Agriculture, water resources and water policies in Italy

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1. Introduction

This paper provides an overview of the Italian water management system (WMS), with particular reference on the links between agriculture and water resources, and emphasis on underground resources.

Our objective is mainly descriptive at this level; nonetheless, we try to evaluate patterns of interaction between agriculture and water resources plicy from the point of view of water sustainability: that is, we shall try to assess whether or not actual patterns of interaction arise in unsustainable use of water resources.

We employ here a concept of "water sustainability" that has been developed particularly by authors like Barraqué (1995) and Kraemer and Kahlenborn (1997): that is to say, we rely not only on environmental targets, but also on economic aspects (renovation and long-term maintenance of the water infrastructure) and ethical aspects (concerning the key issue of accessibility of water and affordability of water prices). Readers that are not familiar with this approach to water sustainability can find an excellent operational application of these concepts in the outcomes of the Eurowater and the Water21 research networks, financed by the EC-Dg12 (Correia 1998, 1999).

Agriculture is by far the largest water user in Italy: it can be estimated that nearly 2/3 of available water resources are used for irrigation. Nonetheless, water for irrigation is only exceptionally extracted from the underground, especially when water supply is obtained through collective bodies (Reclamation Boards), that cover the largest part of irrigable land. Only in a few areas is abstraction of underground water for irrigation a significant pressure arising usustainable patterns of underground water use.

Far more relevant is the impact that irrigation has on river outflow patterns and management of lakes and reservoirs; if the issue of "low flows", linked to environmental, recreational and landscape water uses, has gained attention and importance; if the traditional meaning of "reclamation" is now perceived as environmental-unfriendly (eg for the sake of wetlands conservation), it must be stressed however that irrigated farmland and artificial drainage are activities lasting for many centuries, particularly in Northern Italy, and contributed strongly to the creation of the rural landscape.

The impact of agriculture on underground water resources is on the other side more important if we take into account pollution of the water table arising from intensive agriculture and disposal of livestock waste. This impact is particularly severe since it undermines the whole system of drinking water supply in a large part of the Country: public aqueducts normally rely on undergrund water and used so far to be managed at a very local level, even because of the high degree of territorial dispersion of the Italian population. Therefore coping with underground water pollution will mean the need to invest significantly in order either to develop drinking water treatment facilities or to connect the water network in order to concentrate supply on safer resources.

So far, Italian water resources policy has been dominated by infrastructural aspect; regulation of pollution has been sought basically through command and control regulation, whose effectiveness however has been questionable even because of the very poor records in terms of monitoring, control and enforcement. We shall therefore argue that a far more decisive policy action needs to be concentrated on the system of (direct and indirect) incentives provided to intensive agriculture and thus to agricultural pollution.

The new CAP, in particular in the form that it is taking in the Agenda 21, sets a framework that is broadly consistent with this necessity. However, as Romano (1998) and Marangon (1998) have shown, the Italian agricultural policy still has not fully appreciated the new opportunity offered by the European structural and agro-environmental funds, and still continues to sprawl available resource without a proper finalization to environmental policy targets – including water resources policy.

This paper is structured as follows.

In section 2, we shall describe the fundamentals of water policy in Italy, providing some basic information about water availability, water use and water policy institutions. A short description of the structure of the Italian agricultural sector is also provided.

In section 3 we analyze the most important issues facing the water policy system with respect to underground water, and discuss the most relevant policy options and ongoing strategies.

Finally we try to evaluate the system performance from the point of view of sustainability, and offer some perspectives for future research and policy debate. There is not the intent to provide policy-relevant advice at this stage; rather, our purpose is to set the framework for the debate, even in order to set a sort of “research agenda” for the next steps of the SAGA project.

2. Water resources management in Italy

2.1 Availability

Water in Italy is relatively abundant, since yearly net average rainfall per head is around 5.200 m^3, corresponding to a mean per-capita availability of 2.700 m^3.

Yet available water resources are much lower, since a great variability should accounted for: the yearly, seasonal and regional distribution of rainfall is very high, like in all Mediterrenean Countries.

Given the irregular outflow paths and the technical and natural constraints, true availability is far lower: 2.000 m^3 if we consider potentially usable resources; and only 928 m^3 if we consider just the amount of water that can actually be used, given the available infrastructure and storage capacity. The mountaineous nature of the largest part of the Italian territory reduces the scope and technical feasibility of internal water transfers, forcing thereby many Regions to rely on their own rsources only, unless very high costs are incurred into.

Table 1 provides most recent estimates concerning available resources. There are important differences throughout the Country. Northern Italy, thanks to the Alps and to the natural storage capacity provided by glaciers and lakes, enjoys regular and abundant per-capita endowment. In central and Southern Italy and in the islands available resources are much lower, seasonal variability of runoffs is at the highest. This is shown by table 2.

While the outflow from the Alpine rivers is well distributed during the year (9%, 24%, 41% and 26% respectively for winter, spring, summer and autumn), in the rest of the Country a share between 60 and 90% of total outflow is concentrated in winter and spring (Rusconi 1995). The National Hydrographic Service (*Servizio Idrografico Nazionale*) has issued a map showing that a large part of the South suffers from consecutive periods without rain of 100-150 days.

While these patterns of distribution heavily impact on water resources availability, they also pose dramatic problems of flood control.

Table 1 - Available water resources in Italy (billion of m^3)

	Estimate 1970	Estimate 1989
Rainfall	296	296
Evaporation	132	132
Losses	9	9
Total outflow	155	155
Potentially usable surface resources	110	110
Underground resources	13	12
Existing reservoirs	7,7	8,4
Reservoirs in construction	2	2
Other potential reservoirs	6,5	6,5
Usable surface resources	42	40
Total available resources	55	52

Source: Conferenza Nazionale sulle Acque (1972); Ministero dell'Agricoltura e Foreste (1990) (from Rusconi, 1996)

Table 2 - Regional variations of water resources availability in Italy (m^3/year per-capita)

Hidrologic area	Rainfall	Available			Storage capacity
		Surface	Underground	Total	
Po Basin	4.654	1.045	290	1.334	142
North East	6.693	1.707	268	1.975	167
Liguria	3.557	207	171	377	16
Romagna-Marche	6.126	294	183	478	63
Toscana	5.853	152	123	275	39
Lazio-Umbria	4.173	242	195	437	78
Abruzzo-Molise	7.728	1.594	161	1.755	392
Puglia	3.429	136	84	220	103
Campania	4.290	229	172	400	14
Calabria-Lucania	9.110	954	226	1.180	429
Sicilia	3.865	152	237	388	148
Sardegna	11.854	1.161	137	1.298	885
Italy	5.273	705	216	921	150

Source: our elaboration on Rusconi (1996)

Thus the relative abundancy of water resources is more apparent than real, since the Italian water system is capable of using just a small fraction of potential outflow. This is in part a result of natural patterns of seasonal and regional water distribution, but in part depends on the size and the efficiency of water facilities and the inefficiency of water use patterns.

In this picture, a decisive importance is held by underground resources, that account for 25% of usable resources on average, and nearly 50% in some Regions. Nonetheless, knowledge on this crucial resource is far from accurate, either from the quantitative or the qualitative point of view.

From the qualitative point of view, the situation is again very differentiated throughout the Country. Surface water quality is almost never terrible, but also almost never exceptionally good.

The largest rivers are normally in fair conditions, even if their quality worsens notably during low-flow seasons.

A great number of “black spots” contributes to the general deterioration of river quality. These situations arise in particular when medium or small streams drain areas with high urban and industrial concentration. Among the most critical cases we can mention the river Lambro – draining the area of Milano, still now very poorly equipped with sewage treatment capacity – the lagoon of Venice, the reaches of Po, Arno and Tevere downstream the cities of Torino, Firenze and Roma. The presence of industrial districts with heavy environmental impact – eg tanning and textile industry in the North, food industry in the South – are also an important cause of severe pollution.

Given the geographic structure of the Country, there are many areas that are vulnerable to nutrient pollution, in particular large lakes and the upper Adriatic Sea, to which flow the rivers draining the most densely populated and industrialized part of the Country.

From 1976 on, a massive effort has been made in order to provide sewage treatment equipment and address water pollution; this effort, though considerable, is largely incomplete. While 1/3 of the pollution load is still not treated, water policy so far has been able to block, but always never to reverse, the trends of worsening river quality. Some remarkable results have been obtained with respect to lakes and even to the Adriatic Sea. In this last case, for example, end-of-pipe treatment and pollution prevention measures have reduced by 90% the nutrient load discharged into the Sea.

Nonetheless, biological and chemical quality of largest rivers does not show signs of improvement; while the number of “unpolluted” sites has been dramatically decreasing, thus showing that water pollution cannot be considered as a problem only in highly urbanized areas.

Water tables used to be of excellent quality until the recent past; this is also one of the reasons why the largest part of the public supply systems rely on the underground, with a very local management of the water service. Nonetheless, in the last 20 years, the quality of underground resources has been rapidly deteriorating in many areas of the Country.

Clear signs of overexploitation have been repeatedly noticed in the lower reaches of the Po plains and in the surroundings of Venice: excess abstractions – especially for industrial uses – together with the extraction of gas and oil are the most likely causes. In other regions – and especially in the Southern part of Puglia, or in the coastal plains of Campania, Calabria and Sardegna – the problem is basically salt intrusion. In these cases, the overabstraction can be attributed to private abstractions for agriculture and, in a more localized way, to public water supplies, even if these are gradually being re-oriented on surface resources.

From the qualitative point of view, in the lack of a complete and general report, we must rely on spot observations. According to these data, the situation of the largest part of the Italian plain lands is now very alarming. Nitrate concentrations above 50 mg/l (the limit for the destination to public supply according to the European Directives) are now commonly recorded in a large number of cases, with particular frequency in the coastal plains, along the basin of the Tevere and above all in the Po basin: in this last area, which is one of the most populated and intensely developed of the Country, the most vulnerable area is located unfortunately in the upper reaches of the plain, where the table recharge occurs.

Around the areas where intensive cultivation is practiced, heavy concentration of pesticides have also repeatedly been detected, with peaks around the beginning of the 90s. Still now, some million of people in Lombardia and Veneto receive a water supply that derogates from the legislative standards.

The water table also suffers from bacteric and heavy metals pollution, whose causes are above all soil contamination (due to landfills and abandoned industrial sites, but also to direct discharge – now abandoned and forbidden almost everywhere – and to the use of polluted fertilizers, like compost and sewage sludge.

2.2 Water use

The relatively high endowment in terms of water resources is corresponded by a relatively high per-capita water use. Table 3 provides a general picture of all offstream uses, broken down by territorial areas and use.

Table 3 – Water abstractions in Italy (hm^3/year)

	Civil	Industrial	Irrigation	Energy	Total
NorthWest	2.268	3.520	8.193	1.863	15.884
NorthEast	1.453	1.648	5.277	2.538	10.915
Center	1.618	1.482	970	72	4.142
South	1.803	879	3.506	36	6.223
Islands	798	457	2.191	-	3.447
Italy	7.940	7.986	20.136	4.509	40.571

Note: Energy column includes only the use of freshwater for thermoelectric plant cooling, and NOT hydropower; the largest number of thermopower plants uses sea water.

Source: our elaboration from various sources

As we can see, Northern Italy alone accounts for nearly 70% of total water consumption. Irrigation represents a half of the total; yet this figure is much higher in Southern Italy (56%) and especially in the islands (64%).

It is also important to note that the data used for table 3 are highly disomogeneous, and refer to different years. Civil uses are accounted for with greater precision, yet the last statistical campaign dates back to 1987. Industrial uses are estimated according to average consumption indexes calculated in the 70s for each sectoral branch, and never updated since then. Demand for cooling is derived from the updated news released by Enel with respect to the total thermoelectric capacity located in the interior and still not using closed-cycle cooling techniques.

Yet the least certain data is the one regarding agriculture. Estimated provided in the 70s and 80s forecasted a far higher volume (25-30 km^3/year, with an expected figure of 26 for the year 2000). Yet the scenario we adopted takes into account a substantial reduction, especially in the North, due either to the abandonment of some highly-demanding irrigation practises (eg marshlands), diffusion of less consumptive techniques particularly for water-intensive crops like rice and corn, and finally reduction of irrigated land and move towards more extensive crop patterns, fostered by the Common Agricultural Policy.

Civil uses are basically relying on underground water. This is particularly true in the North, where underground and springs account for roughly 90% of household supply. On the other side in Southern Italy and especially in the Islands water supplies are obtained for 15-25% from surface resources, reservoirs and transfers. Whole provinces rely on upstream reservoirs for the entire supply.

The water table also represents the main source of aupply for industrial uses, especially in the North, in general with direct private abstractions. Industrial use of surface waters occurs only for cooling purposes.

Surface waters in the North are thus used essentially for irrigation, in general after an intensive development in the mountain reaches of river basins for hydropower generation. The hydropower network – made out of some hundreds of reservoirs, interbasin transfers and by-passes, later transfers the water to downstream reservoirs intensely used for supplying the irrigation system, ran by Reclamation Boards.

A further 10-25% of water for irrigation is nonetheless derived from the underground, small streams, small private rainwater storing systems and sources. In the North and Center, this occurs basically in mountain and hilly areas, where irrigation is often practiced during the winter in order to prevent damage from hard-frost; in the South and the Islands, on the contrary, underground water is used intensively during the summer, either in internal areas or along the coastal plains.

These patterns of water use are reflected in the organization of the water supply organization.

In the North, water supply is highly segmented. Public supplies are operated at the local level under municipal or intermunicipal organizations. Irrigation is managed collectively through farmers associations (Reclamation Boards). Industrial facilities are almost always self-supplied, and when they are not, they rely on dedicated networks. Therefore, water systems in the North are highly segmented and separated, with very little interrelations or interactions among each other.

On the contrary, Southern Italy uses are highly interdependant, since they often rely on the same large water storage and transfer schemes, operated by State-owned organizations and/or irrigation biards. Artificially-collected water is then allocated to various uses, each through its own adduction system. Local resources – basically underground water and "non conventional" sources like desalinated and brackish water – are used as complimentary resources.

Patterns of generation of pollution loads are, once again, highly differentiated throughout the Country. The Italian population is far less urbanized than in other Countries. There are almost 8,000 municipalities, for an average size of approximately 6,000 inhabitants. Many municipalities, especially in rural areas, are further composed by a number of centers and dispersed dwellings: this helps to explain the high fragmentation of sewage collection, as well as water supply networks (there are nearly 13,000 separate networks, 10,000 of which are equipped with sewage treatment installations..

This data perhaps over-estimates the degree of fragmentation, since 25% of population lives in the 46 *Comuni* with more than 100,000 inhabitants and nearly 70% in the 2,100 centres or more than 10,000 inhabitants.

The relevant information to be retained is, in any case, the relatively low concentration of population in great metropolitan areas and the great number of small and medium towns, with a tradition of autonomy and self-government that dates back to the Middle Age (Italian unification as a nation dates just from 1861 to 1918).

Around urban areas, the process of rapid industrialization and economic growth undergone in the past 50 years has left an inheritance of almost chaotic and poorly planned urban development. Especially in the last 30 years, this process has been characterized by very limited centralization and polarization.

The model of "industrial districts", very typical of Italian industrial pattern of development, is widely diffused in the North as well as in Central and increasingly Southern Italy. It is characterized by high concentrations of quite specialized industrial activities, located in particular areas, often independently from "central" urban poles and networks.

This pattern of development explains the very dispersed model of urban settlement and the low level of polarization of industrial activities (*urban sprawl*), causing evident difficulties to infrastructural network planning, and sewerage networks among others. In fact the whole Po lowlands and most important side valleys can be considered as a single, large semi-urbanized area. Much the same happens along rivers such as Arno, Tevere and along the coast.

In the South, the largest towns are usually located around the coast, and their pollution load is generally discharged into the sea. This has obvious repercussions on bathing water quality; even the primary sector can be nonetheless affected, especially for what concerns fish farming and shellfisheries

Livestock farming, though diffused in the whole Country, is as well very concentrated. Lombardia has 24% of cattle and 38% of pigs, concentrated in 2-3 provinces. Veneto and Emilia Romagna have the largest share of poultry.

On the other side, a relevant amount of diffused pollution should be accounted for. This is not related only to agriculture – for which see below. Small urban centers and isolated fractions – often constrained by orography – discharging into small watercourses; high quantity of small industrial activities, sprawled around in the territory and relying on household wastewater collection network or discharging directly; soil contamination due to landfills and abandoned industrial sites; and finally rainwater contamination are among the main sources of diffused pollution, that the characters of urban development in Italy make more severe than elsewhere.

2.3 Institutions and policy instruments

In the last century, water has progressively abandoned the nature of “free good” to enter the public domain. This process of development of public rights on water resources has witnessed a substantial acceleration in the last 2 decades, in particular due to the increased role of the EU as a driver of environmental policy. In fact, the largest part of environmental legislation in Italy can be regarded as a consequence of the implementation of European Directives.

However, although the Italian legislative and institutional framework of water policy is now broadly coherent with the rest of Europe, the distance between paper legislation and proper implementation is very large, partly due to the delay in the development of environmental policy, partly because of structural difficulties (eg prevalence of non-point impact sources).

Before 1994, the public property of water resources needed to be explicitly declared by the public authority, on a case-by-case basis. In practice, this meant that all surface waters of some importance were considered as public, and therefore required an abstraction and use license from the competent authority. The use of underground resources, on the contrary, was free and considered as a part of the rights of landowners.

Only in 1994 this dual regime has ended: the law 36/1994 states that all water uses, including abstractions from the underground, need to be licensed. The implementation of this measure is not easy: some tenth of thousands of private abstractions need to be individuated and monitored.

According to the law, water abstraction licenses are released in order to meet demands; arising conflicts were traditionally left to the discretional power of the licensing authorities, that had the right to decide which use could better serve the public interest. Nowadays, this discretional power is constrained by a number of rules: the need to respect the water balance planned at the basin level; the need to release minimum flows; the need to respect a priority ladder that poses drinking water supply first, than agriculture – in case of a water stress – and finally all other productive uses.

The competent authorities were originally the peripheral administrations of the Ministry of Public Works. From the 70s on, with the creation of Regions, these acquired competences on many issues, including a part of water policy. They have newly gained full competence to the whole water abstraction license matter. Water balance issues concerning more than two Regions are dealt with in the Basin Authorities, that are a board in which all Regions included in a river basin and some State ministries are involved.

A similar regime characterizes the water quality issue. Regions are now free to regulate discharges into watercourses according to a plan that individuates water quality objectives and use destinations. Regional water quality plans can introduce special measures in order to protect the water environment from pollution; the approach based on “water protection zones” – eg nitrate vulnerable areas, sensitive areas for eutrophication – is newly foreseen in the legislation, following the input of European Directives.

Pollution control and environmental monitoring have been reorganized under the Regional Environmental Agencies.

Even in the case of water quality, however, the approach dominated by final use requirements is a recent achievement; so far the water quality policy has meant basically the enforcement of a discharge regulation, based on emission standards set up at a national level; and the financing and construction of the baseline sewage treatment network, started in Italy only after 1976.

The level of development of water policies at the Regional level is very differentiated. Especially in the South, the records of environmental protection are very poor.

According to this picture, the Italian regime of water resources management entails different levels:

- State (whose competence is mainly that of frame legislation and implementation of European Directives);
- Regions (competent for water resources planning, pollution control and for all administrative issues; issues of interregional interests are dealt with in Basin Authorities)
- Local authorities, that are in charge of the organization and management of water services, increasingly under inter-municipal organizations, even imposed by the legislation

- Other uses, when not self-supplied, are often served through corporatistic institutions, like users associations and syndicates, often with the involvement of some level of public administration and sometimes with the acknowledgment of a public status (that means in particular entitlement to public subsidies and right to impose/forbid, according to decisions of elected representatives)
  ➔ In particular, irrigation is managed by collective associations of farmers (Reclamation Boards) set up in the 30s having a public status

Table 4 resumes the most important and typical policy instruments foreseen by the Italian legislation.

Table 4 – Environmental policy instruments in the Italian WMS (*)

	Water resources use	**Water quality**
Planning	• Water resources plans aimed at meeting demand and programming infrastructure • **Basin plans should program water balances for relevant sections of watercourses according to use destinations and quality requirements**	• Water quality plans aimed at programming the supply of sewerage schemes • **Basin plans should program water quality requirements according to use destinations**
Licenses	• All water uses need to be licensed (max 70 years) è *Also for groundwater since 1994* • Discretional definition of "public interest" for the release of licenses • *Priority ladder with respect of minimum flows and environmental needs (still lacks proper technical definition with particular respect to minimum flows)*	• All discharges into watercourses and into public sewers need to be licensed • Need to respect concentration standards and absolute limits imposed by legislation è *Unless water quality plans set different emission standards in order to meet quality targets*
Regulation / prevention	• Very weak monitoring and control of actual abstractions	• **Code of good agricultural practice obligatory in vulnerable areas, eg:** ➔ **Disposal of livestock waste** è **Use of fertilizers**
Zoning	• Water resources plans can vinculate particular resources to drinking supply schemes and define appropriate protection measures	• **Functional to implementation of policy measures (eg nitrate vulnerable zones, pesticide vulnerable zones, sensitive areas)** • Protected areas (parks, natural reserves)
Environmental taxation	• Abstraction fees (very modest: 80 ME/year) ➔ Ear-marked for financing investment in the water sector (basically flood control) • *Charges for water services set on a cost-recovery base (not full-cost, especially in the case of agriculture and large water transfers)*	• *Charges for the use of sewerage systems set on a cost-recovery base (not full-cost so far)*
Environmental subsidies	• Water transfer infrastructure almost totally financed by the state • Public budget covers a relevant part of the operational budget of water supply organizations, especially in the case of irrigation	• Public budget has covered the most substantial part of capital expenditure for sewerage and sewage treatment
Water markets	• Not used unless through informal agreements between public bodies entitled to abstraction rights	•
Self regulation /voluntary instruments / Management agreements	• **EMAS recognized as a merit indicator in case of conflicting demands for abstraction license**	• Increasingly used in agriculture, but not specifically for water protection ➔ Codes of good practice voluntary outside vulnerable areas ➔ Voluntary programs for reducing pesticides and fertilizers

(*) in Bold if forthcoming in the legislation; in Italics if foreseen in the legislation but not fully implemented

Command-and-control instruments

The basic policy instrument is represented by use license and authorizations. In the case of water, this instrument is applied for water abstractions, water discharges, works of any kind in the river territory; authorizations are also required for many activities that are potentially harmful for the water environment, such as the disposal of waste and the handling of pesticides. In this last case, 2 levels of authorization are required: one is referred to the product, the other to the technical skill.

Discharges into the soil or into the watercourses require a license unless they are assimilated to household discharges: in this last case they must be connected a public sewer system, if available; otherwise they are enrighted to discharge directly, following the prescriptions of regional plan.

Licenses and authorizations are released in order to meet objectives set up at the planning level.

In theory, regulatory powers of Regions are virtually unlimited: they can impose virtually any kind of regulation. This is linked with the “sovereign” nature of the public authority. As a general rule, however, the public authority is entitled to use only *erga omnes* measures; ad-hoc regulations – eg the restriction of a single permit – are admitted if justified, but generally require compensation.

So far, however, the only concrete alternative to the imposition of general regulations – that is obviously strongly resisted – has been the subsidization of alternative infrastructural measures.

In practice, Italian water policy has been largely dominated by infrastructural and supply-side approach, with a heavy financial involvement of central and regional government. This has regarded water supply – and especially large water transfers aimed at meeting estimated “water needs” – drinking water treatment, sewers, sewage treatment plants. All sectors, including industry and electric power generation, have benefitted from public subsidies; nonetheless it can be believed that the most subsidized one so far has been agriculture.

Much the same can be said in the case of the regulation of harmful activities. Here again the public authority has a virtual power to do anything, yet the true capacity to use this power is subject to many constraints.

In the case of agriculture, in particular, regulations issued at the regional level involve basically the use of pesticides and the handling of fertilizers and livestock waste.

In particular, livestock farms with less than 40 kg of N/ha are assimilated to household discharges; in the other cases management of livestock waste should comply with regulations imposed by regional water quality plans. Fig. 1 shows a more detailed analysis of regulatory measures foreseen in the Regions of the Po basin.

In the case of pesticides, the law disciplines the criteria for releasing authorizations (eg admitted active principles, prohibition to authorize products whose effects on the environment are demonstrated as dangerous), sets norms for labeling and packaging, foresees duties of care to be followed in specific circumstances, and sets concentration limits for residues in food. Most of these rules derive directly from Dir. 91/414 and 94/43

This set of rules is recognized as largely insufficient to achieve the desired level of environmental protection, and in particular for avoiding the penetration of fertilizers and pesticides into the water table (Cori 1997).

It is basically through other levers that a reduction and control in the use of these substances is achieved: this occurs in particular through a voluntary approach based on the issue of - facultative – codes of good agricultural practice, whose adoption is incentivated in many ways, including the provision of funds under the EU agricultural funds (Reg. 2078/92) and the promotion of product policies.

A new piece of legislation, whose adoption is almost complete, is going to be issued according to Dir. 91/271 (wastewater) and 91/676 (nitrates). One of the distinctive new instruments will be the obligation for farmers to adopt the CGP within areas that will be delimited as vulnerable to nitrate and pesticide pollution; in case of pesticide contaminations, Regions will be enrighted to ban the use of a particular substance in a certain area. The new act also introduces criteria for the provision of sewerage systems, according to the final destination of discharges (normal areas, seneitive areas, less sensitive areas).

Figure 1 – Livestock waste management regulation in the Regions of the Po basin

Environmental parameter	**Piemonte**	**Lombardia**	**Veneto**	**Emilia-Romagna**
Definition of slurry	Regions adopt slightly different definitions; normally all liquid waste originating from solid and liquid animal dejection and residues from feeding and washing			
Acceptable load (live weight/ha or N/ha)	40 q/ha live weight 250-500 kg of N, according to nature of soil	35 q/ha (cattle) 30 q/ha (pigs) 20 q/ha (poultry)	Varies according to livestock species and zones (A, B, C, D)	Varies according to livestock species and zones
Minimum size that renders slurry application plans obligatory	50 heads cattle 200 heads sheep 2000 heads poultry	8.000 kg of live weight (3.000 for poultry)	always	Always, but simplified for farms generating less than 500 mc of slurry
Fertilization plans	Not foreseen	Obligatory in certain areas with heavy loads individuated by Region	Obligatory in order to demonstrate to be able to exceed the above limits	Obligatory in order to demonstrate to be able to exceed the above limits
Competent authority for administration	Province	Municipality, with veto power by Health Authorities and Agricultural Inspectorates	Province	Province
Vulnerable areas	Not foreseen	Not foreseen unless for determining where fertilization plans are necessary	Zone B: lagoon of Venice Zone C: aquifer recharge, flood expansion areas, areas that are vinculated for hydrogeologic reasons	Individuated according to regional guidelines
Registers of slurry application	Foreseen	Foreseen	Not foreseen	Foreseen
Slurry storage capacity	120 days	180 days with 3 comprtments	180 days (poultry and pigs) 120 days otherwise	120 days for cattle 180 days otherwise
Bans on slurry application	If soil is frost or covered by snow; if there is stagnation of water; if the water table is less than 1,5 m deep	Open flood expansion areas Frost or snow-covered soil; stagnation of water	Frost and water-saturated soils; in zone A, forbidden in non agricultural land, if steep exceeds 15%, in quarrying areas and in areas subject to erosion Around drinking water captations	Urban areas Quarrying areas Around drinking water captations Open flood expansion areas Protected areas Eroded soil
Temporal bans	Not foreseen	1 Nov – 28 Feb	Not foreseen (municipalities can dispose ad hoc bans if necessary)	15 Dec – 28 Feb (1 Dec – 15 Mar in hilly and mountain areas)

Source: Ministero dell'Ambiente, 1998

Economic instruments

Economic instruments are very little diffused. As we have alredy seen, even the full-cost pricing of water services is generally not achieved, particularly in the case of irrigation and sewerage.

The only "environmental taxation" used in the water sector is represented by abstraction fees, that are due in exchange for the license. Their level is very poor (see table 5); the total revenue can be estimated around 80-100 million Euro, almost totally obtained from hydropower licences and industrial uses.

As we see from table 5, the current level of abstraction fees has substantially decreased in real terms since 1933.

Other environmental charges can be considered the sewage collection and treatment charge, whose level had to be calculated in order to cover cost, but in practice used to be determined centrally through budget laws setting maximum level.

In a very similar way, other collective bodies – such as Reclamation Boards, Sewerage Syndicates – raise charges from their associates in order to finance at least part of their activities.

Table 5 – Abstraction fees in Italy, according to water use

Use	Unity of measure (*modulo*)	Fee 1933 (ItL./*modulo*)	Fee 1994 (ItL./*modulo*)	Fee 1994 (ItL./mc)***	Fee 1933 at 1994 prices (L./*modulo*)
Irrigation (*)	1000 l/sec	200	70.400	0,01	255.785
Irrigation (*)	1 ha	2	640	-	2.558
Fish farming	100 l/sec	-	500.000	0,16	255.785
Sport facilities	100 l/sec	-	500.000	0,16	-
Human consumption	100 l/sec	200	3.000.000	0,95	-
Industrial use (**)	100 l/sec	free	22.000.000	6,98	-
Hydropower	1 kW	12	20.467	-	15.347

(*) The fee for irrigation is reduced by 50% if water is left perculating into the soil
(**) The fee for industrial uses is reduced by 50% if water saving measures are adopted
(***) For irrigation we have assumed a season of 90 dd/year; for other uses we assumed a continuous abstraction along the whole year.

Source: Malaman (1995) and our elaboration

Subsidies are more frequently used. In particular, the public budget has subsidized, directly or indirectly, the most part of the water and sewerage infrastructure, as well as other environmental protection assets, not only for households, but for the productive sectors as well. Agriculture has largely benefitted from the public financing of water transfer schemes and irrigation management.

It must be stressed that the collective management of various environmental infrastructures dedicated to industry and agriculture, in Italy, has to be linked with the small size of individual dwellings, thereby assimilating many water users and polluters to diffused sources, whose monitoring is hihgly problematic. In practice, the provision of a public service – not necessarily integrated with the traditional urban water and sewerage systems – in many cases represents the only credible alternative to "free access" solutions, given the high costs and difficulties of enforcing traditional command-and-control measures. Therefore in all these cases full cost recovery should be evaluated against the disincentive to use the service; and in any case non-marginal cost pricing schemes need to be practiced in order to minimize this disincentive.

In the agricultural sector, other forms of subsidy are used, as compensative measures (eg in the case of "respect areas" around drinking water sources) or in the logic of "management agreements" ained at reducing agricultural pollution. These have received a strong impulse from the CAP, and especially from Reg. 2078/92; yet only in exceptional cases the use of these financial resources has been explicitly targeted to water policy objectives. Subsidies are nonetheless offered to farmers that accept to reduce pesticide and fertilizers application according to measures that vary between Regions. The level of these subsidies is however rarely high enough to stimulate a response that is visible in terms of water policy achievements.

Nor is it generally sufficient to compensate restrictions to agricultural practices in the areas closely surrounding drinking water catchments. Many water supply operators could largely benefit if they could compensate farmers in a wider range in order to achieve a better protection and save money for later removal of nutrients and pesticides. This possibility is largely used in Germany (Barraqué 1995), but not in Italy.

No use is made of tradeable permit systems; however, the Po basin authority has proposed the creation of a "livestock waste bank", foolowing the Dutch example. This proposal has not been yet accepted by Regions.

Voluntary instruments

An increasing diffusion is experimented by water policy measures inspired to the "voluntary approach".

We have already talked about "management agreements", since they normally involve subsidies; and we have already noticed the poor capacity to terget these funds to "environmental" objectives. In fact some Regions have adopted criteria that privilege sensitive areas, protected areas, river corridors etc for the application of these schemes; yet implementation is usually much less strict.

Incentive effects are therefore very often diluted: elected aras are too large, incentives paid are too low, measures are not always well supported by technical assistance and promotion.

Other applications of the voluntary approach that might have beneficial effect on water policy targets – although again not generally targeted specifically to these – are the voluntary programs aimed at the diffusion of biologic agriculture and/or reduced application of pesticides and fertilizers. These programs are typically included in product policies aimed at the creation of trademarks (eg the "Melinda" trademark used for apples in Trentino, requiring a maximum content of pesticide residues among their quality criteria). In other Regions, technical support agencies promote the use of integrated pest management, like in the dedicated program implemented in the grapes/wine sector in Friuli-Venezia Giulia.

The growing commercial success of "environment-friendly" agricultural products – not only in the field of biologic agriculture, but also in the development of high-quality market niches in particular agricultural *filiéres* is also fostering a rapid development of less polluting farming techniques; yet it must be noted that this development hardly regards the areas where intensive farming is more diffused, but more often those areas that are usually defined as "marginal" (see below).

Finally, some "greening" of the agricultural sector – even with respect to water – is promoted by means of technical assistance, more or less formalized into "Codes of Good Practice". The Code of Good Practice for the Protection of Groundwater from Nitrate has been released at the national level, yet every Region can adapt and integrate it according to local specificity. The adoption of the Code has been entirely voluntary so far; the new act implementing Dir. 91/676, however, will make it obligatory within Nitrate vulnerable areas.

Other fields of action of technical support agencies and/or local public services operators include, for example, the creation of dedicated services for collective management of livestock waste; separate collection of toxic waste originating from agriculture (eg pesticide packaging; used oil); facultative use of energy, water and waste treatment facilities

2.4 Agriculture and water resources in Italy

It cannot be a purpose of this paper a full and exhaustive description of the Italian agricultural sector; nonetheless some basic information are needed in order to appreciate the nature of problems arising for water resources management.

A first notable feature of Itlaian agriculture is *fragmentation*. There are more than 3 million farms, for an average surface of 7,5 ha. Small direct property is very diffused.

On the other side, Italian agriculture is typically concentrated at the territorial level, even as a consequence of orography. Productive agriculture is thus concentrated in a few areas, with a strong product segmentation.

Less than 50% of agricultural surface is used for crops and other productions; 18% is grazeland; 24% is devoted to wood/forestation; 9% is unproductive.

A further typical feature is represented by *dualism*.

Thus on one side we have a productive sector, well inserted into international markets of agricultural commodities, accounting for the largest part of total value-addedc in the sector; on the other side, a very large portion of the usable agricultural surface can be considered as "marginal" from the point of view of the market: almost negligible in terms of production and value added, this part of the sector is nonetheless very important in terms of employment and especially for the sake of territory conservation.

Dualism also occurs between "professional" and "part-time/hobby" agriculture: the latter is particularly relevant in the North, usually practiced on very small land portions by people that are elsewhere occupied. Part-time farms are of course far less "vital" and ready to respond to environmental policy measures.

The link between agriculture and water policy occurs in many different ways.

First of all, we have to consider the use of water for irrigation.

As we have seen in chapter 2.2, agriculture is by far the largest water consumer in Italy. Nearly all rivers in the North are intensively developed in order to provide resources for irrigation: this arises a typical conflict with instream uses and/or with river quality. The construction of reservoirs impacts on the natural landscape; during their operation, seasonal peaks and loads are also a cause of

In the South, the conflict occurs more often with other offstream uses, given that irrigation schemes are supplied by the same reservoirs: given the torrential nature of most rivers in the South, the issue of minimum flow itself is scarcely meaningful.

On the other side, it must be stressed that irrigation is a fundamental input for Italian agriculture: it can be estimated that 40% of the value added in agriculture and 60% of agricultural export depends on irrigation (Anbi 1992).

Due to water stress situations irrigation needs to be suspended causing severe losses of production; given that a large part of the agricultural system, especially the "productive" part, has been organized according to the expected availabiity of water, short term losses can be even higher. During the severe drought of 1988-1990, for example, out of an irrigable area of 450,000 ha in the South, only 260,000, 134,000 and 144,000, respectively, could be actually irrigated, for an estimated loss of nearly 1 million Euro every year (Irsa-Cnr 1999).

Irrigated agriculture is of course dependant not only on the availability of water, but also on its quality. From this point of view, irrigated agriculture is particularly vulnerable to specific sources of pollution (eg heavy metals, toxic substances, bacteric pollution); on the other side, it is far less exigent with respect to organic pollution and nutrients.

Even from the point of view of environmental impact of water abstractions and effects on the rural landscape, it must be underlined that agriculture has not only negative effects. In fact it contributes to the replenishment of aquifers: for example it has been shown that a reduction of the agricultural water consumption in the area upstream of the Venice lagoon could severely impact in terms of land subsidence due to the reduced inflow to the water table. The Italian countryside landscape is largely "artificial" since the Middle Age through irrigated agriculture and drainage; whole provinces – like the "rice district" around the river Ticino, in the Po basin – owe to intensive agricultural use of water their phisical character.

A second area of conflict between agriculture and other uses of the water environment is related to soil drainage. Like in the case of irrigation, drainage is a long-lasting challenge, lasting from the ancient Romans and increasingly practiced since the Middle Age. This beneficial effort has transformed previously unlivable regions into developed ones.

In more recent times, however, the environmental costs of drainage have been appreciated more clearly, with respect to the need of conserving wetlands (for sake of biodiversity and filter-ecosystems). Other negative consequences of an excessive land drainage are the stress posed on the hydraulic network in case of heavy rainfalls, with an augmented risk of flooding; and the reduced infiltration of rainwater to the underground, with potential suffering water table levels during drought periods.

Of course agriculture is not the only nor the most important cause of this phenomenon, that is more generally related to the increase of human activities in the plainlands and the consequent pressure exercised on river beds for urban development.

A symmetric problem is represented by the rapid decline of argiculture in marginal areas, causing a sudden abandonment of cultivation and often arising in bad management of the soil, with consequences on the formation of flood peaks, landsliding and soil erosion.

Agriculture also impacts on water resources in a third manner, through pollution it generates.

Surface water pollution is not a very important effect: it is basically caused by point discharges of large livestock farms (concentrated in the North especially along the lowland reaches of the Po basin) and/or eventual accidents. Mismanagement of fertilization and pesticide use (eg intense application just before heavy rainfalls) can be regarded as a further possible source of surface contamination.

Especially in Southern Italy, nutrient loads due to excess of fertilizers are among the causes of eutrophication of large reservoirs used for drinking supplies, in particular in summer, when their level is the lowest.

Much more relevant is the impact of agricultural pollution on underground water, basically to be reconduced to three factors:

- bacteric pollution (especially from open-air livestock)
- nitrates from artificial fertilizers and livestock waste disposal
- pesticides
- toxic substances from non-natural fertilizers (eg waste-derived compost, sewage sludge)

Table 6 – Use of mineral fertilizers in Italy (thousands of tons)

	1990	1992	1993	1994	1995	1996	1997
N	820,5	906,8	910,0	917,9	879,2	918,9	894,0
P	607,9	662,0	613,0	589,2	584,7	545,6	528,0
K	337,7	415,4	397,0	394,1	427,0	418,8	397,5
Total	1766,1	1984,2	1920,0	1901,5	1890,9	1883,3	1819,5

Source: Inea, 1998

Italian agriculture is among the largest users of fertilizers and pesticides in the Oecd.

Total consumption of mineral fertilizers has reached a peak in 1992; in the following years the total quantities have somewhat decreased; yet the mean annual quantity remained substantially stable between 1991 and 1994 around 65 kg/ha of nitrogen, 46 kg/ha of phosphorus and 27 kg/ha of potassium. Some Regions reach far higher figures: Lombardia, Piemonte, Emilia-Romagna, Veneto and Friuli-Venezia Giulia among the others, with figures that are 50-100% higher than the national average (Ministero dell’Ambiente 1998)

Table 7 – Use of pesticides in Italy (thousands of tons)

	1990	1994	1995	1996	1997
Herbicides	27,8	25,9	25,9	25,0	24,9
Insecticides	36,5	33,4	33,4	31,4	30,5
Fumigants	6,7	4,1	4,7	4,9	5,1
Fungicides	65,7	46,8	49,4	48,3	45,8
Other	4,5	4,1	4,3	4,5	4,4
Total	141,2	114,2	117,7	114,1	110,7

Source: Inea, 1998

A slightly better data can be shown for the use of pesticides. After a dramatic increase in the period 1985-1988 (reaching a mean annual of 165 kg/ha) consumption has now decreased on average to 120 kg/ha, below the levels of the early 80s. Nonetheless there is a huge regional variability: Regions like Emilia Romagna and Trentino-Alto Adige – where fruit production is concentrated – reach figures that are 2 to 3 times higher.

In any case, despite the relative reduction in the last 10 years, Italy remains one of the highest consumers of pesticides in the Oecd countries: 766 kg/kmq, against 502 of France, 442 of Germany and 417 of the UK. Only Netherlands, Belgium and japan have higher unitary consumption. Italian figures are in any case not too much higher than the ones of other Mediterranean Countries, like Spain (654) and Portugal (754). It can be believed that these differences are due to the different productive specializations, and especially to the higher share of crops like fruit, grapes etc.

3. Strategies and trends in underground water resources management

3.1 Issues and possible remedies

To sum up, there are three basic issues regarding the effects of agriculture on the water table, therefore determining a conflict between agriculture and other users of the water resources – including the environment itself.

Generally speaking, the linkages between agriculture and underground water resources in Mediterranean Italy are not particularly relevant and widespread. The impact of agriculture on water is much more relevant in terms of the use of surface waters and the arising conflict with alternative offstream uses (especially and increasingly drinking supplies) and the environment (minimum flows, recreational uses).

Excessive abstractions for irrigation are a problem only in very particular areas, like the South of Puglia and Sardegna.

It must be stressed that the Italian rural environment is highly artificial – since drainage and irrigation have been practiced for centuries; therefore, the equilibrium between water and the soil is a result of a long-term adaptation between agriculture and other human activities. In other words, phenomena like land subsidence – or, on the opposite, a sudden rise of the level of water tables – can be linked to agriculture because measures that are apparently environmental-friendly – like the reduction of water needs through the introduction of spray irrigation and the abandonment of traditional irrigation by submersion – may result in negative environmental outcomes, causing harm to other users.

Underground pollution is perhaps the most important negative externality arising from agriculture to the water table. Nonetheless, the diffusion of this phenomenon is highest in the North of the Country and especially in the Po plain or in the North East: these areas however, from an hidraulic and climatic point of view, are much more similar to continental Europe than to "Mediterranean" countries. In Mediterranean Italy, on the contrary, this particular problem is much more limited and to some extent easier to manage, since surface water resources and springs are more important sources for public supplies than the water table itself; and a more serious problem is represented by the eutrophication of upstream reservoirs eventually caused by agriculture.

Figure 2 shows the basic issues in underground water management and the main links with agriculture.

Figure 2 – The main links between agriculture and underground water

	Rising water table	**Lowering water table**	**Pollution of the water table**
Effect	Reduced abstractions cause the sudden rising of the water table in some areas. The main link with agriculture regards the abandonment of traditional farming activities like the flooding of "marshlands" for feed production	Excess abstraction from the underground cause soil subsidence and salt intrusion Spray irrigation reduces infiltration of water to the underground.	Fertilization and pest management cause infiltration of nitrates and toxic substances into the water table Slurry, sludge and waste-derived fertilizers can be contaminated by heavy metals and other toxic substances
Affected areas	Concentrated in a few areas, especially in the surroundings of Milano	The most important cases attributable to irrigation are in Southern Italy (Puglia, Sardegna); in all coastal plains irrigation is one of the causes, but not the most important one.	All the main plainlands, but especially the Po basin, the High Adriatic basins, internal and coastal plains in the South.
Other causes	Reduced abstractions from heavy industry	Excess abstraction is also due to industrial uses (especially in Northern Italy) and public water supplies (coastal plains in the South)	Contamination of soil is also caused by other activities: waste disposal, abandoned industrial sites, rainwater
Affected use	Infiltration of water into cellars and buildings under the soil level Eg: the Milano Metropolitan Railway is frequently flooded	Salt intrusion makes the water table permanently unusable for drinking water supplies Soil instability causes damage to buildings and infrastructure	Contaminated water tables are no longer usable for drinking water supplies
Remedies	Artificial pumping of water Incentive for the restoration of water-intensive agricultural practices Creation of artificial wetlands	Compensate underground water with water transfers Reduce water needs / abandon irrigation Innovative irrigation practices (eg use of brackish water) Favour infiltration of rainwater Favour infiltration of water used for irrigation	Introduce cleaner farming techniques Prevention of pollution in vulnerable areas Invest in potabilization techniques and monitoring systems Divert water supplies / concentrate on cleaner resources with interconnection Evaluate trade-offs between soil contamination and other opportunities for waste and wastewater management

It is on the other side difficult and to many respects meaningless to isolate the impact of agriculture from that of other human activities. Either in the case of excess (or reduced) abstractions, or in the case of pollution, agricultural impact is linked to other sources of impact.

Therefore we should consider the spectrum of all relevant sources of impact causing a particular phenomenon in order to devise alternative actions and remedies. In other words, water problems reveal once more their *transversal* nature, and require an integrated policy, oriented at *problems* and not at *sectors*. As we shall see later on, this is a particularly difficult task in Italy, given that water resources policy as such has a much weaker ranking in the policy agenda than – say – industrial policy, and until recently even agricultural policies. These policy areas have rarely been closely integrated with the aim of orienting policy action to common goals. The example of the poor capacity to address instruments set up by agro-environmental policy is enlightening: this limited capacity to target agricultural policy measures to the achievement of environmental goals is largely dependant on the fact that these policies and funds are managed by agricultural administrations (Ministry of Agriculture, Regional Agricultural Departments) whose sensitivity to environmental policy objectives is comprehensively lower than to the requirements of the traditional "stakeholders" of agricultural policy.

This is obviously linked to the *supply-side* orientation of Italian water policy, that we discussed earlier on, in the sense that water stress situations in a similar context are easily perceived as problems of absolute scarcity, whose solution can be found in the construction of the proper infrastructure. As soon as the water policy begins to face a limit – either environmental or financial – in the provision of new infrastructure, the opposition between of a new approach based on use regulation and demand-side management and other sectoral policies becomes more evident (Massarutto 1997).

With this remark, we can try to single out specific actions that can be directed on the agricultural sector in order to mitigate the negative externalities – or increase the eventual positive externalities – that agricultural activity might have on underground water resources.

There are, basically, three available strategies.

The first one consists in the *supply-side* approach, that is the dominant solution in the past. In order to tackle with underground water stresses, appropriate infrastructure can be realized. This involves either infrastructure directed to agriculture in order to mitigate the impact: for example, collective treatment plants for livestock farms, or long distance transfers in order to prevent abstractions from the water table; or infrastructures for the uses that are negatively affected by agriculture: for example, drinking water treatment plants and monitoring systems.

The second strategy involves a direct action on the agricultural sector aimed at a reduction of negative externalities. Programs aimed at the reduction of polluting farming practices or to the reduction of underground water demand for irrigation are the first obvious example; yet we should consider other less direct actions: reduction of the indirect contamination due to the polluting content of waste-derived fertilizers and sludge;

Symmetrically, a third strategy can try to valorize the positive externalities that the agricultural activity can have in order to mitigate underground water stress. We have observed for example that highly-consumptive irrigation practices in some areas used to generate as a side benefit the partial drainage of the upper part of the water table. In other cases, irrigation entails an artificial recharge of the water table through some sort of a "transfer" between surface water and the water table: this water would otherwise flow to the sea instead of infiltrating into the soil. Other potential external benefits can be represented by the use of irrigation and irrigation infrastructure in order to produce "environmental services" to other sectors: the use of wastewater effluents for irrigation, the use of sewage sludge and compost as a fertilizer, the use of drainage systems and agricultural soil as an expansion area for flood waters are further examples of this. Of course the environmental benefits should be carefully evaluated in an integrated manner: it is not particularly beneficial to remove pollutants from wastewater through effluent treatment, if the same pollutants are later redistributed onto the soil via the sewage sludge.

3.2 Integrated management

Given the rising vulnerability and economic scarcity of the water resources in Italy, one of the trends that are increasingly characterizing the WMS is *integration*.

As we have seen before, the Italian WMS, among the rest of Europe, is one of the most fragmented, either because of the *separation* of water uses – the same water is rarely used twice – or because of the limited *territorial scale* of the technical systems. Moreover, each use is generally concentrated on only one resource, and this increases the degree of vulnerability of the whole system.

Integration is thus sought for in each of these three meanings.

From the point of view of *territorial* integration, the trend is interesting particularly public water supply in the North and partially in Central Italy – while in the South, as we have seen, the presence of large supply system is more normal. In the North integration basically occurs at the provincial or sub-provincial level: the law 36/94 aims at the creation of intermunicipal water and sewerage utilities on an appropriate territorial size, whose extension is determined by Regions. Nearly all Regions have already indicated the provincial level as the most suitable. As soon as the management system will be integrated, it is also more likely that network interconnections will be promoted in order to concentrate production and treatment of drinking water into the same facilities, in order to benefit from scale economies and privilege the use of the best-quality waters. These are usually located in the upper plainland reaches (alluvial conoids) and/or in the springs originating from the Prealpine chain and the Appennine. Around these new sources, the new supply systems are increasingly designed and protection actions concentrated.

From the point of view of integration between *water users*, there is an increasing – thow still slow – trend in favour of the condivision of infrastructures between the same uses. This occurs sometimes between irrigation and industry (water supplied for irrigation is prevoìiously used for compatible industrial activities, eg for cooling purposes). Irrigation and drainage networks are also increasingly involved in the management of sewage effluents, either through direct reuse of treated waters or through the use of sewage sludge as a fertilizer. Again industrial offtakes are sometimes governed through the creation of joint supply facilities in the place of individual pits and/or the generalization of wastewater recycling after appropriate treatment. Water reservoirs used for irrigation and/or power production are increasingly being involved in agreements with public supplies in order to give water in case of a sudden water stress (eg a peak in the demand, unforeseen quality problems) and therefore avoid the necessity of realizing new and expensive transfer systems.

One significant example for our purposes is the option of reusing wastewater for irrigation. This is considered with growing interest, particularly in the South. In table 8 we show the potential water quantities involved: the potential increase is 29% on average; much more interest is the consideration that in Southern Italy – where the water stress is higher – this increase is more significant (36%).

Table 8 – Potential increase in the available resources for irrigation from urban wastewater reuse

	Available resources for irrigation million of m^3	Water supplied to households million of m^3	Potential increase %
North	13.470	2.855	21%
Center	970	1.130	116%
South	3.506	1.274	36%
Islands	2.191	539	25%
Italy	20.137	5.798	29%

Source: Irsa-Cnr, 1999

Of course these figures can provide only a rough estimate: first of all, because not all the wastewater can easily and economically be reused, even because the largest part of it is generated near the coast and irrigable land is located upstream. We must nonetheless consider that the quantitative issue is not the only part of the story. Particularly in the North, wastewater reuse could provide significant benefits since it could prevent discharges into the watercourses, particularly in sensitive areas. In this way, costly add-on treatments – like the removal of nutrients – could be avoided, since the presence of nutrients is definitely a welcome addition to the water used for irrigation. On these grounds, reuse of treated urban effluents is regarded as an “environmental friendly” technique, and is promoted even at the legislative level: the new water act implementing the Urban Wastewater Directive mentions it explicitly among the “appropriate technologies” that can be used in alternative to traditional ones. So far, this option has been disincentivated from the fact that there were no specific technical guidelines and quality standards: effluents had therefore to meet the general requirements for discharges into watercourses, thus generating useless extra-costs (eg for reducing organic pollution and nutrients) while not removing other harmful substances (like heavy metals or bacteria).

Finally, from the point of view of integration between *water resources*, the interconnection of water neworks at the provincial level eases a policy in which both surface and underground waters are used. This allows for example to maximize the use of surface resources when available, and use the water table essentially as a buffer supply system. Artificial infiltration of surface water is also sometimes practiced in order to improve the storage capacity: this is particularly important in Southern Regions, where seasonal concentration of rainfalls and outflows is the highest.

3.3 Prevention of pollution

As we have seen in section 2, the prevention affecting the agricultural impact on the water table occurs basically through administrative regulation and voluntary instruments.

A wide set of regulatory measures have been introduced in the recent past, mostly as a result of European Directives.

Among the most recent measures, as we have seen, we can mention the generalization of public property on all underground waters and thus of the licensing for all water abstractions; and the introduction of a zoning approach aimed at a better targeting of preventive measures concerning activities such as fertilization, pest management and livestock waste disposal.

In recent years, while the development of command-and-control regulation is still strong – though in a way weaker than in the previous decade – an increasing importance is held by the voluntary approach, in part through the use of European funds (Reg 2078/92, *set-aside* etc), in part through autonomous policies managed by Regional agencies, in the field of technical assistance, product *filiére* promotion, education and demonstrative actions.

The *rationale* of this approach is that cleaner agricultural productions would impact significantly, but not dramatically, on production costs; and this impact could be largely compensated provided an effective market segmentation is realized in order to distinguish cleaner products from others.

In general, most efforts seem to be directed not to "biologic agriculture", that is considered as a promising market niche, but not a concrete and practicable option for a significant majority of farms, especially if we concentrate our attention on the highly-productive farms located in the most developed areas – that are also the most polluting ones. Rather, policy efforts seem to search for a gradual but stable improvement (eg reduction, and not elimination, of fertilizer/pesticide application; promotion of local biodiversity, cultural rotation and/or biological and integrated pest management; increase of land / livestock ratios through incentives offered to extensive cultures and / or disincentives to large livestock farms).

In order to maximize the effect in environmental terms, however, it must be stressed that the voluntary approach – especially instruments like land management contracts – should be better targeted to water policy –

As we have argumented before, this difficulty in concentrating the available financial resources on really meaningful environmental targets is one of the main explanation of the limited success encountered so far.

New pieces of legislation, either at the regional or national scale, provide a possible framework through zoning instruments: zones could be used not only with the purpose of graduating command-and-control mesure, but also in order to concentrate in these areas incentive measures.

Another proposal that has been made is the abandonment of a single-case approach in the planning of agro-environmental measures (Irsa-Cnr, 1999). So far, management contracts foreseen in different pieces of European legislation and/or Regional planning documents have been managed separately, thereby generating some confusion among the potentially interested farmers and possibly conflicts among the effects of different measures. The idea could be to reconduce management contracts to *vectors of measures*, whose achievement could be demonstrated, for example, through the use of environmental accounting or multi-criteria techniques.

As we showed before, no use of economic instruments – leaving apart subsidies – has been made so far in order to prevent agricultural pollution. In fact the possibility to use environmental taxation mechanisms is particularly difficult in Italy given the relatively small size of individual farms. Taxes on fertilizers and pesticides have been sometimes proposed (Romano 1998); yet it cannot be believed that the economic incentive alone would significantly modify patterns of use of these substances or encourage technological transitions of any kind.

Livestock waste banks, following the Dutch example, have also been proposed even at the institutional level (for example by the Po basin authority).

We can believe that a joint use of these instruments together with an improvement of the more traditional ones is required in order to achieve better results in the field of protection.

3.4 Demand side management

Demand-side management is considered as an important policy action particularly where a reduction in irrigation demand is the objective.

As we have seen before, all water uses – but in particular irrigation – have largely benefitted from public subsidies that cover still now an important part of the water cost – and the 100% of capital cost.

This has encouraged a highly dissipative use pattern. Infiltration is still the most diffused technique, with a water demand per hectare that can be double than in the case of spray irrigation. Heavy losses need to be accounted in the distribution system, particularly in the North, where water transport canals are nearly always open and not impermeabilized. Nonetheless, it can be estimated that a large part of the reduction in the overall water consumption that has been documented in the last 10 years is due to the abandonment of highly consumptive irrigation practices – submersion of marshlands in particular – substitution of irrigation techniques[1]

This statement should not generalized too far. In fact the areas with the most serious water stress are also the ones where, comparatively, water-saving techniques have the largest diffusion. So for example it is in the “fruit district” of Romagna and in Puglia that drop irrigation is most commonly practiced.

In Puglia it is also beginning to be practiced as an experimental technique the use of brackish / salty waters.

As far as underground water is concerned, however, things are more complicated.

The irrigation system is managed collectively, but it does not reach necessarily all farms; moreover, individual farmers used to integrate the quantity of water received from the collective irrigation facilities with the water extracted from their own wells.

While it is possible for the operator of the collective system to incentivate the diffusion of water-saving technologies – even with the use of the price lever, but more often through technical advice and / or coercitive measures – this option is of course much more difficult to practice in the case of individual wells.

We are now still in the necessity of knowing with some precision how many wells are still open – presumably some tenth of thousands in the whole Country – not to say that each of them should be metered and regularly controlled. It will presumably require a very long time before this will be possible.

It is hardly believable that an increase in the water price alone will determine a significant reduction of water demand, particularly where water saving techniques are already practiced. Anbi (1992) estimates that irrigable land can produce an average per-hectare yearly income of nearly 4,500 Euro, against 1,800 of the case of dry-farming; at the same time, the cost of new water transfers could be estimated in around 800-1,000 Euro/ha/year.

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[1] A constant increase in the diffusion of spray irrigation in the Po basin can be documented, as well as less demanding irrigation techniques for rice. Rice alone accounts for 36% of the whole water consumption for irrigation in the basin (Bernini Carri et al. 1998)

Even if these figures have been estimated in a pre-Mac Sharry scenario and perhaps emphasize exaggerately the value of irrigated production, it is easy to note that the income differential is in any case very high.

Other studies conducted on specific water districts seem to confirm that the elasticity of water demand is quite low. This occurs with great evidence in a short-term analysis (irrigation technology, crops and water distribution system given), simulating a seasonal water stress (Massarutto 1999); but it also occurs in a long-term scenario, where foreseeable price increases are never able to induce radical water saving measures apart the abandonment of some water-intensive crops (Dono 1995).

This statement is still more probable in the case of underground water, since in the absence of a charge for the irrigation service, the only possibility to increase the cost of water is through environmental taxes raised on direct abstractions. Leaving apart all the difficulties and administrative costs entailed in a similar option, a tax on underground water use that could significantly hamper the convenience of irrigation would probably be far too high for having political support; on the other side, a full-cost pricing of collectively supplied water could further incentivate the use of private wells.

Of course it is not particularly useful to reason on this figures on an aggregate basis: much more relevant would it be to consider the available option within definite territorial areas suffering from water stress and/or overuse of the water table. It is in these areas that any concrete alternative for reducing water consumption – including a return of dry farming, even incentivated through agro-environmental funds – should be evaluated.

4. Some perspectives and concluding remarks

In this paper we have tried to show the main important links occurring in Italy between agricultural practices and the stock of underground water resources.

We have seen that underground water use in Italy is far from being “sustainable”, in the broad meaning of this concept that we have mentioned in the introduction.

From the environmental point of view, the use of underground water in some areas seems to have exceeded the natural recharge capacity; agricultural – and not only agricultural – pollution is threatening the quality of aquifers for a long foreseeable future.

From an economic point of view, it must be stressed that the current generation is far from reaching an equilibrium between the true full cost of the water infrastructure and the amount of revenues devoted annually to its renovation and maintenance. The poor level of investment is demonstrated by the limited efficiency of the water network as a whole; this has also an indirect conesequence on underground water, since it generates a further incentive to concentrate supplies on the locally-available, cheaply-developed water table, instead of sustaining the cost of alternative water supplies.

Finally, the delicate issue of access to water at a reasonable price is not definitely solved yet: a significant part of the population, especially in the South, is still relying of insufficient water deliveries; at the same time irrigation remains the largest user of water, and still the demand largely exceeds the available resources. This occurs even because in the past decades the diffusion of irrigated agriculture has been largely promoted in Southern Italy as an option of modernization and development of the local economy: however, the environmental consequences of this policy have been largely neglected.

What are the trends that we can foresee for the future, given the actual policy scenarios?

No doubt that the last decade has shown significant signs of improvement.

Irrigation demand has been stably decreasing; yet this occurred especially in the North – and has been not necessarily and not always beneficial, as we have argumented; while in the South reduction in per-hectare water needs due to the introduction of more efficeint techniques has been a far less important cause of reduction than quantitative restrictions due to droughts and water stresses. The development of water-saving techniques in any case is hardly motivated by the need to save water: it is more probably a welcome, but not totally desired, indirect outcome of actions whose first motivation is the saving of manpower costs, given the higher potential of automation and the far lower labour-intensity of spray or drop irrigation.

Fertilization and pest management practice are on the whole far more controlled and skilled than in the past, and it can be believed that the inflow of residues of these substances into the soil has been reducing with respect to the past; nonehteless, Italy remains one of the largest consumers of fertilizers and pesticides in Europe, and still a lot of work needs to be done in order to improve the technological base of farmers and more generally in order to achieve a better control of the whole *filiéres* of pest management and fertiizing agents (including producers and intermediaries- these last dominated by user cooperatives and public agencies).

So far, achievements in this field have been due partly to administrative regulation, partly to the use of management contracts and voluntary practices, partly to the emerging market scenarios.

Administrative regulation has been largely developed in the past 15 years. New regulations are being introduced right in these very days through the new Water Act implementing the Wastewater and the Nitrate Directives, namely the obligation to adopt the Code of Good Practice within wulnerable areas.

It is hardly believable that it will be possible to increase further command-and-control measures in the future. Even the implementation of the new measures (designation of vulnerable areas, monitoring and licensing of underground water abstractions) will be definitely a difficult task; not all Regions seem to be politically strong enough – and willing enough – to implement them properly.

In fact, it seems evident that a zoning approach aimed at differentiating administrative regulations on agricultural activities will succeed only if the same mesures will be accompanied with a correspondent use of subsidies and management contracts. Therefore, a first important policy issue at the moment seems to be the “reconciation” of these two policy areas, so far managed by different administrative bodies – the Environment and the Agricultural Departments – in order to finalize more effectively both measures to the protection of the environment.

In any case, the costs necessary for the implementation of these measures should not bee emphasized too much.

Pasca (1991) shows that a significant reduction of the environmental impact could be achieved without excessive sacrifices in terms of costs or reduced productivity; this result requires, however, a development of technical and management skills, and therefore significant investment in R&D and vocational training; while well practicable from larger farms, this option poses completely different problems when small farms are involved.

Cori (1999) quotes a study made by Inea with respect to apple production, showing that organic farming techniques and integrated pest management strategies allow higher gross production, lower production costs and far higher margins than traditional techniques (table 9).

Table 9 – Input-output analysis of apple cultivation in Emilia-Romagna

	Traditional	IPM	Organic
Inputs			
Labour (hours)	576.65	560.69	478.36
Machinery (hours)	166.41	122.54	120.06
Chemical fertilizers (100 kg)	5.74	2.94	-
Organic fertilizers (100 kg)	6.36	57.13	291.79
Pesticides (kg)	186.86	134.67	128.29
Fungicides	78.90	47.28	126.07
Insecticides	95.06	77.39	2.22
Acaricides	9.42	5.58	-
Herbicides	3.39	1.92	-
Others	0.09	2.50	-
Energy			
GJ/ha	48.32	31.65	23.97
MJ/100 kg output	120.08	96.30	93.57

Economic results (1,000 lira)			
Gross production	9,526	10,368	18,158
Expenses for fertilizers and pesticides	1,891	1,312	1,427
Gross margin			
Per hectare	7,635	8,600	14,566
Per 100 kg output	21	26	57

Source: Cori, 1997 (quoted from Inea, 1995)

On the other hand, it must be stressed that small individual farms – and especially "part-time" or "hobby" farms, increasingly characterizing the agricultural landscape in many areas – rely on external services for these "technologically intensive" activities: of course these service providers maximize their revenue by selling as much "fertilization" and "pest management" as possible. Fertiliziers and pesticides are produced by firms whose objective is again the maximization of their specific revenue. Therefore a further important policy action should be concentrated on this part of the agricultural *filiére*, and not only on farmers themselves, whose technological awareness is obviously not good enough to compensate the heavy information asymmetry against external providers.

Will the new CAP, and the Agenda 21, impact significantly on the demand of water for irrigation?

This question is not so easy to answer. As we have seen, it is hardly believable that the reduction of agricultural prices and the increase of the water cost will induce a significant change in irrigation patterns; nonetheless, the incentive could be indirect, given the trend towards the progressive abandonment of intensive farming.

It seems clear that the abandonment of intensive farming practices and the development of "greener" techniques – including, but not exclusively, "biologic" agriculture – could gain a significant premium on the final market, provided that a clear segmentation and differentiation of these products is made.

From this point of view, Italy could enjoy a great opportunity (Romano 1999). While in the past the CAP has forced the competition on costs and productivity – thereby concentrating production in a few areas and incentivating the "marginalization" of entire Regions, a strategy based on product quality could alter significantly the competitive advantage of marginal areas, through the development of specific product *niches* based on local products. Such a shift could be largely beneficial to water policy itself, since it could reduce significantly the incentive to engage in "intensive" agriculture even in the areas – eg Puglia, Sicilia – where its cost-competitiveness is definitely scarce and can be maintained only at the expense of cost-subsidization, and low-cost water supply is obviously one of the most important subsidies.

On the other hand, this incentive will not necessarily be highest in the areas with the highest water stresses.

While certainly reducing the appeal of intensive farming in general, these measures are nonetheless likely to increase the vulnerability of all the areas where a productive agriculture will be maintained. This means that in these areas the expected value of irrigation will be much higher than in the past, particularly in the driest climate situations. Paradoxically, the water stress in agriculture would perhaps be more important in the short run – a particularly dry season: these are also the cases in which the conflict with other uses – recreational, but also for water supply in areas with heavy touristic demand – is likely to be highest.

In order to deal with these cases, it seems much more promising to develop an approach to solving water stresses that is more open to direct negotiations between the affected users at the local level, instead of relying on centralized policy instruments.

In the end, we can believe that the ongoing market scenario provides good opportunity for reconducing actual patterns of impact of the agricultural sector on water resources – and aquifers in particular – to sustainability. Yet this effect will not be an automatic consequence of the new PAC and the Agenda 2000: it will require a complex and difficult policy action. This needs to be based on a much wider and effective set of policy instruments, including those based on economic incentivation: yet the greatest difficulty lies in the need to make a better use of already available instruments, that need to be much more focussed and coherent.

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