acts as a fixed part of the tariff; though varying from case to case, the free allowance can be high enough to outweigh completely the variable part.
For the variable part, an incremental block structure is adopted: increasing amounts of consumption are charged more. The structure contains 5 blocks (*subsidized, basic, I-III blocks)* The *basic tariff* is obtained by dividing the total cost by the total amount of water sold. The first units of consumption are charged less; the resulting difference is approximately covered by charging a higher unitary price for blocks exceeding the base block. Different cities adopt different boundaries between blocks. For example, in the city of Rome, the size of blocks is determined as follows: subsidized (up to 23 mc quarterly); basic (from 24 to 46 mc quarterly); first block (1-1,5 times the basic block); second block (1,5-2 times the basic block); third block (more than 2 times the basic block). The size of blocks is freely determined by each municipality, and this makes comparison rather difficult. The fixed amount, corresponding to the cost of the meter, is at present very low (some Euros /year per family) having been fixed (and never updated) in 1974. So far, the charge for sewage disposal has been paid as a *fixed proportional charge*, consisting of a wholly variable tariff with no blocks; until 1996, this charge was applied to 80% of water consumption, while this proportion has later been increased to 100%. The Standard Charging Method foresees the inclusion of sewerage costs in the same tariff as for water supply, and therefore extends to sewerage a similar increasing-block structure.
Many observers claim that the existing block structure is not efficient and advocate for a more rational structure. The mostly agreed proposals entail:
- an extension of the fixed part (to 1/3 of the total);
- an elimination of free allowances;
- a highly progressive structure for increasing blocks, in order to discourage high consumption.

Tariff levels

The prices of water and of sewage disposal have experienced a substantial increase during the last 10 years. In the absence of systematic surveys with continued data sets, it is difficult to provide proper figures; yet, it can be estimated that, between 1992 and 1998, in nominal terms the increase has been of the order of 40%, corresponding to an average annual increase of 2% in real terms (Massarutto, 1998). This trend continues the process of gradual recovery of costs through water prices, which cannot yet be considered as complete, at least in the case of sewerage disposal (see below). In other words, the increase in the prices for water and for sewage disposal is mostly due to the transfer of costs from the public budget onto consumers, rather than to an increase of the costs themselves.

As a result, Italian water bills cannot be regarded as «the lowest in Europe», anymore, a common statement at the end of the 80s. Though Italian prices are still far below those paid in countries like France, Germany and the UK, increases in the past 15 years have been significant; water prices are now on average around 0,75 €/ m^3, with substantial differences among different management areas.

A sample of Italian cities

Below, we show results of a study performed by the *Observatory for Tariffs and Prices* of the *User Association Cittadinanzattiva.* The average annual expenditure of a family consisting of three persons consuming a total of 192 m^3/year (a value estimated by CO.VI.RI.) was evaluated throughout the country. The investigation has considered tariffs of the Water Service for domestic use applied in 2004 in all Provinces of the 20 Italian regions throughout the 7 month period between September 2004 and March 2005. Data have been collected by the managers of S.I.I. in each city and tariffs include the I.V.A. tax (10% everywhere, except in Puglia where a 20% rate is applied). The Figure 4.3 shows the expenditure in the 10 dearest and in the 10 cheapest towns while the Tab. 4.5 reports the expenditure in different regions with contributions from different items shown.

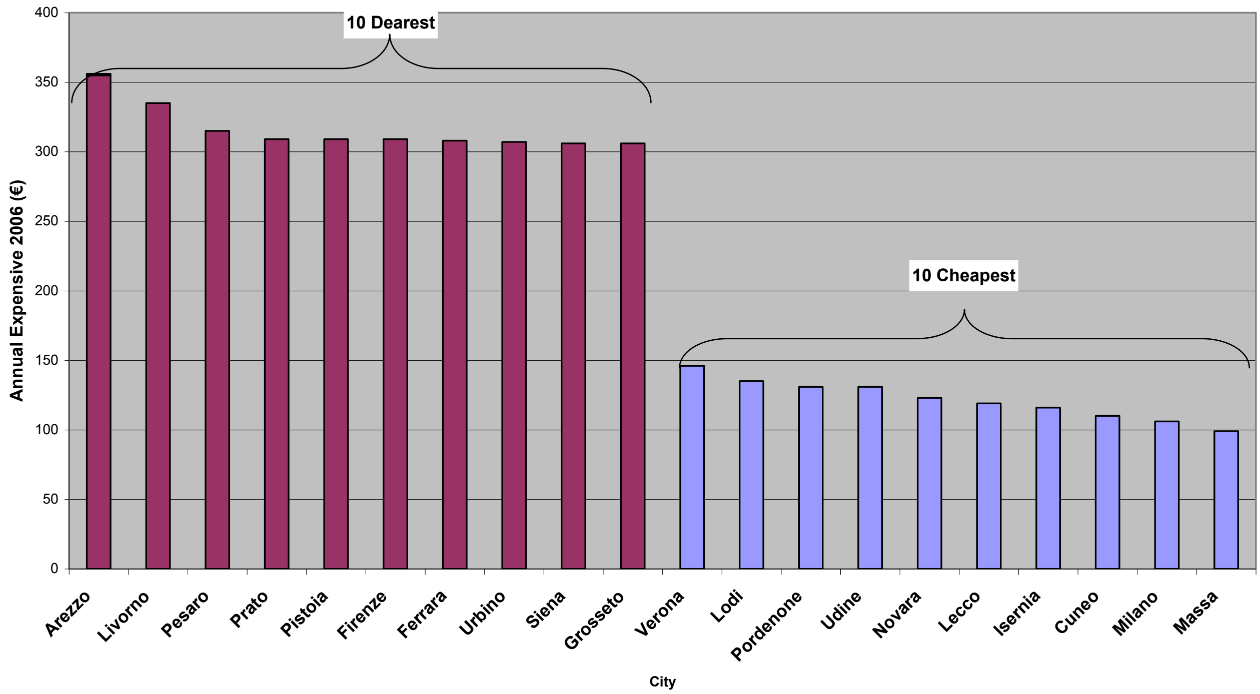
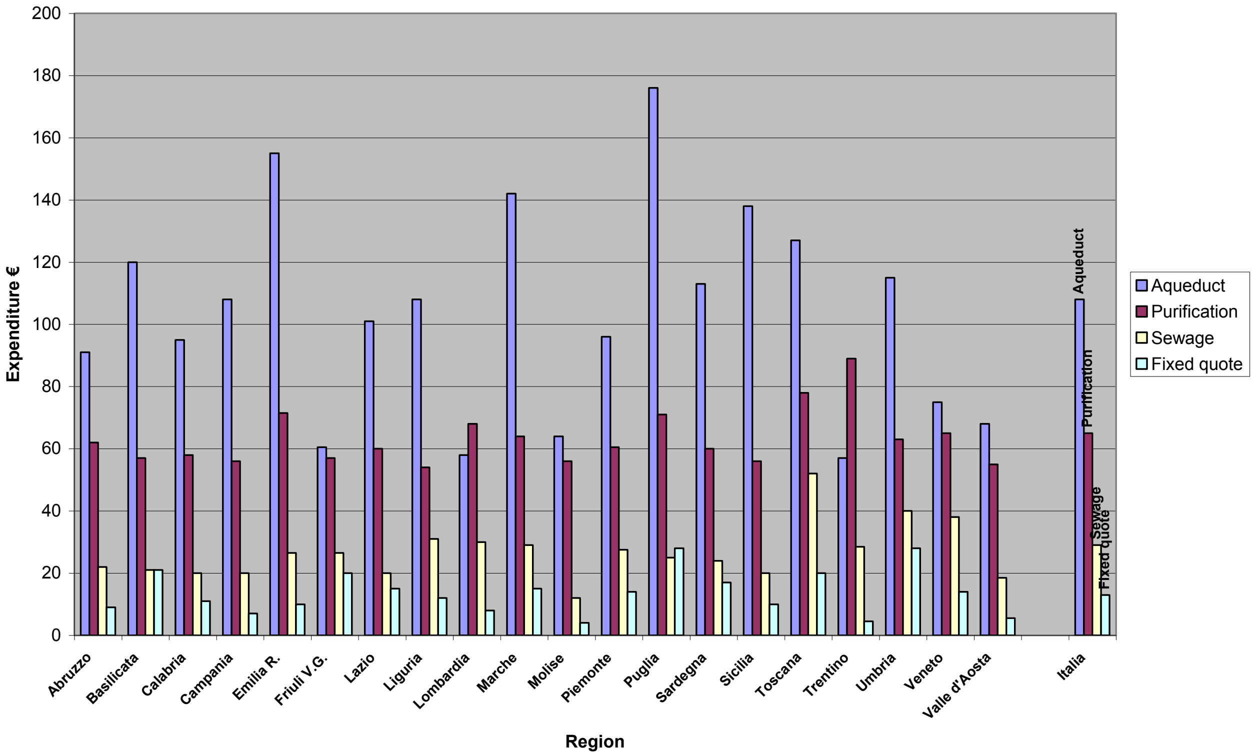


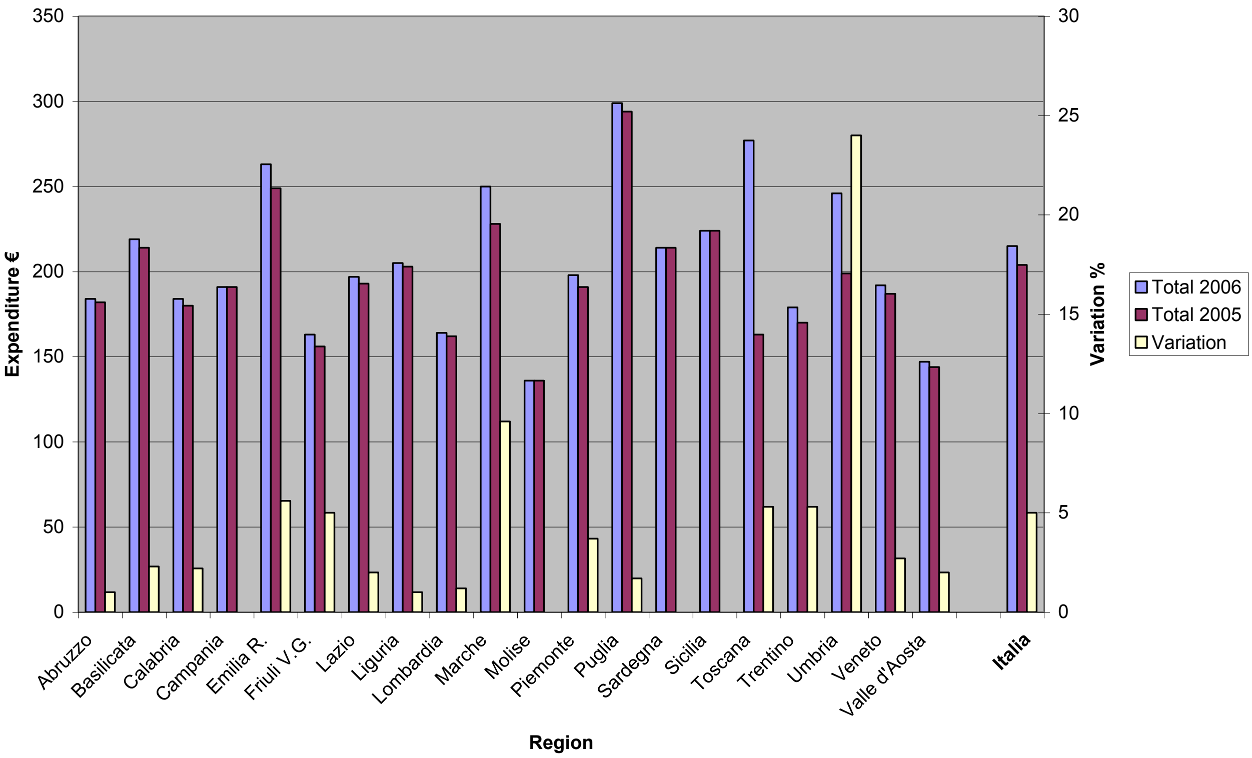
Fig. 4.3 – *Average annual expenditure of a family consisting of three persons in the 10 dearest and in the 10 cheapest towns (Source: Cittadinanzattiva, 2007)*

Various observations arise:
i) tariffs are *dearer in the South*: three of the dearest regions, namely Basilicata (average expenditure in 2006: 219 €), Sicily (224 €) and Puglia (299 €) are located in the South, the average national expenditure in 2006 being 215 €;
ii) Tariffs for drinkable water in a province (e.g. Arezzo) may be as much as three times larger than in some other province (e.g. Milan) !!
iii) Even within the same Region tariffs may differ enormously. For example, in Toscana the yearly expenditure in the province of Massa is less than half the corresponding expenditure in Arezzo.
iv) Variations experienced between 2005 and 2006 also vary strongly among different Regions, ranging from zero up to roughly five times the national average of 5%.

The above results are confirmed by the "Report Indis - Unioncamere 2003" on water tariffs, which provides a comprehensive picture of the national situation, analyzing in detail the performances of 115 ATO managers (25 being public managers). The number of users involved was roughly 24 Million (41% of the Italian population). Users lived in 1.557 Municipalities and were served by a water supply network of roughly 106,000 Km. The analysis of this sample showed that management was generally efficient, with average ratio proceeds/costs of 93%. (Note that the above analysis did not include capital costs). Values of the above ratio ranged from 100% in the North East, 97% in the Centre, 89% in the North West and 79% in the Islands. The unit cost ranged from 0.48 €/ m^3 (NorthWest) and 0.61 €/ m^3 (South-Islands) with a national average of 0.56 €/ m^3. The range of proceeds is wider: the national average being 0.51 €/ m^3, maximum of 0.71 €/ m^3 (North-East) and minimum 0.43 €/ m^3 (North-West). In fact, tariffs applied by managers are quite widespread: 80% of them fall in the range 0.22-0.77 €/ m^3 and the average tariff is smaller than the average cost (0.42 versus 0.56).



a)



b)

Fig. 4.4 *Average annual expenditure of a family consisting of three persons in the 20 Italian Regions. Contributions of single items (a) as well as totals and variations between 2005 and 2006 are also shown (b). (Source: Cittadinanzattiva, Osservatorio prezzi e tariffe, 2007).*

4.2.2. The Costs of water in the Integrated Water Service.

Let us then attempt to compare proceeds from tariffs with total costs of the Integrated Water Service. We refer to data of balances (2004) of managing companies of ATOs operating in the Po Basin, provided by CO.VI.RI. (2005).
It turns out that the total yearly tariff proceeds from all the ATO 's of the Po Basin amount to 835.45 M€/year (53 €/cap •year), to be compared with total operational costs of 714.22 M€/year (45 €/cap •year) to be added to a total of 296.9 M€/year (19 €/cap •year) for investments plus 50.93 M€/year (3 €/cap •year) of public funding for investments.
The above data show that proceeds are barely able to balance operational costs but are not able to cover costs for investments. Moreover, the above picture is not sufficient to fully clarify the actual unbalance between proceeds and total costs as it does not consider the actual size of the supply networks and the need for tariffs to fully account for the devaluation of infrastructures.
A few simulations performed by the Basin Authority of the Po River concern the water infrastructures present in two major Regions, namely Lombardia and Emilia Romagna. They show (Figure 4.5) that the present water tariff is hardly able to cover 50% of the total cost, if capital costs (calculated on the basis of the present value of infrastructures) are included.
It is important to note that these figures correspond to the full reconstruction value of all assets (they represent in other words the long-run cost, once all replacements have been taken place at least once). This will happen only in the very long run; meanwhile, the logics of the system is that operators will take the responsibility for new investments and maintenance, while existing assets will be provided as a free loan by municipalities. This consideration helps to understand the difference between the figures estimated in Fig. 4.5 and those provided by the Central Government, showing that ATO plans with tariff increases that remain within the limits set by the "standard

method" will be able to finance an investment effort of around 50 billion €. The Fig. 4.5 shows that in fact this investment effort, while very high and surely higher than those experienced during the 90s, is insufficient to correspond to the real depreciation of existing assets, and will need to be compensated by still higher investment in the future.

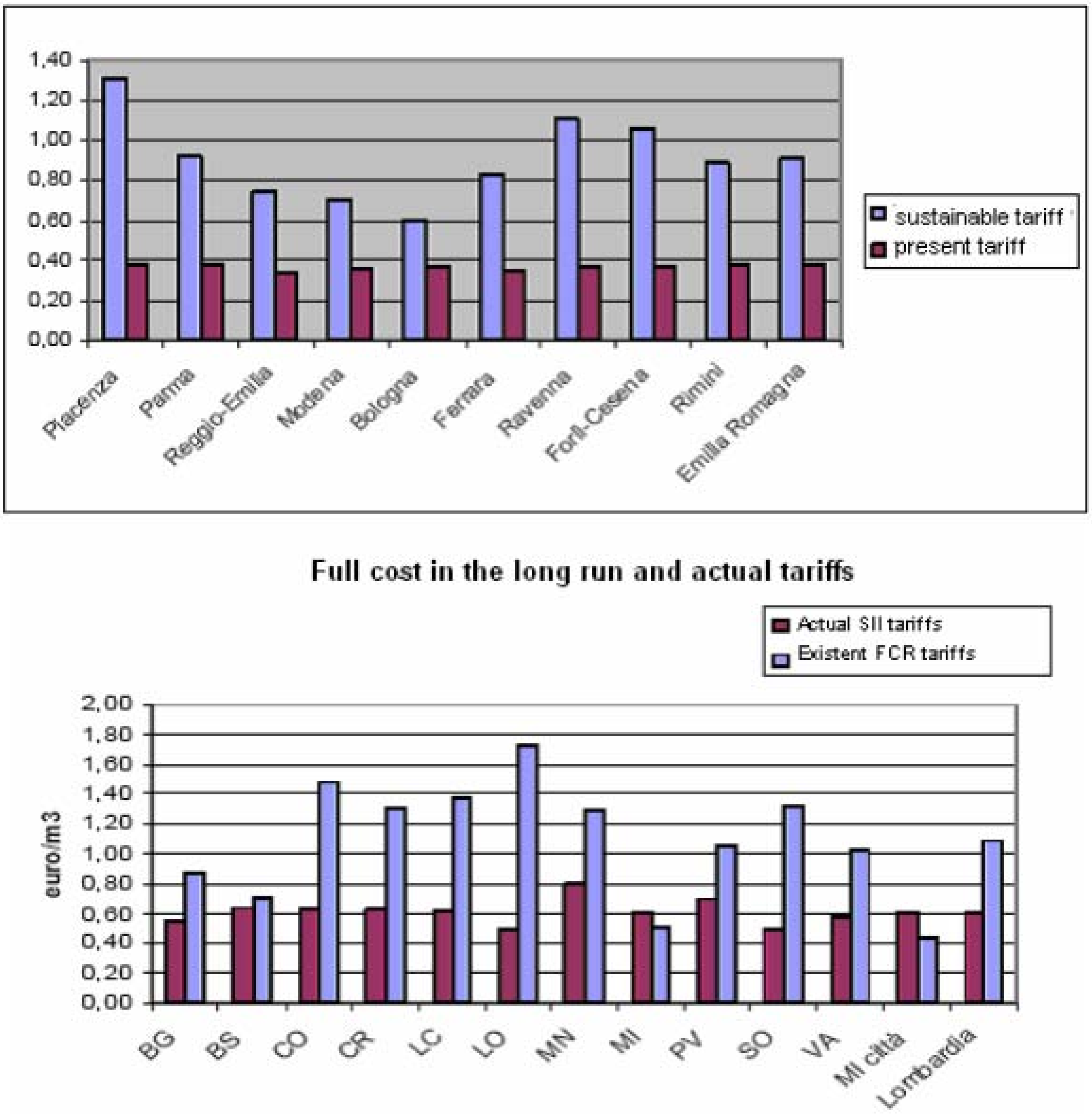


Figure 4.5 – Full cost in the long run and actual tariffs in a sample of ATOs : Emilia Romagna and Lombardia.

Other uses of water

Irrigation, intended as a collective service provided by public bodies (Land Reclamation Boards), concerns approx. 75% of the total agricultural use of water. Boards normally charge their associates a price, that roughly matches – or at least should match – operational costs of the service. Capital costs are entirely borne by the state; it must be stressed that the most significant part of the irrigation infrastructure of Italy has been built during the last 100 years, while investment is at present mostly represented by improvements of existing networks, only occasionally complemented by new transfer schemes.

Land Reclamation Boards raise an annual revenue (early 90s) of 265 million €, 103 of which are irrigation fees (the remaining is mostly related to soil drainage). Nearly ¾ of this figure is raised in

the North. On average, this figure would correspond to an annual per hectare expenditure of 36 € (0,006 €/ m^3). This average value probably underestimates actual payments – since it results from non homogeneous data. In any case, the figure is purely indicative: actual payments are highly variable on the national territory, and even within each consortium. The large majority of consortia charges on a *per hectare* basis; unit charges are often differentiated, according to the irrigation technology (open channels or pipes, infiltration or spray), kind of crops, nature of irrigation (occasional or systematic), etc. Only a few consortia, mainly located in the drier South, adopt metering together with a *per volume* charge. It is hardly believable that these revenues allow for a full cost coverage. It is true that many consortia exhibit a sound balance between revenues and operational costs; nonetheless, in a good number of cases, public resources need to be devoted to covering unbalances, that in some cases reach even 50% of costs: this occurs particularly in the South, where the capacity of consortia to effectively raise the charges is much lower.
Capital costs are always paid by the public budget. It is hard to have appropriate figures, since the whole matter has been regionalized in the 70s, and each Region adopts its own regulations and mechanisms. Capital expenditure for projects presented by Land Reclamation Boards can often be merged together with other expenditure in the field of flood protection, river corridor management and even water supply projects. This has been particularly true in recent times, given the attempt to realize *multipurpose* water investment. A substantial new investment (around 500 million Euro) has been part of the National Programme 1994-1999 for the use of EU structural funds (Objective 1). Irrigation, as well as all other consumptive water uses, pays an *abstraction fee* to the licensing authority. On a unitary base, this is much lower than for other uses (35 €/year for every m^3/s), corresponding to an insignificant fraction of cent of Euro per m^3.

As we have seen before, *industry* is normally self-supplied. Only sanitary uses are supplied by the public networks. Nonetheless, in some cases we have examples of collective systems, aimed either at providing process water in order to avoid excess underground abstractions (e.g. industrial aqueducts of Carpi, Imola,Treviso) or in order to facilitate water provision from long-distance supply.
In other cases, particularly in the South, the state has financed projects aimed at supplying water to large industrial plants for the sake of local economic development (e.g. desalination plants). We have no data concerning the charging levels and structures adopted in these cases. It is quite typical that initially investment is subsidized, in part of totally, by state contributions; yet local institutions (banks, chambers of commerce, industrial associations etc) do also normally play a role. In some cases users contribute directly to the investment with the acquisition of a share of the plant property. Later on, costs are normally shared on a *per volume* basis, which does not represent in general a problem given the high WTP of industrial uses. However, when the aim is declaratively to use the facility for the sake of environmental policy – in order to avoid self-supply – charges, at least in the initial phase, must not be significantly higher than the individual cost of abstraction.
Similar arrangements, yet much more widespread, are practiced for industrial sewerage. While industrial aqueducts are dedicated to industry only, industrial sewerage schemes are mostly combined and coordinated with civil sewerage using the same facilities. Particularly in highly-industrialized areas, sewage treatment plants that serve industrial discharges receive civil effluents, that can enjoy very low charges thanks to the economies of scale.
According to the law, disposal of industrial sewerage should be charged on a cost-recovery base, according to a complex formula that takes into account not only the volume but also the chemical nature and the pollution load of the discharge. There is no data showing whether this rule is systematically applied or not; evidence from some case-studies shows that the balance is usually reached – if ever – for operational costs, sometimes for ordinary maintenance, while adaptation and new investment is usually paid, in a way or the other, through public subsidies. The Fig. 4.6 provides a preliminary evaluation of the above costs.

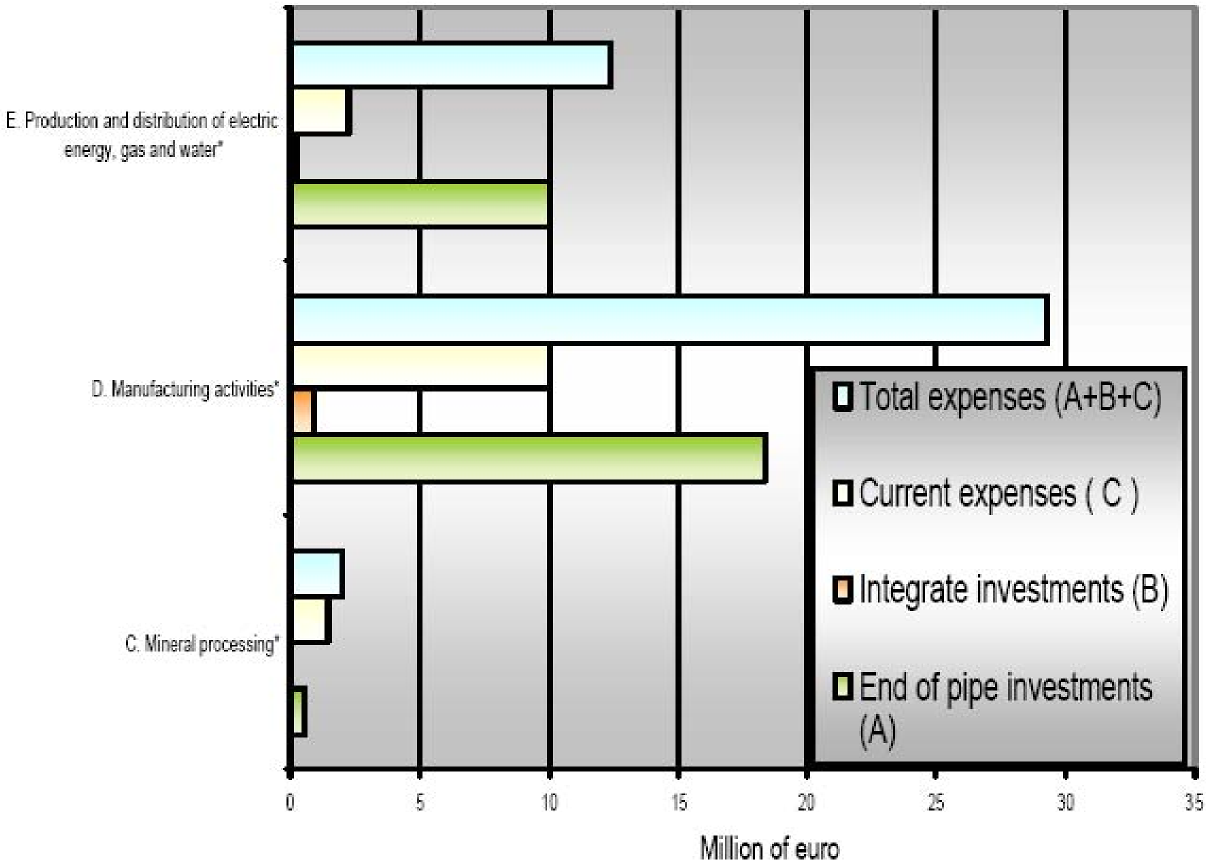


Fig. 4.6 Costs borne by industry to prevent pollution of surface waters (Source: IEFE from data ISTAT, 2005).

5. Pressures on and major impacts of groundwater resources.

5.1. Natural versus anthropogenic.

Pressure on ground water arises typically from two classes of factors: *natural* and *anthropogenic*.
- The first class includes *natural pollution* and *droughts*.
- The second class includes *overexploitation* with the related phenomena of *salt intrusion*, *anthropogenic subsidence, anthropogenic pollution* and *water misuse*.

5.2. Natural factors.

Natural pollution of groundwater may arise from *point* as well as from *distributed sources*. The former sources are typically associated with aquifers flowing through particular rock and/or mineral formations. This type of natural pollution gives rise to strongly mineralized springs: examples are the pickled layers which form at the contact with oil fields, in areas where saline formations dominate (e.g. in the southern-western part of Sicily); waters which flow slowly through deposits of mixed sulphides (e.g. in the Iglesiente region of Sardinia) or through diverse metallic minerals, containing Cr, As, Cu or U; waters flowing through chalk-sulphur formations (found in Emilia, Piedmont and Sicily), or the strongly sulphured waters which often spring at the foot of carbonate formations of the Apennines.
Further phenomena, mostly due to overexploitation of some aquifers, have emerged fairly recently in various areas of the Po Valley, Tuscany and many other parts of the Italian peninsula: in some tectonic structures or in the presence of particular rock formations, fluids often display a rich

content of dangerous metal pollutants (e.g. monometric Al or As). This is a worrying phenomenon whose impact on drinkable waters, hence on human health, is rapidly increasing (ARPAER, 2005 b). The areas of Italy where aquifer contamination from As is frequent are found in *Lombardia* (Tellina valley, the Como, Varese and Bergamo provinces where the maximum admitted values of concentration (CMA) may be largely exceeded (10 $\mu g/l$)); *Veneto* (the middle-upper part of the Veneto plain, including the triangle Padua – Vicenza – Venice); *Emilia – Romagna* (the plain North to Parma, Reggio Emilia, Modena, Bologna and a wide area south to Ravenna); *Toscana* (a few zones in the Provinces of Livorno and Grosseto); *Lazio* (the Vico Lake area); *Campania* (the volcanic areas around Vesuvio, Campi flegrei and Roccamonfina); *Sardinia* (various mining areas, like Sulcis-Iglesiente and Bacu Locci). Further areas where natural pollution from metals like Fe, Mn, Al, Cd, Cr, U, Hg, Cu, etc. is known to occur, have been listed by the Italian Istituto Superiore di Sanità (National Health Institute) in a Report delivered in 1991.

Droughts generally arise from an absolute scarcity of rainfall (a phenomenon widely recorded in the past) but may also result from the sudden increase in water demand due to a socio-economic transformation of local communities. Droughts represent nowadays a practically *endemic problem in a few regions of the South* of Italy, like Puglia, Calabria, Sicily and Sardinia, where precipitations are fairly modest and aquifers are not extensive. In the Po valley droughts represent a progressively increasing problem which is threatening the economy of an agricultural region which has traditionally relied on the availability of an abundant resource. Whether or not enhancement of droughts may be the consequence of climate change cannot be easily assessed. What can be safely stated is that, since the ‘80s the occurrence of water crises in Italy has intensified considerably.

5.3. Factors of anthropogenic origin.

5.3.1. Overexploitation.

Loosely speaking, overexploitation of ground water is quite widespread in the Italian territory, most notably in the (either permanently or temporarily) most densely populated areas and in plain or coastal regions, where extraction from wells, rather than from well exploited springs, is most common. Well known examples are: the *large urban settlements* of northern Italy (e.g. Turin, Milan, Bologna, Modena, Reggio Emilia, Forlì etc.), the tourist areas of the coasts of Romagna and Toscana; areas close to *large industrial settlements* (e.g. Marghera, Ferrara, a few areas of Piedmont, Lombardia, Veneto, Toscana, Oristano, Augusta etc.); at last, *densely cultivated areas*, most notably the Po valley, which are subject to ever increasing occurrence of water crises, irrigation and livestock production bearing primary responsibility (see the Table 5.1).

Product	Litres/kg	Product	Litres/kg
Potatoes	2000	Beef	15500
Wheat	1100	Pork	4900
Rice	2200	Sheep	5100
Soia	1800	Milk	990
Mais	1900	Tinned meat	230
Orzo	1400	Tunna	58
Sugar cane	175	Bread	130
Green coffee	8000	Chicken	4000
Toasted Coffee	17400	Beer	300
Cotton	20700	Fruit juice	500
Tea	9200	Wine	700
Paper	236	Orange	500
Sugar	160	Apple	700

Table 5.1 – Water consumption (in litres) for the production of 1 kg of a few agricultural products and livestock (data averaged on an international basis – Sources: ISTAT and UNESCO).

The consequences of overexploitation are: lowering of the water table, subsidence and, in coastal aquifers, salt intrusion.

The first consequence: anthropogenic subsidence

Natural subsidence, driven by tectonic processes and sediment compaction, is a slow process which proceeds (typically, though not invariably) with a rate of the order of few mm/year. Aquifer overexploitation, drainage (specially in peat soils) and extraction from gas fields may accelerate or may even trigger this process. In Italy the areas mostly affected by this phenomenon are located in the Po-Veneto valleys (including the southern edges of the alpine lakes) and in many coastal plains (e.g. the Pianura Pontina and the Piana of Sibari). Among them, most notable for their artistic and economic relevance are the cases of Ravenna, Po delta and Venice lagoon. Subsidence problems experienced by the Ravenna Municipality have been carefully investigated in the last century: these studies are summarized in Teatini et al. (2005). These problems arose in response to groundwater withdrawal from a well developed multiaquifer system underlying the coast and to gas extraction from deep reservoirs scattered throughout the area and still productive nowadays.

With the help of an appropriate geo statistical interpolation technique applied to the levelling measurements carried out since 1897 by the Italian Geographic Military Institute, and more recently by local Authorities, they show that ".. *land settlement, occurred at an average rate of about 5 mm/year until World War II, increased greatly up to an order of magnitude in the Ravenna industrial area, mainly due to the aquifer overdraft in connection with the post-war economic growth. The construction of new public aqueducts using surface water during the late 1970s and 1980s has significantly reduced the subsurface water consumption and the settlement rates to the pre-war values. However, local areas of significant land subsidence are still present because of local groundwater pumping and the development of deep gas reservoirs. The cumulative land settlement, accounting for both the natural and the anthropogenic components, has achieved the alarming value of 1.6 m from 1897 to 2002 in the industrial area located between the city and the seashore, with the coastland and the historical centre settled by more than 1 m* ".

The case of Venice Lagoon has also been thoroughly analyzed (see Gatto and Carbognin, 1981): the total subsidence experienced by the city of Venice throughout the last century amounts to 14 cm, with an acceleration experienced around the '70s when the Marghera industrial settlement was established and large volumes of water were pumped from the underlying aquifer.

Data collected by APAT suggest that the phenomenon of subsidence in Italy concerns 623 sites (7.8% of the total number of municipal towns), mostly located in the North and particularly in the Po delta, Veneto with 239 sites (37.8%), Emilia Romagna with 168 sites (26.5%), Lombardia with 137 sites (1.6 %) located between the northern bank of the Po river and the southern edges of the lakes. In Central Italy the coastal plains of northern Toscana (24 sites) and southern Lazio (8 sites), while in the South of Italy the most affected regions are Campania (5 sites in the provinces of Napoli and Salerno) and Ionic Calabria (39 sites).

The second consequence: salt intrusion

The most typical distributed source of aquifer pollution is the *sea*, which penetrates through coastal aquifers. This phenomenon is progressively emerging in several areas of Italy with an increasing *trend.* The coastal zones of Italy where the impact of salt intrusion is highest are depicted in fig. 5.1: most relevant being the Puglia coast of Murge, Salento and Gargano as well as extensive reaches of the coasts of Toscana, Veneto, Romagna, Marche and Sicily. Nearly all the aquifers of flood plains of rivers of Abruzzo and Lucania have recently undergone more or less severe salt intrusion.

.

Fig. 5.1 – The main areas where coastal aquifers have undergone salt intrusion (after Civita M.V., 2005).

As for *Sardinia*, few studies suggest that most coastal aquifers suffer from salt water intrusion. However, in the case of Sardinia, this appears to be due not only to ground water overexploitation but also to the exploitation of coastal lagoons for fish breeding (Ardau et al., 2000), which makes lagoons unavailable for the natural recharge associated with river flooding (e.g. Flumendosa estuary, Campidano plain). Salt intrusion in the Capoterra aquifer has further causes: sea-spray and wind carried salt originating from salt mines are deposited on the ground and dissolved into the soil by winter precipitations. Investigations on the Oristano aquifer (Barrocu et al., 1995) compared data available for surface as well as deep aquifers referring to 1979, 1990 and 1995, finding general lowering of the water table and high salinity, mainly in the surface aquifer but also in deep aquifers adjacent to the coast.

5.3.2 Anthropogenic Pollution.

Ground water pollution of anthropogenic nature can be either *direct* or *indirect.* It may arise from products discharged above the ground, including the drainage network (*surface pollution*), into the ground above the water table of the underlying aquifer (*subsurface pollution*) or below the water table (*aquifer pollution*). Sources of contamination may be *concentrated* (CSC) (e. g. cesspool) or *diffused* (DSC) (e.g. a cultivation field where fertilizers or pesticides are employed).
The overall pattern of vulnerability to contamination of Italian aquifers has been investigated from 1986 to 2004, in the framework of research programs pursued by the National Group for Hydrogeological Catastrophes of CNR (Fig. 5.2). A number of goals have been achieved:

- *selected test cases* have been thoroughly investigated in order to propose adequate strategies for structural as well as non structural actions to be undertaken to prevent aquifer pollution;
- *guide-lines* have been proposed (APAT, 2001) for a multipurpose management of quantity and quality of ground water, identifying strategic resources able to cope with water crises and technical tools to improve aquifer recharge.

Below, we briefly review the available knowledge on the characteristics of various types of CSCs.

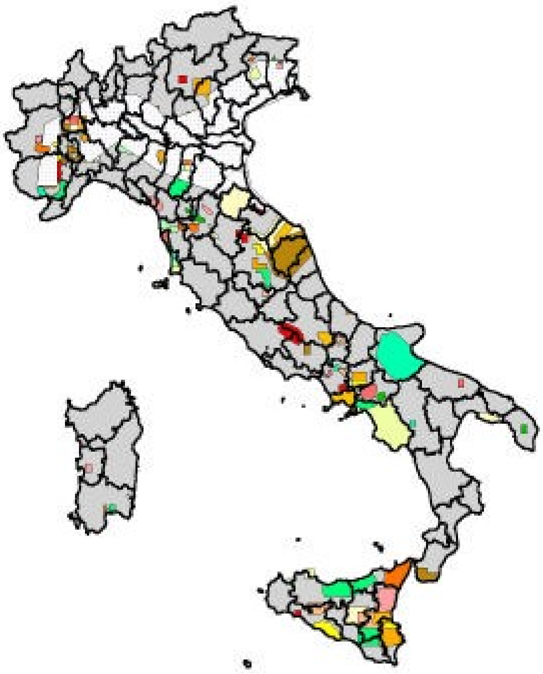


Fig. 5.2 – Covering of the vulnerability Chart of pollution of Italian aquifers (Source: GNDCI- LR n.4)

Industrial settlements

Industrial settlements are sources of ground water contamination depending on a variety of factors (e.g. location, production process, water use, quality-quantity of waste products and method of disposal, atmospheric emissions). It is also convenient to distinguish the waste products of *organic-biologic* nature from those of prevailing *organic* nature which are hardly biodegradable and those of *inorganic* nature, bearing in mind that an industrial settlement is a *complex aggregate of* CSCS. In Italy as many as 700,000 environmentally impacting industrial settlements can be identified. About 700 plants (60% in the North of the country) are classified as *bearing a significant risk of major accidents*.

Water withdrawal for *industrial uses* in Italy is not readily estimated, as official data are not available. Rough estimates suggest that the total yearly withdrawal ranges about 1.5 Gm^3 (ISTAT, Industry Census 2001): the largest consumer being the food and tobacco industry, followed by the production of metals, fabrics and cloths, paper, wood and plastics. The nature of pollution is organic degradable (5%), organic non degradable (22%), inorganic (nitrates, phosphates, chlorides, metals: 39%), microbiologic (32%) or chemical-physical (2%) (Fig. 5.3).

On the basis of the information of the Ministry of Health, collected in the 2000 Report prepared to fulfil the requirements of Directive 80/778/CEE, a synthetic picture of ground water pollution associated with threshold values of 60 chemical, physical and microbiologic parameters being stably exceeded (Fig. 5.4) is provided. Detected pollution is mostly microbiologic (16 Regions out of 20, mainly in the Centre- South regions) and anions driven (nitrites, nitrates, sulphates, chlorides, sulphides and boron). Several pollution phenomena are due to chlorinated solvents, deriving essentially from fabric washing, pesticide production, paints and plastics.

An increased pollution driven by chlorinated solvents is evident in the industrial settlements located around large cities like Turin and Milan. Often this type of pollution is associated with high concentrations of Cr^{6+} and TRIS (tricloroetilphosphate), heavy metals and fluorides[3].

---

(3) 3 Sources of these data are various ARPA and Istituto Superiore della Sanità (National Institute of Health) of Italy.

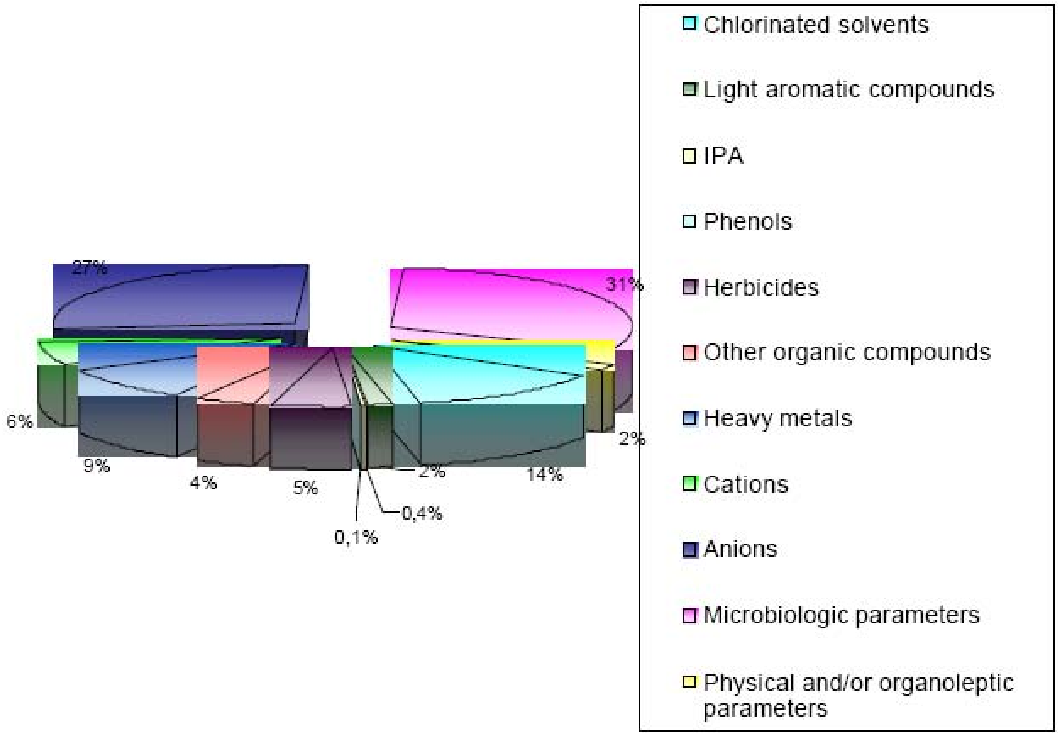


Fig. 5.3 – Groundwater pollution : number of events displaying concentrations of polluting substances larger than legislative thresholds referring to classes of parameters (Source: IRSA -CNR, 1999).

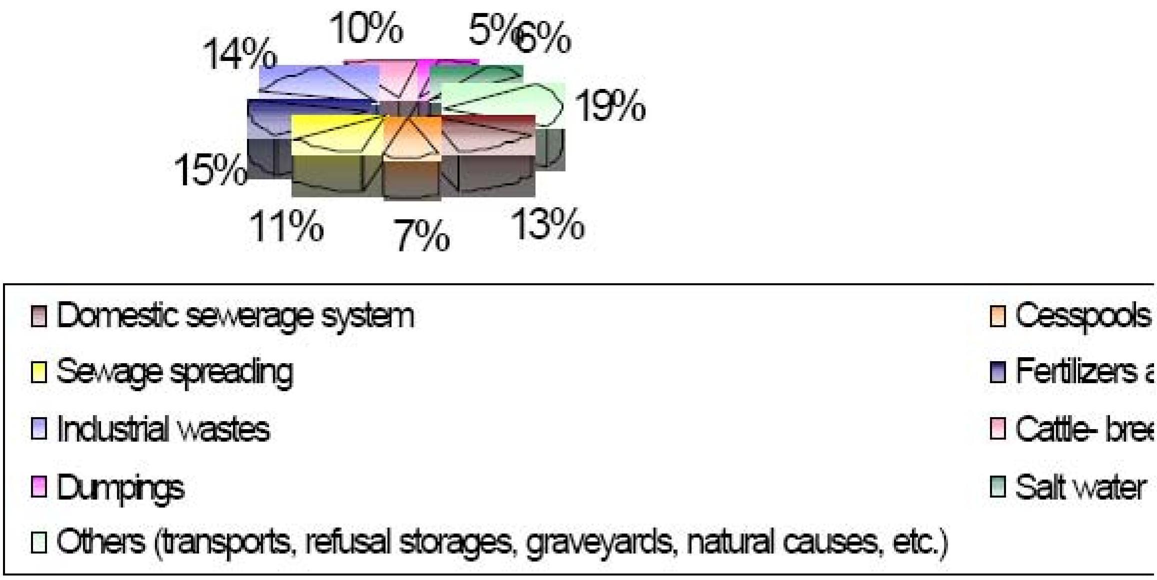


Fig. 5.4 – Origin of pollution of ground waters to be purified: number of events displaying concentrations of polluting substances larger than legislative thresholds (Source: IRSA -CNR, 1999).

Agriculture and livestock production
It is well known that agriculture induced pollution of ground water has constantly increased in the last 20 years due to spreading of agricultural practices based on an increased content of nutrients (N, P, K) in the ground, through addition of both *organic* and *inorganic fertilizers*. The total amount of fertilizers employed yearly in Italy ranges about 5 G Kg with a total content of N, P, K ranging

about 2 G Kg. Adding the contribution associated with cattle breeding, urban wastes and industry, one ends up with the picture emerging from the Figure 5.5.

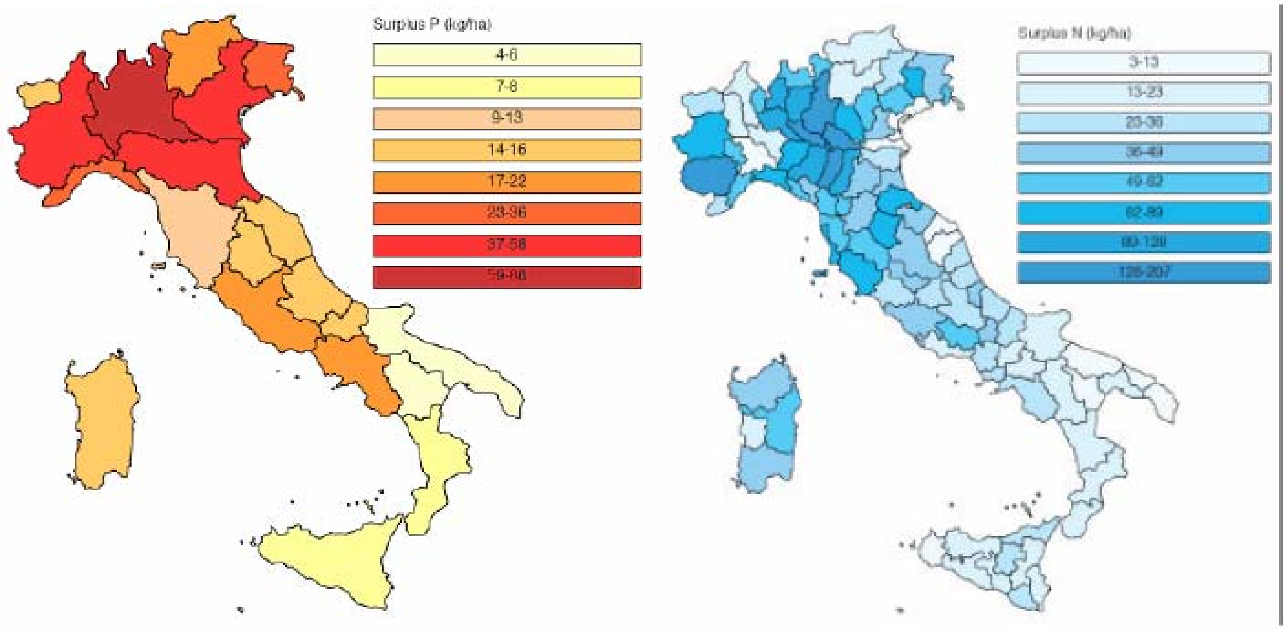


Fig. 5.5 – Surplus of nitrogen and phosphorus for each region in Italy (kg/ha) (Source: ANPA, 1999).

A second source of groundwater pollution is associated with the use of *plant protection products,* including chemical additives used to protect plants from pests and fungi (*pesticides*) or to selectively remove weeds from cultivations (*herbicides*). These are very dangerous products, toxic even at very low doses, spread into the ground by irrigation. In Italy, where an average of more than 160 M kg of plant protection products is yearly employed, water supply for drinking has undergone severe crises in several zones of Piedmont and Lombardia, due to pollution from atrazine, symazine, molinate. Symazine has been detected in concentrations exceeding the maximum admitted values in various areas of the Veneto, Piedmont, Lombardia, and Friuli regions. Propazyne has been detected only in Piedmont, molinate spreads over the whole rice production fields located between Piedmont and Lombardia, bentazone is found in groundwater throughout the whole Po valley. Irrigation driven aquifer contamination is also extensive in horticulture as well as fruit and flower cultivation in *green houses*, which are also subject to intensive use of fertilizers and plant protection products. Even more direct is aquifer contamination driven by irrigation consisting of waste water dispersal by means of spray irrigation techniques, submersion or filtration through storage basins.

Groundwater contamination associated with *livestock production* is determined by the industrialization of the latter activity which has replaced the traditional semi-wild breeding of poultry, cattle, goat and sheep, pigs. The largest volumes of contaminants are produced by cattle and pig farms, though intensive breeding of poultry may also contribute significantly. While in the past the above production was directly employed to manure cultivation fields, nowadays cattle manure is the only one to be stored, while poultry and pig manure is directly disposed into the drainage network with a strong impact on pollution from nitrates (Civita *et al*., 2003). Cesspools or tanks are employed to store manure, a technique whose effectiveness depends on how accurately their walls are made impermeable. The quality of aquifers of the Po valley, where agriculture is widespread, varies strongly among different zones, as shown in fig. 5.6.

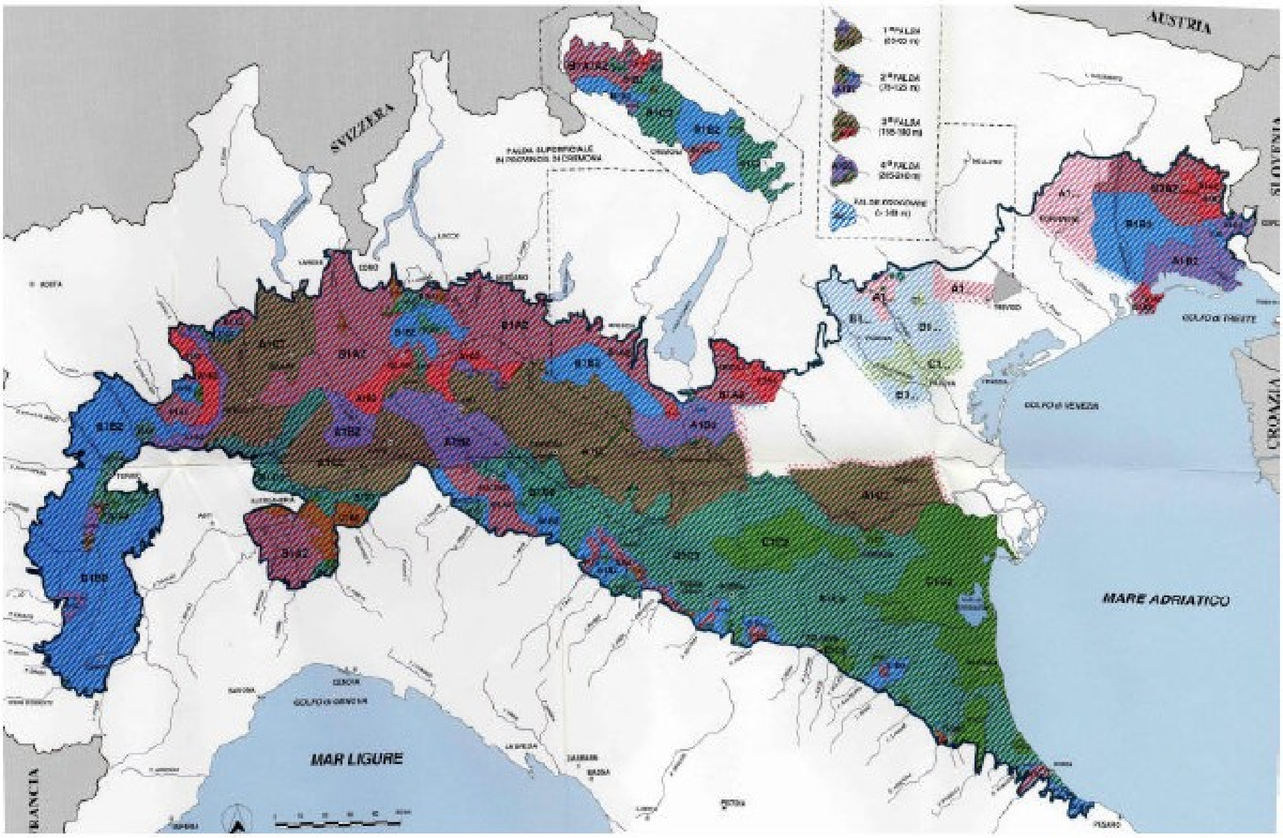


Fig. 5.6 – Map showing the quality of ground water of Po valley (Source: Giuliano, 1996).

Waste disposal

An average of 15 G kg/year of solid urban wastes (SUW), 50 G kg/year of industrial wastes (IW), 10 of which belonging to the class PNW (*poisonous or noxious wastes*), are produced in Italy. The above values must be compared with an overall treatment capacity not exceeding 15% of the said amount. This simple statement makes it clear that the origin of the problems met in some areas of the country (notably in the Campania region) derives also from an insufficient attention paid in the past to the issue of waste disposal: note that it is estimated that more than 4,800 illegal waste disposal sites are spread throughout the country.

About 200 plants for urban waste disposal with *thermal energy recover* have been constructed: though these plants allow for complete waste disposal, however the process employed produces various waste products (gas, solids or liquids) with the prevalence of water heavily contaminated by ammonia, tar, cyanides, phenols, sulfides.

Recycling is an ecologically appropriate response to the problem of waste disposal. This notwithstanding, some of the preparatory activities to actual recycling may themselves be identified as potential CSCs. This is the case of *centres for machines and automobile demolition*, which typically dispose highly contaminated fluids (hydrocarbons, acids, heavy metals, etc.) in the ground in an uncontrolled way. A few hundreds of such centres have been *authorized* in Italy but the *total* number of centres is as yet unknown.

Mining Activities

Mining activities, performed both above- and under-ground, affect the local hydrogeology and may lead to ground water contamination: due to the effects of *dewatering*, which is performed through large power plants; due to waste storage in *uncontrolled open air disposal sites*, where wastes react with precipitations and produce infiltration of contaminated waters; due to collapse of abandoned galleries, which drives surface *subsidence* and enhanced infiltration of contaminants. The mining

industry is fairly intense in our country: involving the extraction of materials like clay, limestone, sand , gravel, ornamental stones, chalk among others. Many thousands, mostly open air, mines have been authorized, but tens of thousands of them, possibly illegal, have been abandoned. Ground water contamination often derives from the emergence of the water table and the consequent direct disposal of waste waters into the aquifer.
Oil and gas extraction plants , the latter extensively present around the half of the last century in the region of the Po delta, are also quite risky activities. In fact, large amounts of potential fluid pollutants are mobilized: they include hydrocarbons, salt waters, drilling muds, water pumped at large depths to pressurize oil reservoirs and contrast subsidence.

Urban settlements
Urban settlements provide a number of potential sources of ground water contamination, associated with activities such as urban transports, industrial and commercial activities, domestic life and heating, hospitality, among others. The degree of pollution related to each CSC is mostly dependent on how effective is the waste disposal service. In Italy, even though 7742 out of 8086 Municipalities are equipped with some kind of sewerage system, several villages or parts of expanding settlements are not yet satisfactorily equipped. In most cases, wastes are discharged into surface water bodies. Only in 43 – 44 % of the cases, wastes are subject to treatment. Where sewerage treatment plants are not available, then wastes are disposed locally, in 85% of the cases through traditional septic tanks, in the remaining cases through disposal systems of different types, either controlled (aerobic treatment plants, filtering mattresses) or uncontrolled (cesspools).

Transports.
Transports also provide a number of sources of groundwater pollution, the more so in Italy, where the average number of accidents leading to accidental spillage of highly polluting substances transported by aircrafts, trains and lorries is as large as 40,000/year. Pipelines and pipe networks employed to transport oil products, natural gas (nearly 7.500 km), ammonia, coal, sulphur, food fluid products, are also highly liable to leakage.
Subsurface excavations performed below the piezometric surface of an aquifer lead to quantitative degradation of the aquifer. This may typically occur when tunnels are dug for railways or highways without previous investigations of the local hydrogeology. Clear examples of inadequate forecasts of the impact of tunnel excavation in Italy have been reported by Civita (2005) (see also fig. 5.7). Insufficiently investigated is also the role of additives, catalyzers and chemical grouting used in engineering works connected to tunnel constructions.

6. Italy and WFD: conclusions and recommendations.

The above overview has hopefully clarified some sources of difficulties likely met when attempting to implement the WFD in our country. A number of directions for future actions emerge.

6.1. Technical actions.

6.1.1. Controlling aquifer overexploitation.

The law 152/99 delegated Regions to perform an extensive activity of collection of data and information able to complement a number of previous studies performed by various Agencies in the ‘80s and ‘90s (CEE -CMP 1980, SINA Prismas Project, Assessment of Aquifer Vulnerability, GNDCI). The more recent Dlgs 152/06 and latest modifications stipulate strict deadlines for planning and installing suitable metering facilities able to allow censing of all water withdrawals. Until this aim will be fully achieved, no further withdrawal may be authorized. A few significant examples of sites where withdrawals have been highly reduced (e.g. Venice, Ravenna, Bologna – Ferrara plain, etc.) encourage to pursue this approach further, as the response of aquifers in terms of lifting of the water table has been prompt and satisfactory. As mentioned in sect. 1.1.4, APAT (the Italian National Protection Agency) is delegated to provide a unified framework able to overcome the fragmentation of the *monitoring* activity experienced so far: the SINA network, managed by APAT, is the Italian National Focal Point of EIOnet (Environment Information and Observation network) of the European Agency for the Environment (AEA) and also participates in the consortia European Topic Centre.

Fig. 5.7 – The effect of interaction of the Serena Tunnel, Railway Line Parma – La Spezia, with the surrounding aquifer (Source: *Civita, M.V., 2005*).

6.1.2. Spreading the practice of artificial recharge.

Artificial recharge is not a common practice in Italy yet and no special attention is devoted to it in Dlgs 152/06.

This notwithstanding, few pilot realizations are known. In particular, the artificial recharge of the Prato aquifer in Toscana and the artificial recharge of the highly polluted aquifer of the Metauro river (Marche Region). In the latter case, water is withdrawn from the river and pumped into the aquifer through wells such to reduce the concentration of nitrates in the ground waters. Further artificial recharge systems have been realized:

- in Piedmont (upstream of the town of Roccaforte Mondovì, Cuneo);
- in the upper Friuli valley, where the Ledra – Tagliamento Irrigation Consortium, has drilled dispersion wells in three fields located downstream of Udine;
- in the upper Treviso valley, where the Drainage and Irrigation Board of Piave (right bank) has performed a feasibility study based on field tests (Dal Prà, 1989).

Note that the few plants of this type realized so far in Italy have often met opposition of local communities. However, the practice is bound to spread specially in the Po valley, in the plains of Veneto and Friuli as well as in several areas located at the foot of mountains of the central and southern parts of the country, where water crises may possibly be contrasted using the surplus of surface waters during the periods of no irrigation. Several Water Protection Plans recently issued by Basin Authorities include artificial recharge among the actions favourably considered to achieve a more sustainable use of ground water. This is the case of Toscana, where the artificial recharge of the sandy-gravel aquifer of the Versilia Plain has been recently planned.

6.1.3. Enhancing water reuse.

A consequence of the low price of water has been the insufficiently implemented practice of water reuse both in the industry and in agriculture The Italian legislation on water reuse has been released only in 2003. The recent Dlgs 152/06 delegates the Regions to release norms regulating this practice, providing also incentives for industries adopting water recycling and reuse.

Reuse of industrial wastewaters
Few examples of reuse have been attempted, notably in the *Toscana Region*, Arno Basin. Here, a water recycling plant exploiting wastewaters produced by the textile factories of the Prato area produces 5.5 Mm^3/year of recycled water which is used to recharge the aquifer artificially, with an average cost of about 0.155 – 0.180 € /m^3. This successful attempt encourages the extension of this practice to other industrial districts. Recently, similar measures have been planned to reuse water employed by factories of the leather industry.

Reuse of purified urban wastewaters for irrigation purposes
In a few Regions pilot initiatives involving this practice have been implemented. In particular, the Toscana Region has promoted the development of various experimental plants for the reuse of urban and industrial wastewaters for irrigation of cultivations of ornamental plants. Results are encouraging and have provided a number of suggestions for improving treatments, irrigation techniques and use of fertilizers. Most *Water Protection Plans*, recently issued by Basin Authorities, have included reuse among the measures to be implemented soon. The European Community may play an important role to enhance this practice. In fact, several Italian Drainage Boards have submitted *projects* to EC through Objective 1 Regions. In particular, five of the ten submitted by Sardinia have been funded with a total financial support of 45 M€. These projects also involve third stage treatment of urban wastes such to reduce the load of phosphates and prevent eutrophication of reservoirs where treated effluents are to be stored in winter.

6.1.4 Prevent misuse of high quality groundwater.

High quality ground water is the most obvious candidate for drinking. Choosing the source appropriate to different purposes is far from being implemented in this country. It is not uncommon for water managers (e.g. Turin and Florence) to be forced to employ purified waste waters to replace ground water employed for less appropriate purposes. Only recently, in the Italian legislation there appear to be signs of attempts to address this issue, while the European Commission itself has only recently adopted a Communication on Water Scarcity and Drought (COM 2007 414 final) where the often extravagant use of water in European Countries is blamed.

6.1.5 Reduce water losses in the supply networks of aqueducts

The fig. 6.1 shows that the domestic use of ground and surface water is characterized by an unbalance between supply to and actual consumption by end users. This is mostly due to the large losses experienced throughout the abstraction, collection and distribution process. Comparing withdrawal with domestic consume of freshwaters (i.e. the water actually supplied to end users, except for the fraction which is not measured) one can grossly estimate losses. The fig. 6.1 shows that they reached about 20% of the abstracted volume in 1975. Twelve years later the increment of volume supplied to users was balanced by a nearly equal increase of losses! Even though interpretation of these data is not simple as losses are definitely overestimated due to lack of metering, however losses experienced in Italy are undoubtedly larger than in any other European country. This is a plague which will hardly be removed unless maintenance and further investments will become economically feasible, an issue strictly dependent on the tariffs of water. Note that the network of aqueducts is extremely large (291,000 km in length) and consists of 13,503 aqueducts, most of them municipal or local, the average age of which is 32 years.

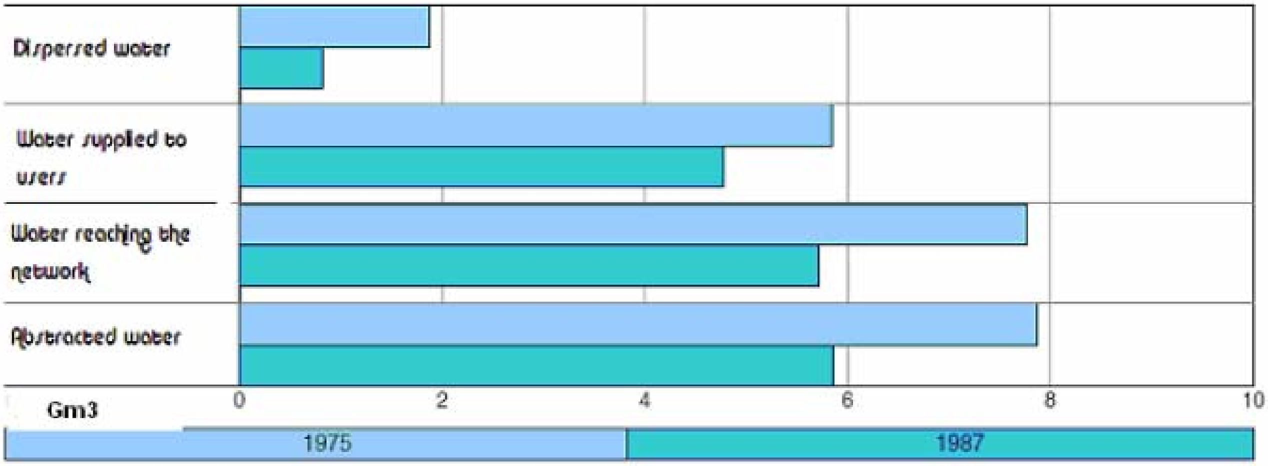


Fig. 6.1 – Estimated losses of supply networks: comparison between the years 1975 and 1987 (Source ISTAT, 1987)

6.1.6 Capturing submarine ground water springs

Ground water may be directly transferred by aquifers into the sea either through underground filtration (Fig. 6.2, left) or through the numerous existing coastal springs (Fig. 6.2, right).
This resource is presently being investigated throughout the world (mostly in USA, Japan, Australia) using appropriate techniques (Thermography I.T., geophysical surveys, hydrochemical analyses, subaqueous surveys) with the aim to ascertain exploitability of these valuable fresh waters by capturing them before they mix with sea water. Note that, while a piezometric gradient to the sea is usually welcome as it opposes salt water intrusion, however a few shortcomings may arise: a significant flux from coastal aquifers may discharge significant amounts of contaminants (nutrients, heavy metals, hydrocarbons, fertilizers, etc.) which may negatively affect coastal *habitats;* ecological perturbations, e.g. an abnormous growth of vegetal organisms and micro-organisms) may also arise from temperature modifications and the formation of 'dead zones' (e.g. the so called 'Iron Curtain' generated by redox of dissolved Fe).

Fig. 6.2 – Left*: ground water filtration into the sea along the Amalfi coast.* Right*: subaqueous spring. (Civita M. V., 2005)*

Fig. 6.3 – Loss of ground water to the sea through subaqueous or coastal springs (Civita M.V., 2005).

6.2. Management Actions

6.2.1 Integrated management

Achieving WFD targets will be very difficult and prohibitively costly if based only on the traditional actions inspired by the "supply side model" – namely, adding new infrastructure. This policy will nonetheless provide an important contribution in a large number of river basins; but for what concerns "black spots" and above all reducing vulnerability of groundwater, more integrated actions are needed. In particular, as mentioned above, intensive wastewater reuse could not only improve surface water quality, but also alleviate the excessive pressure on some aquifers especially where industry is involved. Land management contracts could also be very useful in order to promote preventive measures that go beyond legal requirements. The diffusion of economic instruments based on the market approach (direct bargaining; water quality trading) could help providing the legal means for similar agreements, that at present rely on public commitment and resources.

6.2.2 Reclamation of contaminated land

One of the major sources of groundwater contamination and vulnerability depends on past dumping of toxic substances in the soil. Although these practices have long been forbidden and bans on illegal dumping quite successfully enforced, inheritance from the past is overwhelming especially in the areas characterized by early industrial development. Reclamation is in theory a responsibility of the landowner, but enforcing this measure is impossible due to prohibitive costs. Extraordinary actions, probably based on a strong public support, are needed. Land reclamation plans establishing priorities and medium-long term agendas are required, and should become a fundamental part of basin plans as well as management plans.

6.2.3 Public participation

Integrated actions and discretional water policy require a large basis of social consensus in order to legitimate decisions and ensure governance. This is utmost true when actions involve a multiplicity of actors and sectors, and costs (both in term of direct cost or failed profit opportunities) spread across them. Perception of equity and fairness is a fundamental ingredient of consensus. Italian water policy is still dominated by ivory towers, with a lack of transparency and a very poor level of involvement of the public opinion and stakeholders. Planning, both at the basin and at the regional level, is still conceived as a top-down engineering exercise, and should be radically innovated both in the approach, the culture and the scope. On the other hand, Italy – as other central European countries – has a strong tradition of stakeholder-based institutions on the management side (e.g. Land reclamation boards, Industrial development boards) that could be enhanced and promoted in this respect.

6.2.4 Professional management and regulation in the household supply and sewerage industry

The attempt to create a professional and self- sufficient water industry, started in 1994, is still lagging behind. We believe that the reform of water services has severely underestimated the difficulty of the transition from direct public undertakings to professional water corporations and the related regulatory and financial issues. The public opinion and politics are still prisoners of the "private vs. public" debate. In the meanwhile, investment has been blocked for more than 15 years.
Restarting the whole process again requires a much more incisive strategy that regards planning styles, regulatory approaches, public participation to key decisions regarding water services, improved transparency. It also challenges the usual approaches to competition. We believe that competitive tendering is not suitable if the managing company is also required to accept economic risks related to investment in the long run. The choice of alternatives should be aware of the tradeoff between risk allocation and competition, in the sense that delegated management via competitive tendering usually requires risk-sharing arrangements that the actual Italian legislation does not make possible.
Another critical aspect regards the impact on water management of EU competition policy in the field of Services of General Interest, that dramatically affects the traditional Italian model (based on publicly-owned corporate multiutilities). If the latter is intended too rigidly and with no attention to national specificities, the result will be either to force a transition to the market, for which the regulatory system is largely unprepared; or, on the contrary, to encourage municipalities to re-create public management undertakings, suitable for "in house provision", but by enlarge less efficient and reliable than professional water companies.

6.2.5 Professional management and regulation in the other segments of water management

Professional management, financial self-sufficiency and economic viability are not only required by urban water services; an effort for a modernization of water management systems is required in many other segments, and especially irrigation, rainwater, industrial supply and sewerage, land drainage. A professional management is a pre-requisite for terminating the extensive model of water supply and treatment largely based on self-supply and/or inefficient technological patterns.

6.2.6 Water pricing, full-cost recovery and economic instruments

Economic water pricing and full-cost recovery (FCR) are regarded as a cornerstone of the policy strategy launched by the WFD. While the rationale behind this approach seems well rooted in the

microeconomic theory, it also entail severe implications that prevent it from being fully adopted, at least in Italy.
While economic instruments and market solutions can be advocated in some cases – especially where water scarcity is at stake – it is highly doubtful that FCR based on volumetric prices is a necessary requirement as far as water industry viability rather than water scarcity, is at stake. Also, it is unclear whether pricing would have any meaningful effect on water pollution and groundwater vulnerability. On the other hand, the concept of "cost" is also misleadingly confused, especially if it fails to consider that infrastructure cost depends crucially on the financial model adopted and on how the economic risk is allocated. While FCR is needed to ensuring industry viability and restore its investment capacity, we believe that water companies' revenues could be generated through a plurality of channels, including ear-marked taxes, connection fees, inter-sector compensative payments. Also, a more careful approach to public subsidies should be adopted: it is not wrong, in principle, that some dimensions of general interest are financed by taxpayers rather than by water users. This applies in particular to basic infrastructures for drinking supply and sewerage, rainwater, reclamation. Extraordinary plans aimed at restoring highly contaminated aquifers will be simply unfeasible if too rigidly based on the PPP and FCR. A more flexible approach, which relies on the usefulness of economic instruments but avoids making a fetish out of them, appears to be needed.

References

APAT (ANPA) (2001).– Linee-guida per la redazione e l'uso delle Carte della vulnerabilità degli acquiferi all'inquinamento. A cura di Civita M., De Maio M., Farina M., Zavatti A. Manuali e linee-guida dell'ANPA, 4/2001, 99 pp., 1 CD-ROM.

Ardau F., R. Balia, G. Barbieri, G. Barrocu, E. Gavaudò, G. Ghiglieri, A. Vernier (2000). Geophysical and Hydrological Studies in a Coastal Plain affected by Salt Water Intrusion – Proceedings of Symposium on the Application of Geophysics to Engineering and Enviromental Problems, Crystal City, Arlington, Virginia, February 20-24.

ARPAER Emilia Romagna (2005 a). Le caratteristiche degli acquiferi della Regione Emilia Romagna. Report 2003, Grafiche Pioppi, Scandiano (RE), 244 pp.

ARPAER Emilia Romagna (2005 b). Presenza e diffusione dell'Arsenico nel sottosuolo e nelle risorse idriche italiane. A cura di M. G. Scialoja, Quaderni ARPA, 227 pp.

Barrocu G., G. Ghiglieri, G. Uras (1995). Intrusione Salina e Vulnerabilità degli Acquiferi della Piana di Oristano – Convegno Gestione Irrigua in Ambiente Mediterraneo, Oristano, 15-16 Dicembre, 1995, Pubblicazione n. 1383 del GNDCI-CNR U.O. 4.12.

Berbel Vecino, J., Gutierrez Martin C., (eds.) (2004), *Sustainability of European irrigated agricolture under WFD and Agenda 2000*, European Commision, DG Research, 2004

Cas Mez Cassa per il Mezzogiorno (1983). Progetti speciali per gli schemi idrici nel Mezzogiorno – Idrogeologia dell'Italia centro-meridionale. 4/2, Stampe Grafiche Magliana, Roma, 225 pp. + 1 Carta.

Civita M. V. (2005). *Idrogeologia Applicata e Ambientale*. CEA, Milano, 794 pp.

Civita M. V., Olivero G., Vigna B. (2000 a). *Le risorse idriche sotterranee del territorio cuneese (Piemonte Meridionale). Parte 1: il settore alpino. GEAM*, 37, 1, pp. 69-83.

Civita M., Fiorucci A., Olivero G., Vigna B. (2000 b). *Le risorse idriche sotterranee del territorio cuneese (Piemonte Meridionale). Parte 2: il settore di pianura*. GEAM, 37, 4, pp.75-93.

Civita M. V. , De Maio M., Fiorucci A., Rancurello S., Vigna B. (2003) - *Valutazione del rischio d'inquinamento da Nitrati: approccio e validazione su test-site*. IGEA, 18, p. 25-44.

De Vincenti C., Vigneri A., (2006), *Le virtù della concorrenza. Regolazione e mercato nei servizi di pubblica utilità*, il Mulino, Bologna

Gatto P., Carbognin L. (1981) - *The lagoon of Venice: Natural environmental trend and man-induced modifications*. Hydrol. Scienc. Bull., 26, 4, pp. 379-391

Giuliano, G. (Ed) (1996): Vulnerabilità naturale e rischio di inquinamento delle acque sotterranee nella pianura padana. Esempi di cartografia sperimentale a scala regionale IRSA, Rapporti tecnici 145, 14 Tavv., Roma.

GNDCI (1985 – 2001) – Linea di Ricerca 4: Assessment of Aquifer vulnerability - Complete Bibliography in *Catalogo delle Pubblicazioni – Sintesi 1985-2001* Tipografia Grifo, Perugia (2003), 412 pp.

IRSA-CNR (1999). Un futuro per l’acqua in Italia, Quaderni 109, Roma, 235 pp.

Massarutto A. (1993), *Economia del ciclo dell’acqua*, FrancoAngeli, Milano

Massarutto A., (1998), “Le tariffe dei servizi idrici in Italia”, *Economia delle fonti di energia e dell’ambiente*, n.2

Massarutto A., (ed.), (2002), *Ciclo integrato delle acque: regole di mercato e strumenti operativi a confronto*, FrancoAngeli, Milano

Massarutto A., (2003), “Water pricing and irrigation water demand: efficiency vs. sustainability”, *European Environment*, 13/2003, 100-119

Massarutto A., (ed), (2007). Manuale per la valutazione economica delle politiche idriche, FrancoAngeli, Milano (forthcoming).

Mazzanti M., Montini M., (2004). Le determinanti della domanda di acqua per usi domestici. Applicazioni di modelli panel a dati comunali dell'Emilia Romagna, Economia delle fonti di energia e dell’ambiente, n.1.

Muraro G., (2004), “La riforma dei servizi idrici e il ruolo del Comitato di vigilanza”, *Economia delle fonti di energia e dell’ambiente* , n. 3

Musolesi A., Nosvelli M., (2004). Domanda e stili di consumo, dell'acqua domestica: un'analisi econometrica su dati Panel comunali, Economia delle fonti di energia e dell’ambiente, n.2.

Robotti L., ed., (2002), *Competizione e regole nel mercato dei servizi pubblici locali*, il Mulino, Bologna

Teatini P. , Ferronato, M. , Gambolati, G. , Bertoni, W. and Gonella, M. (2005). *A century of land subsidence in Ravenna, Italy*, Environ Geol (2005) 47: 831–846 DOI 10.1007/s00254-004-1215-9

Vaccà S., (ed.), (2003), *Problemi e prospettive dei servizi locali di pubblica utilità in Italia* , FrancoAngeli, Milano

References non cited.

Civita M.V. (2008) – *L'assetto idrogeologico del territorio italiano: risorse e problematiche*. Quaderni SGI, n. 3, Pubblicazione su www.socgeol.it

Flaccovio D., (2000). *Acque sotterranee ricerca e sfruttamento*, editore Hammil-Bell.

Rapporto Bruntland, (1987). *L'Italia e il problema dell'acqua*.www.tetide.geo.uniroma1.it