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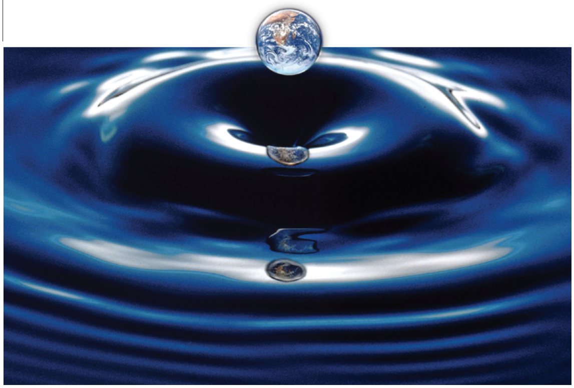

Water resources assessment and water use in agriculture

Istat

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Water resources assessment and water use in agriculture

Essays n. 18 - 2006

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CONTENTS

FOREWORD

This publication reports the results of a project co-financed by Eurostat (Grant agreement n. 200071400004), in order to promote harmonisation of data collection practices, and better comparing the international statistics on Inland Water. Inland Water is an important environmental issue, relevant for determining the hydrological process and for the statistical representation of physical phenomena.

The nine questionnaires on the state of the environment - established in 1980 by Oecd, joint in 1988 by Eurostat - are the first attempt to set up coherent data collections on environmental issues. Inland Water is one of these questionnaires; variables included in the questionnaire, and analyzed in this project, are: fresh water resources, actual external inflow and actual outflow from/to neighbouring territories, annual water abstraction by source, water use by supply categories. This publication gives a focus on methodological aspects and on data sources for the assessment of the main variables of hydrological cycle and describes the connections between water flows. Estimations are given mainly for precipitation, evapotranspiration, total actual outflow to the sea, water exchanges between neighbouring territories. Water use in agriculture is the most relevant among all uses, and the relative environmental effects can be described by statistics on water abstraction by sources, on water supply by categories and by water requirements for crop production and livestock breeding.

Methodological problems are underpinning each of these aspects and are strictly linked to decisions of localisation of gauging station, to collection and treatment of data, and on assessment processes.

Isabella Pierantoni, head of the former Environmental methodologies and statistics Unit in Istat.

One of the results of this study is the review of available data and of the gaps now existing on this issue.

This publication contains the results of the research work carried out in Istat, and finalised with the final report "*Assessment of water resources and water use in agriculture in Italy: methods and data sources*", delivered to Eurostat on February 2004.

A basic contribution has been given by the Central office for agricultural ecology (Ucea), who made a specific study in order to provide a yearly mean and a long term average value both for precipitation and evapotraspiration. Helpful advices were received by Stefano Lo Presti (Agriconsulting s.p.a.) and Graziano Ghinassi (University of Florence); stimulating discussions occurred with Giulio Leone (Land reclamation and irrigation consortia national association, Anbi). Data were provided by Interregional departments, Po River Basin authority, Anbi, National institute of agricultural economics (Inea).

ACRONYMS

AET	Actual Evapotranspiration
Anbi	Land reclamation and irrigation consortia national association (Associazione nazionale delle bonifiche delle irrigazioni e dei miglioramenti fondiari)
Apat	Environmental protection agency and technical services (Agenzia nazionale per la protezione dell'ambiente e per i servizi tecnici)
CWR	Crop Water Requirement
Enav	National institute of air assistance (Ente nazionale di assistenza al volo)
ET	Evapotranspiration
GIWR	Gross Irrigation Water Requirements
Inea	National institute of agriculture economics (Istituto nazionale di economia agraria)
Irena	Indicator reporting on the integration of environmental concerns into agriculture policy
JQ	Joint Oecd/Eurostat questionnaires on the state of the environment
LTAA	Long Term Annual Average
Mop	Multiregional operative programme

Morecs	Meteorological office rainfall and evapotranspiration calculation system
NIWR	Net Irrigation Water Requirements
NUTS	Nomenclature of Territorial Units for Statistics
PET	Potential Evapotranspiration
Ran	National agrometeorological network (Rete agrometeorologica nazionale)
RAW	Readily Available Water
RB	River Basin
Sim	Italian hydrographic and oceanographic service (Servizio idrografico e mareografico)
Smam	Meteorological service of military aeronautic (Servizio meteorologico dell'aeronautica militare)
UAA	Utilised Agricultural Area
Ucea	Central office for agricultural ecology (Ufficio centrale di ecologia agraria)
WMO	World Meteorological Organisation

CHAPTER ONE

INTRODUCTION

The assessment of water resources and water uses in a given country is a basic task in order to monitor the available resources, to promote a sustainable water use, contributing to mitigate the effects of floods and droughts.

The assessment of quantity and dynamic s of water flow and water uses is also established in the Water framework directive of the European parliament and of the council of 23 October 2000 (Directive 2000/60/Ec). This directive establishes a framework for the protection of water resources and according to it, Member states shall protect, enhance and restore all bodies of surface water with the aim of achieving good water status. Member states are so requested to ensure the establishment of programmes for monitoring of water status within each basin. In this sense, the quantity and dynamics of water flows represent the most important elements to monitor. From the data requirements point of view Member states, every two years, are requested to provide data for the *Inland waters* questionnaire, which is one of the nine Joint Oecd/Eurostat questionnaires on the state of the environment (JQ).

The assessment of water resources is realised inside the framework of the hydrological balance. The hydrological balance encompasses all components involved in the hydrological cycle, which in a natural meaning refers to the overall transfer of water between atmosphere, sea and land, in solid, liquid and gas states. The sun is the driving force behind the flow of these resources.

Generally speaking, the hydrological balance has the aim to analyse the distribution of the precipitation among water available for vegetation or evaporations in atmosphere, water which will run on surface of land, water

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Mara Cammarrota, Istat.

which will leach in sub-soil and will replenish ground water tables. Thus the components to analyse in a simplified hidrological cycle are mainly the precipitation, the evapotranspiration, the internal flow and the inflow coming from neighbouring countries, the outflow into the sea and the outflow into neighbouring territories.

The internal flow is the total volume of river run-off and ground water generated in natural conditions exclusively by precipitation into a territory, less actual evapotranspiration generated by natural processes. Total actual outflow is the outflow of rivers and ground water into the sea and outflow in neighbouring territories, included all human induced alterations. These definitions imply methodologies of estimation not really different, since the main difference relates to the criteria of selection of river basins and meteorological and gauging stations.

Updating water resources monitoring was necessary since the main complete information source on this subject in Italy dates back to seventies. In fact the last official data about water resources were elaborated during Water national conference in 1971 (Conferenza nazionale delle acque, 1972) and by Agriculture and forestry Ministry in 1989 (Ministero dell'agricoltura e delle foreste, 1990). Over the last decade Italy has not provided regularly estimates of water resources, due to the lack of studies on this matter.

This report reviews some methodologies for the assessment of water resources in Italy, and gives estimations on some components of the natural hydrological cycle, mainly precipitation, total actual outflow to the sea together with an estimation of actual external inflow and outflow into neighbouring countries.

Water resources assessment is mainly devoted to know quantities of water available in river basins and at national level, and to monitor different uses of the resources in space and in time.

Among water uses, the more relevant one comes from agriculture sector. In this economic sector water is necessary for irrigation, which is responsible for the highest requirements, livestock breeding and fishing follow. Besides direct measurements, water used for irrigation purpose might be estimated through soil water balance calculation. In this way water deficit can be monitored and the appropriate watering practice can be applied. Livestock water requirements include water use for physiological purpose and stable management. An estimation for this use is also possible.

The present study will give an overview on irrigation phenomenon according to diverse perspectives: methodologies applied, diverse data source content and basic data availability. Few highlights on theoretical aspects have been here reported. The analyses mainly focused on recent Italian experiences on data collection and/or estimation of irrigation parameters, and on data available at the National institute of statistics.

The work carried out with this project focused on the investigation of available methodologies, of current data produced by organisations and research institutes concerning the assessment of water resources. The Italian situation is particular with reference to territorial configuration and with the plurality of the institutions involved in services management and in data collecting. These peculiarities made more difficult to carry out this project.

After the identification of the institutions involved in data collection, we started to cooperate with them, in order to assess the availability of data and to create a future network which will have the task to provide up-to-date figures.

This publication reports the results of the research work carried out in Istat with reference to “Grant agreement n. 200071400004 on the investigation of data sources on water abstraction and consumption, as well as estimation of water abstraction and consumption both in agriculture”, supported by Eurostat. The aim of the Grant agreement was to analyze methodologies and to provide data for the 2002 JQ *Inland waters* questionnaire, with reference to tables 1a, 2.1, 2.2 and 3.1 (see Annex 1). The first table *Fresh water resources* includes all variables relevant for the hydrological cycle that is: precipitation, actual evapotranspiration, internal flow, actual external inflow and total actual outflow (of which into the sea and into neighbouring territories). Tables 2.1, 2.2 and 3.1 are involved in this project with reference to agriculture items. In more detail table 2.1 *Annual fresh water abstraction by source* and table 2.2 *Other sources of water* request water abstraction by agriculture, forestry and fishing (of which irrigation) separately for fresh surface water, fresh ground water, non fresh water sources and reused water, whereas table 3.1 *Water use by supply category and by sector* requests water use by agriculture, forestry and fishing with reference to public water supply, self supply and other supply (of which for irrigation purposes).

The parameters relevant for this work are listed in Annex 2 together with their definitions as given in JQ 2002.

This report has the following structure.

Chapter 2 gives a description of territorial configuration of Italy and the institutional point of view. A synthesis of the legislation aspects related to water resources and of the most relevant institutions in charge of monitoring precipitation and outflow of rivers, and managing network of water abstraction and irrigation for agriculture uses is given.

Chapter 3 analyses the principal components of hydrological cycle. These components are looked in detail with reference to an inventory of available data and the different institutions involved in collecting data. Methods commonly used for estimating precipitation (Paragraph 3.1.1), evapotranspiration (Paragraph 3.2.1) and actual outflow (Paragraph 3.4.1) are briefly described. For each of these components, the methodologies used to estimate values for Italy are described together with the results obtained (Paragraphs 3.1.2, 3.2.2, 3.4.2). Paragraph 3.5 provides an estimation of water exchanges between neighbouring countries. The last paragraph of this chapter (Paragraph 3.6) give an overview of obtained results.

Chapter 4 deals with water uses related to agriculture sector. Data available for water abstraction and uses in agriculture are described together with the water balance approach for the estimation of crop water requirement. The paragraphs are developed as such: a description of issues related to water uses in agriculture and a first data analyses of the irrigation practice trend and distribution in Italy is given (Paragraphs 4.1, 4.2). Then a screening of data available to fill JQ *Inland waters* (Paragraph 4.3) has been performed for water abstraction by source (Paragraph 4.3.1) and delivering by supply (Paragraph 4.3.2). To overcome lack of data on water used for irrigation purpose, crop water requirement can also be estimated applying different methodologies. Thus, methodologies, estimates and basic data availability (Paragraph 4.4.1) have been described. An estimate of livestock water requirement has also been applied (Paragraph 4.4.2).

CHAPTER TWO

OVERVIEW OF ITALIAN SITUATION

2.1 Climate, territorial and land use characteristics

In Italy, water resources distribution is affected by the particular geologic, climatic and land use aspects.

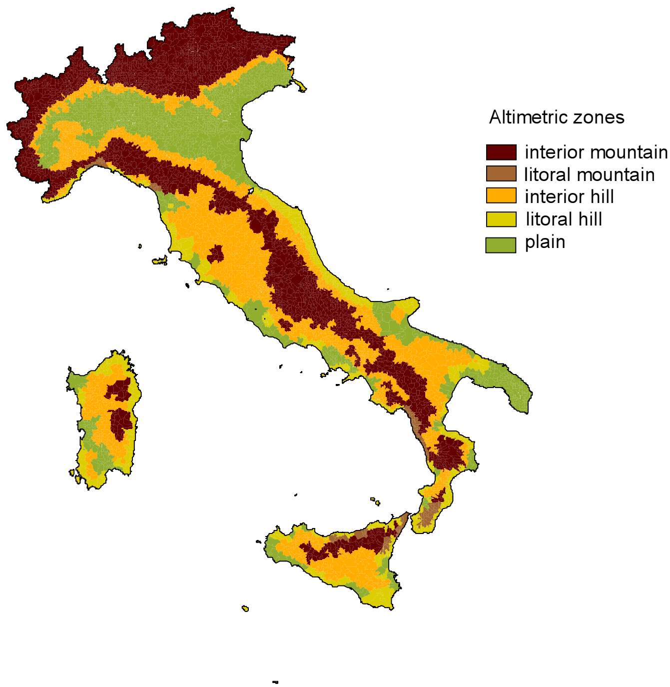
Climatic conditions are mainly affected by the land morphology. Beyond being a *peninsula*, which determine an extension of coasts for 7,456 kilometres, Italy is characterised by mountainous and hilly chains developed along the whole country, as shown in figure 2.1.

The extension of the Italian territory accounts for 30,133,333 hectares. Most of it is classified as hill with a share of 41.6 percent of the total; mountain and plain areas show respectively a share of 35.2 percent and 23.2 percent. Mountain areas are mainly concentrated in northern regions (52.1 percent of the total mountainous area), hilly areas characterise the 52.2 percent of central regions surface, whereas plains are mainly located in northern regions (60 percent of the total plain). Furthermore looking at central regions is evident that they are dominated by hilly areas, which account for 63.8 percent of the regional territorial surfaces (Table 2.1).

Italy is included in a climatic transition zone, between the European continental zone and the Mediterranean one; particularly the borderline is represented by Toscana, Emilia Romagna and Sardegna regions. In the northern side of the borderline precipitation appears more concentrated in high intensity events. In the southern side of this borderline, it is possible to observe a lower degree of precipitation, with a tendency towards long periods of drought.

Giampaola Bellini, Istat (paragraph 2.1); Stefano Tersigni, Istat (paragraph 2.2).

FIGURE 2.1 **Altimetric zones in Italy - Year 2000**



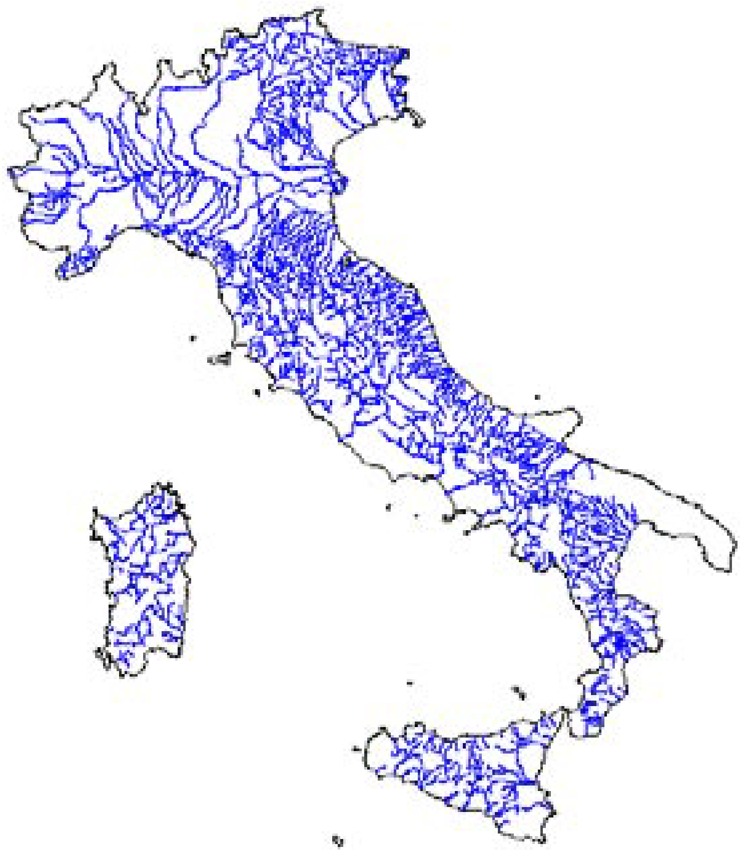
Source: Istat

TABLE 2.1 **Territorial surface per altimetric zone and geographical area – Year 2000** *(surface in hectares)*

GEOGRAPHICAL AREAS	Mountains			Hills			Plains	Total
	Interior	Litoral	Total	Interior	Litoral	Total		
				ABSOLUTE DATA				
North	5,483,688	48,127	5,531,815	2,104,713	167,892	2,272,605	4,187,559	11,991,979
Centre	1,545,845	30,209	1,576,054	2,915,089	808,110	3,723,199	535,307	5,834,560
South	3,111,831	391,390	3,503,221	4,114,029	2,433,513	6,547,542	2,256,031	12,306,794
ITALY	**10,141,364**	**469,726**	**10,611,090**	**9,133,831**	**3,409,515**	**12,543,346**	**6,978,897**	**30,133,333**
				% COMPOSITION				
North	99.1	0.9	46.1	92.6	7.4	19.0	34.9	100.0
Centre	98.1	1.9	27.0	78.3	21.7	63.8	9.2	100.0
South	88.8	11.2	28.5	62.8	37.2	53.2	18.3	100.0
ITALY	**95.6**	**4.4**	**35.2**	**72.8**	**27.2**	**41.6**	**23.2**	**100.0**
				% COMPOSITION				
North	54.1	10.2	52.1	23.0	4.9	18.1	60.0	39.8
Centre	15.2	6.4	14.9	31.9	23.7	29.7	7.7	19.4
South	30.7	83.3	33.0	45.0	71.4	52.2	32.3	40.8
ITALY	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Istat

FIGURE 2.2 **Italian river network**



Source: Istat

Precipitation and temperature trend during the year in a specific location is thus determined mainly by its latitude and altitude position. Those rainfall might have different destinations, such as evaporation, runoff and deep infiltration, depending on geologic characteristics, land morphology and rainfall trend and intensity.

As regards the Italian river network (Figure 2.2), unlike France and Germany dominated by a few big watercourse with regular flow, northern Italian regions are characterised by big river's systems (such as Po, Adige, Piave, Tagliamento, Brenta-Bacchiglione), mainly with regular flow, coming from Alps and flowing into the Adriatic sea. In peninsular Italy, on the other side, the drainage networks are more limited and have more irregular flows, from the seasonal point of view.

Rivers like Tevere, Arno, Liri-Garigliano, Volturno represent an exception.

Land use also contributes to water resource availability. The role of agriculture on land has been recently recognised. In fact agriculture for centuries shaped the landscape in order to cultivate areas with different morphological (slope, plain, etcetera) and climatic conditions, even in areas characterised by extreme climatic events such as flooding or drought. Referring to water resource availability, soil tillage for crop cultivation allows a high rainfall infiltration, thus increasing soil water storage and ground water recharge. At the same time agriculture is one of the most water demanding human activity.

The distribution of agricultural activity among the country gives an understanding of water management and requirement. The national extent of the Utilised Agricultural Area (UAA) is equal to 13,206,297 hectares. The geographical area, which contributes mostly to this activity, is the south of Italy, which cultivates 27.1 percent of the national surfaces, while Puglia is the region with the largest UAA (9.5 percent of the national total); the north-east of Italy (19.8 percent) and central Italy (18.6 percent) follow. Last are the Italian islands (17.4 percent), which include Sicilia's 9.7 percent, and north-western Italy (17.0 percent). The regions that present the relatively lowest surfaces are Valle d'Aosta and Liguria, each representing 0.5 percent of the national UAA (Table 2.2).

Agriculture is the most land consuming human activity, being conducted over 43.8 percent of the national territory. The south of Italy and the islands are the geographical areas where the percentage incidence of the UAA on territorial surface is over the national average, with values of 48.9 percent and 46.2 percent respectively. The regional analysis points out the highest values for Puglia and Basilicata with 64.5 percent and 53.9 percent respectively; on the other side it is possible to find the lowest

TABLE 2.2 **Utilised Agricultural Area region - Year 2000** *(surface in hectares)*

REGIONS	ha	% composition	% of territorial surface *(a)*	Ha per 100 inhabitants *(b)*
Piemonte	1,069,564	8.1	42.1	24.9
Valle d'Aosta	71,188	0.5	21.8	59.0
Lombardia	1,039,817	7.9	43.6	11.4
Trentino-Alto Adige	414,404	3.1	30.5	43.9
Veneto	852,744	6.5	46.4	18.8
Friuli-Venezia Giulia	238,124	1.8	30.3	20.0
Liguria	64,713	0.5	11.9	4.0
Emilia-Romagna	1,115,380	8.4	50.4	27.8
Toscana	857,699	6.5	37.3	24.2
Umbria	367,141	2.8	43.4	43.7
Marche	507,182	3.8	52.3	34.5
Lazio	724,751	5.5	42.1	13.7
Abruzzo	432,040	3.3	40.0	33.7
Molise	214,941	1.6	48.4	65.7
Campania	588,206	4.5	43.3	10.2
Puglia	1,249,645	9.5	64.5	30.6
Basilicata	538,472	4.1	53.9	89.0
Calabria	558,220	4.2	37.0	27.3
Sicilia	1,281,655	9.7	49.9	25.2
Sardegna	1,020,411	7.7	42.4	61.9
ITALY	**13,206,297**	**100.0**	**43.8**	**22.8**
North-west	**2,245,282**	**17.0**	**38.7**	**14.8**
North-east	**2,620,652**	**19.8**	**42.3**	**24.5**
Centre	**2,456,774**	**18.6**	**42.1**	**22.0**
South	**3,581,524**	**27.1**	**48.9**	**25.4**
Islands	**2,302,066**	**17.4**	**46.2**	**34.2**

Source: Istat, Agricultural Census, Year 2000
(a) Surface area - 31st December 2000.
(b) Resident Population - 1st January 2001.

values for Liguria (11.9 percent) and Valle d'Aosta (21.8 percent), which can be explained by means of their orography (Table 2.2).

The relationship between UAA and inhabitants provides us with a further important indication of the territory's propensity to agricultural production. At national level, the UAA represents 22.8 hectares per 100 inhabitants; the Islands and the south of Italy register 34.2 and 25.4

TABLE 2.3 **Utilised Agricultural Area per altimetric zone - Year 2000** *(surface in hectares)*

REGIONS GEOGRAPHICAL AREAS	Mountain		Hill		Plain	
	ha	% of altimetric zone	ha	% of altimetric zone	ha	% of altimetric zone
Piemonte	278,647	25.4	312,496	40.6	478,420	71.3
Valle d'Aosta	71,188	21.8	-	-	-	-
Lombardia	212,122	21.9	96,913	32.7	730,783	65.1
Trentino Alto Adige	414,404	30.5	-	-	-	-
Veneto	101,935	19.0	112,310	42.2	638,499	61.6
Friuli-Venezia Giulia	25,037	7.5	45,007	29.6	168,081	56.1
Liguria	40,469	11.5	24,244	12.8	-	-
Emilia-Romagna	124,617	22.4	271,353	45.3	719,410	68.1
Toscana	125,630	21.8	650,415	42.5	81,654	42.3
Umbria	95,745	38.7	271,396	45.4	-	-
Marche	103,994	34.4	403,188	60.4	-	-
Lazio	151,806	33.8	433,153	46.6	139,793	40.8
Abruzzo	230,172	32.7	201,868	53.6	-	-
Molise	94,259	38.4	120,683	60.9	-	-
Campania	216,250	46.0	286,845	41.6	85,112	42.7
Puglia	16,354	57.1	568,276	64.8	665,016	64.4
Basilicata	200,958	42.9	287,095	63.7	50,419	62.8
Calabria	172,817	27.4	310,680	41.9	74,724	55.2
Sicilia	309,953	49.3	806,401	51.1	165,301	45.4
Sardegna	126,419	38.5	672,771	41.1	221,222	49.7
ITALY	**3,112,773**	**29.3**	**5,875,093**	**46.8**	**4,218,431**	**60.4**
North-west	**602,426**	**21.9**	**433,653**	**34.5**	**1,209,203**	**67.4**
North-east	**665,993**	**23.9**	**428,670**	**42.1**	**1,525,989**	**63.8**
Centre	**477,174**	**30.3**	**1,758,153**	**47.2**	**221,446**	**41.4**
South	**930,808**	**36.6**	**1,775,445**	**53.2**	**875,270**	**60.5**
Islands	**436,371**	**45.6**	**1,479,172**	**46.0**	**386,522**	**47.8**

Source: Istat

hectares respectively per 100 inhabitants. The north-western area presents the lowest value (14.8 hectares per 100 inhabitants). The regional analysis carried out shows extreme values for Liguria (only 4 hectares per 100 inhabitants), while Basilicata registered 89 hectares per 100

1 The classification of municipalities, where farms are located, by altimetric area makes possible to differentiate flat country, hill and mountain farms.

inhabitants and Sardegna 61.9 (Table 2.2).

The distribution of agricultural activity by altimetric areas[1] shows that 52.7 percent of the 2,553,454 farms is situated on hills, 28.4 percent on plains and 18.9 percent in mountains. Referring to UAA, the percentage compositions per altimetric zone present trends similar to those described for farms. Indeed, whereas 44.5 percent of UAA is located on hills, 31.9 percent and 23.6 percent of such surfaces are situated on plain and on mountains respectively (Table 2.3).

Analysing the incidence of UAA on each altimetric zone it's possible to point out that 60.4 percent of plain is utilised in agriculture, while in hilly and mountainous areas the value decreases to 46.8 percent and 29.3 percent, respectively (Table 2.3).

Mountainous area is more used for agricultural purpose in Islands where the percentage incidence reaches 45.6 percent, whereas regions where hill is mostly cultivated are the southern one (Islands excluded) with 53.2 percent. Finally UAA represents more than 60 percent of the plain in northern regions (Table 2.3).

2.2 The institutional point of view

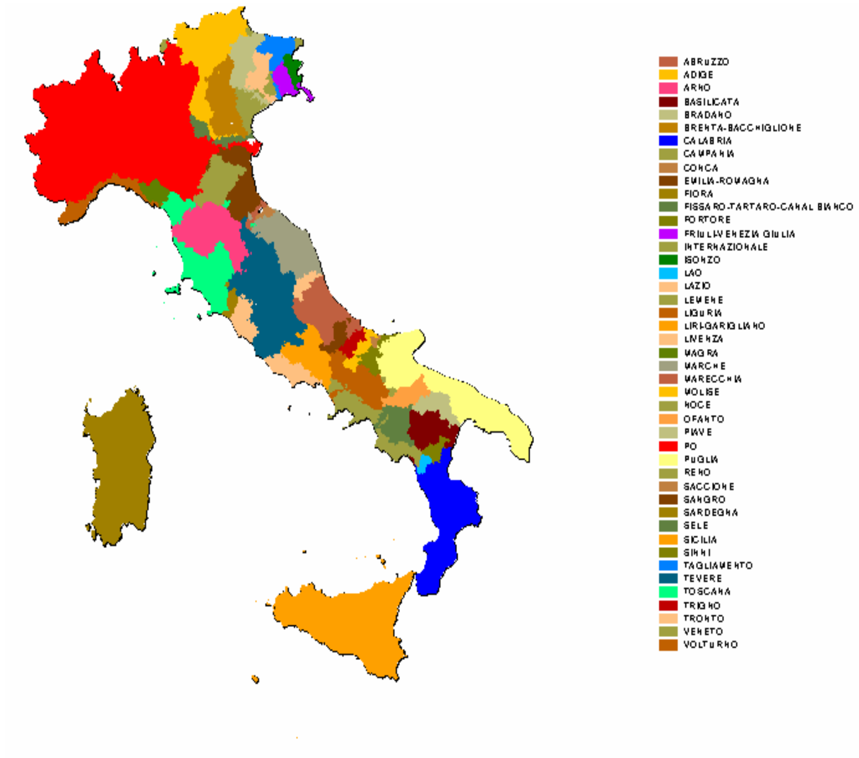
From the institutional point of view, many institutions are in charge of functions related to the hydrological water cycle. Some of them are territorial authorities or managing firms.

Environment Ministry, Regions and River Basin (RB) authorities have the most relevant competencies about water resources.

In particular, the law on land protection n. 183 of 1989 identifies in the River Basin authority the local authority which can, besides other functions, make the hydrological balance and monitor and plan water uses at river basin level. Since authorities settle themselves, they have to express their opinion on water abstraction permissions based on basin water balance, taking into account the resource availability at a specific territorial and temporal level, given the existing water abstraction permissions.

The 183/1989 Act specifies that all national territory, islands included, must be subdivided in RBs. For the aim of the Act, RBs are classified as national, interregional and regional (art. 13). The Act then identifies national (art. 14) and interregional (art. 15) RBs inside the nation-

FIGURE 2.3 **River Basins in Italy**



Source: Istat elaboration on Environment Ministry data

al territory. Moreover, there are small portions of territory, in the Alpine arch, which belong to RBs overlapping with the territory of other nations (international RBs). Nevertheless, international RBs are not considered in 183/1989 Act.

The 183/1989 Act set up the authorities of national RBs (art. 12), in order to pursue the aims of the Act. Regions, with their own legislation, defined the authorities of regional and interregional RBs.

Figure 2.3 describes the territorial localisation of the RBs, defined with 183/1989 Act, while in the following, they are listed together with the Regions involved.

The national RBs in Adriatic area are (art. 14):

Isonzo (Friuli-Venezia Giulia);
Tagliamento (Veneto, Friuli-Venezia Giulia);
Livenza (Veneto, Friuli-Venezia Giulia);
Piave (Veneto, Friuli-Venezia Giulia);
Brenta – Bacchiglione (Veneto, Trentino-Alto Adige);
Adige (Veneto, Trentino-Alto Adige);
Po (Piemonte, Valle d'Aosta, Liguria, Lombardia, Trentino-Alto Adige, Veneto, Toscana, Emilia Romagna).

The national RBs in Tyrrhenian area are (art. 14):
Arno (Toscana, Umbria);
Tevere (Emilia-Romagna, Toscana, Umbria, Marche, Lazio, Abruzzo);
Liri – Garigliano (Lazio, Campania, Abruzzo);
Volturno (Abruzzo, Lazio, Campania).

The RB Alto Adriatico authority is competent for all rivers flowing into Adriatic sea, from north of Adige RB to national border (art. 14). In the same way RBs of Liri-Garigliano and Volturno are under the same authority (DPCM of 10 August 1989).

The interregional RBs in Adriatic area are (art. 15):
Lemene (Veneto, Friuli-Venezia Giulia);
Fissero – Tartaro –Canal Bianco (Lombardia, Veneto);
Reno (Toscana, Emilia-Romagna);
Marecchia (Toscana, Emilia-Romagna, Marche);
Conca (Marche, Emilia-Romagna);
Tronto (Marche, Lazio, Abruzzo);
Sangro (Abruzzo, Molise);
Trigno (Abruzzo, Molise);
Saccione (Molise, Puglia);
Fortore (Campania, Molise, Puglia);
Ofanto (Campania, Basilicata, Puglia).
The interregional RBs in Ionic area are (art. 15):
Bradano (Puglia, Basilicata);
Sinni (Basilicata, Calabria).
The interregional RBs in Tyrrhenian area are (art. 15):
Magra (Liguria, Toscana);
Fiora (Toscana, Lazio);
Sele (Campania, Basilicata);

Noce (Basilicata, Calabria);
Lao (Basilicata, Calabria).

Conca and Marecchia RBs are under a unique authority and the same is for Sinni and Noce RBs.

All territories not included by the law in art. 14 and 15 are regional RBs (art. 16) and their limits must be defined by Regions (art. 10 and 13). In these cases all administrative functions are delegated to Regions.

Till now the delays in the definitions of basin planning, the recent constitutional change, which gave regions more functions, have hampered the take-off of these authorities's normal activities.

The above mentioned national legislative system will be changed by the national implementation of the Water Framework Directive This directive states that Member states have to ensure the appropriate administrative arrangements, including the identification of the appropriate competent authority and the application of the rules of this directive within each RB District lying in their territory.

Moreover, Member states have to ensure that a RB management plan is produced for each RB district lying entirely within their territory. In the case of an international RB district falling entirely within the European community, Member states have to ensure co-ordination with the aim of producing a single international RB management plan.

Apart from the legislative functions of the River Basin authorities, the Italian hydrographic and oceanographic service (Sim) is a relevant technical institution born with the aim to give tools in order to analyse climatic, hydrological and oceanographic phenomena, as support to land defence and to proposals of different uses of water resources. Sim monitors both hydro-meteorological and national oceanographic networks. The monitoring activities were developed from Sim through its 14 Interregional departments, which didn't match with regional aggregation. Starting from D.p.r. n. 207 of 8 August 2002 Sim is located in the Environmental protection agency and technical services (Apat) and their Interregional departments should become component of the Region.

From the point of view of water use management, one of the main Italian law is the law n. 36 of 1994, which imposes the installation of water meters and stresses the need of imposing by law wastewater use limits. Both statements didn't take place and in 1999 the D.l. n. 152 had to reaffirm the necessity of measurements and of rules for wastewater use. For some years only urban wastewater coming from treatment plants could be spread on agricultural soils. At present a new national law, the D.m. n. 185 issued the 12 June 2003, has been released to define the management and the limit for using treated wastewater of industrial settlement origin. Among others, irrigation of land cultivated for human food, fodder or for non-food production represents one way of reusing treated wastewater, with a quantity that won't exceed the crop water requirement. Differentiated parameters have been set for such uses referring to chemical, physical microbiological water characteristics. Apat receives, through the region services, the information on the monitoring activity referring to the agronomic, ecological and pedological effects of wastewater use from the distribution network manager. The delivering network manager is also in charge of monitoring quality of delivered treated wastewater. The wastewater use on agricultural land is anyway constrained according to the code of good agricultural practices (D.m. of 19 April 1999). Furthermore this kind of water has a nitrogen content which has to be taken into account making the annual fertilisation plan.

D.l. n. 152 of 1999 also introduces the basic concept of minimum vital flow of a natural watercourse, beyond which, the existence of the ecosystem depending from it can be threatened. A standard method to calculate it has not been defined yet.

As regards water uses for irrigation purpose, we have to mention also Land reclamation and irrigation consortia national association (Anbi) that play an important role in water management for the agriculture sector. Consortia manages complex infrastructures and represent, mainly in northern regions, the most common water supply (Anbi, 1999, 2000, 2001). Consortia spread across the country are about 200 - not taking into account the complex situation of Piemonte region. Consortia functions have been established with the law on Land reclamation dated 1933 (R.d. n. 215, 13 February 1933). Since they provide a public service their activity is under administrative region surveillance (D.p.r. n. 616 of 1977). Besides their traditional role, they can manage water for recreational reasons and divert water for not consumptive use, like electric power generation or other industrial activity. Moreover they can organise the distribution of wastewater.

A local authority, by means of water abstraction permission, allows access to public water. A water abstraction request has to be applied declaring the amount of water needed (measured in volume of water per second), the final use (hydroelectric power, irrigation, livestock breeding, industrial activity) and, once this permission is given, a predefined fee has to be paid to the public administration. From the farms perspective, farmers have to pay money for water use to the public administration in case of direct abstraction (case of self supply) or to the manager of the water works (case of other supply), which abstracts water.

In the past, the reference authority was the Region, but in the last few years this function passed to the Province. This created problems in terms of information availability, since not all regions have already decentralised their functions. The consequence is that archives are often spread spatially and temporally among different institutions.

This particular situation makes clear that different institutions are involved in this matter and the related functions are split up between a high number of territorial authorities and managing firms. This explains why these kinds of projects request more time and resources.

CHAPTER THREE

HYDROLOGICAL BALANCE

Knowledge about hydrological balances implies a complex process of integration of information and statistics coming from different sources and related to different issues. Geological data, climatic and meteorological data, data on run-off and ground water flow are requested. Analysis of these issues implies different expertise, technical institutions and financial resources devoted to research in order to develop and to implement the necessary knowledge.

In Italy the main complete information source on this subject is given by data elaborated during Water national conference, organised by Republic senate in 1971 (Conferenza nazionale delle acque, 1972). Results of this conference have been updated by Agriculture and forestry Ministry in 1989 (Ministero dell'agricultura e delle foreste, 1990). Since then no more complete national estimates on hydrological balances have become available. There are only some estimates on small areas at local level. The river basin authorities, whose take-off is very slow, in the future could improve the knowledge.

Hydrological balance is formed by the following components:

- precipitation (rain, snow, dew, hail);
- evapotranspiration;
- internal flow, or total volume of river run-off and ground water generated by precipitation into a territory;
- actual external inflow and outflow, which represent exchanges of water between neighbouring countries;
- total actual outflow of rivers and ground water into the sea and into neighbouring countries;
- ground water recharge.

Mara Cammarrota, Istat (paragraphs 3, 3.1, 3.2, 3.3, 3.4, 3.4.1, 3.6); Stefano Tersigni, Istat (paragraphs 3.4.2, 3.5).

These components are reported in figure 3.1.

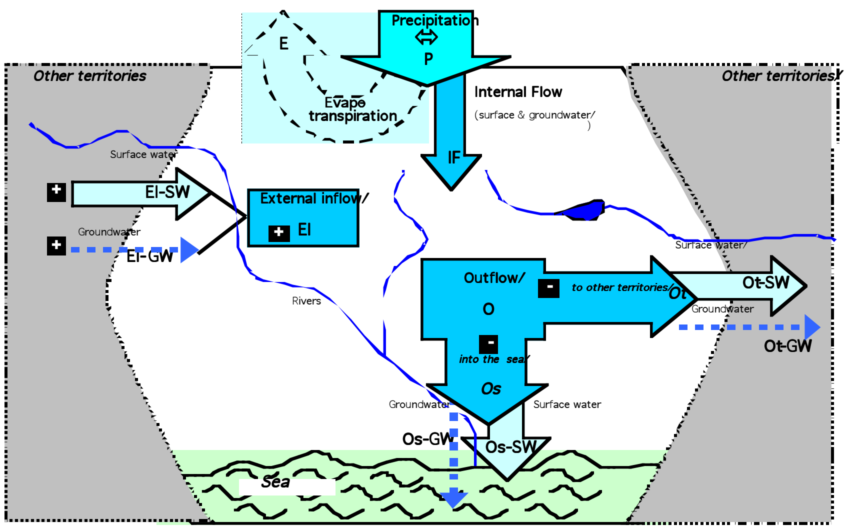
The relationship between the components of a hydrological cycle in an average year, with no changes in water stocks (and prior to exports/imports and water consumption) can be so defined:

IF + EI = Os + Ot

where:

IF = Internal flow
EI = Actual external inflow (from other territories)
Os = Actual outflow into the sea
Ot = Actual outflow into neighbouring territories.

FIGURE 3.1 **A simplified hydrological cycle**



Source: Joint Oecd/Eurostat Questionnaire 2002

In order to calculate the total volume of river run-off and ground water generated by precipitation into a territory, that is internal flow, we have to consider the evapotranspiration. These variables can be so related:

IF = P-AET

where:

P = Precipitation
AET = Actual evapotranspiration.

The Actual external inflow, Actual outflow to the sea, Actual outflow to other territories are composed by surface water and ground water, so we have:

$$P - AET = EI_{SW} + EI_{GW} + Os_{SW} + Os_{GW} + Ot_{SW} + Ot_{GW}$$

where:

EI_{SW} = Surface water external inflow
EI_{GW} = Ground water external inflow
Os_{SW} = Surface water outflow into the sea
Os_{GW} = Ground water outflow into the sea
Ot_{SW} = Surface water outflow into other territories
Ot_{GW} = Ground water outflow into other territories.

All these variables relevant for the hydrological cycle define the *fresh water resources*.

The estimation of total fresh resources have to consider however the total volume of water obtained through the development of new technologies in a given country. These "non conventional resources" refer to water coming from desalination and from wastewater reuse. Moreover ground water available for annual abstraction has to be considered.

In order to assess the components of an hydrological balance, it is necessary to have available data systematically collected and filled, the most important of which are:

— rain, snow, dew and hail for precipitation;
— climate and temperature for evapotranspiration;
— river flows, ground water levels and outflows, lake and artificial levels for all flow measures.

All these variables can be potentially measured through gauging stations and can represent the basic input for estimation models.

In the following paragraphs an overview referring to the most widely methods used for estimating the components of the hydrological cycle will be given. Moreover the available data in Italy will be detailed analysed in order to provide update figures for the JQ 2002.

3.1 Precipitation

The spatial and temporal fluctuations of the hydrological cycle are directly caused by general atmospheric circulation patterns and local factors. In this sense precipitation is a basic variable of the hydrological cycle.

The amount and pattern of rainfall can be determined by a variety of methods, all of which begin with some forms of precipitation measurements. In order to have an overall view of the precipitation amount in a given country, these measurements come from self-reporting raingauge stations in wilderness areas and in more populated regions.

In Italy, the basis for the precipitation assessment is the information coming from the existing national and/or regional monitoring networks.

Nowadays, the raingauge stations spread across our country are managed by different institutions such as Sim, Meteorological service of military aeronautics (Smam), National institute of air assistance (Enav) and Central office for agricultural ecology (Ucea), but also regions manage stations at local level.

However, most of the meteorological stations are managed by the Sim. Raingauge and hydrometric stations compose its monitoring network. It collects data coming from about 3,600 raingauge stations.

Sim provides yearly reports containing data related only to a certain number of stations managed and for selected parameters. These Hydrological yearbooks are divided in two parts: the first one presents data related to raingauge and meteorological variables, while the second one refers to watercourses data. Monthly hydrological summaries are also published by the Sim.

The collaboration created with the Sim enabled us to clarify the real availability of data. For instance, data contained in the mentioned Hydrological yearbooks, coming from the different Interregional departments of Sim, have not the same updating and most of them date back to nineties. Moreover data coming from Sim unfortunately are not all computerised.

Smam and Enav manage stations located near airports, so data are referred to particular situations. These data are always computerised, however lack of data often appears, due to malfunctioning of some stations. Smam and Enav stations belong to the international network of meteorological observatories created among the World weather watch of the World Meteorological Organisation (WMO), so the instruments characteristics and collection methodologies follow the WMO recommendations.

Ucea is a research institute depending on the Agriculture and forestry Ministry policy, whose duty is to monitor weather conditions for agricultural purposes, through a network of meteorological stations (National agrometeorological network, Ran). Most of them monitor rainfall and temperature trends, whereas the rest records more parameters including wind speed, solar radiation, etcetera. The stations are located where agricultural activities are mostly practised, that's why their distribution is mainly at low altitudes.

Ucea manages also a database of the National agricultural information system (National agrometeorological database) containing meteorological and climatological time series for the last 40 years. Data collected come not only from Ucea's stations (starting from 1961) and Ran's stations (starting from 1990), but the network also includes stations belonging to the Smam (starting from 1951) and Sim (from 1951 to 1973).

Ucea disseminates data through a Monthly agrometeorological bulletin.

Due to the growing interest in meteorological phenomenon Istat in 1959 started to disseminate a specific publication on Meteorological statistics.

At first the publication referred to 270 raingauge stations managed by Sim and, for a small number, by Ucea; in 1961 some data coming from Smam were added.

During the last years a reduction in the number of stations contained in the Istat Meteorological statistics appeared. In the last Istat Meteorological statistics handbook, containing data related to 2000-2001-2002 years, 108 stations are considered (Istat, 2005). The chosen stations belong to Smam and to National agrometeorological network of Ucea.

This data sources overview shows that some problems arise in terms of representativeness of time series and spatial data precipitation.

The raingauge stations are spread across the country, but rainfall figures appeared to be low in mountain regions. In fact, the monitoring stations are located mainly at medium and low altitudes and they are not present at high altitudes, apart from some stations belonging to the Sim. This lack of data is relevant since precipitation is a phenomenon more relevant at high altitudes, where precipitation can assume solid forms.

Moreover, there are difficulties to obtain data from all the stations and anyway this vast heritage of observations isn't still almost entirely available, since it has been only partially filled in digital form.

Due to these problems a few studies were realised in order to have an estimation of yearly precipitation in Italy. As mentioned before, in Italy the main complete information source on this subject is given by data elaborated during Water national conference (Conferenza nazionale delle acque, 1972). With reference to this source the yearly value of precipitation calculated for year 1971 was equal to 296 cubic kilometre. Since then no more complete national estimates on precipitation have become available.

In the following, the most common methods used for estimating precipitation will be presented. Furthermore, methods calculating precipitation for a given year and for long term for Italy will be applied.

3.1.1 Methods for estimating precipitation

Methods for estimating precipitation aim at representing the spatial distribution of the precipitation over the territory starting from data recorded at the raingauge stations.

The most common methods used are: arithmetic mean, the Theissen method, Isohyet method and Kriging method.

In selecting the most suitable method, we have to consider the spatial and temporal distribution of the precipitation, the density and distribution of the measurements network, the operativity of the method and availability of data.

The simplest way to determine rainfall amount over a region is the arithmetic mean. This is done using the rainfall collected data for the area considered and figuring an average. This method is valid when there are a large number of stations uniformly distributed in space, when the orography is reasonably flat, and there is a little variability in precipitation measurements.

The Theissen and Isohyet methods take a weighted average of the rainfall data, taking into account that data from one station may represent a larger area than data from another station. In general, however, the reliability of rainfall measurements is a function of the distance of the gauge from the representative area, the size of the area, topography, the nature of the rainfall event concerned, and local storm pattern characteristics.

The Theissen method uses areas subdivided into polygons to achieve a weighted average. To develop the polygons a line is drawn between a station and its immediate neighbours. Each line is then bisected with a line perpendicular to the first one. This line continues until it reaches the next bisector. This process continues until each station is surrounded and the area is covered with the polygons. Finally, the area of each polygon is multiplied by the amount of rainfall at the station it surrounds, the results are added, and the sum is divided by the number of stations. The Thiessen method is used when data are available from stations that are not uniformly distributed in space.

The Isohyetal method consists in a topographical map in that lines of equal rainfall are superimposed over a map of the area. These lines are based on interpolation between raingauge stations. The location of each station is plotted on a map and the amount of rainfall for each station is indicated on the map at its respective station. Next, an interpolation between points is performed and rainfall amounts at selected increments are plotted. Points of equal rainfall are then connected forming an isohyet, a line of equal precipitation. By taking the arithmetic mean between isohyet and calculating the area between each isohyet, the amount of rainfall of that area can be determined. After repeating these steps for all areas in a given area, the final average can be determined by multiplying the mean for each area by the total area, adding the results, and dividing by the number of areas.

The Kriging method, which can be viewed as one of weighted linear interpolation, takes the existing spatial correlation between stations and does so through the semi-variogram. The co-krigged technique can then be used to include other types of information, such as the orography, in rainfall estimation. The advantage that this method holds over other interpolation methods is that Kriging makes it possible to evaluate the error in rainfall. This conventional interpolation method is more suitable for handling data which are distributed with relatively high density and in local area, where the regional conditions are almost homogeneous. With this method data are interpolated using only their spatial statistical characteristics.

The before mentioned methods can be applied on different time scales, hourly, daily, monthly, seasonal, yearly.

3.1.2 Calculation of precipitation for Italy

In order to estimate a yearly value - with reference to year 2000 - for precipitation, we compare two different methodologies: one based on a simple arithmetic mean and the second using the Kriging method.

With reference to the first simple method we processed data published by Istat in the Meteorological statistics handbook (Istat, 2005).

Data referred to 108 raingauge stations managed by Sim and, for a small number, by Ucea, whose spatial distribution is not regular. In the Istat database daily values are recorded in mm. Since some precipitation stations have gaps in their records, for each station, monthly value is calculated when 80 percent of daily values is available.

In calculating a monthly value for the considered stations, we applied the simplest arithmetic mean. The yearly value is the sum of the monthly values from January to December.

In more detail we applied the following equation:

$$P_{year} = \sum_{m=1}^{12} \mu_m$$

where μ_m is the montly mean for all stations.

The amount of precipitation for year 2000 so calculated is equal to 741.8 millimetre. This low value is certainly not representative due to the fact that the arithmetic mean is not suitable for the universe of stations we consi-dered. We started from a few number of stations not uniformly distributed in space: the considered station density is about 1 station per 2,700 square kilometres. Moreover, the orography is not reasonably flat and there is a great variability in precipitation measurements.

The consideration of a greater number of stations and the application of a more suitable method, that is the Kriging method, provide a more representative value. In this sense, Ucea collaborated with Istat and estima-ted precipitation values for year 2000 and for long term by mean of Kriging method, starting from data coming from Ran’s stations and Smam stations, contained in its National agrometeorological database

In more detail, Ucea used the spatial interpolation model that is the Kriging method with an external drift (Matheron, 1970, 1971).

Starting from the consideration that meteo-climatic variables are characterized by variation in space and in time (Sian, 1990, Libertà et al., 1991), the methodology developed considers the meteorological measures divided in two components. The first one, climate, is not variable from year to year and represents the average behaviour of the meteorology system with spatial scales of 200 kilometres. For each meteorological variable, this climate component for a given area is equal to the average seasonal behaviour of the meteorological system. The second component, called residual, represents the spatial-temporal variations from ave-rage behaviour of the meteorology system at a smaller-scales (smaller than 10 kilometres) and characterizes the climatic and meteo-rological variability of the local area.

A particular linear combination provides separately an estimation for “climate” and “residual”, starting from data related to stations sited in the neighbours of the area considered. Different weighted coefficients were calcula-ted for each station point using the spatial contiguity of the meteorological event (through the variogram). The variogram was estimated by classifying pairs of weather stations on the basis of orientation, distance and diffe-rences in altitude, so considering morphological and orographical aspects of land and orographic morphology. For example, the Apennine that runs parallel to the coast of central Italy and the morphological lines of Pianura Padana have been considered. In the last case, the north-south direction has a meteorological variability greater than that of east-west direction. Also the spatial correlations in different season periods have been considered. In fact, it is clear that winter periods have a greater time variability and a clo-ser spatial correlation than summer periods.

The Kriging method has been used to estimate average precipitation amount at the nodes of a regular grid (30 x 30 kilometres).

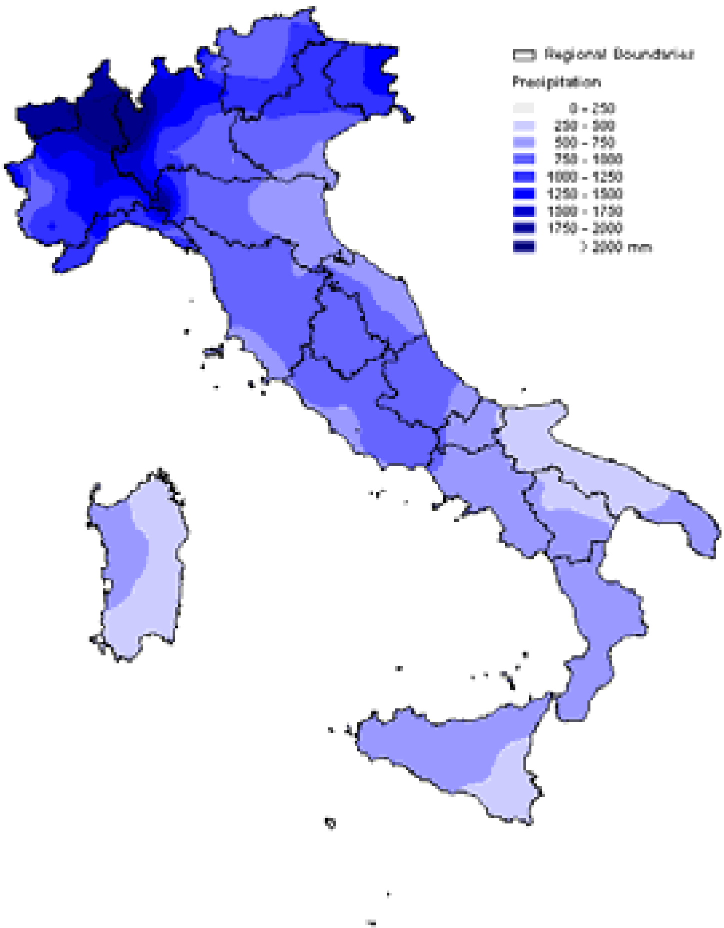
The 544 nodes considered are plotted in figure 3.2.

FIGURE 3.2 **The 544 nodes of a regular grid** *(30 x 30 kilometres)*

Source: Ucea

The amount of precipitation for year 2000 has been obtained by calculating the mean of the values of the 544 nodes. The value so calculated by Ucea for year 2000 is equal to 811.65 millimetre. Figure 3.3 describes the spatial distribution of amount of precipitation for year 2000**.** The map was obtained by interpolating total precipitation value for the points sele-cted (nodes).

FIGURE 3.3 **Total amount of precipitation – Year 2000**



Source: Ucea

The estimation has also been realised computing a time series covering more than 50 years (1951-2002). The related long term average value is equal to 808.14 millimetre.

3.2 Evapotranspiration

The evapotranspiration is the amount of water that is removed from a surface due to the processes of evaporation and transpiration. Evaporation can be defined as the process by which liquid water is converted into a gaseous state, so it can only occur when water is available. Transpiration is the process of water loss from plants through stomata. Stomata are small openings found on the underside of leaves that are connected to vascular plant tissues. Some dry environment plants have the ability to open and close their stomata. The process of transpiration is largely controlled by the humidity of the atmosphere and the moisture content of the soil.

Scientists distinguish between two different aspects of evapotranspiration*:* potential evapotranspiration and actual evapotranspiration.

Potential Evapotranspiration (PET) is a measure of the ability of the atmosphere to remove water from the surface through the processes of evaporation and transpiration assuming never short of water. In the JQ, PET is defined as the water loss from a crop or surface where water supply is sufficient to allow unhindered evapotranspiration. The evapotranspiration rate is influenced by the weather and crop physical factors.

Actual Evapotranspiration (AET) is the quantity of water that is actually removed from a surface due to the processes of evaporation and transpiration. According to the definition contained in JQ the AET is the total volume of evaporation from the ground, wetlands and natural water bodies and transpiration of plants. According the definition of this concept in hydrology, the evapotranspiration generated by all human interventions is excluded, except unirrigated agriculture and forestry[2].

Scientists consider these two types of evapotranspiration for the practical purpose of water resource management. Around the world peasants are involved in the cultivation of a variety of plant crops. Many of these crops grow in environments that are naturally short of water. The two types of evapotranspiration, among other variables, can help in

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[2] In the JQ 2002, it is recommended to not report potential evapotranspiration which is the maximum quantity of water capable of being evaporated in a given climate from a continuous stretch of vegetation covering the whole ground and well supplied with water.

determining how much supplemental water is needed, in order to balance the water deficit, by means of irrigation.

As AET is defined as the amount of water loss actually occurring, it will be less than or equal to the potential rate, depending on rainfall and soil water availability.

The term PET has caused confusion because it has been observed that some crops (like maize) in semi-arid areas had AET rates higher than the PET. In order to solve this problem the Food and agriculture organization of the United nations (Fao) proposed the use of the term reference evapotranspiration" (ET_o) (Allen et al., 1998). This ET_o is defined as the evapotranspiration rate from an extensive surface covered by green pa-sture having a uniform height of 8 to 15 cm that is growing in a normal way, completely covering the ground, affording its own shade and which has sufficient water.

The JQ requests calculation of AET so we'll describe in the following the most widely used means of estimating evaporation independently, rather than treating it as a residual in a water balance equation. Some of these methods have been applied in order to provide an AET estimate for Italy, both for year 2000 and for a long term average value.

We have to outline that a few studies have realised in order to have an estimation of yearly evapotranspiration in Italy. Also in this case the main complete information source dates back to 1971 (Conferenza nazionale delle acque, 1972). With reference to this source the LTAA value of evapotranspiration calculated was equal to 129 cubic kilometres.

3.2.1 Methods for estimating potential and actual evapotranspiration

Few methods for measuring directly AET are available. In fact, direct calculation of AET for specific points in time and in space needs measuring instruments, such as lysimeter, which costs are very high and that can never perfectly recreate the particular soil conditions.

Due to the lack of direct evapotranspiration measurements, indirect methods are commonly used. Among these methods we distinguish:

— methods that calculate AET from PET using a reduction factor, where this factor is a function of soil moisture and the characteristics of the soil-vegetation complex;

— methods that calculate AET from equations which relate this variable to mean value of precipitation and PET.

In the two groups of methods, PET is primarily calculated starting from rainfall and climate data.

The major difference between the various models used to estimate PET derives from the input data they require. For example, if daily air temperature, solar radiation, maximum and minimum relative humidity and wind speed are available, then the Penman-Monteith equation may be used to calculate PET. Where radiation data are available, the Priestley-Taylor equation can be used to estimate the PET. Where only temperature data are available, the Hargreaves or Thornthwaite equations can be used to estimate the potential evapotranspiration.

In the following we present these common methods.

PENMAN-MONTEITH EQUATION

The Penman-Monteith equation (Monteith, 1965) was derived from the classic Penman equation (Penman, 1948) by introducing the concept of resistances to make the wind function explicit.

The resistance nomenclature distinguishes between aerodynamic resistance and surface resistance factors. The surface resistance parameters are often combined into one parameter, the "bulk" surface resistance parameter which operates in series with the aerodynamic resistance. The surface resistance (r_s) describes the resistance of vapour flow through stomata openings, total leaf area and soil surface. The aerodynamic resistance (r_a) describes the resistance from the vegetation upward and involves friction from air flowing over vegetative surfaces. Although the exchange process in a vegetation layer is too complex to be fully described by the two resistance factors, good correlations can be obtained between measured and calculated evapotranspiration rates, especially for a uniform grass reference surface.

The Penman-Monteith form of the combined equation is:

$$\lambda PET = \frac{\Delta(R_n - G) + \rho_a \cdot c_p \dfrac{(e_s - e_a)}{r_a}}{\Delta + \gamma\left(1 + \dfrac{r_s}{r_a}\right)}$$

where R_n is the net radiation, G is the soil heat flux ρ_α is the mean air density at constant pressure, c_p is the specific heat of the air, $(e_s - e_a)$ represents the vapour pressure deficit of the air, Δ represents the slope of the saturation vapour pressure temperature relationship, γ is the psychometric constant, r_s is the surface resistance and r_a is the aerodynamic resistances calculated from wind speed and crop height.

Most of the parameters are measured or can be readily calculated from weather data. The equation can be utilized for the direct calculation of any crop evapotranspiration as the surface and aerodynamic resistances are crop specific.

PRIESTLEY-TAYLOR EQUATION

An empirical approximation of the Penman-Monteith combined equation is made by the Priestley-Taylor equation (Priestley and Taylor, 1972) to eliminate the need for input data other than radiation.

It is reasonable that under ideal conditions evapotranspiration would eventually attain a rate of equilibrium for an air mass moving across a vegetation layer with an abundant supply of water, the air mass would become saturated and the rate of AET would be equal to the Penman rate of PET. Under these conditions evapotranspiration is referred to as equilibrium potential evapotranspiration (PET_{eq}). The mass transfer term in the Penman combination equation approaches zero and the radiation terms dominate.

Priestley and Taylor found that the AET from well watered vegetation was generally higher than the equilibrium potential rate and could be estimated by multiplying the PET_{eq} by a factor α:

$$PET = \alpha \; \frac{1}{\lambda \, \rho_w} \left[\frac{\Delta}{\Delta + \gamma} R_n \right]$$

where R_n is the net radiation, Δ is the slope of the saturation-vapour pressure versus temperature curve, γ is the psychometric constant, ρ_w is the mass density of water, and λ is the latent heat of vaporization.

Although the value of α may vary throughout the day (Munro, 1979), there is general agreement that a daily average value of 1.26 is applicable in humid climates (De Bruin and Keijman, 1979; Stewart and Rouse, 1976; Shuttleworth and Calder, 1979), and temperate hardwood swamps (Munro, 1979). Morton (1983) notes that the value of 1.26, estimated by Priestley and Taylor, was developed using data from both moist vegetated and water surfaces. Morton has recommended that the value should be increased slightly to 1.32 for estimates from vegetated areas as a result of the increase in surface roughness (Morton, 1983; Brutsaert and Stricker, 1979). Generally, the coefficient α for an expansive saturated surface is usually greater than 1.0. This means that true equilibrium potential evapotranspiration rarely occurs; there are always some components of advection energy that increase the actual evapotranspiration. Higher values of α ranging up to 1.74, have been recommended for estimating potential evapotranspiration in more arid regions (Asce, 1990).

THE HARGREAVES MODEL

The Hargreaves model is empirical in nature and with some recent modifications (Hargreaves and Samani, 1982) takes the form:

$$PET = 0.0075 \cdot R_a \cdot C_t \cdot \delta^{\frac{1}{2}} \cdot T$$

where R_a is the total incoming extraterrestrial solar radiation in the same units as evaporation, C_t is a temperature reduction coefficient which is a function of relative humidity, δ_t is the difference between the mean monthly maximum and mean monthly minimum temperatures, and T is the mean temperature in the time step.

THORNTHWAITE METHOD

The empirical Thornthwaite equation (1948) calculates the evapotranspiration in dependence of air temperature:

$$PET = 16 \cdot L_d \left(\frac{10 \cdot T}{I} \right)^{\alpha}$$

where:
T = mean monthly temperature;

I = heat index for the 12 months in the year, that is $I = \sum_{c=1}^{12} i_c$ where $i_c = \left(\frac{T}{5}\right)^{1,514}$;

$$\alpha = \frac{675 \cdot I^3}{10^9} - \frac{771 \cdot I^2}{10^7} + \frac{1,792 \cdot I}{10^5} + 0.49239 \;;$$

L_d = daytime hours in units of 12.

To reduce the calculated PET to the AET some reducing factors can be used, where these factors can be a function of soil moisture, soil temperature and forest vegetation.

Moreover, other models consider the key question of the reduction of PET to AET for the large space scales and long time scales appropriate to climate modelling. Long-term average relationships on the basis of observed records, conceptual modelling at RBs scale, and parametrization of the equations of physical hydrology derived for conditions at a point, have been suggested.

Turc, Pike, and Budyko proposed three methods for estimating the annual evaporation from the annual potential evaporation and the annual precipitation.

Turc (1955) assumed that there would be a limiting rate of evaporation as annual precipitation increased and, on the basis of records of 250 RBs in different climatic regimes, proposed the formula:

$$AET = \frac{P}{\sqrt{0.9 + \left(\frac{P^2}{PET^2}\right)^2}}$$

where AET, PET and P are, respectively, the annual values of actual evapotranspiration, maximum possible evapotranspiration (based on a cubic relationship with mean annual temperature), and precipitation. Pike (1964) replaced the estimate of limiting evaporation by the Penman estimate of open-water evaporation and found that replacing 0.9 by 1.0 gave better results. In more detail, the maximum possible evapotranspiration is based on a cubic relationship with the mean annual temperature:

$$PET = 300 + 25T + 0.05T^3 \;.$$

When data are available, the mean annual temperature can be corrected with mean monthly precipitation, so we have:

$$PET = 300 + 25Tp + 0.05Tp^3$$

where:

$$Tp = \sum_{i=1}^{12} \frac{P_i T_i}{P}$$

where P_i are monthly precipitation (if water balance refers to one year) or monthly means (if water balance refers to a certain number of years), T_i are mean monthly temperature and P is annual precipitation or mean precipitation of reference period.

Budyko (1948) found that data from the water balance of a number of RBs were intermediate between the exponential and the hyperbolic tangent relationships proposed before. Accordingly, he proposed the geometric mean of the two relationships. Thus:

$$AET = \left[PET \cdot \tanh\left(\frac{P}{PET}\right) P\left(1 - e^{-\frac{PET}{P}}\right)\right]^{\frac{1}{2}}$$

where PET is calculated as a function of the total incoming extraterrestrial solar radiation.

3.2.2 Calculation of actual evapotranspiration for Italy

In Italy there are not stations registering AET data, so it is necessary to apply some estimation procedures.

In order to provide a yearly estimate - with reference to year 2000 - for actual evapotranspiration we compare two different methodologies: one based on the Turc equation and the second using the method followed by Meteorological office rainfall and evapotranspiration calculation system (Morecs), based on a slightly modified version of the Penman-Monteith equation.

With reference to the first simple method (Turc equation) we processed data for 108 raingauge stations.

For each station, starting from the mean monthly temperature and the annual precipitation, we estimated the maximum possible evapotranspiration based on the cubic relationship, mentioned in the previous paragraph, and the mean annual temperature has been corrected with monthly precipitation.

For the 108 stations analysed, we obtained an AET estimation for year 2000 equal to 476.6 millimetres, using a simple arithmetic mean. This value is certainly not representative due to the fact that the arithmetic mean is not suitable for the universe of stations we considered.

To have a more representative data, considering Ucea experience in this matter, Istat involved its experts in making evaluations.

Ucea usually calculates both actual[3] and potential evapotranspiration starting from its agrometeorological stations. The method used to estimate evapotranspiration refers to the Morecs defined by the UK Meteorological office. Data related to PET and AET are analysed by Ucea for three different crops (grass, wheat and barley) and are disseminated by Ucea through its Monthly agrometeorological bulletin. The published data refer to each decade (ten days) of the months.

For this project, Ucea made a study to provide a yearly estimate with reference to year 2000 and a long term estimate for AET related to grass.

The method of Morecs used by Ucea uses a slightly modified version of the Penman-Monteith equation, based on solar radiation, air temperature, vapour pressure, and wind speed, for estimating both potential and actual evapotranspiration; in the latter case adjusting the bulk surface resistance according to the magnitude of the soil moisture deficit.

Starting from the AET values for grass land use so calculated for each station, the spatial interpolation model (Kriging method) described in paragraph 3.1.1 was used by Ucea in order to estimate average AET for grass at the nodes of a regular grid (30 x 30 kilometres) (see Figure 3.2 in Paragraph 3.1.2).

The amount of AET for year 2000 has been obtained by calculating the mean of the values of the 544 nodes. The value so calculated by Ucea,

[3] The definition of actual evapotranspiration calculated by Ucea is quite different from the one used for JQ 2002, since it includes evapotranspiration generated by all human interventions.

assuming a uniform grass cover, for year 2000 is equal to 514.74 millimetres.

This estimation has been realised for a time series over more than 50 years (1951-2002) and the related long term average value is equal to 515.17 millimetres. As these estimations considered a territory totally covered by grass, we can consider these value as referring to the maximum theoretical value of AET in Italy.

3.3 Internal flow

According to Oecd/Eurostat definition, *internal flow* is “the total volume of river run-off and ground water generated, in natural conditions, exclusively by precipitation into a territory. The internal flow is equal to precipitation less actual evapotranspiration and can be calculated or measured. If the river run-off and ground water generation are measured separately, transfers between surface and ground water should be netted out to avoid double counting”.

Not all rivers, and mainly those belonging to small river basins, are monitored by means of gauging stations, and in many cases gauging stations are not sited just where necessary in order to estimate inflow. In all cases river flows, lacking basic data, must necessarily be estimated.

In Italy the hydrometric gauging station networks are managed by the Interregional departments.

The hydrometric monitoring network embraces 1,100 flow measurement stations, of which 400 in telemetering.

The internal flow can be estimated through difference between precipitation and AET. Otherwise it is possible to measure it, through water flow measured by national hydrometric network, at particular conditions (Rees and Cole, 1997, Eea, 2003). The condition that the flow is net of the human influence, in order to capture the net natural process of inflow, imposes a constraint on selecting the representative areas, rivers and gauging stations. It is recommended the selection of representative river basins – in terms of geological area, of precipitation and land use - where the human impact is absent or very limited; time series of at least 30 years must be available for at least one station; selected stations must be sited in sub-basins in the upper reaches of rivers close to the headwaters.

Without available data from gauging station network, it is necessary to choose a methodology for estimating runoff. This is first of all necessary for less important rivers, where there are not gauging stations, and flows can be estimated only applying a coefficient of run-off measured on other rivers to the related precipitation, which are similar from the hydrological point of view.

These estimates can be made through indirect approaches, in which the main variable is the atmospheric wet precipitation (rain, snow, hail, ...), usually measured by meteorological institutes. The relationship between the precipitation and the water flow can be derived using deterministic or statistic approaches.

Methods to estimate run-off can be physical models, conceptual models or multivariate analysis models.

In physical models - i.e. in precipitation-runoff approach - after the estimate of average precipitation, a simulation is done on the functioning of natural laws related to the real physical models of the river basin, including atmosphere, vegetation, land, soil, ground, surface water courses and ground water, and their exchange mechanisms and with other close river basins.

As these models are very complex to develop, in national and regional analysis of water resources it is more usual the use of black box models. In black box models there is not the attempt to use physical laws or define the nature of the system; river basin is assumed to convert input in output through pair of precipitation and run-off values related to the same period, for a long time series.

Conceptual models are, moreover, really very simplified physical models, as they make use of physical laws but they schematise in a very simple way functioning of single natural and anthropic elements inside the river basin.

An example of conceptual model is the Probability Distributed Method (PDM) developed by the Institute of hydrology of Wallingford (UK) (Rees and Cole, 1997).

The PDM is based on precipitation and evapotranspiration data, and is very data demanding (soil properties and vegetation). Data on soils were derived from Fao (1991).

3.4 Actual outflow

Total volume of the actual outflow into the sea takes into account the volume of actual outflow of rivers and volume ground water directly flowing to the sea.

Data referring to outflow of watercourses can be measured by means of gauging stations sited close to the outfall, whereas the volume of ground water discharged into the sea cannot be directly measured. This last parameter can only be estimated.

The number of the hydrometric gauging stations is not large enough to represent all Italian watercourses. Sometimes they are not sited at the outfall of the watercourse since, in the past, the aim of the monitoring network was not directed to evaluate the water resources, but to monitor areas where could be sited specific plants (that is dams, infrastructure or agriculture farms). Outfalls, moreover, can be an unstable point of location of stations, because the unstableness of river-beds and the effects of tides on river stream.

In the following we analyse briefly some estimation methods and than we describe the deepening work realised in collecting and elaborating outflow data.

3.4.1 Methods for estimating actual outflow

In 1989 (Ministero dell'agricoltura e delle foreste, 1990) some measurements and some remarks about methodologies of estimation were given. In particular, an example of multivariate analysis of outflow was presented. This methodology considers:

$$O_i = \mu_i \cdot P_i$$

where P is precipitation, O is outflow and μ is the runoff coefficient, all for the i^{th} month.

As O_i is function of raining days in the month (U_i), of the average temperature (T_i) which brings about evapotranspiration, P_i and O_i change from year to year with different trends. These relations can be so written:

$$O_i = \alpha_i P_{ij} + \beta_i U_{ij} + \gamma_i T_{ij} + O_0$$

where $i = 1,..,12$ is the month and $j = 1,\dots n$, is the year. Coefficients α_i, β_i and γ_i are related to different months, but they don't depend from the year and can be estimated from data through regression analysis. O_0 is a constant.

When higher outflows are caused by high saturation of soil, caused by high precipitation of previous months, an Autoregressive Mobile Average Model (ARMA model) can be used, according to deterministic or probabilistic approaches. These models suppose that each month is influenced by the meteorological situation of the previous months.

For example, a deterministic autoregressive model can consider the outflow at time *t* as linear function of the precipitation of time *t* and of the outflow at time *(t-1)*:

$$O_t = \alpha \cdot O_{t-1} + \beta \cdot P_t$$

α and β have different values in different cross-sections of measurement. If coefficients are related to few reliable and quantifiable variables it is possible to apply this same model to sections different from the observed one, using these same coefficients. For example, in the central area of Calabria region, coefficients are written as function of surface (S) in square kilometres of the river basin, its mean altitude (H) in metres above sea level and the mean monthly precipitation (P) (in millimetres) (Ministero dell'agricoltura e delle foreste, 1990).

Anyway the more usual methodology to estimate outflow of watercourses, when there are not direct available measurements, is by the runoff coefficient. The mean outflow $(\overline{O})$ of a section of a water course can be estimated with the following equation:

$$\overline{O} = \mu \cdot \overline{P} = \mu \cdot \overline{h} \cdot S$$

where $\overline{P}$ is the mean yearly precipitation, $\overline{h}$ is the mean rain height on the river basin, S is upstream area of the considered section. The μ is runoff coefficient applied to the total volume of precipitation and it helps to define the total volume of outflow O of a watercourse, when O is not directly measured.

In condition of very low permeability of soil there is not the infiltration phenomenon in deep stratum of soil; in this case the coefficient μ captures evapotranspiration. Otherwise it is important to know the hydrological and morphological characteristics of RB (surface, mean altitude, slope and drainage network) in order to have a reliable estimate of O.

In Italy the only national study according to estimation RB outflow was done in 1971 (Conferenza nazionale delle acque, 1972) by Prof. C. Fassò. He estimated the outflow of rivers, and main results are given in table 3.1. In this study the outflow in river basins with outfall to the sea was estimated, applying the runoff coefficient approach, calculated through the average discharge, measured by gauging stations sited and active in the most important river basins.

TABLE 3.1 **Average yearly precipitation, outflow to the sea and runoff coefficient in Italian River Basins**

RIVER BASINS WITH OUTFALL TO THE SEA	Average yearly precipitation				Average yearly outflow				Runoff coefficient
	mm	l/s per km^2	km^3	%	mm	l/s per km^2	km^3	%	%
Po river	1,070	33.9	71.8	24.2	670	21.3	47.0	30.3	62.0
RB of Veneto and Friuli Venezia Giulia	1,160	36.8	42.8	14.4	810	25.8	30.0	19.4	70.0
RB of Liguria	1,340	42.5	6.4	2.2	990	31.4	4.8	3.1	74.0
RB of Romagna and Marche	940	29.8	20.6	7.0	460	14.6	10.1	6.5	49.0
RB of Toscana	1,010	32.0	20.9	7.1	470	14.8	9.7	6.3	47.0
RB of Lazio	1,020	32.3	24.1	8.1	440	13.8	10.3	6.6	43.0
RB of Abruzzo and Molise	900	28.5	11.9	4.0	490	15.5	6.5	4.2	54.0
RB of Campania	1,200	38.1	23.2	7.8	670	21.3	12.9	8.3	56.0
RB of Puglia	660	20.9	13.2	4.5	150	4.6	2.9	1.9	23.0
RB of Lucania	800	25.4	7.9	2.7	200	6.5	2.0	1.3	25.0
RB of Calabria	1,170	37.1	16.1	5.4	560	17.9	7.8	5.0	48.0
RB of Sicilia	730	23.1	18.8	6.4	190	6.0	4.9	3.2	26.0
RB of Sardegna	780	24.7	18.3	6.2	250	8.0	6.1	3.9	33.0
ITALY	**990**	**31.3**	**296.0**	**100.0**	**510**	**16.3**	**155.0**	**100.0**	**52.0**

Source: Conferenza nazionale delle acque, 1972

From table 3.1 it results that in river basins sited in the north of Italy (Liguria, Veneto and Po RBs) high levels of precipitation meet high runoff coefficients, while in river basins sited in the south of Italy (Puglia, Sicilia and Sardegna RBs) low levels of precipitation meet very low runoff coefficients. This implies the necessity to investigate better the meaning of the runoff coefficient.

If the μ runoff coefficient is interpreted, it is possible to understand the relation between P and O in different river basins. In order to do this, it is necessary to develop a more deep analysis on hydrological characteristics of river basins. In fact, the discrepancy between precipitation and outflow can encompass not only evapotranspiration, but also infiltration. In a study of Penta (1990), river basins of Calabria, with very low permeability conditions, were selected and for each of them data of O and P measured by Sim were chosen. From the relation:

$$\mu = 1 - bP^{(n-1)}$$

where P is the mean long term value of precipitation, b and n are the same coefficients for all watercourses present in the same region, and $0<n<1$. As precipitation, outflow, temperature and evapotranspiration are the main variables, from the study run by Penta (1990), the result is that for homogeneous regions of south Italy (from Campania to Sicilia) the behaviour of not permeable river basins are almost the same in relation to distribution among losses and outflow. The various functions $\mu=\mu(P)$ are very close between them, so it is reliable to hypothesise that evapotranspiration is the main loss and that μ can be used in order to estimate outflow O, when data are lacking.

As regards smaller river basins with high mean altitude, where more residuals were verified in the relation $\mu=1\text{-}bP^{(n\text{-}1)}$, the analysis of the monthly flows in gauging station in summer months showed the mainly contribution of ground water to the outflow. In this case the author estimated two different coefficients, in order to isolate the contribution of ground water to the outflow.

3.4.2 Calculation of actual outflow for Italy

The basis for the total actual outflow assessment, in this study, has been the information derived from existing national and regional hydrometric monitoring networks.

The considered territorial reference for defining the total volume of the actual outflow of rivers into the sea has been the RB; for each RB we collected data monitored by gauging stations managed by the Interregional departments.

In more detail, we requested the Interregional departments to provide basic mean monthly discharge data available for gauging stations managed, for the last 30 years.

We obtained heterogeneous data: daily and/or monthly data; data related to different period (often less than 30 years and sometimes for not following years) and not always the requested variables. Only in few cases we obtained from Interregional departments an estimate value of total actual outflow of the given RB. Moreover data were not always provided in digital form.

Due to this heterogeneity, in order to define the volume of the actual outflow for each RB, we applied three different methodologies considering the availability of data:

— a direct measure;
— a statistical estimation procedure on the basis of runoff coefficient;
— a combination of the above mentioned means.

A direct measure has been obtained starting from data coming from gauging stations representative for a given river basin. In more detail, we consider the gauging stations sited close to the outfall or far some kilometres from the mouth. Furthermore, we considered data for which a sufficient time series was available.

In this case, for each gauging station, starting from monthly mean discharge data for each year (D_{mi} in cubic metres per second, m^3/s), the monthly mean outflow data (O_{mi}) have been calculated considering the seconds present in a month, that is:

$$O_{mi}=D_{mi} \cdot s$$

$m = 1,\dots,12$

$i = 1, \dots, N$ is the number of years varying for the given stations
where s = number of seconds in a month. According to the month, $2{,}419{,}200 \leq s \leq 2{,}678{,}400$.

Than monthly mean outflow data have been calculated for the observed period by an arithmetic mean and the total outflow for a long term (O_{LTAA}) has been obtained by adding these monthly outflows (O_{LTAAm}):

$$O_{LTAA} = \sum_{m=1}^{12} O_{LTAAm}$$

where $$O_{LTAAm} = \frac{\sum_{i=1}^{N} O_{mi}}{N}.$$

In some cases, Interregional departments provided only data related to hourly, or a fraction of hour, for stage or water level (h), that is the elevation of a water body relative to a fixed site. After estimating the mean daily value of this variable, we calculated the daily mean discharge by a numerical scale. The numerical scale refers to a particular cross-section of a given river and it provides the mean discharge value related to any level of water. These numerical scales were provided for a given cross-section and for a given period (that is a year or more years) by the Interregional departments. The relation between mean discharge and water level allowed us to estimate the mean discharge data not provided, according to the most usual analytical representation:

$$D = a\left(h - h_o\right)^b$$

where constants a, b and h_0 relate to the studied cross-section, but they can change during the time. h_0 is the lowest point of the section in relation to the zero of water level (Ferro, 2002).

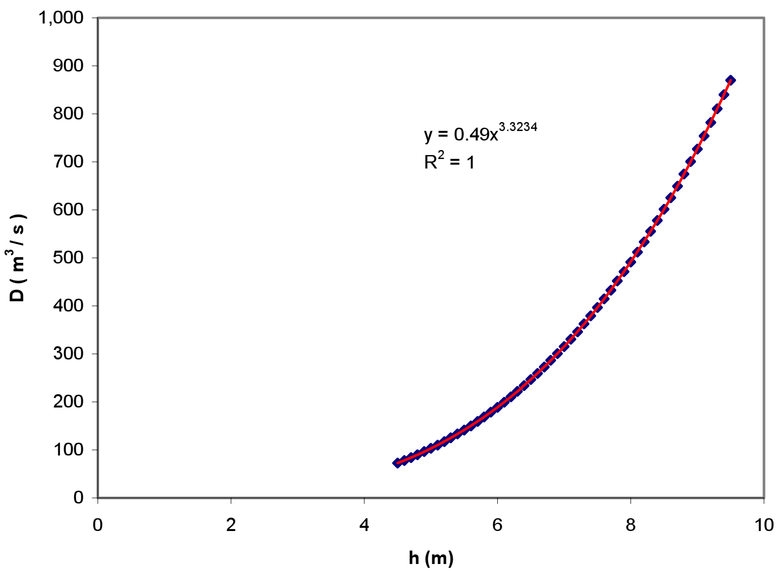
In figure 3.4 we report an example of numerical scale provided by the Interregional department of Rome with reference to Ripetta hydrometric station (Tevere river). The coefficient of exogenous variable so estimated was applied to available level of water values and allowed us to define the corresponding mean discharge values.

When we hadn’t data for representative gauging stations for the river basin, we used a statistical estimation procedure on the basis of runoff coefficient, in order to estimate the outflow. The choice of this simple methodology was due to the great spatial and temporal heterogeneity of data that doesn't permit the application of more complex procedures.

The runoff coefficient of the neighbouring watercourses with the same hydrological characteristics has been used to estimate the outflow of the river where there are not any gauging stations. If we hadn't data also for the neighbouring watercourses, we referred to runoff coefficients coming from scientific papers. These data are the results of monitoring studies realised for a limited period.

When mean discharge data were available but with reference to gauging stations not sited closed to the outfall, we used a combination of the above mentioned means. We calculated a direct measure as previously described for the gauging station with available data. Than the runoff coefficient obtained for this station has been used to estimate the outflow of the RB.

FIGURE 3.4 **Numeric scale for the Ripetta hydrometric station (Tevere river) – Year 1997**



In case of lack of basic data, we provide the estimation of outflow coming from monitoring studies realised in a given river basin for a limited period.

Total actual outflow into the sea for Italy has been calculated adding the outflows related to the different RBs.

Data coming from the gauging stations for which a direct measure has been calculated (gauging stations sited and not sited closed to the outfall), have been stored in a Microsoft Access database. Temporal reference for data is the month. Time series recorded for each gauging stations have different length. In Scheme 1 variables recorded for each gauging stations are reported.

In the following tables (Tables 3.2, 3.3, 3.4) the actual Long Term Annual Average (LTAA) outflow of the RBs is reported.

SCHEME 1 Variables for selected gauging stations recorded in the database

GENERAL INFORMATION ABOUT GAUGING STATIONS	Data recorded *(a)*
Station name	Mean discharge (m^3/s)
River basin/river of location	Maximum discharge (m^3/s)
Length from the outfall (km)	Minimum discharge (m^3/s)
Stream (river) of confluence	Outflow (mm)
Length from the confluence (km)	Precipitation (mm)
Zero of water level (m above sea level)	Runoff coefficient
Latitude	
Longitude	
River basin surface (km^2)	
Maximum altitude of reference basin (m above sea level)	
Mean altitude of reference basin (m above sea level)	

(a) Data are recorded for each month.

In more detail, table 3.2 refers to RBs for which we applied a direct measure and the time series analysed is listed; table 3.3 deals with RBs whose estimations have been realised by mean of a statistical estimation procedure on the basis of runoff coefficient. Table 3.4 lists RBs in which a combination of the above mentioned means was applied.

In each table, the name, the surface and the institutional typologies of RBs are also reported. table 3.2 reports also the time series available for each RB.

As before mentioned, we obtained a direct measure starting from data coming from gauging stations sited close to the outfall or far some kilometres from the mouth, so in table 3.2 we report the total surface of the RB for the first case (gauging stations sited close to the outfall) while in the second case (gauging stations far some kilometres from the mouth) only the upstream area of the RB related to the station is considered (see footnote in Table 3.2). For the residual part of these RBs the estimation of runoff coefficient has been applied (see Table 3.3).

TABLE 3.2 **Actual outflow to the sea estimated with a direct measure**

RIVER BASIN NAMES	River basin surface *(km²)*	Regions included	River basin typology (L. 183/89)	Time series analysed	Actual outflow LTAA *(m³)*
Adige	12,114	Trentino Alto Adige, Veneto, Switzerland	National	1961-1986, 1988-2000	6,217,746,947
Entella	370	Liguria	Regional	1951-75, 1991-96	453,715,748
Lerrone	271	Liguria	Regional	1954, 1956-66, 1968-69	26,183,829
Arroscia (a)	224	Liguria	Regional	1951-75, 1990-94, 1996	170,088,181
Argentina (a)	208	Liguria	Regional	1951-71, 1974-77, 1990-96	156,113,009
Nervia	187	Liguria	Regional	1951-55, 1957-73, 1975	83,129,535
Bevera (a)	155	Liguria, France	Regional	1957-59, 1964-70, 1972-75	82,746,329
Neva (a)	135	Liguria	Regional	1951-54, 1965-71, 1973-77, 1991-96	85,683,735
Impero	94	Liguria	Regional	1952-71, 1973-77	48,247,592
Sansobbia (a)	66	Liguria	Regional	1951-77	36,560,832
Petronio	60	Liguria	Regional	1957-60, 1962-72	41,280,019
Verde (a)	56	Liguria	Regional	1967-70	30,502,656
Varatello (a)	43	Liguria	Regional	1951-59	16,662,144
Bisagno(a)	34	Liguria	Regional	1951-54, 1964-77	45,614,728
Teiro	28	Liguria	Regional	1968-69, 1994, 1996	27,512,496
Lerone (a)	21	Liguria	Regional	1964, 1967-74	14,263,980
Magra	1,694	Liguria, Toscana	Interregional	1951-77, 1987-96	1,217,854,117
Roja (a)	478	Liguria, France	Regional	1951-59, 1962-77	415,408,539
Reno	4,925	Emilia Romagna, Toscana	Interregional	1970-78, 1981-83, 1997-2000	1,186,148,063
Savio	647	Emilia Romagna	Regional	1970-83	311,415,099
Lamone	530	Emilia Romagna	Regional	1971-83	134,956,002

TABLE 3.2 continued **Actual outflow to the sea estimated with a direct measure**

RIVER BASIN NAMES	River basin surface (km^2)	Regions included	River basin typology (L. 183/89)	Time series analysed	Actual outflow LTAA (m^3)
Po	71,057	Piemonte, Valle d'Aosta, Liguria, Lombardia, Veneto, Emilia Romagna, Toscana, Trentino Alto Adige, Switzerland, France	National	1963-2000	49,111,870,000
Arno	8,228	Toscana, Umbria	National	1960-2000	2,541,447,826
Tevere	17,270	Umbria, Lazio, Toscana, Abruzzo, Marche	National	1924-30, 1935-2000	6,979,639,543
Fiora	826	Lazio, Toscana	Interregional	1964-66, 1968 1970-80 1999-2000	245,980,800
Pescara	3,188	Abruzzo	Regional	1922-31, 1936-43, 1945-61, 1965-76, 1982, 1984-2000	1,573,729,586
Biferno	1,300	Molise	Regional	1935-41, 1943, 1948-50, 1953-78, 1986-2000	463,928,290
Feltrino	56	Abruzzo	Regional	1937-40, 1953-67, 1969-78, 1981-94	9,675,936
Volturno	5,445	Campania, Molise, Abruzzo	National	1970-75, 1979-93	2,209,241,381
Sele	3,235	Basilicata, Campania	Interregional	1970-86, 1988-94	1,529,315,153
Alento	414	Campania	Regional	1970-74, 1976-83, 1985-86,1988, 1990-94	127,133,230
Ofanto	2,764	Campania, Basilicata, Puglia	Interregional	1930-43, 1946-97	405,202,170
Carapelle (a)	720	Puglia	Regional	1935-43, 1946-50, 1954-78, 1980-81	92,639,548
Cervaro (a)	657	Puglia	Regional	1928-39, 1941-43, 1946-47, 1899-92, 1994-97	83,262,145

(a) The river basin surface reported refers to the upstream area of the considered gauging stations.

TABLE 3.3 **Actual outflow to the sea estimated with the runoff coefficient**

RIVER BASIN NAMES	River basin surface *(km^2)*	Regions included	River basin typology (L. 183/89)	Runoff coefficient	Precipi-tation LTAA *(mm)*	Actual outflow LTAA *(m^3)*
Fissero-Tartaro-Canalbianco	2,885	Lombardia, Veneto	Interregional	0,70	645	1,302,577,500
Lemene	1,018	Friuli Venezia Giulia,Veneto	Interregional	0,70	1300	926,380,000
Other river basins of Liguria	674	Liguria	Regional	0,74	1340	668,338,400
Other river basins of Emilia Romagna	1,966	Emilia Romagna, Toscana	Regional	0,55	826	893,335,520
Other basins of Marche	5,644	Marche, Umbria	Regional	0,45	886	2,250,262,800
Other river basins of Toscana	5,880	Toscana	Regional	0,47	900	2,487,240,000
Other river basins of Abruzzo and Molise	7,111	Abruzzo, Molise	Interregional, Regional	0,54	900	3,455,946,000
Other river basins of Campania	4,167	Campania	Regional	0,56	1200	2,800,224,000
Other river basins of Puglia	15,859	Puglia	Regional	0,21	650	2,164,753,500
All river basins of Calabria	15,573	Calabria	Regional	0,48	723	5,404,453,920
All river basin of Sicilia	25,710	Sicilia	Regional	0,27	679	4,713,414,300

We outline that over 90 percent of the total outflow of the gauging stations considered in table 3.2 have been calculated with time series data greater than 30 years. For the four national RBs (Adige, Po, Arno, Tevere) we have a time series even greater than 35 years. The outflow of these four RBs accounts 85 percent of the total actual outflow for RBs considered in table 3.2.

In Annex 3 a deepening section is devoted to these national RBs with reference to their territorial characteristics and some data related to mean discharge and actual outflow are reported.

As regards RBs where gauging stations are not present and for which no detailed studies have ever carried out, table 3.3 presents the related outflow LTAA estimated with runoff coefficient. The LTAA is also reported for precipitation.

The estimation has been calculated considering RBs with similar characteristics as a whole. For these groups of RBs the same runoff coefficient and the same mean precipitation value have been applied.

In more detail for all RBs of Sicilia, the values used refer to a detailed study (Maione, 2003).

For RBs of Puglia the runoff coefficient equal to 0.21 refers to the mean of outflow coefficients related to gauging stations sited on rivers Carapelle, Cervaro and Ofanto flowing in the northern part of Puglia. Mean precipitation value has been estrapolated from the isoyetic map of the Puglia, realised for the project “Banca dati tossicologica del suolo e prodotti derivati” (Regione Puglia, 2001)

The runoff coefficient and mean precipitation value for RBs of Emilia Romagna (rivers Riuniti, Bevano, Rubicone and Canale Candiano) relates to the “Piano stralcio per il rischio idrogeologico dell’Autorità dei bacini regionali della Romagna” (2001).

For RBs of Marche the runoff coefficient refers to the mean of runoff coefficients related to gauging stations sited on rivers Potenza, Tronto, Foglia and Metauro which run and flow in Marche territory. Mean precipitation value refers to a LTTA value for that region calculated by centro Operativo agrometeorologico della regione Marche.

RBs of Toscana, reported in table 3.3, are small RBs whose mouths are uniformly distributed in the region. For these RBs the mean precipitation value refers to that calculated for river Cecina, which has climatic and

TABLE 3.4 **Actual outflow to the sea calculated with reference to studies**

RIVER BASIN NAMES	River basin surface *(km^2)*	Regions included	River basin typology (L. 183/89)	Reference	Actual outflow LTAA *(m^3)*
Brenta-Bacchiglione	5,840	Veneto	National	Gruppo 183, 2003	2,333,664,000
Water course of "Bassa Friulana" (risorgive)	560	Friuli V.G.	Regional	Antonelli, Dal Prà,1980	3,784,320,000
Isonzo	3,400	Friuli V.G., Slovenia	National	Gruppo 183, 2003	4,225,824,000
Livenza	2,222	Veneto	National	Gruppo 183, 2003	2,680,560,000
Piave	4,100	Trentino, Veneto, Friuli	National	Gruppo 183, 2003	3,942,000,000
Sile and plain between Piave and Livenza rivers	1,000	Veneto	Regional	Autorità di Bacino del fiume Sile e Pianura tra Piave e Livenza, 2002	1,671,408,000
Tagliamento	2,916	Friuli,Veneto	National	Gruppo 183, 2003	2,585,952,000
Bacini Conca – Marecchia	1,142	Emilia Romagna, Toscana, Marche	Interregional	Autorità Interregionale di Bacino Marecchia – Conca, 2000	1,973,376,000
Main river basins of Marche included the Tronto river basin	8,146	Marche, Umbria, Lazio, Abruzzo	Regional	Ambiente Italia srl - Istituto di ricerche, 2000	4,159,762,651
Albegna	530	Toscana	Regional	Pizzi G., 1998	185,744,448
Bruna	241	Toscana	Regional	Pizzi G., 1998	78,541,920
Cecina	634	Toscana	Regional	A.A.T.O. 5 Toscana Costa, 2000	196,000,000
Ombrone	3,494	Toscana	Regional	Pizzi G., 1998	1,009,152,000
Pecora	128	Toscana	Regional	Pizzi G., 1998	28,854,144
Serchio	1,565	Toscana	Regional	Autorità di Bacino del fiume Serchio, 2001	1,450,656,000
Other river basins of Lazio	3,832	Lazio	Regional	Boni et al., 1993	1,324,512,000
Marta	1,071	Lazio	Regional	Boni et al., 1993	233,366,400
Mignone	496	Lazio	Regional	Boni et al., 1993	88,300,800
Sangro	1,545	Abruzzo	Regional	Consorzio Mario Negri Sud, Progetto Territoriale Sangro-Aventino, 2001	920,851,200

TABLE 3.4 continued Actual outflow to the sea calculated with reference to studies

RIVER BASIN NAMES	River basin surface *(km²)*	Regions included	River basin typology (L. 183/89)	Reference	Actual outflow LTAA *(m³)*
Liri-Garigliano	5,884	Lazio, Abruzzo, Campania	National	Boni et al., 1993	2,838,240,000
Agri	1,660	Basilicata	Regional	LaTIBI 1999	582,257,840
Basento	1,537	Basilicata	Regional	LaTIBI 1999	381,637,100
Bradano	2,811	Basilicata, Puglia	Interregional	LaTIBI 1999	236,082,000
Cavone	568	Basilicata	Regional	LaTIBI 1999	123,867,600
Noce	260	Basilicata	Regional	LaTIBI 1999	302,563,800
Sinni	1,292	Basilicata, Calabria	Interegional	LaTIBI 1999	658,532,400
All river basins of Sardegna	24,090	Sardegna	Regional	Commissario Governativo per l'Emergenza Idrica in Sardegna, 2002	2,775,168,000

hydrological characteristics similar to them. The runoff coefficient considered has been used by the Water national conference in 1971 (Conferenza nazionale delle acque, 1972) for Toscana area.

Mean precipitation value for RBs of Fissero-Tartaro-Canalbianco and Lemene are reported in the Progetto di piano stralcio per l'assetto idrogeologico of the related RB authorities. The runoff coefficient considered has been used by the Water national conference in 1971 (Conferenza nazionale delle acque, 1972) for Friuli Venezia Giulia and Veneto RBs.

As regards RBs of Calabria, the runoff coefficient considered has been used by the Water national conference in 1971 (Conferenza nazionale delle acque, 1972), while mean precipitation value refers to nine raingauge stations managed by Smam uniformly sited in the region and for a time series between 1951 and 1980.

For Liguria, Campania, Abruzzo and Molise, Water national conference in 1971 (Conferenza nazionale delle acque, 1972) was the source of runoff coefficients and mean precipitation values.

Table 3.4 lists the RBs whose runoff coefficients are published in scientific and technical papers reporting works carried out in the last years, in same cases, for limited surface of the territory. However, the studies we analysed for Sardegna region and RBs flowing in Alto Adriatico refer to the all area of them.

3.5 Water exchanges between neighbouring territories

The water exchanges between neighbouring territories are functions of the territorial localisation of the country and of the geomorphology of its land. In Italy, the exchange of water through International rivers represents a less significant part of the water balance. In fact, water exchanges of flow rivers and ground water incoming in the country (actual external inflow) and going into the neighbouring countries (actual outflow into neighbouring countries) occur only in the Alpine arc and include also the flows of two big Alpine lakes bordering to Switzerland (Maggiore and Lugano lakes). These areas refer to RBs whose boundaries do not match with the national border.

The identification of all major rivers which cross national boundaries has been conducted through a detailed analysis of cartography (1:200,000 scale).

Only in few cases (Bevera and Roja rivers) there are gauging stations close to the border, so in general it is possible to quantify the flow variables by means of estimation methodologies.

Different methodologies were used to estimate the long term annual average for the actual external inflow and actual outflow into neighbouring countries for each RB, considering the availability of data.

A direct measure has been calculated only for Bevera e Roja rivers, sited at the boundaries with France. For these rivers the Interregional department provided mean monthly discharge data coming from gauging stations. The available time series are reported in table 3.2.

As regards estimations for rivers Doria Riparia, Diveria, Mera e Ram, whose RBs are sited for the major part in foreigners countries, the statistical estimation procedure on the basis of runoff coefficient has been applied. In more detail a runoff coefficient equal to 0.80 has been used. This runoff coefficient refers to Alpine basins with reference to glaciers (Ciabatti, 1982).

The map reporting the spatial distribution of amount of precipitation realised by Cnr-Irsa (Irsa, 1999) and a detailed analysis of cartography (1:200,000 scale) helped us in estimating the precipitation data for the given RB and the Italian surface of RB.

A complex situation characterised the boundary area with Switzerland (Maggiore lake, Lugano lake and Ticino RB) due to a lot of flow exchanges. For these rivers we considered a total inflow starting from the mean discharge data of the two lakes, as reported in the Information bulletin of the international commission for Italian-Switzerland protection water (Cipais, 2003).

Due to the lack of any kind of references for Isonzo river, the estimation of amount inflow coming from Slovenia has been considered as the 66 percent of total outflow to the sea of this river. This percentage refers to the Italian surface of its RB.

Table 3.5 reports the actual long term annual average external inflow of the major rivers crossing national boundaries. Some associated attributes for rivers, such as the name of the RBs, neighbouring countries and Italian regions involved, are also reported. The different methodologies used and, in case of direct measure, the time series analysed are listed.

The major Italian rivers for which actual outflow into neighbouring territories has been estimated are listed in table 3.6. The three rivers refer to International Danube RB and they feed its major effluents (Inn, Drava and Grail). Also in these cases the statistical estimation procedure on the basis of runoff coefficient has been applied. The runoff coefficient used is equal to 0.80 and mean precipitation value refers to the spatial distribution of amount of precipitation realised by Cnr-Irsa (Irsa, 1999). The Italian surface of RB has been calculated from a detailed analysis of cartography (1:200,000 scale).

Total actual external inflow and total outflow into neighbouring countries have been obtained adding the inflows and outflows calculated for each river. The total actual inflow of rivers coming from neighbouring territories amounts to 7,501 cubic hectometres, while the total outflow of rivers to neighbouring territories amounts to 704 cubic hectometres.

TABLE 3.5 **Actual external inflow**

RIVER OR LAKE NAMES	River basin name	Neighbouring countries	Italian regions	Time series analysed	Methodology used (a)	Actual external inflow LTAA (m^3)
Bevera R.	Bevera	France	Liguria	1957-59, 1964-70, 1972-75	A	82,746,329
Roya R	Roya	France	Liguria	1951-59, 1962-77	A	415,408,539
Dora Riparia R.	Po	France	Piemonte		B	63,072,000
Diveria R.	Po	Switzerland	Lombardia		B	200,000,000
Ticino R.-Maggiore L.-Lugano L. system	Po	Switzerland	Lombardia		C	3,694,127,040
Mera R.	Po	Switzerland	Lombardia		B	145,600,000
Ram R.	Adige	Switzerland	Trentino Alto Adige		B	102,400,000
Isonzo R.	Isonzo	Slovenia	Friuli Venezia Giulia		C	2,798,043,840

(a) The methodologies used are: (A) direct measure; (B) statistical estimation procedure on the basis of runoff coefficient; (C) combination of the above mentioned means.

TABLE 3.6 **Acual outflow into neighbouring territories**

RIVER NAMES	River basin name	Neighbouring countries	Italian regions	Actual outflow LTAA *(m^3)*
Tresenda R - Gallo L.	Inn - Danube	Switzerland	Lombardia	294,400,000
Drava R.	Drava - Danube	Austria	Trentino Alto Adige	208,000,000
Predil L. - Slizza R.	Gail - Danube	Austria	Friuli Venezia Giulia	201,600,000

These values referred exclusively to surface water. As regards ground water, it was not possible to make an estimation. No direct measures exist and no general studies have ever been carried out in Italy.

3.6 An overview of estimated hydrological components for Italy

In order to assess the components of an hydrological balance, in the previous paragraphs we proposed estimates for some components of the hydrological cycle.

The estimations were obtained applying different methodologies not only for a given component but also for the same component, in consideration of the available data.

In the following we give a summary of the results we obtained with reference to precipitation, evapotranspiration, total actual outflow into the sea together with an estimation of external inflow and outflow into neighbouring countries. We report the long term annual average (LTAA); only in few cases we were able to calculate value both for year 2000 and LTAA, due to the lack of data.

As regards the estimation of precipitation for year 2000, we compare two different methodologies starting from the same basic data. The results obtained showed a great discrepancy, revealing the best suitability of the Kriging method compared with a simple arithmetic mean. The results confirm in fact that the mean estimation methodology is not suitable when we consider data with a great spatial and temporal heterogeneity, such as meteorological data.

The Ucea precipitation estimation, using the Kriging method, for year 2000 is equal to 811,65 millimetre. In terms of million cubic metres, it is:

$P_{2000} = 244{,}577.$

As regards LTAA precipitation, the Ucea estimation is 808.14 millimetre. In terms of million cubic metres, it is:

P_{LTAA}=243,519.

LTAA estimation for precipitation reported during the Water national conference (Conferenza nazionale delle acque, 1972) accounted for 990 millimetres of precipitation, that refers to 296 cubic kilometres. The reduction would be probably related to the different methodologies used. The Water national conference estimation was calculated for a greater number of stations (more than 3,000) but with an old reference period (1921-1950).

Also for the estimation of AET for year 2000, we compare two different methodologies. The first one implied the processing of data by mean of the Turc equation, the second one refers to the Ucea estimation, using the Morecs methodology. In this case the discrepancy between the results obtained is related to the methodology used to aggregate data, in order to provide a national value. In the first case a simple arithmetic mean was applied to the AET values calculated for each stations. The more reliability of Ucea estimation is strictly related to the spatial interpolation method (Kriging method) used, however this estimation refers only to grass.

The Ucea AET estimation for year 2000 for grass, is equal to 514.74 millimetres, which in terms of million cubic metres is:

AET_{2000} =155,108.

As regards the average long term actual evapotranspiration, the Ucea estimation is 515.17 millimetres, which in terms of million cubic metres is

AET_{LTAA}= 155,238.

Estimation reported during the Water national conference (Conferenza nazionale delle acque, 1972, Ministero dell'agricoltura e delle foreste, 1990) accounted for 129 cubic kilometres of water with reference to losses, which they considered determinated by AET. No comparison can be made between this Water national conference estimation and Ucea estimation, since the first one has been calculated as difference between precipitation and total outflow. Moreover, as these Ucea estimations consider a territory totally covered by grass, we can say that 155,238 million cubic metres represent the maximum theoretical value of AET_{LTAA} in Italy.

As regards internal flow, due to the lack of direct assessments, we could estimate it through difference between precipitation and AET. Since we have a maximum theoretical value of AET_{LTAA} we can only say that internal flow is surely superior to 88,282 million cubic metres.

As regards water exchanges between neighbouring territories only in few cases there are gauging stations close to the border, so in general it is possible to quantify the flow variables by means of estimation methodologies. In order to estimate the average long term for actual external inflow and for outflow into neighbouring countries related to the RBs, we applied different methodologies, considering the availability of data. Then the total actual external inflow and total outflow into neighbouring countries have been obtained adding the inflows and outflows calculated for each river. So, in terms of million cubic metres, we have:

$EI_{LTAA}= 7{,}501$ and $O_{t,LTAA}= 704$.

These values referred exclusively to surface waters. As regards ground water external inflow and outflow into neighbouring territories, it was not possible to make an estimation. No direct measures exist and no general studies have ever been carried out in Italy.

As regards LTAA estimation for total actual surface outflow into the sea a detailed study was realised due to the great heterogeneity of data. Different methodologies were used for groups of RBs (a direct measure, a statistical estimation procedure on the basis of runoff coefficient, a combination of them). Adding estimation obtained, in terms of million cubic metres, we have:

$O_{s,\ LTAA} = 144{,}013$.

We outline that the outflow measured from the gauging stations represent the 52.9 percent of the total value, the 18.8 percent of outflow comes from estimation with runoff coefficient and the residual 28.3 percent has been obtained considering scientific and technical publications.

As regards total actual ground water outflow into sea, it was not possible to make an estimation.

Adding estimated outflow into neighbouring countries and estimated outflow into the sea we obtained the total actual surface outflow:

$O_s + O_t = 144{,}717$.

Estimation reported during the Water national conference (Conferenza nazionale delle acque, 1972, Ministero dell'agricoltura e delle foreste, 1990) accounted for 155 cubic kilometres of actual surface outflow into the sea. This estimation was the result of runoff coefficient methodologies.

CHAPTER FOUR

WATER RESOURCES FOR THE AGRICULTURE SECTOR

In this part, an overview on water use in agriculture mainly on irrigation phenomenon is given, taking into account that in the questionnaire of JQ *Inland waters* abstraction and water use are the main issues. Water abstraction and water use are related to two different aspects of the same phenomenon. From the point of view of water abstraction it is possible to stress existing pressures on different sources of water (ground and surface), which have different ecological importance. From the point of view of water uses it is possible to focus on delivering aspects.

Methodologies applied, diverse data sources content and basic data availability are analysed. Few highlights on theoretical aspects have been here reported. The analysis mainly focuses on recent Italian experiences on data collection and/or estimation of irrigation parameters, and on data available at the National institute of statistics.

Nevertheless, we have to underline that the results obtained are not comparable for a number of reasons, referring to different areas, aspects, years, resulting from the adoption of different methodologies.

The paragraphs are developed as such: a description of issues related to water uses in agriculture and a first data analysis of the irrigation practice trend and distribution in Italy is given (Paragraphs 4.1, 4.2). Than a screening of data available to fill JQ *Inland waters* (Paragraph 4.3) has been performed for water abstraction by source (Paragraph 4.3.1) and delivering by supply (Paragraph 4.3.2). To overcome lack of data on water used for irrigation purpose, crop water requirement can also be estimated applying

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Giampaola Bellini, Istat (paragraphs 4, 4.1, 4.2, 4.3, 4.4, 4.4.1); Aldo Femia, Istat (paragraph 4.4.2).

different methodologies. Thus, methodologies, estimates and basic data availability (Paragraph 4.4.1) have been described. An estimate of livestock water requirement has also been applied (Paragraph 4.4.2).

Furthermore in Annex 4 a detailed description of data collected through Agricultural Census in year 2000, that might be used as basic data in estimation procedures, will be given.

Due to the consortia role in delivering water for agriculture uses, a wide overview on their water network characteristics is presented in Annex 5.

4.1 Phenomenon overview

Several studies and estimates to understand and monitor uses of water in agriculture have been carried out in the last decades. According to the Water national conference (Conferenza nazionale delle acque, 1972), crop water requirement for agricultural activity account for around 26 cubic kilometres. Twenty years later the Agriculture and forestry Ministry estimated water requirement for a similar amount (25,6 cubic kilometres) (Ministero dell'agricoltura e delle foreste, 1990). More recent studies showed that almost 50 percent of total water abstraction is used for agriculture employment accounting for almost 20 cubic kilometres (Irsa, 1999).

Even if figures come from application of different methodologies with consequent less comparability, it is clear that water use in agricultural activity remains a crucial point in water uses assessment, monitoring and planning.

On Italian territory, water demand for crop cultivation accounts for the major share of water consumption in the agriculture sector. In fact, due to the peculiarities of Italian climate some crops require additional water to grow. The main reason is that rain is concentrated in spring and in fall seasons, whereas the growing season (for spring-summer crops) is dry. Only in some cases raising ground water level and soil water content can satisfy water requirement of growing crops.

Nevertheless Crop Water Requirements (CWRs) are highly varying with the species and variety and with pedo-climatic conditions. CWR is mainly function of climate conditions (temperature, humidity, etcetera), crop characteristics (leaf area index, root system depth, etcetera) and physical, chemical, biological soil parameters, which in turn determine soil water content. Recent studies, carried out under the Climatic changes and agriculture (Cambiamenti climatici e agricoltura, Climagri) programme analysing the effect of climate change on agricultural activity showed that CWRs variability between years is very high depending on effective rainfall and evapotranspiration in the same period of time (Campi, et al., 2003).

In some cases, when the season is dry and the evapotranspiration is very high, availability of water can become a limiting factor for irrigation. Recently, for few years, rainfalls have been very poor and year 1999 has been one of the worst in terms of water supply for irrigation purpose (Anbi, 2001). Especially the southern regions have been affected since most of the supply is provided through artificial water basins that drastically lowered their level. Irrigation was then very difficult in Sardegna and Sicilia.

Irrigation water in many arid and semi-arid areas is a vital need to increase productivity, to extend the crop growing period or to shift to a crop production with a higher economic value. Nevertheless excessive water abstraction can have negative consequences, such as salinisation of ground water in coastal areas (Irsa, 1999).

Access to water largely depends on landscape characteristics and watercourses presence and water abundance. Thus, resorted sources of water and supply system follow different patterns and schemes in northern and central-southern regions. The northern regions are dominated by the Po river hydrological system where natural drainage and the regulation of the sub-alpine lakes ensure water availability. In the rest of the country irrigation is realised thank to the creation of artificial basins in order to regulate discharges from rivers and streams. They have torrential nature with problems linked to continuity of the flow during the year. The Italian registry of dams shows that 136 dams out of the 546 recorded have been built with irrigation purpose. Furthermore some thousands of hill reservoirs have been detected through remote sensing. According to some estimates, the volume of water that can be stored in such artificial water bodies is around 2 cubic kilometres (Irsa, 1999).

Information on kind of source resorted, in order to abstract water, can have a great importance, since water sources can have different environmental value ranging from surface, ground, transitional, till non-conventional (treated wastewater and desalinated) water.

Possible ways to access water in agricultural activity are:

- irrigation and land reclamation consortia delivering water network;
- self-supply, where water is diverted or pumped directly by users;
- public water supply;
- other forms.

Water use at farm level can be influenced by the efficiency of the irrigation method applied. So that in areas where there is a need for a more strict and rational use of water, the use of irrigation technologies with a higher efficiency rate is recommended. Efficiency rates for the most widespread irrigation systems, as reported in the Blue Plan document (Blue Plan, 1999), are the following:

- 40-50 percent for superficial water flow and lateral infiltration;
- 60 percent for aspersion system;
- 90 percent for low pressure sprinklers and drip-emitters.

Also at international level (CEC, 2000, 2001) in the field of agrienvironmental indicators, it has been stated that irrigated surface by irrigation method is a fundamental variable (Bellini, 2003).

The amount of losses (mainly lost for evaporation in the aspersion method or for deep soil infiltration in the flooding methods) is correlated to the type of irrigated crops as well as to the extension of the system applied.

Water saving methods, such as localised irrigation, which arose quite recently as result of new technology developments, are mostly applied to irrigate high value crops, such as orchard vegetables and fruit tree species. They don't imply a structural change in landscape being a quite flexible tool if compared to other irrigation equipment; this flexibility is partially responsible for the increase recorded in the values of the irrigable agricultural land.

Besides water used for irrigation purpose, other agricultural activities can require considerable amount of water. At farm level, livestock can consume water both for physiological need and for dejection management, depending on typology of stables. Nevertheless it has to be pointed out that water uses in agriculture largely depends on intensive farming system oriented to meat production. In fact maize and rotational forage cover a large part of the irrigated surface.

Also fishing in fresh water and artificial basins is a growing business, requiring an increasing volume of water.

4.2 Highlights on irrigation phenomenon trend and pattern

Agricultural Census results represent the main data source to perform analysis on the irrigation phenomenon at a detailed territorial level, since information is collected at municipality level (level 5 of Nomenclature of Territorial Units for Statistics, NUTS5). In the present study just few highlights are presented, whereas a more detailed data analysis is contained in Annex 4.

In Italy, according to last Agricultural Census (Istat, 2000), 731,082 farms irrigate a surface of 2,471,379 hectares, which extends over 18.5 percent of UAA and of wood arboriculture surfaces.

As concern irrigated crops, the most widespread are grain maize and rotational forage. They changed their pattern in the last decades. Grain maize slightly increased reaching 623,155 hectares, rotational forage showed a decreasing trend, ending with 267,560 hectares in year 2000. Together these two crops cover the 36 percent of total irrigated area. Besides them, the most widespread irrigated crops are vegetables, vine and fruit trees with surfaces close to 200,000 hectares each.

In terms of resorted sources, census results showed that surface watercourses represent the supply source for 233,010 farms, 33,790 have access to surface water bodies (both natural and artificial ones), whereas other sources - which include ground water – were used by 531,853 farms.

Figures reveal that in year 2000 consortia delivered water to 302,872 farms, whereas 429,325 used other kind of supply – which include self supply also.

As regards irrigation system, the most used irrigation methods are represented by aspersion system - which serves 333,711 farms -, and by the superficial flowing water and lateral irrigation system - with 322,313 farms served -. The dripping irrigation system registered a considerable increase, with 114,369 farms applying it in year 2000. In terms of surface, aspersion system covers 41.4 percent of irrigated area, superficial flowing water and lateral irrigation system follow with 33.5 percent.

Other data sources are analysed in the following, resulting from some experiences of data collection and/or estimation. The Land reclamation and irrigation consortia national association (Anbi) carried out a survey at national level (Anbi survey). Two other projects, worthy to be mentioned, have been carried out at multiregional level: one by the Po RB authority (Po RB authority project) and the other one by the National institute of agriculture economics (Inea - Mop project), referring to the southern area of the former Objective 1 regions (Regulation 2081/93/Eec).

Due to the consortia role in delivering water for agriculture uses, a wide overview on their water network characteristics is presented in Annex 5.

4.3 Data available for water abstraction and water use

Water abstraction and water use by economic sectors are issues poorly covered by existing statistics. Statistical information needs to be implemented and several methodological problems need to be faced in order to overcome data gaps. The main problem is unavailability of water abstraction measurements, even if water meters installation is mandatory since the Italian law n. 36 was passed in year 1994. Estimates could be calculated but the methodological approach can vary depending on sources of available information.

Water abstraction and water use are related to two different aspects of the same phenomenon. From the point of view of water abstraction it is possible to stress existing pressures on different sources of water (ground and surface), which have different ecological importance. From the point of view of water uses it is possible to focus on delivering efficiency. The difference between the water abstracted by sources and the delivery realised through different supply categories represents water loss during transportation. These losses can have different nature as it will be shown forward.

4.3.1 Water abstraction by source

Referring to JQ *Inland waters* table 2.1, categories of sources encountered are *Fresh water*, divided in *Ground* and *Surface water*, and *Other sources of water*, divided in *Non-fresh water sources* (seawater and transitional water) and *Reused water*.

In the following an overview on main issues related to water abstraction by source is given.

As regards fresh water source, water abstraction permission archives represent a potential source of information. We tried to verify updating, possibility to access data, reliability, format, information homogeneity. As already said permission archives might contain the following information: permission holder name, diverted flow (cubic metre per second), final use (hydroelectric power, irrigation, livestock breeding, industrial activity), water body's name or typology (spring, artificial channel, river, lake, well, etcetera), location (municipality), term. The latter refers to the fact that the permission validity lasts for a certain period of time. Data quality control would be necessary proceeding with this data source. Moreover the actual amount of abstracted water is not available and should be estimated linking the diverted flow with other data (information from consortia or farmers). The variable *water abstraction by source for agriculture purpose* could become available, but more difficult would be to discriminate between uses for irrigation or livestock breeding. In fact in case of multiple uses, the amount diverted to each one of them is not specified.

These archives have been on paper form for long time and Regions have been taking care of them since they settled. Afterwards the function to release the permission passed to Provinces and almost at the same time RB authorities' archives started being implemented. Some of the RB authorities are trying to organise a database of water abstraction permissions, which allows them to give an opinion on water abstraction request in real time. So different archives can exist for the same area (national river basins have a *multi* and/or *trans* regional territory) and an assessment to choose one of them should be carried out.

Besides fresh water sources, *Other sources of water* (JQ Table 2.2) can be exploited.

Among this category, the variable *Non-fresh water sources* (seawater and transitional waters) will be difficult to fill out. In Italy one of the most important cases of abstraction from transitional waters appears in the Po estuary region. In this area the phenomenon has a seasonal pattern, since only when precipitation is very low and evapotranspiration is high (summer time) the sea tide is able to push saline water into the estuary, up to 30-40 kilometres from the river mouth. Anyway distinguishing between fresh surface water and this other kind of source will be very difficult.

Another phenomenon that should be recorded as abstraction from *Non-fresh water sources* is when saline water intrudes fresh ground water. This is widespread in agricultural areas close to the coast when abstraction pressure on the resource is high, namely in summer season.

As already mentioned, only urban wastewater coming from treatment plants can be spread on agricultural soils by law. Referring to the *Reused water* source, there are data sources to exploit but no data are available at the moment.

4.3.1.1 Available sources of data directly collected

Data on agriculture water abstraction are spread among several local institutions at different territorial levels. In many cases specific projects have been carried out at local level in order to fill data gaps and to make possible both monitoring and planning of water abstraction.

ANBI SURVEY

Anbi conducted a survey in 2001 among 138 associated consortia collecting data on their water network characteristics and related water management.

Results show that the total volume of abstracted water accounts for 24,329 million cubic metres, of which 22,860 delivered by consortia and 1,469 directly diverted by final users from consortium canals. The northern regions have the highest share abstracting 22,666 million cubic metres, of which 21,344 delivered by consortia and 1,322 directly diverted. As stated by the authors, data published for the northern regions are calculated on the basis of continuous water flow through channels and have to be considered an overestimation of the amount actually used in field. In fact not all the amount of the flow in water network is used by farmer. The figures encountered in central and southern regions can be considered closer to the use values. As general consideration, the Anbi states that the amount estimated in previous studies as 20 billion cubic metres, has to be considered reasonable.

Furthermore the published figures can be affected by an error due to the possibility of a double counting of a certain amount of water. In fact in some areas (mainly Piemonte and Lombardia regions) channel overflow can be used downstream, as it is shown in the project carried out by the Po River Basin authority.

TABLE 4.1 **Consortia water abstraction – Year 2001** (a) *(volume in 1,000 m³)*

REGIONS GEOGRAFICAL AREAS	From consortia		Directly diverted from final users		Total
	Volume	Volume per ha	Volume	Volume per ha	
Piemonte	9,901,427	33.6	466,134	21.5	10,367,561
Valle d'Aosta	-	-	-	-	-
Lombardia	7,256,027	20.7	114,480	1.5	7,370,507
Trentino-Alto Adige	-	-	-	-	-
Veneto	3,452,501	16.8	343,067	1.4	3,795,568
Friuli-Venezia Giulia	186,164	4.6	40,000	3.3	226,164
Liguria	-	-	-	-	-
Emilia-Romagna	547,153	4.5	358,575	1.7	905,728
Toscana	13,620	2.6	9,212	3.0	22,832
Umbria	22,770	4.2	12,000	10.3	34,770
Marche	61,834	4.5	-	-	61,834
Lazio	122,575	2.4	30,000	1.1	152,575
Abruzzo	54,980	1.8	-	-	54,980
Molise	45,486	2.3	-	-	45,486
Campania	189,273	4.2	20,612	2.3	209,885
Puglia	154,708	1.7	2,614	1.4	157,322
Basilicata	326,538	7.5	-	-	326,538
Calabria	66,343	3.1	10,550	105.5	76,893
Sicilia	133,839	2.2	1,637	1.7	135,476
Sardegna	325,096	5.3	60,000	5.2	385,096
ITALY	**22,860,334**	**15.6**	**1,468,881**	**2.1**	**24,329,215**
North-west	**17,157,454**	**26.6**	**580,614**	**5.8**	**17,738,068**
North-east	**4,185,818**	**11.4**	**741,642**	**1.6**	**4,927,460**
Centre	**220,799**	**2.9**	**51,212**	**0.5**	**272,011**
South	**837,328**	**3.3**	**33,776**	**3.0**	**871,104**
Islands	**458,935**	**3.8**	**61,637**	**4.9**	**520,572**

Source: Anbi, 2003
(a) Provisional data.

Breakdown of the volume abstracted per water source is also available: 54 percent of the total is abstracted from natural water courses, 38 percent from artificial water bodies, 4 percent from common wells, other sources account for the remaining 8 percent.

PO RB AUTHORITY PROJECT

The Po RB covers 69,979 square kilometres, which represents 23 percent of the Italian territory. The RB authority carried out the project on irrigation activity managed by consortia. Published data refer to period 1991-1996 and to consortia active in 10 different areas. These areas were identified according to specific features related to cropping pattern, water network and irrigation methods that resulted to have higher homogeneity in each specific area. Regions involved are Piemonte, Lombardia, Emilia-Romagna and Veneto, all of them partially covered.

A first step of Po RB authority project consisted in identifying all the existing water network management organisms, by means of information coming from different local sources. Only a sample of them was included and investigated in the following steps on the base of the derivation dimension (only derivations with flow greater than 1 cubic metre per second). Several data have been collected: annual abstraction of water (volume) by source and by final use (agriculture or other activities), amount of reused water, characteristics of the permission to abstract water, typology of irrigated crops, irrigable area, irrigation method adopted, scheduling of water delivery, characteristics of irrigated soils.

A short dissertation is required when northern system of canals is considered. In fact due to the drainage nature of the canals, to the abundance of water for most of the territories included in the left side of the river, and to the high level of the water table, water is diverted from natural stream to canals in a quantity which is quite always higher than CWRs, thus deep infiltration finally recharge ground water and flowing water not infiltrated – like the one diverted to rice fields - become a source for downstream fields. Due also to the sandy nature of the soil, to its alluvial origin and to the high water table level, the ground water is easily and quickly reached. This phenomenon can complicate the calculation of water actually diverted leading in some cases to double counting. The Po RB project tried to solve this problem making an estimate of the released amount of water. Figures reveal that most of the abstracted water, which accounts for about 17 billion cubic metres in the study area, comes from a surface source (90.3 percent). 22 percent of the abstracted water is than released in the system (see Table 4.2), the highest value is recorded in Piemonte were rice fields represent more than 50 percent of the irrigated area.

TABLE 4.2 **Consortia and related irrigation services** *(surface in hectares, volume in million cubic metres)*

REGIONS	Irrigated UAA (a)	Abstracted volume				Released volume	
		Total	Per ha *(1,000 m^3)*	of which from ground water (%)	of which from surface water (%)	Total	% on total abstraction
Piemonte	354,535	8,957	25.3	9.0	91.0	3,109	35.0
Lombardia	534,466	6,876	12.9	12.1	87.9	520	8.0
Veneto	38,460	213	5.5	..	100.0	..	..
Emilia-Romagna	214,669	851	4.0	0.5	99.5	89	10.0
TOTAL	**1,142,130**	**16,898**	**14.8**	**9.7**	**90.3**	**3,718**	**22.0**

Source: Po RB authority
(a) Average 1991-1997.

In the following, data published from this study will be presented at study area level. The relationship between region and area number is presented in the table below. The study area covers partially the irrigation phenomenon in the mentioned regions. This is due to the fact that the study doesn't cover completely Piemonte and Lombardia region, leaving

TABLE 4.3 **Irrigated land from different data sources** *(surface in hectares)*

REGIONS	Irrigated UAA (a)	Irrigated agricultural land			Area's number
		1990	1993	1995	
Piemonte	354,535	370,240	374,552	396,838	1-3
Lombardia	534,466	616,744	605,957	671,209	4-6, 8 (part)
Veneto	38,460	270,739	258,304	298,832	7,8 (part),9, 10 (part)
Emilia-Romagna	214,669	274,303	251,006	279,870	10 (part)
TOTAL	**1,142,129**	**1,532,026**	**1,489,819**	**1,646,749**	**1-10**

Source: Po River Basin authority, Istat, Agricultural Census 1990, Farm Structure Survey 1993, 1995
(a) Average 1991-1997.

TABLE 4.4 **Water abstraction by type of source and study area (average years 1991-1996)** *(volume in million cubic metres)*

STUDY AREAS	Source										Irrigated UAA (ha)	Volume abstracted per ha (1.000 m^3)
	Surface flowing water	Surface water bodies	Spring	Well	Through	Pouring out water	Treated waste-water	TOTAL				
								Total	(a) of which from Surface water	(a) of which from Ground water		
Area 1	5,771.6	5.5	..	5.8	716.6	300.0	21.4	6,820.9	6,793.7	5.8	255,254	26.7
Area 2	1,280.9	..	..	..	..	..	20.0	1,300.9	1,280.9	..	43,874	29.7
Area 3	750.4	..	37.4	27.2	18.5	1.9	..	835.4	770.8	64.6	55,406	15.1
Area 4	2,476.7	..	..	275.2	263.0	208.8	14.3	3,238.0	2,948.5	275.2	164,441	19.7
Area 5	1,944.5	..	..	61.6	213.5	14.7	5.0	2,239.3	2,172.7	61.6	219,777	10.2
Area 6	1,031.3	287.3	3.1	18.6	..	..	..	1,340.3	1,318.6	21.7	125,448	10.7
Area 7	76.4	11.3	..	3.9	..	0.1	2.0	93.7	87.8	3.9	26,654	3.5
Area 8	352.6	..	..	0.7	..	20.0	7.8	381.1	372.6	0.7	112,882	3.4
Area 9	103.9	0.5	..	..	..	4.0	0.1	108.5	108.4	..	20,512	5.3
Area 10	475.1	..	..	..	..	60.0	4.5	539.6	535.1	..	117,881	4.6
TOTAL	**14,263.4**	**304.7**	**40.7**	**393.1**	**1,211.7**	**609.5**	**75.1**	**16,897.7**	**16,389.1**	**433.6**	**1,142,129**	**128.9**

Source: Po RB authority
(a) Treated waters are not included.

out their mountainous area, whereas Veneto and Emilia-Romagna are partially included in the Po RB area.

Breaking down water abstraction by source it becomes evident that there is a wide range of source types, which characterises this particular area as described above (through and pouring out from the canal network). Treated wastewater still represents a very small percentage of total abstraction.

INEA - MOP PROJECT

The National institute of agriculture economics (Inea) carried out a project on water resources and uses for agriculture purposes, involving eight regions (Abruzzo, Molise, Campania, Basilicata, Calabria, Puglia, Sicilia and Sardegna) of the former Objective 1 area, funded by the European union through the Multiregional operative programme (Mop) initiative from 1994 until 1999 (Inea - Mop).

The project consisted, among other activities, in a survey collecting information on water abstraction for agriculture use from consortia. Where available, direct information on water abstracted/distributed and areas of irrigated crop were filed, otherwise ancillary data were collected such as diverted flow of abstraction works or power for pumps and related electricity consumption. All these information could help in the estimation of the amount of water abstracted/distributed to farms.

Nevertheless, information collected through the survey was in most cases incomplete. Only in rare cases the water management system was able to give information on water abstracted and/or distributed.

Information available on used sources of water only refer to the number of available sources. The table below shows that over the 741 exploited sources 376 are in Puglia region. In 500 source points water is pumped from ground reserve. Nevertheless information collected on these sources were very poor, in fact only for 47 of them time data series[4] were available.

Furthermore estimation of abstracted water, taking into account abstraction infrastructure characteristics, was not attempted. In some

4 Only sources with a data series higher than 4 years were included.

cases also data on irrigated crop and on irrigation system adopted were not available.

TABLE 4.5 **Consortia and related resorted source by source type**

REGIONS	Consortia	Source					
		Total	Of which surface	Of which ground water	Other work	Reused water	With known time series data on abstracted volumes
Abruzzo	5	35	21	11	3	-	11
Molise	3	3	3	-	-	-	3
Campania	11	78	35	41	2	-	-
Puglia	6	376	9	361	6	-	-
Basilicata	3	65	27	37	1	-	12
Calabria	16	88	57	26	5	-	-
Sicilia	10	71	45	24	1	1	7
Sardegna	11	25	25	-	-	-	14
TOTAL	**65**	**741**	**222**	**500**	**18**	**1**	**47**

Source: Inea – Mop project

The project, in order to give an answer to the question on the amount of water required for irrigation, ended estimating CWRs after estimating irrigated area by crop type and applying specific CWR differentiated per hectare and per area. Volume of water necessary for irrigation purpose has been calculated at consortium level. It is not clear whether this information would cover irrigated area managed only by consortia or includes also crops irrigated through self-supply or any other source of water.

Also information on waterlines managed by consortia are available for some of them (length, material of construction, typology of network). Referring to water network system it is very important to know characteristics of:

- abstraction infrastructure;
- number, mechanic and topographic characteristic of lifting apparatus;
- storage capacity;
- characteristic of the distribution network.

Referring to water network, characteristics to know are water flow capacity and storage capacity. The first can help in understanding the amount of water abstracted - depending also on water source availability

- whereas the second one can give information on the possibility of water overflows, when water flow exceed crop water need and storage capacity of the system. Other ways to lose water through transportation are evaporation from open-air channels, and leakage from water lines.

Water system loss can be monitored through a deep analysis of geometric infrastructure characteristic, pump power and energy consumption and water availability. Nevertheless, loss can be a structural factor in areas where water is abundant, but knowledge on existence of this phenomenon can help in case water demand increases and new strategies might be necessary in order to face new necessities.

4.3.2 Water supply by category: main issues and data available at Istat

With reference to water supply category, the related JQ *Inland waters* Table focuses on water delivery systems. The identified categories are *public water supply*, when water is delivered through water pipe systems serving households, *self supply*, when water is pumped or delivered directly from final users, and other supply, which include delivering through irrigation and land reclamation consortia.

As already mentioned none direct information are available from farmers, whereas consortia might represent an important source of information.

Another approach could imply calculation of the amount of water delivered to farmers through the amount of money paid, but unfortunately the fee, that users have to pay, is mainly based on the water flow (volume per second) diverted on the irrigated area.

The first delivery system cited in the JQ refers to the *public water supply*, which at present delivers a small amount of water to agricultural holdings. Referring to this variable, results are available from the *Water supply system* questionnaire, belonging to the Istat Water surveys system[5]. The variable considered in this questionnaire refers to invoiced water delivered to agricultural holdings.

[5] Referring to 1999, Istat collected data on water by means of a Water survey system (Wss), concerning urban water cycle and composed by six sub survey using different questionnaires and responding units. Questionnaires, regarding the different water cycle segments (water pipes, water supply system, sewerage system, wastewater treatment plants), have been sent to the correspondent management companies operating in Italy and was self-administered. Another questionnaire has been sent to each Municipality to collect data about population connected to water services.

TABLE 4.6 **Invoiced water for agricultural use per region - Year 1999** *(volume in thousands cubic metres)*

REGIONS	Total	% composition	% of total economic activity use (a)	% of total uses (b)
Piemonte	6,464	7.73	12.45	0.024
Valle D'Aosta	743	0.89	32.95	1.461
Lombardia	12,916	15.44	6.16	0.003
Trentino - Alto Adige	4,228	5.05	22.61	0.121
Bolzano – Bozen	*2,847*	3.40	27.42	0.264
Trento	*1,381*	1.65	16.61	0.200
Veneto	8,796	10.52	13.94	0.022
Friuli - Venezia Giulia	1,387	1.66	13.09	0.124
Liguria	4,716	5.64	13.76	0.040
Emilia – Romagna	7,016	8.39	14.42	0.030
Toscana	1,801	2.15	6.53	0.024
Umbria	853	1.02	11.55	0.156
Marche	2,312	2.76	15.48	0.104
Lazio	3,604	4.31	20.00	0.111
Abruzzo	2,188	2.62	30.55	0.427
Molise	691	0.83	36.22	1.898
Campania	6,422	7.68	28.93	0.130
Puglia	13,956	16.68	59.92	0.257
Basilicata	921	1.10	38.38	1.599
Calabria	3,461	4.14	36.57	0.386
Sicilia	856	1.02	8.49	0.084
Sardegna	320	0.38	12.79	0.511
ITALY	**83,651**	**100.00**	**14.27**	**0.002**

Source: Istat, Water surveys system, Year 1999
a) It includes agricultural uses, other economic activity uses, other uses.
b) It includes municipal uses, economic activity uses, other uses.

The invoiced water accounted for around 84 million cubic metres. At national level this represents 14.27 percent of the invoiced water delivered to the economic sectors as a whole and only 0.002 percent of the total invoiced water delivered by the public water supply for all kind of uses. At regional level Puglia, Lombardia and Veneto are the territories where agricultural activity and livestock breeding received the highest volume of water with rates of, respectively, 16.7, 15.4 and 10.5 percent of the total.

Self-supply, for the agriculture sector, refers to water abstracted and managed directly by users. The information could theoretically be get from water abstraction permission archives (whether an individual holder could be distinguished from any other private organism). Farmer can provide basic information that can help in estimation of CWR.

Water delivered to final users *via* network is to be included in other supply. All the information referred to this category can potentially be derived from consortia. Nevertheless the experiences carried out showed that diverted water can be monitored or calculated with less effort.

4.4 Estimation of water requirements for crop production and livestock breeding: methodologies and available data

Besides direct data collection, in order to fill data gaps, estimates can be attempted. In the following different methodologies will be described and results presented, where available. As already mentioned, main activities requiring water are irrigation for crop production and livestock breeding.

Irrigation water requirement can be estimated from CWR, applying the soil water balance approach. Referring to livestock water requirements, estimation is also possible applying different coefficients to the livestock in breeding.

In both cases basic data are necessary in order to make calculations. In crop production the water requirement for irrigation purpose results from water deficit, calculated applying the soil water balance, multiplied by irrigated crop surface. In livestock breeding, number of head per specie and category are necessary to obtain the water requirement (for instance the drinking water requirement).

For this reason we put emphasis on the role that can be played by statistical institutes in basic data collection. Thus data availability on the phenomenon, with reference to watered crops and irrigation practice adopted at farm level, is analysed. The recent Agricultural Census database has a rich content that can be exploited to fill data gaps in estimation procedures.

4.4.1 Irrigation water requirement

The general approach for the estimation of CWRs focuses on climatic, pedological and agricultural factors that need to be taken into account in order to estimate the amount of water, expressed in millimetres, to be supplied to compensate water evapotranspiration. Actual volumes to apply are than calculated considering the surface irrigated per crop type. Efficiency related to water distribution from the abstraction point to the farm and to the irrigation method adopted plays also an important role.

4.4.1.1 Methodology for crop water requirement estimation

To analyse the irrigation phenomenon it is possible to follow the estimation approach of the proxy CWR starting from the soil water balance. The soil water balance can be applied to calculate the soil water deficit and many variables need to be known: rainfall, evapotraspiration (ET), soil water content, raising water from subsoil, runoff.

For rainfall more details on methodologies and institutions involved have been given in paragraph 3.1.

The Penman-Monteith equation is recommended by Fao as standard method to estimate reference and crop evapotranspiration.

In order to estimate CWRs, the water balance is applied to the root zones. This can be schematically represented as a container where losses and gains are accounted. Water requirement is expressed as root zone depletion in water depth (millimetres). Rainfall, irrigation and capillary rise of ground water towards the root zones add water to the container; whereas soil evaporation, crop transpiration, and percolation represent system losses. The root zone depletion represents the water needed to reach soil field capacity[6]. The daily water balance is:

$$D_{r,i} = D_{r,i-1} - (P-RO)_i - I_i - CR_i + Et_{c,i} + DP_i$$

where:

$D_{r,i}$ = root zone depletion at the end of the day i;

$D_{r,i-1}$ = root zone depletion at the end of the previous day;

P_i = precipitation on day i;

3 Field capacity is the amount of water that a well-drained soil should hold despite gravitational forces. As water uptake progresses, the water remaining into the soil becomes strongly absorbed to the particles and plants are not able to extract it any more. At this point plants reach the wilting point.

RO_i = runoff from the soil surface on day i;
I_i = net irrigation depth on day i that infiltrates the soil;
CR_i = capillary rise from the ground water table on day i;
$Et_{c,i}$ = crop evapotraspiration on day i;
DP_i = water loss out of the root zone by deep percolation on day i.

Few remarks have to be made on the mentioned variables. In case the daily precipitation is less than 0,2 ET_0, the correspondent amount cannot be taken into account in the balance since it will completely evaporate. Runoff during precipitation can be predicted using standard procedures from hydrological text. Capillary rise depends on soil type, depth of the water table and root zone wetness and if water table is 1 metre below the bottom of the root zone it can be assumed to be zero. ET_c can be assumed equal to K_c*ET_0 when soil water depletion[7] is smaller than Readily Available Water (RAW). As soon as $D_{r,i}$ exceed RAW the crop evapotranspiration is reduced and ET_c can be computed with a different equation taking into account the water stress[8]. Computing ET_c with the crop coefficient approach it is assumed that all the weather conditions are incorporated into ET_o and the crop characteristics into K_c. This parameter is crop specific and within each crop type can assume 4 different values in relation to the plant growth stages. More information about these stages can be found in Fao Irrigation ad drainage Paper N. 24. Deep percolation occurs when soil water content exceed field capacity, otherwise is zero.

Only when water balance is negative in a given period, which means that water offer (soil moisture available and rainfall) doesn't compensate crop evapotranspiration, irrigation is required. The soil water balance approach allows to plan timing and depth of future irrigations, taking into account that we want to avoid water stress - intervening before the RAW is depleted - and deep percolation - keeping net irrigation depth smaller than or equal to the root water depletion -.

Applying water balance, soil water content and contribution of raising water from subsoil represent often the limiting factor. In fact these data are available only for specific areas.

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[7] K_c is the crop coefficient that applied to ET_0 reduces the potential evapotranspiration to the actual value.

[8] The Readily Available Water (RAW) is part of the total available water in the root zone, which represents the difference between the water content at field capacity and wilting point.

The water balance approach is made more complex by the fact that the Italian territory is very diverse from the climatic, pedological and morphological point of view. This lead to the fact that crop water request cannot be standardised, since soil characteristics, morphology and climate of the specific site location can vary a lot even in nearby areas.

To make this approach feasible quite often a simplification is made. The "container" is considered isolated and the only parameters affecting the balance are ET_C and P as shown in the following paragraphs.

At international level an example comes from the methodology applied by Fao in order to estimate irrigation water requirements in some critical areas of the world (Fao, 1997; Fao, 1992).

Even if the Italian area is not included in the mentioned papers, the applied approach can be analysed to assess its suitability to the Italian case. The first step is the definition of the basic territorial unit, identified on the basis of river basins and administrative limits. The irrigation water requirements are calculated identifying the major irrigation cropping pattern zones, areas are considered homogenous in terms of irrigated grown crops, crop calendar, cropping intensity and gross irrigation efficiency. The definition of the area of influence of the climate stations is realised using the Thiessen polygons method. The two layers are merged in Geographic Information System (GIS) technology identifying a certain number of zones.

CWRs were than calculated using the following formula:

$$CWR = \sum_{t=0}^{T} (K_{c_t} \cdot ET_{o_t} - P_{eff_t}) \text{ unit in mm}$$

where:

K_{c_t}= crop coefficient of the given crop during the growth stage t;

T = final growth stage;

P_{eff} = effective precipitation.

Net Irrigation Water Requirements (NIWR) represent the sum of individual crop requirements. The Gross Irrigation Water Requirements (GIWR) is the water to be extracted (by diversion, pumping, other ways) and applied to the irrigation scheme. It includes NIWR plus water losses. It can be calculated applying the formula:

GIWR = 1/E * NIWR

where E is the global efficiency of the system.

The global efficiency can be actually separated into two components: the one at farm level related to the irrigation method applied and the other one at water abstraction/delivering level, where efficiency depends on water system efficiency. This efficiency is function of transportation losses, evaporation, and deep percolation, all of them depending on the structure of the canals. Open canal irrigation may have high evaporation rate whereas broken pressure pipelines might have problems of leakage.

At national level two main projects applying the water balance approach have been carried out at transregional level, one is the Po RB authority project and the second one is the Inea - Mop project.

PO RB AUTHORITY PROJECT

One of the main aims of the Po RB authority project was to identify water requirements for irrigation purpose in its territory.

Irrigation water requirements have been deeply investigated through the identification of homogenous agricultural areas. The parameters utilised to classify these areas relate to physical soil characteristics, meteorological variables and crop peculiarities.

According to the water balance approach the following equation was applied to calculate D_i what they called the climatic deficit (millimetre unit):

$$D_i = (ET_0 \, K_c - P_e) - RAW - Cr$$

where:

ET_0 = maximum evapotranspiration (Blaney and Criddle formula);
K_c = crop coefficient (Doorenbos, Pruitt, 1977[9]);
P_e = effective rain (USDA-CSC method);
RAW = readily available water (RAW = z * TAV);
Cr = capillary rise (Cr = % ET_0).

Furthermore with fields cultivated on slope the effective rain was reduced multiplying by a 0.8 factor. Both z and Cr values, depending on

9 Doorenbos and Pruitt (1977), in order to estimate crop coefficient, separated the season into initial (date A-B), rapid (date B-C), midseason (date C-D), and late season (date D-E) growth periods. Furthermore they also provide an estimation of the numbers of days for each of the four periods to help identifying the end dates of growth periods.

root depth and soil characteristics, have been determined at local level.

The Blaney-Criddle (Fao, 1986) method is simple[10], using measured data on temperature only. Here the calculation formula is reported:

ET_o = p (0.46 T mean + 8)

where:

ET_o = Reference crop evapotranspiration (mm/day) as an average for a period of 1 month;

T mean = mean daily temperature (°C);

p = mean daily percentage of annual daytime hours.

To obtain gross irrigation requirement estimation the climatic deficit value was multiplied by irrigated crop and irrigation method surfaces. At the end an arithmetic average between estimated values and locally applied volumes has been applied to achieve a more efficient use of water for irrigation purpose.

INEA - MOP PROJECT

Inea in the Mop project attempted to apply the water balance approach. Three different data sets have been implemented in this project:

1 agri-meteorological data set, including meteorological data recorded by 400 stations. Ucea participated to realise the data set. Local station networks have been added to the stations belonging to the national network, but they refer to 10 years only. Only 30 stations can record the variables necessary to calculate the Penman-Monteith formula, so that Ucea was involved in the project also to calibrate the Hargreaves-Samani formula, that could be calculated with the parameters recorded from all the stations (Dal Monte G., L. Perini, F. Thiery, 1999);

2 cartographic data set, obtained analysing cartographic map available at national (CORINE Land Cover) and local level (Region). The resulting map permitted to identify irrigated and irrigable areas. The information became more detailed adding different remote sensing data, so that even the kind of cultivated crop could be

[10] It should be noted, however, that this method is not very accurate; it provides a rough estimate or "order of magnitude" only. Especially under "extreme" climatic conditions the Blaney-Criddle method is inaccurate: in windy, dry, sunny areas, the ETo is underestimated (up to some 60 percent), while in calm, humid, clouded areas, the ETo is overestimated (up to some 40 percent).

identified;

3 pedological data set, available only for 5 limited areas, with scale of work 1:25,000.

Where all the requested information were available the water balance was applied to calculate CWRs. Since the pedological data set was really poor in terms of spatial coverage the calculation was not possible for the regions involved in the project. The project showed that the unavailability of a national pedological database is the limiting factor.

As reported in paragraph 4.4.1.3 a different calculation was than applied.

4.4.1.2 Basic data availability at Istat

As far as the estimation of agriculture water demand needs basic data to be applied, Istat tried to collect more information from farms in 1998 through the Farms Structure Survey and in 2000 through Agricultural Census.

The first experience to extend the survey on water use has been conducted in 1998. In fact the standard Farm Structure Survey questionnaire was integrated with an additional form on “Environment and territory”. Variables related to water use were: i) quantity of water used; ii) irrigated area by crop type and by irrigation method; iii) number of watering operations to irrigate fields; and iv) kind of water source (surface water, ground water, wastewater treatment plant). The experience carried out in 1998 showed that farmers don’t know the amount of water used for agricultural activities, but they can provide basic data at farm level on irrigation methods adopted, water management, and kind of water source. Data are available at regional level (NUTS2). The information collected were really rich in terms of content and some results can still be taken into account.

The most interesting thing of this survey was the attempt to get with only one question the information about type of crop irrigated, related irrigation method and number of watering operations carried out. Just an example of the results obtained is presented in table 4.7 for the most extended irrigated crops such as grain maize, rotational forage crops, vine, fruit trees, vegetables, and the most used irrigation methods such as aspersion, superficial flowing water and lateral infiltration, and

TABLE 4.7 **Irrigated surface per watering operation classes per irrigation method and crops - Year 1998** *(surface in hectares)*

CROP	Watering operation classes								
	1 - 2	3 - 5	6 - 8	9 - 11	12 - 14	15-19	20-39	≥40	TOTAL
				ASPERSION					
Grain maize	139,873	90,533	28,921	6,815	2,639	3,761	978	798	274,318
Rotational forage	139,233	157,390	46,274	19,747	8,418	11,377	8,668	6,774	397,881
Vine	73,885	15,809	2,313	735	703	51	453	-	93,949
Fruit trees	26,931	43,546	9,196	6,292	3,220	5,673	6,683	759	102,300
Vegetables	21,021	48,587	16,613	14,306	5,540	5,955	7,472	7,265	126,759
				SUPERFICIAL FLOWING WATER AND LATERAL INFILTRATION					
Grain maize	67,266	146,871	49,695	11,805	3,843	1,517	1,619	36	282,652
Rotational forage	-	-	-	-	-	-	-	-	-
Vine	14,100	6,825	1,562	567	489	73	31	22	23,669
Fruit trees	8,498	8,231	4,666	850	502	659	2,752	137	26,295
Vegetables	2,312	8,180	4,943	2,936	607	914	2,289	3,358	25,539
				MICROIRRIGATION (dripping including)					
Grain maize	-	-	-	-	-	-	-	-	-
Rotational forage	-	-	-	-	-	-	-	-	-
Vine	22,126	39,235	13,784	6,047	3,021	4,541	7,111	537	96,402
Fruit trees	13,272	21,076	11,928	8,093	1,946	4,718	7,712	12,184	80,929
Vegetables	3,367	8,700	4,383	5,320	3,379	4,816	12,368	8,033	50,366

Source: Istat, elaboration on 1998 Farm Structure Survey data

microirrigation (dripping included).

Analysing the cumulated frequency of irrigated land per watering operation classes and crops, as presented in table 4.8, it becomes evident that most of the surface watered by aspersion method with interventions minor o equal 5 covers up to 95.5 percent of vine irrigated surface, 84 percent in the grain maize case, and 74.6 percent for rotational forage crops. With an intervention number minor or equal 8, the irrigated maize grain surface increases to more than 94 percent, while 85 percent of irrigated rotational forage crops is watered.

With interventions minor o equal 5, the area irrigated through superficial flowing water and lateral infiltration reaches 88.4 percent of the total for vine, whereas grain maize and fruit trees irrigated surfaces reach 93.3 percent and 81.4 percent respectively with more interventions (minor o equal 8). Microirrigation pattern reveals that in the analysed classes (up to 5 and up to 8 interventions) figures reach lower values. For vine cultivation 5 interventions and less are enough to satisfy 63.7 percent of irrigated area, whereas for fruit trees the percentage of 57.2 is reached with interventions minor o equal 8.

TABLE 4.8 **Irrigated surface per irrigation method, watering operation classes and crops - Year 1998** *(cumulated frequencies of irrigated surface per crop)*

CROPS	Aspersion		Superficial flowing water and Lateral infiltration		Microirrigation (dripping included)	
	≤ 5	≤ 8	≤ 5	≤ 8	≤ 5	≤ 8
Grain maize	84.0	94.5	75.8	93.3	-	-
Rotational forage	74.6	86.2	-	-	-	-
Vine	95.5	97.9	88.4	95.0	63.7	77.9
Fruit trees	68.9	77.9	63.6	81.4	42.4	57.2
Vegetables	54.9	68.0	41.1	60.4	24.0	32.7

Source: Istat, elaboration on 1998 Farm Structure Survey data

Those data should further be exploited in order to analyse which pattern we can find at a more detailed territorial level and get better understanding on to which extent a sampling survey can meet the data demand on this topic. The main problems to be faced are: i) the limits due to an information coming from a sample where not the irrigated surface, neither irrigated crop nor irrigation method are sampling variables; ii) the necessity to get more information containing the statistical burden and survey cost. In fact in 1998 questionnaire, farms could indicate only one irrigation method - and related number of interventions realised - for each irrigated crop, choosing the most representative one.

In order to avoid an excessive burden on respondent the question was simplified in the Agricultural Census questionnaire in year 2000. Nevertheless this source is of fundamental importance for the detail we can reach at territorial level, as data are available at municipal level (NUTS5). The questionnaire covered the following variables: i) irrigated area by crop type; ii) irrigated area by irrigation method; iii) kind of water source (surface water, ground water, wastewater treatment plant); iv) water infrastructure management (self management, consortium, a different farm, other system).

In the following some comments will be provided on census results, whereas a more detailed dissertation is available in Annex 4.

The chosen variables refer to irrigated area in relation to crop area, irrigation method, resorted water sources and kind of supply.

Tables 4.11 and 4.12 have been computed in a similar way, combining separated information collected through the questionnaire. In fact the resorted source and the type of supply were considered as farm classification variables in relation to the total irrigated surface declared by each farm[11]. The results obtained give us an important proxy of the phenomena involved (irrigated surface per source type and per kind of supply) since most of the farms declared to have access to only one source type (91.1 percent of irrigated farms including 82.6 percent of irrigated surface) and supply (95.2 percent of irrigated farms including 85.8 percent of irrigated surface).

This result would support the proposal at national and international level, under the Indicator reporting on the integration of environmental concerns into agriculture policy (Irena) operation, for considering, as long as data on actual amount of water used for irrigation purpose are lacking, surface irrigated per source type and surface irrigated per kind of supply as relevant indicators.

Table 4.9 shows that 36 percent of irrigated land is devoted to grain maize and rotational forage production, fruit trees and vegetables with 7.7 percent each and vine with 7.4 percent follow. Other crops category includes also rice field which can explain the high value reached by this class (24.4 percent). Grain maize and rotational forage are mainly in northern regions where 91.7 percent and 70.2 percent of the respective

[11] The related activity has been realised under the Eu co-funded TAPAS project 2003. *Analysis of data needs and availability for implementation of AEI according to DPSIR logical framework*, published in Istat. *Agrienvironmental indicators: methodologies, data needs and* availability. Roma: Istat, 2006 (Essays n. 16).

TABLE 4.9 **Irrigated surface per crop and geographical area - Year 2000** *(absolute data in hectares)*

GEOGRAPHICAL AREAS	Crop									
	Wheat	Grain Maize	Soybean	Vegetables	Rotational Forage	Vine	Citrus	Fruit Trees	Other Crops	Total
					ABSOLUTE DATA					
North-west	12,988	366,797	38,368	16,249	129,335	2,679	46	19,142	358,817	944,422
North-east	11,174	204,356	39,925	48,202	58,666	52,472	-	103,122	120,684	638,600
Centre	9,716	36,399	217	25,637	24,613	6,601	515	14,007	60,950	178,655
South	52,539	14,639	106	73,383	30,396	78,810	41,305	42,588	152,577	486,343
Islands	13,220	963	1	27,542	24,550	42,131	71,786	10,317	32,848	223,358
ITALY	**99,636**	**623,155**	**78,618**	**191,012**	**267,560**	**182,694**	**113,651**	**189,175**	**725,877**	**2,471,378**
					% COMPOSITION					
North-west	1.4	38.8	4.1	1.7	13.7	0.3	..	2.0	38.0	100.0
North-east	1.7	32.0	6.3	7.5	9.2	8.2	-	16.1	18.9	100.0
Centre	5.4	20.4	0.1	14.3	13.8	3.7	0.3	7.8	34.1	100.0
South	10.8	3.0	..	15.1	6.2	16.2	8.5	8.8	31.4	100.0
Islands	5.9	0.4	..	12.3	11.0	18.9	32.1	4.6	14.7	100.0
ITALY	**4.0**	**25.2**	**3.2**	**7.7**	**10.8**	**7.4**	**4.6**	**7.7**	**29.4**	**100.0**

TABLE 4.9 continued **Irrigated surface per crop and geographical area - Year 2000** *(absolute data in hectares)*

GEOGRAPHICAL AREAS	Crop									
	Wheat	Grain Maize	Soybean	Vegetables	Rotational Forage	Vine	Citrus	Fruit Trees	Other Crops	Total
					% COMPOSITION					
North-west	13.0	58.9	48.8	8.5	48.3	1.5	..	10.1	49.4	38.2
North-east	11.2	32.8	50.8	25.2	21.9	28.7	-	54.5	16.6	25.8
Centre	9.8	5.8	0.3	13.4	9.2	3.6	0.5	7.4	8.4	7.2
South	52.7	2.3	0.1	38.4	11.4	43.1	36.3	22.5	21.0	19.7
Islands	13.3	0.2	..	14.4	9.2	23.1	63.2	5.5	4.5	9.0
ITALY	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Istat, Agricultural Census - Year 2000

national surface is cultivated.

Table 4.10 shows a typical territorial pattern for irrigation method applied, in fact *superficial flowing water and lateral infiltration* and *flood* are mainly adopted in the northern regions (85.1 percent and 98.3 percent respectively), and aspersion is distributed over an area which equals 57.1 percent of national total land irrigated with this method. Even if it’s hoped to substitute these systems with the more water saving ones, it is also necessary to underline that in most of these cases irrigation systems can hardly be replaced due to the existing widely extended water network and to the sandy nature of the soil.

Figures in table 4.11 show that almost 50 percent of total surface is irrigated through water abstracted only from surface water bodies. Ground waters (only this source) follow in terms of importance, as they contribute to irrigation of almost 25 percent of the total irrigated land.

Surface, from the point of view of supply, is mostly irrigated through water delivered by consortia (52 percent), whereas self supply is used to water 23 percent of total irrigated land.

Analysing results coming from *water pipe systems as type of source* and *consortia as kind of supply* questions reveals that some problems in question interpretation were encountered. In fact surface irrigated with water reaching the farm through a water network (aqueduct) equals 270,365 hectares, while surface irrigated with water delivered by consortia is 1,281,424 hectares. In fact the physical infrastructure entity includes consortia, public water supply, etcetera, so that the related irrigated surface should be even higher of the area irrigated by consortia.

In fact 75 percent of farms giving the answer *only water pipe system* to the question on resorted water sources, also gave “consortia” answer to the question on kind of supply. At the same time almost 50 percent of farms answering *only consortia* to the question on kind of supply declared aqueduct as source type. This category of farm should have reached a higher percentage.

TABLE 4.10 Irrigated surface per irrigation method and geographical area - Year 2000 *(absolute data in hectares)*

GEOGRAPHICAL AREAS	Irrigation Method						
	Superficial flowing water and lateral infiltration	Flood	Aspersion	Micro irrigation	Dripping	Other systems	Total
			ABSOLUTE DATA				
North-west	572,394	200,767	188,816	2,721	7,406	7,434	979,538
North-east	151,279	13,067	410,528	14,836	43,995	19,606	653,311
Centre	16,315	556	135,294	5,657	22,123	2,793	182,737
South	84,007	506	201,587	30,124	161,610	18,693	496,527
Islands	26,567	2,640	114,976	21,993	55,572	5,149	226,897
ITALY	**850,561**	**217,536**	**1,051,201**	**75,332**	**290,706**	**53,674**	**2,539,011**
			% COMPOSITION				
North-west	58.4	20.5	19.3	0.3	0.8	0.8	100.0
North-east	23.2	2.0	62.8	2.3	6.7	3.0	100.0
Centre	8.9	0.3	74.0	3.1	12.1	1.5	100.0
South	16.9	0.1	40.6	6.1	32.5	3.8	100.0
Islands	11.7	1.2	50.7	9.7	24.5	2.3	100.0
ITALY	**33.5**	**8.6**	**41.4**	**3.0**	**11.4**	**2.1**	**100.0**
			% COMPOSITION				
North-west	67.3	92.3	18.0	3.6	2.5	13.8	38.6
North-east	17.8	6.0	39.1	19.7	15.1	36.5	25.7
Centre	1.9	0.3	12.9	7.5	7.6	5.2	7.2
South	9.9	0.2	19.2	40.0	55.6	34.8	19.6
Islands	3.1	1.2	10.9	29.2	19.1	9.6	8.9
ITALY	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Istat, Agricultural Census - Year 2000

TABLE 4.11 **Irrigated surface per type of source and geographical area - Year 2000** *(absolute data in hectares)*

GEOGRAPHICAL AREAS	Surface water	Water pipe system	Ground water	Treated wastewater	More than one source	Total
			ABSOLUTE DATA			
North-west	619,544	57,757	88,758	238	178,125	944,422
North-east	390,537	28,820	100,360	498	118,385	638,600
Centre	56,038	15,983	70,029	116	36,489	178,655
South	72,733	116,581	238,723	899	57,408	486,344
Islands	41,203	51,224	91,179	186	39,567	223,358
ITALY	**1,180,054**	**270,365**	**589,049**	**1,938**	**429,973**	**2,471,379**
			% COMPOSITION			
North-west	65.6	6.1	9.4	..	18.9	100.0
North-east	61.2	4.5	15.7	0.1	18.5	100.0
Centre	31.4	8.9	39.2	0.1	20.4	100.0
South	15.0	24.0	49.1	0.2	11.8	100.0
Islands	18.4	22.9	40.8	0.1	17.7	100.0
ITALY	**47.7**	**10.9**	**23.8**	**0.1**	**17.4**	**100.0**
			% COMPOSITION			
North-west	52.5	21.4	15.1	12.3	41.4	38.2
North-east	33.1	10.7	17.0	25.7	27.5	25.8
Centre	4.7	5.9	11.9	6.0	8.5	7.2
South	6.2	43.1	40.5	46.4	13.4	19.7
Islands	3.5	18.9	15.5	9.6	9.2	9.0
ITALY	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Istat, elaboration on Agricultural Census - Year 2000

TABLE 4.12 **Irrigated surface per kind of supply and geographical area - Year 2000** *(absolute data in hectares)*

GEOGRAPHICALS AREAS	Self supply	Consortia	Other farms	Other supply	More than one supply	TOTAL
			ABSOLUTE DATA			
North-west	104,153	606,300	6,586	55,305	172,077	944,422
North-east	117,333	399,666	3,979	28,375	89,246	638,600
Centre	98,646	32,089	1,167	33,907	12,847	178,655
South	171,795	167,218	17,540	80,768	49,023	486,344
Islands	82,217	76,151	5,576	31,763	27,651	223,358
ITALY	**574,145**	**1,281,424**	**34,849**	**230,118**	**350,843**	**2,471,379**
			% COMPOSITION			
North-west	11.0	64.2	0.7	5.9	18.2	100.0
North-east	18.4	62.6	0.6	4.4	14.0	100.0
Centre	55.2	18.0	0.7	19.0	7.2	100.0
South	35.3	34.4	3.6	16.6	10.1	100.0
Islands	36.8	34.1	2.5	14.2	12.4	100.0
ITALY	**23.2**	**51.9**	**1.4**	**9.3**	**14.2**	**100.0**
			% COMPOSITION			
North-west	18.1	47.3	18.9	24.0	49.0	38.2
North-east	20.4	31.2	11.4	12.3	25.4	25.8
Centre	17.2	2.5	3.3	14.7	3.7	7.2
South	29.9	13.0	50.3	35.1	14.0	19.7
Islands	14.3	5.9	16.0	13.8	7.9	9.0
ITALY	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Istat, elaboration on Agricultural Census - Year 2000

4.4.1.3 Data available from other sources

The three main projects mentioned - Anbi survey, Po RB authority project, Inea - Mop project - released data related to the CWR phenomenon. From the Inea - Mop project the CWR estimation came out. For the two other ones only basic data can be analysed.

INEA - MOP PROJECT

In this study, specific CWRs (cubic metre per hectare), defined taking into account the specific area climate, were applied. Irrigated surface per crop type was than defined through remote sensing data and other ancillary information in order to get the total volume required per consortium.

Table 4.13 shows the seasonal water requirements calculated by region. Sicilia is the region with the higher value with approximately 980 million cubic metres, than we find Puglia - 790 million cubic metres -, and Sardegna - 660 million cubic metres -. Water requirement per hectare varies a lot from 1,300 cubic metre per hectare recorded in Abruzzo region to 3,100 for the Sicilian region. Nevertheless we have to underline that in few regions the irrigated area values, computed with the mentioned project, register pronounced differences with the results of Istat surveys, that can be explained by the applied methodology.

TABLE 4.13 **Irrigated area and crop water requirement per region**

REGIONS	Irrigated land Remote sensing (1,000 ha)	Crop water requirement (million m^3 /year)	Crop water requirement per ha (1,000 m^3)
Abruzzo	122	157,03	1.29
Molise	31	83,64	2.70
Campania	219	303,04	1.38
Puglia	361	789,46	2.19
Basilicata	108	231,81	2.15
Calabria	107	317,70	2.97
Sicilia	314	979,04	3.12
Sardegna	349	659,81	1.89
TOTAL	**1,611**	**3,521.53**	**2.19**

Source: Inea – Mop project

ANBI SURVEY

Anbi survey also collected data on irrigation methods adopted.

At national level the highest value is recorded for the aspersion method accounting for 51 percent of the total irrigated area followed by superficial flowing water and lateral infiltration 22 percent, microirrigation 20 percent, and flood 7 percent.

Depending on geographical location, different irrigation methods stand out: flood in Piemonte region (64 percent), superficial flowing water and lateral infiltration in Lombardia (54 percent). Regions where microirrigation is the prevailing method applied are Sicilia, where it covers 68 percent of the regional irrigated area, Puglia and Basilicata with 49 percent. In the other regions aspersion is the most used method.

Data on crops cultivated by *comprensorium* are also provided.

PO RB AUTHORITY PROJECT

The present project also published data on irrigated UAA by irrigation method and by crop type that can be used as basic data for water balance approach. Results refer to the period 1991-1997 and are hereby reported.

Figures reveal that areas are alternately dominated by superficial flowing water (irrigated UAA in Areas 2, 3, 4, and 5) or aspersion irrigation (over 50 percent in area 6, 7, 8, and 9). Flood characterises Area 1 (Table 4.14).

TABLE 4.14 **Irrigated Utilised Agricultural Area by irrigation method** *(absolute data in hectares)*

STUDY AREAS	Irrigation method								
	Superficial flowing water	Underground flow	Flood	Aspersion	Micro irrigation	Sub irrigation	Other	Unknown	Total
				ABSOLUTE DATA					
Area 1	56,986	-	198,181	88	-	-	-	-	255,254
Area 2	38,892	732	3,995	255	-	-	-	-	43,874
Area 3	54,984	-	237	185	-	-	-	-	55,406
Area 4	141,943	-	22,498	-	-	-	-	-	164,441
Area 5	183,803	-	246	35,728	-	-	-	-	219,777
Area 6	48,485	-	10,716	65,167	103	-	977	-	125,448
Area 7	9,486	-	210	16,958	-	-	-	-	26,654
Area 8	15,633	190	1,415	87,112	1,825	1,320	3,629	1,758	112,882
Area 9	635	-	4	15,494	3,795	137	447	-	20,512
Area 10	-	4,784	20,226	47,109	14,154	6,188	19,18	6,233	117,881
TOTAL	**550,847**	**5,706**	**257,728**	**268,096**	**19,877**	**7,645**	**24,24**	**7,991**	**1,142,1**
				% COMPOSITION					
Area 1	22.3	-	77.6	-	-	-	-	-	100.0
Area 2	88.6	1.7	9.1	0.6	-	-	-	-	100.0
Area 3	99.2	-	0.4	0.3	-	-	-	-	100.0
Area 4	86.3	-	13.7	-	-	-	-	-	100.0
Area 5	83.6	-	0.1	16.3	-	-	-	-	100.0
Area 6	38.6	-	8.5	51.9	0.1	-	0.8	-	100.0
Area 7	35.6	-	0.8	63.6	-	-	-	-	100.0
Area 8	13.8	0.2	1.3	77.2	1.6	1.2	3.2	1.6	100.0
Area 9	3.1	-	-	75.5	18.5	0.7	2.2	-	100.0
Area 10	-	4.1	17.2	40.0	12.0	5.2	16.3	5.3	100.0
TOTAL	**48.2**	**0.5**	**22.6**	**23.5**	**1.7**	**0.7**	**2.1**	**0.7**	**100.0**

Source: Po RB authority

TABLE 4.15 **Irrigated Utilised Agricultural Area by crop** *(absolute data in hectares)*

STUDY AREAS	Crop											
	Winter cereals	Maize and sorghum	Soybean and other oleaginous crops	Sugar beet	Rotational forage	Vegetable	Rice	Fruit Trees	Vine	Permanent grassland	Other crops (a)	Total
						ABSOLUTE DATA						
Area 1	2,285	40,964	7,331	735	1,470	98	192,595	588	-	4,335	4,852	255,254
Area 2	6,796	16,586	1,765	3	2,325	1,697	4,194	828	200	9,192	290	43,874
Area 3	9,530	20,744	1,946	231	4,349	6,774	237	4,692	153	4,184	2,566	55,405
Area 4	5,534	39,423	9,219	677	10,143	581	11,611	-	-	5,497	81,756	164,441
Area 5	19,105	118,504	19,278	8,283	17,977	5,189	-	-	88	4,117	27,236	219,777
Area 6	3,052	15,365	6,157	1,925	12,005	215	10,716	934	779	9,233	65,067	125,448
Area 7	2,232	2,247	694	706	978	332	-	41	225	225	18,975	26,654
Area 8	25,579	22,721	7,032	8,309	14,519	4,622	755	12,672	6,146	7,111	3,416	112,882
Area 9	4,093	1,777	813	2,118	2,211	1,120	-	5,965	1,377	151	886	20,512
Area 10	16,381	21,862	19,605	6,180	4,361	11,076	7,157	8,249	52	-	22,958	117,881
TOTAL	**94,588**	**300,192**	**73,841**	**29,167**	**70,339**	**31,703**	**227,264**	**33,968**	**9,020**	**44,045**	**228,002**	**1,142,128**

TABLE 4.15 continued Irrigated Utilised Agricultural Area by crop *(absolute data in hectares)*

STUDY AREAS	Crop											
	Winter cereals	Maize and sorghum	Soybean and other oleaginous crops	Sugar beet	Rotational forage	Vegetable	Rice	Fruit Trees	Vine	Permanent grassland	Other crops (a)	Total
	% COMPOSITION											
Area 1	0.9	16.0	2.9	0.3	0.6	..	75.5	0.2	-	1.7	1.9	100.0
Area 2	15.5	37.8	4.0	..	5.3	3.9	9.6	1.9	0.5	21.0	0.7	100.0
Area 3	17.2	37.4	3.5	0.4	7.8	12.2	0.4	8.5	0.3	7.6	4.6	100.0
Area 4	3.4	24.0	5.6	0.4	6.2	0.4	7.1	-	-	3.3	49.7	100.0
Area 5	8.7	53.9	8.8	3.8	8.2	2.4	-	-	-	1.9	12.4	100.0
Area 6	2.4	12.2	4.9	1.5	9.6	0.2	8.5	0.7	0.6	7.4	51.9	100.0
Area 7	8.4	8.4	2.6	2.6	3.7	1.2	-	0.2	0.8	0.8	71.2	100.0
Area 8	22.7	20.1	6.2	7.4	12.9	4.1	0.7	11.2	5.4	6.3	3.0	100.0
Area 9	20.0	8.7	4.0	10.3	10.8	5.5	-	29.1	6.7	0.7	4.3	100.0
Area 10	13.9	18.5	16.6	5.2	3.7	9.4	6.1	7.0	..	-	19.5	100.0
TOTAL	**8.3**	**26.3**	**6.5**	**2.6**	**6.2**	**2.8**	**19.9**	**3.0**	**0.8**	**3.9**	**20.0**	**100.0**

Source: Po RB authority
(a) Other crops include also unknown irrigated crop, except for Area 1 and 2.

Analysing data referring to irrigated crops it is possible to understand different irrigation scheme distribution. In fact in Areas 2, 3, 4, and 5 maize and sorghum are the prevailing crops, while in Area 8 grain maize and rotational forage prevail. In Area 9 fruit trees cover most of the irrigated area, in 10 maize and soybean, whereas in Area 1 rice fields prevail. In Areas 6 and 7 there is a high incidence of unknown crops, which makes any further evaluation not appropriated (Table 4.15).

4.4.2 A preliminary estimate of livestock' drinking water use

In the framework of the construction of the Economy-wide Material flow balance (Ew-Mfb) for Italy (Femia, 2003), an estimate of the water used for livestock's drinking purposes has been produced with reference to year 1997. This estimate, amounting to around 103 million cubic metres of water, is part of the input balancing items entry of the balance. Indeed, it was necessary to account for this water on the input side because the quantity of manure produced and spread on the soil as fertiliser – part of the *dissipative uses* entry – had been accounted for *as such*, i.e. not in terms of dry matter.

In order to check the consistency of some items featuring in the general balance, a sub-balance for livestock breeding has been drawn up in the framework of the Ew-Mfb work, including both drinking water and manure, along with all other relevant items (mainly fodder, other livestock feedstuff and air on the input side and gaseous emissions, meat, wool, eggs, and the like on the output side).

The estimate has been obtained by first calculating the total weight of live livestock, and multiplying this by a coefficient of 20 cubic metres of water per tonnes of live weight per year (derived from Pizzoli et al., 2002).

The estimate of the total live weight of livestock has been produced on the basis of the number of livestock (as of the 1st of December) given by agricultural statistics of Istat: about 20 different coefficients have been used in this case, varying according to the kind, age and sex of the livestock. The same disaggregation has been used for the calculation of the quantities of manure produced.

In the resulting material balance of the livestock breeding, outputs cover 94 percent of the total material inputs. This confirms the validity of the estimate, at least in its order of magnitude.

Further studies will be carried out, in the framework of the pilot construction of a Physical input output table for Italy, 1997, in order to cover this gap, also by making more precise the estimate for drinking water. In particular, coefficients differentiated by kind of livestock and possibly by geographic area will be sough for and used (some such coefficients can be found in a study carried out by Statistics Canada; see Elliot and Soulard, 2003).

CONCLUSIONS

This publications contains the results of the research work carried out in Istat with reference to "*Grant Agreement n. 200071400004 on the investigation of data sources on water abstraction and consumption, as well as estimation of water abstraction and consumption both in agriculture*", supported by Eurostat, which had the aim to provide data for the *Inland waters* questionnaire, which is one of the nine Joint Oecd/Eurostat Questionnaires on the State of the environment.

The expected results of the operation, as stated in the Grant Agreement, were:

- survey on current data produced by organisations and research institutes concerning the evaluation of water resources;
- report on the adopted methodology to estimate the interested variables;
- sending to Eurostat data for the JQ *Inland waters*;
- utilisation for statistical purposes of administrative archives;
- creating an institutional network which feed up-to-date figures for the future editions of the JQ;
- scientific contribution to reach consensus on methodologies at European level to improve comparability of data.

In particular, the project is related to tables 1a, 2.1, 2.2 and 3.1 of the JQ *Inland waters* 2002.

The first table *Fresh water resources* includes all variables relevant for the hydrological cycle that is: precipitation, actual evapotranspiration,

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internal flow, actual external inflow and total actual outflow (of which into the sea and into neighbouring territories).

Tables 2.1, 2.2 and 3.1 are involved in this project with reference to agriculture items. In more detail table 2.1 *Annual fresh water abstraction by source* and table 2.2 *Other sources of water* request water abstraction by agriculture, forestry and fishing (of which irrigation) separately for fresh surface water, fresh ground water, non fresh water sources and reused water, whereas table 3.1 *Water use by supply category and by sector* requests water use by agriculture, forestry and fishing with reference to public water supply, self supply and other supply (of which for irrigation purposes).

In Italy, the main complete information about water resources dates back to seventies (Conferenza nazionale delle acque, 1972), when monitoring natural phenomena, through an hydrological balance, had the main task to provide information in planning hydraulic works. Nowadays the environmental functions of water is becoming an important complementary task, as water is a basic resource from the quantitative and qualitative point of view for human survival, for environment eco-sustainability and for other uses.

Over the last decades Italy has not provided regularly estimates of water resources, due to the lack of studies on this matter. The lack of updating data was probably due to legislation delays, uncertainty in competence distribution, the great number of involved institutions and the complex territorial and climatic characteristics of Italian territory, which request specific research investments.

This report aims to analyse which sources of data and which methodologies could be adopted in Italy, in order to assess water resources and uses for agriculture sector.

Analysis of methodologies and available sources showed that on one side there is a common knowledge related to hydrological aspects and to measurement methods, on the other side some lack appear in statistical analysis of data collected. The representative distribution of the raingauge and gauging stations is the main statistical problem we have to face in applying interpolation procedure. In fact, classic interpolation procedure are suitable when the stations are well spaced and are sufficiently representative of the climatic variability in the zone. In Italy, there are few meteorological stations compared with the great climatic variability, so serious errors are likely to occur if an attempt is made to interpolate without considering the effects of altitude of the station. Furthermore the lack of continuous data for very long periods requests a detailed statistical study for treating missing data.

The analysis of sources of data showed that many institutions have in charge aspects related to water issues, both at national level and territorial level. This requested a lot of efforts in defining the institutions involved in any water issues aspect, in closing cooperation with them and in data collecting.

Data related to precipitation are available in national institute, while data related to flow discharge, coming from gauging stations, are available in regional organisations. Furthermore, RBs information are available in different institutions. Finally, other information useful in quantifying water resources are available in scientific and technical documents, such as hydrological planning of the individual RB.

In this report existing methodologies on precipitation, actual evapotranspiration, internal flow, total actual outflow are analysed. Moreover, estimations have been provided for: precipitation, evapotranspiration, actual external inflow, total actual outflow into the sea and total actual outflow into neighbouring territories.

As regards the estimation of precipitation for year 2000, we compare two different methodologies starting from the same basic data. The results obtained showed a great discrepancy, revealing the best suitability of the Kriging methods (applied by Ucea) compared with a simple arithmetic mean. The results confirm in fact that the mean estimation methodology is not suitable when we consider data with a great spatial and temporal heterogeneity, such as meteorological data. A deepened analysis of Italian meteorological network is suggested in order to study the proportional distribution of stations with respect to altitude.

The most difficult parameter to measure is actual evapotranspiration, as it is function of a lot of variables such as precipitation, temperature, solar radiation, soil water storage, canopy and wind. Also for the estimation of this variable for year 2000, we compare two different methodologies. The first one implied the processing of data by mean of the Turc equation, the second one refers to the Ucea estimation, using the

Morecs methodology. In this case the discrepancy between the results obtained is related to the methodology used to aggregate data, in order to provide a national value. In the first case a simple arithmetic mean was applied to the AET values calculated for each station. The more reliability of Ucea estimation is strictly related to the spatial interpolation method (Kriging method) used, however this estimation refers only to grass. As these Ucea estimations considered a territory totally covered by grass, we can consider these value as referring to the maximum theoretical value of AET in Italy. The AET is characterised by an extremely variability in relation to seasonal pattern of climatic conditions affecting agriculture activities and crops, so a quantification of AET seems a more difficult task.

Internal flow was only discussed from the point of view of its nature and methodology, but it was not possible to identify pilot area and related gauging stations.

Actual external inflow and outflow into neighbouring territories were estimated, through collection of data available in Interregional departments, now directly dependent by regions. River basins shared with other territories are not many, being Italy a *peninsula*, but some exchanges of water are realised. More detailed data about water exchanges with the neighbouring countries could be assessed by means of collaboration between the hydrographic institutes of the different countries.

The methodology of estimating total actual outflow is discussed. Starting from data collected on the national, interregional and regional river basins, the total LTTA actual outflow has been calculated or estimated, according to the availability of measures of discharges and of precipitation, related to the RBs. The estimated values refer to surface water outflow. It has not been possible to split surface and ground water outflow.

We have to outline that we made estimates on directly measured river flows and so there is not a direct equivalence with assessment derived subtracting estimated actual evapotranspiration from precipitation value.

As regard water use in agriculture, the analysis of available sources pointed out institutional problems linked to delay in adoption of legislative acts, such as the mandatory application of measurements in water abstraction responsible for having data unavailable at farm level and partially available at irrigation consortia level.

Uncertainty in competence distribution, such as planning of new water abstraction permission is furthermore misleading. Quality of the information contained in these archives is not satisfactory, for lack of updating, for being in paper form, and distributed among different institutions. Even if these archives potentially represent a source of information, their information content should be standardised and digitalised in order to be used for statistical purposes. Furthermore also problems related to multiple use of the resource should be faced, whether abstraction is destined to agricultural uses jointly with other ones. Furthermore ancillary data should be collected in order to get the actual volume abstracted instead of the known volume flowing.

Some important experiences, focusing on water abstraction and requirement for irrigation purpose, were carried out at national or sub-national level by different institutions in order to overcome data gaps. The present study was aimed at evaluating them, even if a final shared result has not been reached.

In fact different project results are little comparable due to different methodologies applied, plurality of data sources, for being referred to different years and to different classifications.

Different methodologies have been applied in these studies increasing knowledge either on their suitability and on their limits.

Direct data collection still remain the main approach to get basic data from farm or from irrigation consortia. In some studies, major efforts are still oriented to assess consortia network structure. Information collected at farm level, anyway, is not always the good one to obtain global values of water. A closer co-operation would be required between institutions to eventually integrate different approaches and data sources, in this case the recent experience carried out by irrigation and land reclamation consortia is only the first step.

Knowledge on pattern of the irrigation phenomenon coming from survey conducted by National statistical institute can help in the adoption of different approaches. For instance, from the geographical point of view, supply and access to water pattern distribution in space suggest a modulated approach for different regions, since consortia delivering and resorted surface water is more widespread in northern regions, whereas self supply and resorted ground water dominate in the central and southern regions.

Estimates of water requirement by crops are analysed from the methodological point of view, but much work is needed in this direction. Due to the variability in time and space of the phenomenon, many climatic, pedological and agronomic parameters need to be defined at local level in order to apply methodologies such as soil water requirements.

Data at high detail at territorial level are necessary and statistical methodologies needs to be further developed to overcome problems related to representativeness of the phenomenon in sampling survey.

Furthermore, the experience carried out showed that abstracted water can be monitored or calculated with less effort. Delivered water can than be calculated through estimation of losses.

As long as data on actual amount of abstracted and delivered water is unavailable few proxies can be used to monitor the phenomenon such as *irrigated surface per irrigation method*, *irrigated surface by crop*, *irrigated surface by supply* and *by source*.

As regards water delivered to agriculture through public water supply and livestock water requirements figures are given.

Water supplied by public network to agriculture sector is available, as it has been collected with the Water survey system, run by Istat, but this is a very limited amount of water if compared with the total water required by agriculture aims.

An estimate of livestock' breeding water use is proposed, applying a specific coefficient to live livestock, knowing their number and weight per species and category.

ANNEX 1
REFERENCE TABLES OF THE 2002 JOINT OECD/EUROSTAT *INLAND WATERS* QUESTIONNAIRE

INLAND WATERS	Table 1a: Fresh Water Resources (a)										
Territory:	Contact:										
(mio m^3)	LTAA	1980	1985	1990	1995	1996	1997	1998	1999	2000	2001
Precipitation											
Actual evapotranspiration											
Internal Flow											
Actual external inflow											
Total actual outflow											
of which: into the sea											
of which: into neighbouring territories											
TOTAL FRESH WATER RESOURCES											
Recharge into the Aquifer											
Recharge minus ecological discharge											
Groundwater available for annual abstraction (b											
Regular freshwater resources 95 per cent time											

YOUR FOOTNOTES

The numbers in the labels refer to the "List of Definitions" (i.e. the sheet of this workbook, named "DEF"). Please consult these definitions before filling in the questionnaire.

(a) This table aims at taking stock of Fresh water resources available on the national territory, and of the different flows (inflow and outflow) of which they are composed. The concept of renewable resources excludes by definition the non-renewable resources offered by the potential use of water reserves (essentially ground water).

The data for Table 1, 1a_IF and 1a_OF are for the main part derived from hydrological data.

In order to avoid double-counting while computing regional totals, a breakdown of inflows and outflows by neighbouring territory would be very useful. This breakdown can be entered in worksheet "1b_IF" for the data concerning inflow and in worksheet "1b_OF" for the data concerning outflow.

(b) Same as recharge minus ecological discharge if no other restrictions are considered

Please specify for each type of flow the calculation method used (estimates and measurements), and the reference period covered to calculate long term annual averages (this period should be long enough to build a relatively stable average)

Flow	*Calculation methods*	*Reference period*
* *Precipitation*		
* *Actual Evapotranspiration*		
**Internal flow*		
* *Actual external inflow*		
* *Total actual outflow*		

INLAND WATERS		Table 2.1: Annual fresh water abstraction by source									
Territory:	(mio m³)	Contact:									
	ISIC/NACE	1980	1985	1990	1995	1996	1997	1998	1999	2000	2001
Fresh surface water											
Total gross abstraction											
of which: (a)											
* Public water supply	(41)										
* Agriculture, forestry, fishing	(01-05)										
of which: Irrigation											
* Manufacturing industry	(15-37)										
of which: industry-cooling											
* Production of electricity (cooling)	(40.1)										
* Other activities (b)	(50-93)										
* Households											
Fresh ground water											
Total gross abstraction											
of which: (a)											
* Public water supply	(41)										
* Agriculture, forestry, fishing	(01-05)										
of which: Irrigation											
* Manufacturing industry	(15-37)										
of which: industry-cooling											
* Production of electricity (cooling)	(40.1)										
* Other activities (b)	(50-93)										
* Households											
Total surface and ground water											
Total gross abstraction											
of which: (a)											
* Public water supply	(41)										
* Agriculture, forestry, fishing	(01-05)										
of which: Irrigation											
* Manufacturing industry	(15-37)										
of which: industry-cooling											
* Production of electricity (cooling)	(401)										
* Other activities (b)	(50-93)										
* Households											
* Returned water (before use or without use)											
Net abstraction											

FOOTNOTES:

The numbers in the labels refer to the "List of Definitions" (i.e. the sheet of this workbook, named "DEF"). Please consult these definitions before filling in the questionnaire.

(a) Water abstractions are broken down by selected activity categories according to the ISIC (Rev. 3) and NACE classifications.

(b) "Other activities" refers to self abstraction of categories not elsewhere specified, e.g. transport, services, etc. Please specify the activity if there is any large abstraction in this category.

INLAND WATERS — **Table 2.2: Other sources of water**

Territory: ______ ______ **(mio m³)** **Contact:** ______

	ISIC/NACE	1980	1985	1990	1995	1996	1997	1998	1999	2000	2001
Non fresh water sources (Marine and brackish water)											
Total gross abstraction (a)											
* Agriculture, forestry, fishing	(01-05)										
of which: Irrigation											
* Manufacturing industry	(15-37)										
of which: industry-cooling											
* Production of electricity (cooling)	(40.1)										
* Other activities (b)	(50-93)										
Desalinated water											
* Public water supply	(41)										
* Other activities (b)	(50-93)										
Reused water											
* Agriculture, forestry, fishing	(01-05)										
of which: Irrigation											
* Manufacturing industry	(15-37)										
of which: industry-cooling											
* Production of electricity (cooling)	(40.1)										
* Other activities (b)	(50-93)										
Imports of water.	TOTAL										

FOOTNOTES:

The numbers in the labels refer to the "List of Definitions" (i.e. the sheet of this workbook, named "DEF"). Please consult these definitions before filling in the questionnaire.

(a) Water abstractions are broken down by selected activity categories according to the ISIC (Rev. 3) and NACE classifications.

(b) "Other activities" refers to self abstraction of categories not elsewhere specified, e.g. transport, services, etc. Please specify the activity if there is any large abstraction i

INLAND WATERS		Table 3.1: Water use by supply category									
Territory: ______ ______	(mio m³)	Contact: ______									
	ISIC/NACE	1980	1985	1990	1995	1996	1997	1998	1999	2000	2001
Population connected to public water supply (%)											
Public water supply											
TOTAL											
of which used by:											
* Agriculture, forestry, fishing	(01-05)										
* All industrial activities	(10-45)										
-Total manufacturing industries	(15-37)										
of which for cooling purposes											
-Production and distribution of electricity	(40.1)										
of which for cooling purposes											
* Domestic sector											
-households											
-other activities	(50-93)										
Self supply											
TOTAL											
of which used by:											
* Agriculture, forestry, fishing	(01-05)										
of which for : Irrigation purposes											
* All industrial activities	(10-45)										
-Total manufacturing industries	(15-37)										
of which for cooling purposes											
-Production and distribution of electricity	(40.1)										
of which for cooling purposes											
* Domestic sector											
-households											
-other activities	(50-93)										
Other supply											
TOTAL											
of which used to:											
* Agriculture, forestry, fishing	(01-05)										
of which for : Irrigation purposes											
Losses during transport											
TOTAL											
Evaporation losses											
Leakage											

FOOTNOTES:

*The numbers in the labels refer to the "**List of Definitions" (I.e. the sheet of this workbook, named "DEF"). Please consult these definitions before filling in the questionnaire***

ANNEX 2
DEFINITIONS

PRECIPITATION

Total volume of atmospheric wet precipitation (rain, snow, hail, ...). Precipitation is usually measured by meteorological or hydrological institutes.

ACTUAL EVAPOTRANSPIRATION

Total volume of evaporation from the ground, wetlands and natural water bodies and transpiration of plants. According the definition of this concept in Hydrology, the evapotranspiration generated by all human interventions is excluded, except unirrigated agriculture and forestry. The actual evapotranspiration is calculated using different types of mathematical models, ranging from very simple algorithms (Budyko, Turn Pyke, etc) to schemes that represent the hydrological cycle in detail. Please do not report potential evapotranspiration which is “the maximum quantity of water capable of being evaporated in a given climate from a continuous stretch of vegetation covering the whole ground and well supplied with water”.

INTERNAL FLOW

Total volume of river run-off and groundwater generated, in natural conditions, exclusively by precipitation into a territory. The internal flow is equal to precipitation less actual evapotranspiration and can be calculated or measured. If the river run-off and groundwater generations are measured separately, transfers between surface and groundwater should be netted out to avoid double counting.

ACTUAL EXTERNAL INFLOW

Total volume of actual flow of rivers and groundwater, coming from neighbouring territories. Data measured.

TOTAL ACTUAL OUTFLOW

Actual outflow of rivers and groundwater into the sea plus actual outflow into neighbouring territories. Data measured.

ACTUAL OUTFLOW INTO THE SEA

The total volume of actual outflow of rivers and groundwater into the sea.

ACTUAL OUTFLOW INTO NEIGHBOURING TERRITORIES

The total volume of actual outflow of rivers and groundwater into neighbouring territories.

TOTAL FRESH RESOURCES

Internal flow plus actual external inflow.

FRESH SURFACE WATER

Water which flows over, or rests on the surface of a land mass, natural watercourses such as rivers, streams, brooks, lakes, etc., as well as artificial watercourses such as irrigation, industrial and navigation canals, drainage systems and artificial reservoirs. For purposes of this questionnaire, bank filtration is included under (fresh) surface water. Sea-water, and transitional waters, such as brackish swamps, lagoons and estuarine areas are not considered surface water and so are included under non fresh water sources.

FRESH GROUND WATER

Fresh water which is being held in, and can usually be recovered from, or via, an underground formation. All permanent and temporary deposits of water, both artificially charged and naturally, in the subsoil, of sufficient quality for at least seasonal use. This category includes phreatic water-bearing strata, as well as deep strata under pressure or not, contained in porous or fracture soils. For purposes of this questionnaire, ground water includes springs, both concentrated and diffused, which may be subaqueous.

NON FRESH WATER SOURCES

Includes sea water and transitional water, such as brackish swamps, lagoons and estuarine areas. Such water resources may be of great importance locally, although in a national context, they are usually of lesser importance as compared to surface and groundwater resources.

BANK FILTRATION

Induced infiltration of river water through bankside gravel strata (by pumping from wells sunk into the gravel strata to create a hydraulic gradient) with the intention of improving the water quality. For purposes of the questionnaire, bank filtration is covered under surface water.

GROSS WATER ABSTRACTION (= WATER WITHDRAWAL)

Water removed from any source, either permanently or temporarily. Mine water and drainage water are included. Water abstractions from groundwater resources in any given time period are defined as the difference between the total amount of water withdrawn from aquifers and the total amount charged artificially or injected into aquifers. Water abstractions from precipitation (e.g. rain water collected for use) should be included under abstractions from surface water. The amounts of water artificially charged or injected are attributed to abstractions from that water resource from which they were originally withdrawn. Water used for hydroelectricity generation is an in-situ use and should be excluded.

WATER NET ABSTRACTION (= WATER WITHDRAWAL)

Water gross abstraction minus returned water.

WATER USE

Refers to water that is actually used by end users for a specific purpose within a territory, such as for domestic use, irrigation or industrial processing. Excludes returned water.

SUPPLY OF WATER

Delivery of water to final users including abstraction for own final use (self-supply).

PUBLIC WATER SUPPLY

Water supplied by economic units engaged in collection, purification and distribution of water (including desalting of sea water to produce water as the principal product of interest, and excluding system operation for agricultural purposes and treatment of waste water solely in order to prevent pollution). Deliveries of water from one public supply undertaking to another are excluded.

SELF-SUPPLY

Abstraction of water by the user for own final use.

OTHER SUPPLY

The part of water supply to agriculture which was not included under 'Public water supply' or 'self supply' (that means all system operation for agricultural irrigation which are not individual irrigation systems). This might also include some water from self supply distributed to other users.

IRRIGATION USE

Artificial application of water on lands to assist in the growing of crops and pastures.

IRRIGATION WATER

Water which is applied to soils in order to increase their moisture content and to provide for normal plant growth.

REUSED WATER

Water that has undergone wastewater treatment and is delivered to a user as reclaimed wastewater. This means the direct supply of treated effluent to the user. Excluded is waste water discharged into a watercourse and used again downstream. Recycling within industrial sites is excluded.

WATER LOSSES

Volume of water lost during transport (through leakage or evaporation) between a point of abstraction and a point of use, or between points of use and reuse.

TOTAL WATER CONSUMPTION

Water abstracted which is no longer available for use because it has evaporated, transpired, been incorporated into products and crops, consumed by man or livestock, ejected directly to the sea, or otherwise removed from freshwater resources. Water losses due to leakages during the transport of water between the point or points of abstraction and the point or points of use are excluded. For the purpose of this questionnaire, total water consumption equals consumptive water use plus discharges to the sea.

WASTE WATER

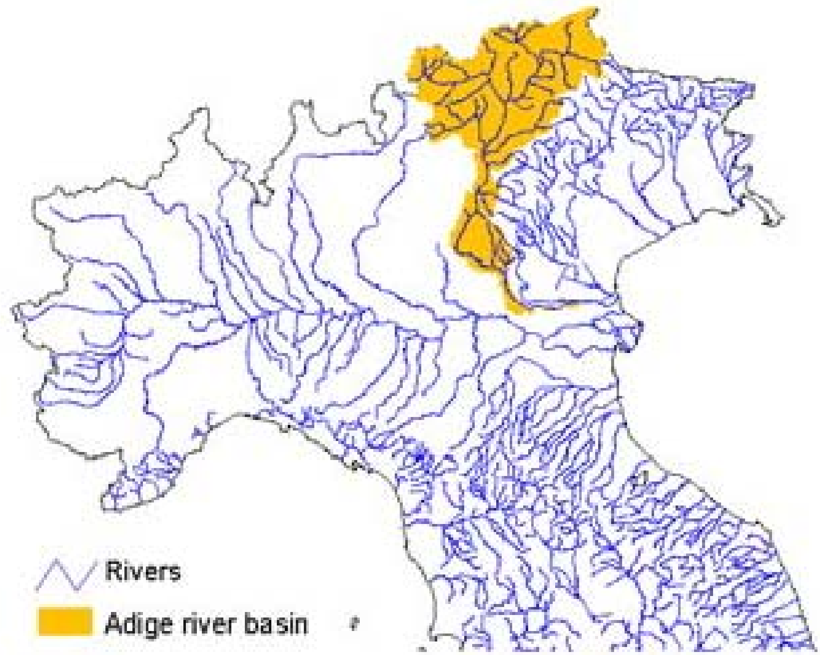
Water which is of no further immediate value to the purpose for which it was used or in the pursuit of which it was produced because of its quality, quantity or time of occurrence. However, waste water from one user can be a potential supply to a user elsewhere. Cooling water is not considered to be waste water for purposes of this questionnaire.

WASTE WATER TREATMENT

Process to render waste water fit to meet applicable environmental standards or other quality norms for recycling or reuse. Three broad types of treatment are distinguished in the questionnaire: primary, secondary and tertiary. For purposes of calculating the total amount of treated waste water, volumes and loads reported should be shown only under the “highest” type of treatment to which it was subjected.

ANNEX 3
CHARACTERISTICS OF THE MAIN ITALIAN RIVER BASINS

ADIGE RIVER BASIN



REGIONS INCLUDED IN THE RB:

Veneto
Trentino Alto Adige

NEIGHBOURING COUNTRIES INCLUDED IN RB:

Switzerland

MUNICIPALITIES INCLUDES IN THE RB (PARTIALLY AND COMPLETELY):

339 in Italy
6 in Switzerland

MORPHOLOGICAL CHARACTERISTICS (PERCENTAGE ON TOTAL RB SURFACE):

Area at altitude < 300 m above sea level: 7.4 percent
Area at altitude ranging from 300 and 600 m above sea level: 6.3 percent

Area at altitude ranging from 600 and 900 m above sea level: 8.8 percent
Area at altitude > 900 m above sea level: 77.5 percent

THE SELECTED GAUGING STATION:

Boara Pisani
Distance to the outfall: 51 km
Zero water level: 8.61 m above sea level

TIME SERIES ANALYSED:

1961-1986, 1988-2000

MEAN DISCHARGE:

196.8 m^3/s

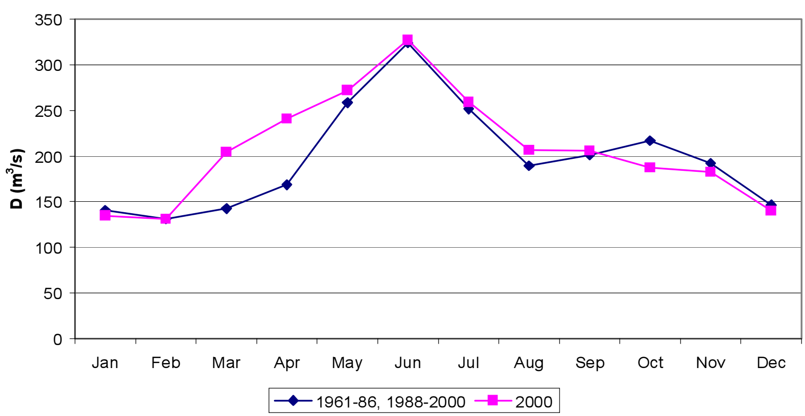
MONTHLY MAXIMUM MEAN DISCHARGE:

616.6 m^3/s (October 1993)

MONTHLY MINIMUM MEAN DISCHARGE:

63.20 m^3/s (April 1997)

Mean monthly discharge



The trend of discharges is typical of a transition nival regimen. There are two maximum values: the principal in June in order to the fusion of the snows, the second in October, less pronounced, that is only due to the rainfall.

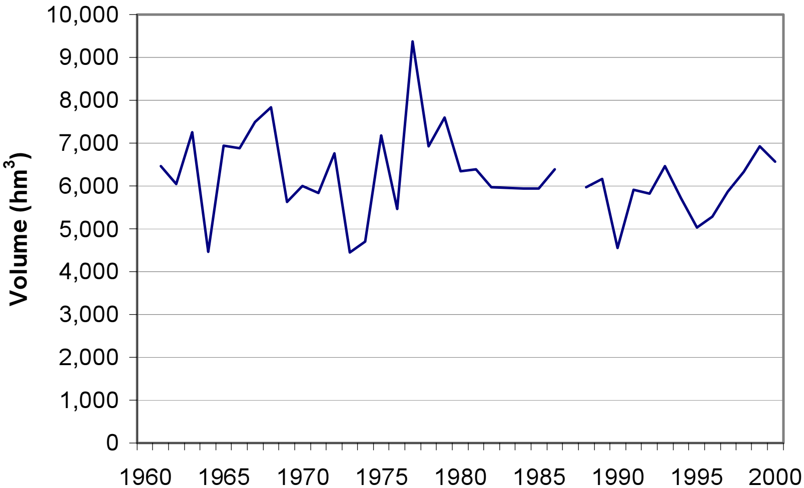
MEAN ACTUAL OUTFLOW DURING 1961-1986, 1988-2000:

6,219 hm^3

MEAN ACTUAL OUTFLOW IN 2000:

6,568 hm^3

Actual outflow



ARNO RIVER BASIN

REGIONS INCLUDED IN THE RB:

Toscana (98.4 percent)
Umbria (1.6 percent)

MUNICIPALITIES INCLUDES IN THE RB (PARTIALLY AND COMPLETELY):

163

MORPHOLOGICAL CHARACTERISTICS (PERCENTAGE ON TOTAL RB SURFACE):

Area at altitude < 300 m above sea level: 55.3 percent
Area at altitude ranging from 300 and 600 m above sea level: 30.4 percent
Area at altitude ranging from 600 and 900 m above sea level: 9.8 percent
Area at altitude > 900 m above sea level: 4.5 percent

THE SELECTED GAUGING STATION:

S. Giovanni alla Vena
Distance to the outfall: 37 km
Zero water level: 6.71 m above sea level

TIME SERIES ANALYSED:

1960-2000

MEAN DISCHARGE:

80.9 m^3/s

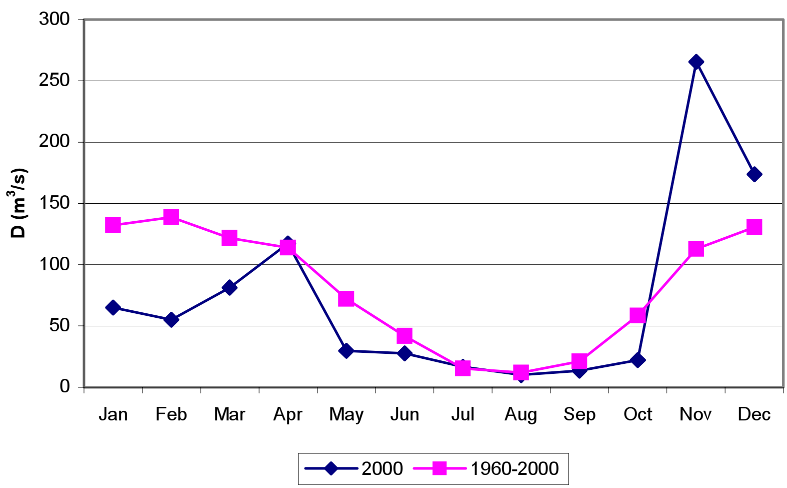
MAXIMUM MONTHLY MEAN DISCHARGE:

396.6 m^3/s (November 1966)

MINIMUM MONTHLY MEAN DISCHARGE:

3.5 m^3/s (August 1998)

Mean monthly discharge



The trend of discharge is typical of a pluvial Mediterranean regimen, with minimum outflow in the summertime. The greatest discharges are in autumn and winter.

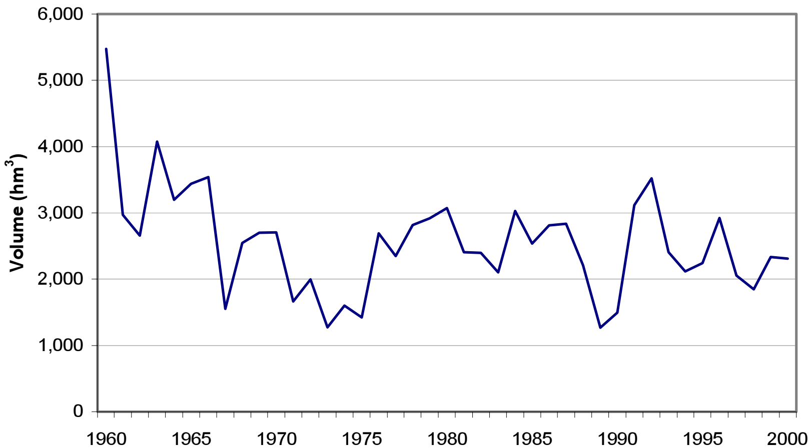
MEAN ACTUAL OUTFLOW DURING 1960-2000:

2,541 hm^3

MEAN ACTUAL OUTFLOW IN 2000:

2,303 hm^3

Actual outflow



TEVERE RIVER BASIN

REGIONS INCLUDED IN THE RB:

Umbria (47 percent)
Lazio (1.6 percent)
Toscana (7 percent)
Abruzzo (3.6 percent)
Marche (1.2 percent)
Emilia Romagna (0.16 percent)

NEIGHBOURING COUNTRIES INCLUDED IN RB:

Vatican City State (0.005 percent)

MUNICIPALITIES INCLUDES IN RB (PARTIALLY AND COMPLETELY):

334

MORPHOLOGICAL CHARACTERISTICS (PERCENTAGE ON TOTAL RB SURFACE)

Area at altitude < 300 m above sea level: 34 percent

Area at altitude ranging from 300 and 600 m above sea level: 34 percent
Area at altitude ranging from 600 and 900 m above sea level: 17 percent
Area at altitude > 900 m above sea level: 15 percent

THE SELECTED GAUGING STATIONS:

Ripetta
Distance to the outfall: 43 km
Zero water level 0.705 m above sea level

TIME SERIES ANALYSED:

1924-1930, 1935-2000

MEAN DISCHARGE:

222.3 m^3/s

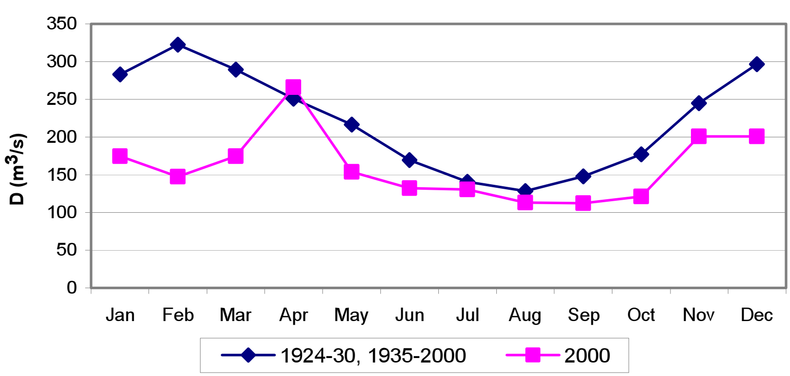
MAXIMUM MONTHLY MEAN DISCHARGE:

1,014.1 m^3/s (December 1937)

MINIMUM MONTHLY MEAN DISCHARGE:

73.1 m^3/s (August 1987)

Mean monthly discharges



The trend of discharge is typical of an Apennine river basin with a pluvial Mediterranean regimen; it presents a minimum discharge in the summertime (August) and the maximum values in autumn and winter

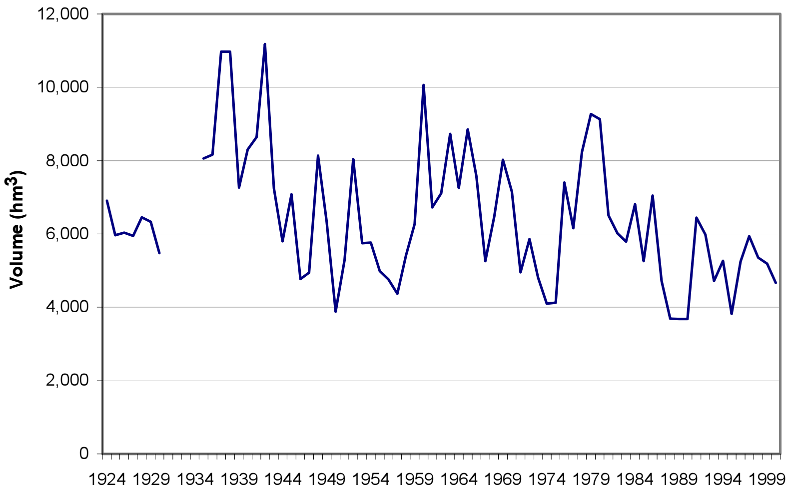
MEAN ACTUAL OUTFLOW DURING 1924-1930, 1935-2000:

6,980 hm^3

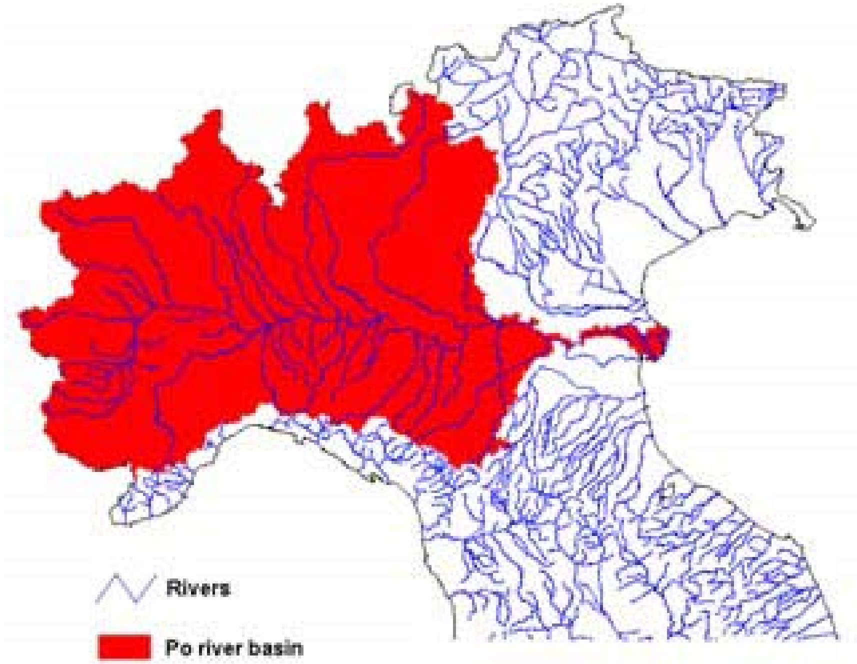
MEAN ACTUAL OUTFLOW IN 2000:

5,062 hm^3

Actual outflow



PO RIVER BASIN



REGIONS INCLUDED IN THE RB:

Piemonte
Valle d'Aosta
Liguria
Lombardia
Veneto
Emilia Romagna
Toscana
Trentino Alto Adige

NEIGHBOURING COUNTRIES INCLUDED IN RB:

Switzerland
France

MUNICIPALITIES INCLUDED IN THE RB (PARTIALLY AND COMPLETELY):

3,210

MORPHOLOGICAL CHARACTERISTICS (PERCENTAGE ON TOTAL RB SURFACE):

Plain: 42 percent
Hill and mountain: 58 percent

THE SELECTED GAUGING STATION:

Pontelagoscuro
Distance to the outfall: 91 km
Zero water level: 8.21 m above sea level

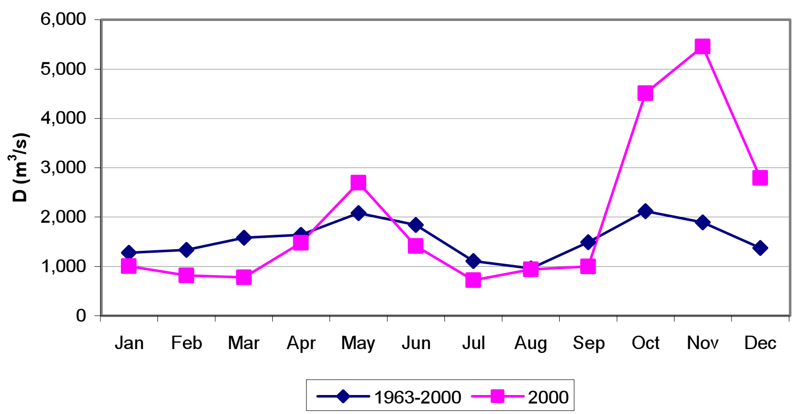
TIME SERIES ANALYSED:

1963-2000

MEAN DISCHARGE:

1,556 m^3/s

Mean monthly discharge



The mean discharges of Po RB, that is the greater RB in Italy, are characterised by a variability caused mainly by the hydrological pattens of its Alpine and the Apennine effluents

MAXIMUM MONTHLY MEAN DISCHARGE:

6,165 m^3/s (October 1993)

MINIMUM MONTHLY MEAN DISCHARGE:

518 m^3/s (July 1976)

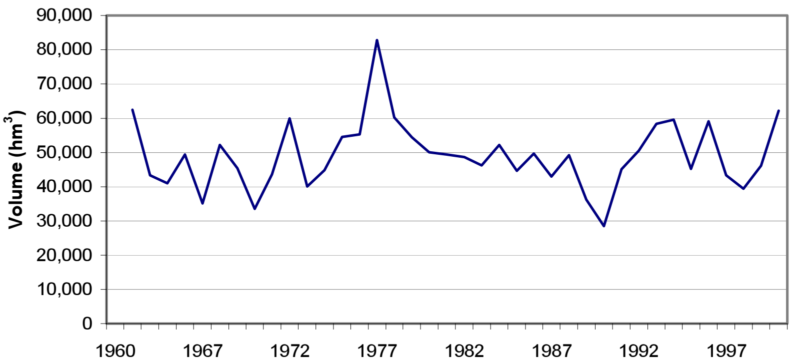
MEAN ACTUAL OUTFLOW DURING 1963-2000:

49,112 hm^3

MEAN ACTUAL OUTFLOW IN 2000:

62,246 hm^3

Actual outflow



ANNEX 4
AN ANALYSIS OF THE IRRIGATION PHENOMENON THROUGH AGRICULTURAL CENSUS 2000 DATA

Generally speaking the intensification of agricultural production during the last decades has increased the pressure on water resources. Problems related to water quantity abstracted mainly rise in areas where the resource scarcity is a well-known issue.

Data referring to the last three censuses with reference to irrigated surface show almost steady or slightly decreasing trend, whereas water saving irrigation systems have an increasing trend.

Table 1 describes the type of supply source the irrigated agricultural farms have resorted, the existing type of management for water distribution and the system of irrigation they adopted from 1982 to 2000. Looking at the figures, we have to specify that the total number of farms has not been obtained by adding the individual modality adopted by the farms, as each one of these can draw from more than one source and it can be served according to various supply modalities.

The analysis of the time series data points out that the number of irrigated farms have underwent considerable variations: while there were 1,059,456 farms in 1990, a 31 percent decrease has been registered in 2000. If we compare 2000 data with data referring to year 1982, the decrease was minor (12.4 percent).

In 2000, surface watercourses represent the supply source for 233,010 farms. Compared to the 1990 and the 1982 censuses, an increase has been verified of 19.7 percent and 46.2 percent respectively. The farms resorting to surface water bodies (both natural and artificial ones) as supply sources account for 33,790 with a 34.4 percent increase compared to the 1990 census. Farms abstracting water from other sources - including groundwater - went from being 341,738 in 1982 to 531,853 in 2000.

The predominant form of management chosen is the irrigation and land reclamation consortium that in 2000 supports 302,872 farms. In 2000, only 35,071 farms resort to other agricultural farms' irrigated water, with a 13.0 percent increase compared to 1990. Self supply (included in other kind of supply) has been increasingly adopted, as farms rose from 35,102 to 429,325 entities using this supply.

As regards the irrigation systems, the most used methods, with reference to the year 2000, are the aspersion system and the superficial flowing water and lateral irrigation system. The dripping irrigation system registered a considerable increase (400 percent), from 28,208 farms using it in 1982, to 114,369 farms in 2000.

Compared to 1990, farms carrying out the irrigation practice reduced of 203,558 units (21.8 percent) and the irrigated agricultural surfaces of about 240,000 hectares (8.8 percent). Compared to 1982, the decrease was of 21.8 percent and 2.0 percent respectively (Table 2).

Irrigated crops changed also their pattern in the last three decades as showed in Table 2. An analysis of the individual plants trend revealed for year 2000 a light increase in the number of farms and in the number of irrigated surfaces, for wheat cultivation, counting 8,162 farms more compared to 1990 and a larger irrigated surface, corresponding to more than 30,147 hectares. The greatest decreases, in terms of percentages, were registered for the soybean cultivation (70 percent less of farms and 61 percent less of irrigated surfaces compared to 1990) and for rotational forages with losses respectively of 51 percent and 39 percent decreases compared to 1990.

At a national level, 37.8 percent of the farms with Utilised Agricultural Area (UAA) and surface for wood arboriculture includes an irrigable surface, while 28.6 percent have an irrigated surface. The irrigable surface amounts to 29.1 percent of UAA and of wood arboriculture surfaces, while the irrigated one extends over only 18.5 percent of UAA and of wood arboriculture surfaces (Table 3).

On a geographical area level, the greatest number of farms with an irrigable surface is situated in the south of Italy. The south of Italy presents also the greatest number of farms with an irrigated surface (274,717 units equal to 37.7 percent of farms with an irrigated surface). On a regional level, the region with most farms with an irrigable surface is Puglia, while Sicilia is the region with most farms having an irrigated surface.

Table 4a to presents data on agricultural farms per irrigated surface classes revealing that 57.7 percent of the national total has less than one irrigated surface hectare, while only 0.2 percent has more than 100 hectares of irrigated surfaces.

The analysis of the farms' geographical distribution per dimension shows that the small farms (with dimension less than one hectare) are mainly situated in the South and in the Islands (43.4 percent in south of Italy and 21.6 percent more in the Islands), while, considering the 5-10 hectares class, more than 50 percent is situated in the North; in particular, in the larger dimension class, over 64.1 percent is located in the North-west, where the highest values can be found in Lombardia (40.8 percent) and Piemonte (20.7 percent), and 18.7 percent, is located in the North-east. Farms with 100 hectares and more are not very widespread in central and southern Italy and on the Islands, except for Puglia, which represents 5.7 percent of the national value.

20.8 percent of irrigated surfaces belongs to farms included in the 20-50 hectares class, while small farms (with dimension less than one hectare) use only 5.5 percent of irrigated surfaces. In the larger dimension class (100 hectares and more), almost 83 percent of surfaces are in the North (61.1 percent in the north-west of Italy and 21.8 percent in the North-east) and, in particular, Lombardia accounts for 38.3 of this class (Table 4b).

Table 5 presents data relative to the irrigated surfaces per type of cultivation and region.

In the Agricultural Census survey for the year 2000, the measure of these surfaces resulted to be equal to 2,471,378 hectares.

The crops examined are, in decreasing order of surface used, grain maize (25.2 percent), rotated forages (10.8 percent), fruits and vegetables (each of 7.7 percent), vines (7.4 percent), citrus fruits (4.6 percent), wheat (4.0 percent), sugar beet (3.3 percent), soybean (3.2 percent), potato (1.1 percent) and sunflower (0.6 percent). A remaining 24.4 percent refers to the other irrigated cultivations that are not further desegregated.

The surfaces used for grain maize cultivation are mainly situated in the north-west of Italy, (58.9 percent), and more particularly, in Lombardia (39.8 percent) and Piemonte (19.0 percent), and in the North-east (32.8 percent); Friuli-Venezia Giulia has 65.1 percent of irrigated surface. The percentage of surfaces used for rotational forage is especially distributed in North-west Italy (48.3 percent), where the highest values are registered in Lombardia (34.8 percent of the national value), and in the North-east (21.9 percent). Sardegna, with 34.4 percent, is the region with the highest percentage of lands used for this type of cultivation on the irrigated regional value.

Almost half of the surfaces used for cultivating vegetables are in the south of Italy (38.4 percent), in particular in Puglia (16.7 percent), and on the Islands (14.4 percent). The percentage is very low as regards the

North-west (8.5 percent). Emilia-Romagna cultivates 19.0 percent of the national value. On a regional level, vegetables make up 24.6 percent of Abruzzo's irrigated surface.

As regards the surfaces for fruit trees production, Emilia-Romagna - with 27,5 percent - and Trentino-Alto Adige - with 15.4 percent - contribute in making Italy's North-east representing 54.5 percent of surfaces used for fruit trees cultivations. In Trentino-Alto Adige, fruit trees productions cover 50 percent of irrigated surfaces.

The vine cultivation is mainly concentrated in the south of Italy (43.1 percent), particularly in Puglia (37.6 percent), and in the Islands (23.1 percent), especially in Sicilia (21.0 percent).

The irrigated surfaces used for citrus fruit production are mainly concentrated in southern Italy (36.3 percent) and on the Islands (63.2 percent), where Sicilia amounts to 59.0 percent. On this island, 41.6 percent of the entire irrigated surface is used for this cultivation.

The wheat cultivation is mainly carried out in southern Italy (52.7 percent of irrigated surfaces used) and, particularly in Puglia (30.2 percent).

The sugar beet cultivation is especially practiced in the North-east of Italy (36.2 percent of surfaces used) and particularly in Emilia-Romagna (21.6 percent).

The surfaces used for soybean cultivation are almost completely situated in the north-east of Italy (50.8 percent), due to Veneto (31.1 percent), and in the north-west (48.8 percent), due to Lombardia (35,5 percent).

The scanty irrigated surfaces used for the cultivation of potatoes are mainly situated in the south of Italy with 51.8 percent of the national total (Calabria accounts for 16.1 percent and Campania for 15.2 percent).

57.1 percent of surfaces used for sunflower cultivation is situated in central Italy (57.1 percent), and in particular, in Toscana (21.9 percent) and in Umbria (17.5 percent).

The surfaces used for other irrigated cultivations, which are mainly to be attributed to rice cultivation, are situated mainly in the north-western regions (55.7 percent) especially in Piemonte (25.8 percent) and Lombardia (25.4 percent). On a regional level, the maximum values were registered in Valle d'Aosta with 96.9 percent of agricultural surfaces used for irrigated cultivation, which has not been illustrated elsewhere.

Figures, reported in Table 6 (irrigated surface per irrigated surface classes and crop**)** for maize and rotational forage, reveal that irrigated surface classes mostly represented are 10-20 hectares and 20-50 hectares both including 41.7 percent of total irrigated area for maize and 48.1 percent for rotational forage.

On the reverse grape and vegetables are mostly irrigated in farms where the extension of the irrigated area is less than 5 hectares, including 57.3 percent of total irrigated area for grape and 52.3 percent for vegetables. Fruit trees also present the same trend (49.6 percent in farms with less than 5 hectares) even if also the class 5-10 hectares is well represented with 23.1 percent of the total irrigated area.

Table 7 presents data referring to the irrigated surfaces by irrigation method and by region. The total surface amounts to 2,539,011 hectares. This value differs from the irrigated surface presented in other tables because of various reasons. Among others, this difference can be attributed to the fact that one same surface can be served by various irrigation systems, contributing to over-estimating them.

The most widespread irrigation methods used by farms are the sprinkler system (41.4 percent of irrigated surfaces), superficial water flowing and lateral infiltration (33.5 percent), drip irrigation (11.4 percent), and 3.0 percent of other water supply saving method, generally indicated under the micro-irrigation entry. 8.6 percent of surfaces are irrigated with the flood irrigation method.

Surfaces, irrigated by means of the sprinkler system, are mainly situated in the North (57.1 percent) and particularly in Emilia-Romagna (15.5 percent), in Veneto (15.0 percent) and in Lombardia (13.5 percent). On a regional level, the sprinkler system is the prevailing method in many regions such as Umbria (85.1 percent), Marche (80.4 percent), and Trentino-Alto Adige (78.5 percent).

The superficial water flowing and lateral infiltration method is mainly used in the north-west of Italy with 67.3 percent of irrigated surface (40.4 percent in Lombardia and 24.9 percent in Piemonte). The superficial water flowing prevails in Piemonte (57.7 percent), in Valle d'Aosta (62.3 percent), in Lombardia (59.1 percent) and in Campania (43.6 percent).

The dripping system is mainly adopted in the south of Italy (55.6 percent), particularly in Puglia with 45.0 percent. Sicilia with 15.0 percent and Emilia-Romagna with 10.8 percent also contribute to the national total.

The micro-irrigation method is mainly used in the south of Italy (40.0 percent), due to Puglia (16.6 percent), and in the Islands (29.2 percent), for the values obtained in Sicilia (24.1 percent).

The flood irrigation method prevails in the north-west of Italy (92.3 percent) and, more precisely in Piemonte (51.2 percent) and Lombardia (41.1 percent).

Irrigated surface per irrigation method shows similar trend for superficial flowing water and lateral irrigation and for aspersion. These methods are applied mainly in farms with 10 and more hectares, covering 62.8 percent in the first case and 54.4 percent in the second one of the irrigated surface per each mentioned method. On the contrary, microirrigation and dripping method are applied mainly in farms with less than 10 hectares, covering 62.7 percent of the surface irrigated by this mean (Table 8).

91.1 percent of irrigated farms use water that comes from only one source, the remaining percentage use several sources (Table 9a).

In 38.9 percent of all cases, the farms that use only groundwater as supply source are mostly situated in southern Italy (46.1 percent) and on the Islands (22.8 percent). In Puglia, the main supply form is groundwater (69.4 percent).

Farms whose water supply comes mainly from superficial sources, such as rivers, streams, canals and lakes account for 34.1 percent of the total, and are situated in North-east (29.7), in the South (27.2) and North-west (22.3 percent). In many regions, it represents the main supply source of water resources: such as Valle d'Aosta (79.5 percent of farms use only superficial waters), Veneto (69.0 percent), Lombardia (64.6 percent) and Piemonte (56.4 percent). Supply from national aqueducts covers 18.0 percent of all requests, and it is mostly widespread in southern farms (44.1 percent) and on the Islands (24.7 percent), with its peak being in Puglia (12.4 percent) and Sicilia (18.0 percent). The use of treated waters regards only 0,1 percent of farms at national level.

82.6 percent of surfaces are irrigated with waters coming only from one source, the remaining percentage uses several sources (Table 9b). 47.7 percent of farms' surfaces is irrigated using superficial waters as only source. 52.5 percent of these surfaces is located in the north-west of Italy and 33.1 percent in the North-east. Only Lombardia represents 34.2 percent of the national value. Supply from groundwater accounts for 23.8 percent of farms' irrigated surfaces. These surfaces are mainly located in the South (40.5 percent) and especially in Puglia, which contributes for 28.8 percent of the national total. Waters delivered by aqueducts and/or consortium networks irrigate exclusively 10.9 percent of surfaces; these surfaces are situated in the South (43.1 percent), especially in Puglia (14.7 percent). Surfaces irrigated with waters coming from various types of sources are mainly located in the north-west of Italy (41.4 percent) and North-east (27.5 percent). At regional level, it is interesting to see Umbria as its surfaces irrigated with several sources cover 34.0 percent of the regional irrigated total.

95.2 percent of farms is supplied with water for irrigation purposes according to one modality (Table 10a).

The most common modality is the exclusive resort to irrigation and drainage Consortia (37.3 percent). In particular, these are used by farms from the North-east of Italy, accounting for 29.6 percent (Veneto being on top of classification with 14.6 percent) and from the South with 28 percent.

35.1 percent of farms manages autonomously the irrigation supply (self supply). These farms prevail in the south of Italy (41.8 percent), especially in Campania (14.3 percent) and Puglia (13.8 percent).

Only in 4.0 percent of all cases, the water from other agricultural farms is used, mainly in the south of Italy (60.7 percent) and especially in Puglia (41.6 percent).

18.8 percent of farms use other form of management, besides those analysed, and are located mainly in the South (46.9 percent).

85.8 percent of surfaces is irrigated based on one management form (Table 10b).

51.9 percent of surfaces is irrigated only with water distributed by Consortia. These are mainly located in the north-west of Italy (47.3 percent), especially in Lombardia (30.3 percent), and in the North-east (31.2 percent), followed by the South, with 13.0 percent of all national surfaces (including Puglia with 4.9 percent), and Islands (5.9 percent), with Sicilia showing its 4.0 percent. Only 2.5 percent of the total is situated in the Centre.

The surfaces irrigated exclusively by self supply, make up 23.2 percent of total and are mainly situated in the South (29.9 percent) and especially, in Puglia (17.0 percent).

Only 1.4 percent of surfaces is irrigated with waters provided by other agricultural farms, of which about 50 percent is in the South, with Puglia accounting for 42.1 percent.

Other management forms of water resources, which have not been further broken down in the tables, cover 9.3 percent of irrigate surfaces. The surfaces covered are mainly in the South (35.1 percent) and in the North-west (24.0 percent) of Italy.

The surfaces irrigated with water that arrives to the farms according to several management forms cover 14.2 percent of the irrigated total. These surfaces are mainly situated in the North-west (49.0 percent), with Lombardia revealing its 25.0 percent, and in the North-east (25.4 percent).

TABLE 1 **Farms with irrigation per supply source and irrigation method - Years 1982, 1990, 2000**

SUPPLY SOURCES IRRIGATION METHODS	Census year		
	2000	1990	1982
SUPPLY SOURCE	731,082	1,059,456	834,424
Sources:			
Surface flowing water	*233,010*	*194,557*	*159,401*
Surface water bodies	*33,790*	*25,134*	*18,891*
Other	*531,853*	*456,401*	*341,738*
Delivering management:			
Irrigation and land reclamation Consortia	*302,872*	*398,913*	*305,465*
Other farms	*35,071*	*31,037*	*32,477*
Other ways	*429,325*	*34,592*	*35,102*
IRRIGATION METHOD			
Superficial flowing water and lateral infiltration	322,313	377,579	241,366
Flood	7,439	48,095	73,533
Aspersion	333,711	583,183	533,423
Dripping	114,369	113,577	28,208
Other systems	31,373	28,164	23,406

Source: Istat, Agricultural Census - Years 1982,1990, 2000

TABLE 2 **Farms and irrigated surface with irrigation by main irrigated crops - Years 1982, 1990, 2000** *(surface in hectares)*

IRRIGATED CROPS	Census Year 2000		1990		1982	
	Farms	Irrigated surface	Farms	Irrigated surface	Farms	Irrigated surface
Wheat	27,178	99,636	18,566	69,489	-	-
Grain maize	124,895	623,155	179,057	507,170	200,002	559,804
Potato	56,872	26,461	90,925	34,710	-	-
Sugar beet	15,282	81,532	18,684	81,965	-	-
Sunflower	2,526	14,260	3,841	18,537	-	-
Soybean	11,971	78,618	40,250	201,083	-	-
Vegetables	152,293	191,012	223,873	233,587	264,015	217,607
Rotational forage	47,439	267,560	96,202	439,376	143,290	650,280
Vine	110,828	182,694	113,119	162,391	136,349	159,177
Citrus	109,136	113,651	137,212	153,815	122,180	146,735
Fruit trees	108,974	189,175	117,355	199,059	82,511	144,329
Other crops	285,184	603,624	384,574	609,999	282,859	643,262
TOTAL	**731,082**	**2,471,378**	**934,840**	**2,711,182**	**934,427**	**2,521,193**

Source: Istat, Agricultural Census - Years 1982,1990, 2000

TABLE 3

Farms and related irrigable and irrigated surface by region and geographical area - Year 2000

REGIONS GEOGRAPHICAL AREAS	Farms with irrigable surface			Irrigable surface			Farms with irrigated surface			Irrigated surface		
	Farms with irrigable surface	% compo-sition	% of farms with UAA and wood arboriculture	Hectares	% compo sition	% of UAA and wood arboriculture	Farms with irrigated surface	% compo-sition	% of farms with UAA and wood arboriculture	Hectares	% compo-sition	% of UAA and wood arboricult ure
Piemonte	47,279	4.9	41.3	449,047	11.5	40.8	38,114	5.2	33.3	355,817	14.4	32.3
Valle d'Aosta	5,872	0.6	92.3	26,212	0.7	36.8	5,496	0.8	86.4	23,623	1.0	33.2
Lombardia	41,963	4.3	57.1	704,517	18.1	65.8	36,287	5.0	49.3	557,752	22.6	52.1
Trentino-Alto Adige	27,332	2.8	50.0	61,774	1.6	14.9	25,874	3.5	47.3	57,768	2.3	13.9
Veneto	81,891	8.5	43.5	435,845	11.2	50.7	57,642	7.9	30.6	265,253	10.7	30.8
Friuli-Venezia Giulia	13,993	1.4	40.4	91,876	2.4	37.4	10,770	1.5	31.1	63,202	2.6	25.8
Liguria	30,320	3.1	69.8	11,391	0.3	17.6	23,452	3.2	54.0	7,230	0.3	11.1
Emilia-Romagna	48,758	5.0	45.8	565,573	14.5	50.1	34,055	4.7	32.0	252,377	10.2	22.4
Toscana	35,102	3.6	26.0	111,603	2.9	12.8	24,352	3.3	18.0	47,286	1.9	5.4
Umbria	17,436	1.8	30.9	66,927	1.7	17.9	11,221	1.5	19.9	32,117	1.3	8.6
Marche	15,242	1.6	23.2	49,559	1.3	9.7	10,489	1.4	16.0	25,199	1.0	4.9
Lazio	65,580	6.8	30.8	150,088	3.9	20.6	44,073	6.0	20.7	74,053	3.0	10.1
Abruzzo	25,856	2.7	31.3	59,358	1.5	13.6	17,593	2.4	21.3	29,995	1.2	6.9
Molise	5,645	0.6	16.8	20,881	0.5	9.7	4,035	0.6	12.0	11,812	0.5	5.5
Campania	98,034	10.1	39.6	125,305	3.2	21.2	75,843	10.4	30.6	86,415	3.5	14.6
Puglia	128,998	13.4	36.6	389,617	10.0	31.2	97,679	13.4	27.7	248,814	10.1	19.9
Basilicata	29,530	3.1	36.2	80,640	2.1	14.9	20,478	2.8	25.1	42,325	1.7	7.8
Calabria	77,659	8.0	39.9	117,247	3.0	20.7	59,089	8.1	30.3	66,983	2.7	11.8
Sicilia	120,723	12.5	33.1	209,036	5.4	16.3	104,559	14.3	28.7	161,044	6.5	12.5
Sardegna	49,057	5.1	44.2	165,707	4.3	15.9	29,981	4.1	27.0	62,314	2.5	6.0
ITALY	**966,270**	**100.0**	**37.8**	**3,892,202**	**100.0**	**29.1**	**731,082**	**100.0**	**28.6**	**2,471,379**	**100.0**	**18.5**
North-west	**125,434**	**13.0**	**52.7**	**1,191,167**	**30.6**	**51.6**	**103,349**	**14.1**	**43.4**	**944,422**	**38.3**	**40.9**
North-est	**171,974**	**17.8**	**44.8**	**1,155,068**	**29.7**	**43.6**	**128,341**	**17.6**	**33.4**	**638,600**	**25.8**	**24.1**
Centre	**133,360**	**13.8**	**28.4**	**378,177**	**9.7**	**15.2**	**90,135**	**12.2**	**19.2**	**178,655**	**7.2**	**7.2**
South	**365,722**	**37.8**	**36.9**	**793,047**	**20.3**	**22.0**	**274,717**	**37.7**	**27.7**	**486,344**	**19.7**	**13.5**
Islands	**169,780**	**17.6**	**35.7**	**374,742**	**9.7**	**16.1**	**134,540**	**18.4**	**28.3**	**223,358**	**9.0**	**9.6**

Source: Istat, Agricultural Census - Years 1982,1990, 2000

TABLE 4a Farms with irrigated surface per irrigated surface class, region and geographical area - Year 2000 *(surface in hectares)*

REGIONS GEOGRAPHICAL AREAS	Irrigated surface class								
	Less than one	1-2	2-5	5-10	10-20	20-50	50-100	100 and more	Total
				ABSOLUTE DATA					
Piemonte	12,347	4,859	6,821	4,914	4,592	3,274	931	376	38,114
Valle d'Aosta	2,929	931	990	375	140	59	25	47	5,496
Lombardia	6,382	4,055	6,345	5,844	5,938	5,137	1,843	743	36,287
Trentino-Alto Adige	11,747	4,585	6,473	2,486	495	73	13	2	25,874
Veneto	19,633	11,775	13,548	6,912	3,729	1,570	316	159	57,642
Friuli-Venezia Giulia	3,073	2,015	2,620	1,483	958	482	105	34	10,770
Liguria	21,964	1,160	294	27	5	1	1	-	23,452
Emilia-Romagna	7,638	5,269	8,821	5,949	3,721	2,061	451	145	34,055
Toscana	17,628	2,297	2,410	1,022	574	321	75	25	24,352
Umbria	7,917	956	1,058	529	387	275	75	24	11,221
Marche	6,389	1,458	1,523	623	291	152	47	6	10,489
Lazio	30,246	5,307	5,228	1,978	848	363	74	29	44,073
Abruzzo	11,301	2,563	2,342	891	369	101	20	6	17,593
Molise	2,402	388	535	420	194	82	11	3	4,035
Campania	57,019	9,204	6,595	1,916	740	298	53	18	75,843
Puglia	51,956	19,221	15,873	6,164	2,761	1,330	270	104	97,679
Basilicata	13,899	2,122	2,514	1,177	471	214	58	23	20,478
Calabria	46,430	6,396	4,118	1,233	507	302	73	30	59,089
Sicilia	70,795	15,737	11,802	3,804	1,564	705	124	28	104,559
Sardegna	20,356	3,300	3,334	1,616	907	384	66	18	29,981
ITALY	**422,051**	**103,598**	**103,244**	**49,363**	**29,191**	**17,184**	**4,631**	**1,820**	**731,082**
North-west	**43,622**	**11,005**	**14,450**	**11,160**	**10,675**	**8,471**	**2,800**	**1,166**	**103,349**
North-east	**42,091**	**23,644**	**31,462**	**16,830**	**8,903**	**4,186**	**885**	**340**	**128,341**
Centre	**62,180**	**10,018**	**10,219**	**4,152**	**2,100**	**1,111**	**271**	**84**	**90,135**
South	**183,007**	**39,894**	**31,977**	**11,801**	**5,042**	**2,327**	**485**	**184**	**274,717**
Islands	**91,151**	**19,037**	**15,136**	**5,420**	**2,471**	**1,089**	**190**	**46**	**134,540**

TABLE 4a continued Farms with irrigated surface per irrigated surface class, region and geographical area - Year 2000 *(surface in hectares)*

REGIONS GEOGRAPHICAL AREAS	Irrigated surface class								
	Less than one	1-2	2-5	5-10	10-20	20-50	50-100	100 and more	Total
	% COMPOSITION								
Piemonte	32.4	12.7	17.9	12.9	12.0	8.6	2.4	1.0	100.0
Valle d'Aosta	53.3	16.9	18.0	6.8	2.5	1.1	0.5	0.9	100.0
Lombardia	17.6	11.2	17.5	16.1	16.4	14.2	5.1	2.0	100.0
Trentino-Alto Adige	45.4	17.7	25.0	9.6	1.9	0.3	0.1	..	100.0
Veneto	34.1	20.4	23.5	12.0	6.5	2.7	0.5	0.3	100.0
Friuli-Venezia Giulia	28.5	18.7	24.3	13.8	8.9	4.5	1.0	0.3	100.0
Liguria	93.7	4.9	1.3	0.1	..	..	..	-	100.0
Emilia-Romagna	22.4	15.5	25.9	17.5	10.9	6.1	1.3	0.4	100.0
Toscana	72.4	9.4	9.9	4.2	2.4	1.3	0.3	0.1	100.0
Umbria	70.6	8.5	9.4	4.7	3.4	2.5	0.7	0.2	100.0
Marche	60.9	13.9	14.5	5.9	2.8	1.4	0.4	0.1	100.0
Lazio	68.6	12.0	11.9	4.5	1.9	0.8	0.2	0.1	100.0
Abruzzo	64.2	14.6	13.3	5.1	2.1	0.6	0.1	..	100.0
Molise	59.5	9.6	13.3	10.4	4.8	2.0	0.3	0.1	100.0
Campania	75.2	12.1	8.7	2.5	1.0	0.4	0.1	..	100.0
Puglia	53.2	19.7	16.3	6.3	2.8	1.4	0.3	0.1	100.0
Basilicata	67.9	10.4	12.3	5.7	2.3	1.0	0.3	0.1	100.0
Calabria	78.6	10.8	7.0	2.1	0.9	0.5	0.1	0.1	100.0
Sicilia	67.7	15.1	11.3	3.6	1.5	0.7	0.1	..	100.0
Sardegna	67.9	11.0	11.1	5.4	3.0	1.3	0.2	0.1	100.0
ITALY	**57.7**	**14.2**	**14.1**	**6.8**	**4.0**	**2.4**	**0.6**	**0.2**	100.0
North-west	**42.2**	**10.6**	**14.0**	**10.8**	**10.3**	**8.2**	**2.7**	**1.1**	**100.0**
North-east	**32.8**	**18.4**	**24.5**	**13.1**	**6.9**	**3.3**	**0.7**	**0.3**	**100.0**
Centre	**69.0**	**11.1**	**11.3**	**4.6**	**2.3**	**1.2**	**0.3**	**0.1**	**100.0**
South	**66.6**	**14.5**	**11.6**	**4.3**	**1.8**	**0.8**	**0.2**	**0.1**	**100.0**
Islands	**67.8**	**14.1**	**11.3**	**4.0**	**1.8**	**0.8**	**0.1**	**..**	**100.0**

TABLE 4a continued **Farms with irrigated surface per irrigated surface class, region and geographical area - Year 2000** *(surface in hectares)*

REGIONS GEOGRAPHICAL AREAS	Irrigated surface class								
	Less than one	1-2	2-5	5-10	10-20	20-50	50-100	100 and more	Total
	% COMPOSITION								
Piemonte	2.9	4.7	6.6	10.0	15.7	19.1	20.1	20.7	5.2
Valle d'Aosta	0.7	0.9	1.0	0.8	0.5	0.3	0.5	2.6	0.8
Lombardia	1.5	3.9	6.1	11.8	20.3	29.9	39.8	40.8	5.0
Trentino-Alto Adige	2.8	4.4	6.3	5.0	1.7	0.4	0.3	0.1	3.5
Veneto	4.7	11.4	13.1	14.0	12.8	9.1	6.8	8.7	7.9
Friuli-Venezia Giulia	0.7	1.9	2.5	3.0	3.3	2.8	2.3	1.9	1.5
Liguria	5.2	1.1	0.3	0.1	..	..	..	-	3.2
Emilia-Romagna	1.8	5.1	8.5	12.1	12.7	12.0	9.7	8.0	4.7
Toscana	4.2	2.2	2.3	2.1	2.0	1.9	1.6	1.4	3.3
Umbria	1.9	0.9	1.0	1.1	1.3	1.6	1.6	1.3	1.5
Marche	1.5	1.4	1.5	1.3	1.0	0.9	1.0	0.3	1.4
Lazio	7.2	5.1	5.1	4.0	2.9	2.1	1.6	1.6	6.0
Abruzzo	2.7	2.5	2.3	1.8	1.3	0.6	0.4	0.3	2.4
Molise	0.6	0.4	0.5	0.9	0.7	0.5	0.2	0.2	0.6
Campania	13.5	8.9	6.4	3.9	2.5	1.7	1.1	1.0	10.4
Puglia	12.3	18.6	15.4	12.5	9.5	7.7	5.8	5.7	13.4
Basilicata	3.3	2.0	2.4	2.4	1.6	1.2	1.3	1.3	2.8
Calabria	11.0	6.2	4.0	2.5	1.7	1.8	1.6	1.6	8.1
Sicilia	16.8	15.2	11.4	7.7	5.4	4.1	2.7	1.5	14.3
Sardegna	4.8	3.2	3.2	3.3	3.1	2.2	1.4	1.0	4.1
ITALY	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
North-west	**10.3**	**10.6**	**14.0**	**22.6**	**36.6**	**49.3**	**60.5**	**64.1**	**14.1**
North-east	**10.0**	**22.8**	**30.5**	**34.1**	**30.5**	**24.4**	**19.1**	**18.7**	**17.6**
Centre	**14.7**	**9.7**	**9.9**	**8.4**	**7.2**	**6.5**	**5.9**	**4.6**	**12.3**
South	**43.4**	**38.5**	**31.0**	**23.9**	**17.3**	**13.5**	**10.5**	**10.1**	**37.6**
Islands	**21.6**	**18.4**	**14.7**	**11.0**	**8.5**	**6.3**	**4.1**	**2.5**	**18.4**

Source: Istat, Agricultural Census - Year 2000

TABLE 4b **Irrigated surface per irrigated surface class, region and geographical area - Year 2000**
(absolute data in hectares)

REGIONS GEOGRAPHICAL AREAS	Irrigated surface								
	Less than one	1-2	2-5	5-10	10-20	20-50	50-100	100 and more	Total
				ABSOLUTE DATA					
Piemonte	4,385	6,959	21,924	35,363	64,789	99,053	63,416	59,930	355,817
Valle d'Aosta	1,140	1,313	3,082	2,585	1,828	1,857	1,669	10,149	23,623
Lombardia	2,952	5,723	20,766	42,266	83,846	158,587	126,013	117,600	557,752
Trentino-Alto Adige	4,826	6,460	20,394	16,592	6,202	2,029	856	409	57,768
Veneto	9,246	16,481	42,231	47,925	50,513	45,840	22,006	31,011	265,253
Friuli-Venezia Giulia	1,467	2,860	8,352	10,493	13,087	14,196	6,896	5,852	63,202
Liguria	4,564	1,526	804	179	67	21	68	-	7,230
Emilia-Romagna	3,164	7,376	28,356	41,336	50,996	61,478	30,061	29,611	252,377
Toscana	3,610	3,009	7,318	6,895	7,645	9,430	4,977	4,401	47,286
Umbria	1,353	1,297	3,249	3,666	5,277	8,146	4,916	4,213	32,117
Marche	1,562	1,961	4,580	4,225	3,916	4,538	3,275	1,142	25,199
Lazio	7,011	6,991	15,666	13,029	11,126	10,619	5,113	4,498	74,053
Abruzzo	3,200	3,401	7,044	5,995	4,977	2,800	1,457	1,122	29,995
Molise	550	533	1,697	2,933	2,627	2,368	705	399	11,812
Campania	16,962	12,243	19,496	12,703	9,882	8,667	3,516	2,946	86,415
Puglia	22,531	26,287	48,272	41,856	37,206	38,803	18,076	15,782	248,814
Basilicata	3,708	2,841	8,063	7,839	6,349	6,416	3,760	3,349	42,325
Calabria	12,843	8,331	11,935	8,084	6,702	8,714	5,045	5,328	66,983
Sicilia	24,214	21,211	35,311	25,673	20,785	20,063	8,005	5,782	161,044
Sardegna	5,664	4,393	10,162	10,893	12,110	11,156	4,254	3,682	62,314
ITALY	**134,951**	**141,197**	**318,702**	**340,528**	**399,930**	**514,782**	**314,084**	**307,204**	**2,471,379**
North-west	**13,041**	**15,521**	**46,575**	**80,392**	**150,531**	**259,518**	**191,166**	**187,678**	**944,422**
North-east	**18,702**	**33,178**	**99,332**	**116,346**	**120,797**	**123,543**	**59,819**	**66,883**	**638,600**
Centre	**13,536**	**13,257**	**30,813**	**27,815**	**27,964**	**32,734**	**18,281**	**14,254**	**178,655**
South	**59,794**	**53,636**	**96,509**	**79,409**	**67,743**	**67,769**	**32,558**	**28,926**	**486,344**
Islands	**29,878**	**25,605**	**45,473**	**36,566**	**32,895**	**31,219**	**12,259**	**9,464**	**223,358**

TABLE 4b continued Irrigated surface per irrigated surface class, region and geographical area - Year 2000 *(absolute data in hectares)*

REGIONS GEOGRAPHICAL AREAS	Irrigated surface								
	Less than one	1-2	2-5	5-10	10-20	20-50	50-100	100 and more	Total
	% COMPOSITION								
Piemonte	1.2	2.0	6.2	9.9	18.2	27.8	17.8	16.8	100.0
Valle d'Aosta	4.8	5.6	13.0	10.9	7.7	7.9	7.1	43.0	100.0
Lombardia	0.5	1.0	3.7	7.6	15.0	28.4	22.6	21.1	100.0
Trentino-Alto Adige	8.4	11.2	35.3	28.7	10.7	3.5	1.5	0.7	100.0
Veneto	3.5	6.2	15.9	18.1	19.0	17.3	8.3	11.7	100.0
Friuli-Venezia Giulia	2.3	4.5	13.2	16.6	20.7	22.5	10.9	9.3	100.0
Liguria	63.1	21.1	11.1	2.5	0.9	0.3	0.9	-	100.0
Emilia-Romagna	1.3	2.9	11.2	16.4	20.2	24.4	11.9	11.7	100.0
Toscana	7.6	6.4	15.5	14.6	16.2	19.9	10.5	9.3	100.0
Umbria	4.2	4.0	10.1	11.4	16.4	25.4	15.3	13.1	100.0
Marche	6.2	7.8	18.2	16.8	15.5	18.0	13.0	4.5	100.0
Lazio	9.5	9.4	21.2	17.6	15.0	14.3	6.9	6.1	100.0
Abruzzo	10.7	11.3	23.5	20.0	16.6	9.3	4.9	3.7	100.0
Molise	4.7	4.5	14.4	24.8	22.2	20.0	6.0	3.4	100.0
Campania	19.6	14.2	22.6	14.7	11.4	10.0	4.1	3.4	100.0
Puglia	9.1	10.6	19.4	16.8	15.0	15.6	7.3	6.3	100.0
Basilicata	8.8	6.7	19.1	18.5	15.0	15.2	8.9	7.9	100.0
Calabria	19.2	12.4	17.8	12.1	10.0	13.0	7.5	8.0	100.0
Sicilia	15.0	13.2	21.9	15.9	12.9	12.5	5.0	3.6	100.0
Sardegna	9.1	7.1	16.3	17.5	19.4	17.9	6.8	5.9	100.0
ITALY	**5.5**	**5.7**	**12.9**	**13.8**	**16.2**	**20.8**	**12.7**	**12.4**	**100.0**
North-west	**1.4**	**1.6**	**4.9**	**8.5**	**15.9**	**27.5**	**20.2**	**19.9**	**100.0**
North-east	**2.9**	**5.2**	**15.6**	**18.2**	**18.9**	**19.3**	**9.4**	**10.5**	**100.0**
Centre	**7.6**	**7.4**	**17.2**	**15.6**	**15.7**	**18.3**	**10.2**	**8.0**	**100.0**
South	**12.3**	**11.0**	**19.8**	**16.3**	**13.9**	**13.9**	**6.7**	**5.9**	**100.0**
Islands	**13.4**	**11.5**	**20.4**	**16.4**	**14.7**	**14.0**	**5.5**	**4.2**	**100.0**

TABLE 4b continued Irrigated surface per irrigated surface class, region and geographical area - Year 2000 *(absolute data in hectares)*

REGIONS GEOGRAPHICAL AREAS	Irrigated surface								
	Less than one	1-2	2-5	5-10	10-20	20-50	50-100	100 and more	Total
	% COMPOSITION								
Piemonte	3.2	4.9	6.9	10.4	16.2	19.2	20.2	19.5	14.4
Valle d'Aosta	0.8	0.9	1.0	0.8	0.5	0.4	0.5	3.3	1.0
Lombardia	2.2	4.1	6.5	12.4	21.0	30.8	40.1	38.3	22.6
Trentino-Alto Adige	3.6	4.6	6.4	4.9	1.6	0.4	0.3	0.1	2.3
Veneto	6.9	11.7	13.3	14.1	12.6	8.9	7.0	10.1	10.7
Friuli-Venezia Giulia	1.1	2.0	2.6	3.1	3.3	2.8	2.2	1.9	2.6
Liguria	3.4	1.1	0.3	0.1	..	..	..	-	0.3
Emilia-Romagna	2.3	5.2	8.9	12.1	12.8	11.9	9.6	9.6	10.2
Toscana	2.7	2.1	2.3	2.0	1.9	1.8	1.6	1.4	1.9
Umbria	1.0	0.9	1.0	1.1	1.3	1.6	1.6	1.4	1.3
Marche	1.2	1.4	1.4	1.2	1.0	0.9	1.0	0.4	1.0
Lazio	5.2	5.0	4.9	3.8	2.8	2.1	1.6	1.5	3.0
Abruzzo	2.4	2.4	2.2	1.8	1.2	0.5	0.5	0.4	1.2
Molise	0.4	0.4	0.5	0.9	0.7	0.5	0.2	0.1	0.5
Campania	12.6	8.7	6.1	3.7	2.5	1.7	1.1	1.0	3.5
Puglia	16.7	18.6	15.1	12.3	9.3	7.5	5.8	5.1	10.1
Basilicata	2.7	2.0	2.5	2.3	1.6	1.2	1.2	1.1	1.7
Calabria	9.5	5.9	3.7	2.4	1.7	1.7	1.6	1.7	2.7
Sicilia	17.9	15.0	11.1	7.5	5.2	3.9	2.5	1.9	6.5
Sardegna	4.2	3.1	3.2	3.2	3.0	2.2	1.4	1.2	2.5
ITALY	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
North-west	**9.7**	**11.0**	**14.6**	**23.6**	**37.6**	**50.4**	**60.9**	**61.1**	**38.2**
North-east	**13.9**	**23.5**	**31.2**	**34.2**	**30.2**	**24.0**	**19.0**	**21.8**	**25.8**
Centre	**10.0**	**9.4**	**9.7**	**8.2**	**7.0**	**6.4**	**5.8**	**4.6**	**7.2**
South	**44.3**	**38.0**	**30.3**	**23.3**	**16.9**	**13.2**	**10.4**	**9.4**	**19.7**
Islands	**22.1**	**18.1**	**14.3**	**10.7**	**8.2**	**6.1**	**3.9**	**3.1**	**9.0**

Source: Istat, Agricultural Census - Year 2000

TABLE5 **Irrigated surface per crop, region and geographical area - Year 2000** *(absolute data in hectares)*

REGIONS GEOGRAPHICAL AREAS	Crop												
	Wheat	Grain maize	Potato	Sugar beet	Sunflower	Soybean	Vegetables	Rotational forage	Vine	Citrus	Fruit trees	Other crops	Total
						ABSOLUTE DATA							
Piemonte	6,127	118,661	762	6,525	601	10,481	5,874	35,966	100	-	15,052	155,668	355,817
Valle d'Aosta	2	24	89	-	-	-	6	6	280	-	335	22,880	23,623
Lombardia	6,832	248,008	1,256	11,125	1,751	27,887	9,259	93,240	1,815	4	3,273	153,301	557,752
Trentino-Alto Adige	23	77	264	4	-	-	598	1,027	9,358	-	29,192	17,225	57,768
Veneto	6,594	115,607	1,362	10,668	450	24,429	10,804	19,228	22,750	-	19,883	33,478	265,253
Friuli-Venezia Giulia	466	41,165	95	1,216	23	6,078	432	2,248	6,073	-	2,039	3,367	63,202
Liguria	27	104	260	1	-	-	1,110	124	484	42	481	4,596	7,230
Emilia-Romagna	4,091	47,508	3,841	17,610	487	9,418	36,368	36,163	14,291	-	52,007	30,595	252,377
Toscana	2,739	8,979	401	3,711	3,118	43	6,814	4,582	1,518	5	2,473	12,904	47,286
Umbria	1,759	10,195	43	3,768	2,500	34	1,249	1,560	469	-	456	10,084	32,117
Marche	1,652	5,554	48	6,093	469	108	4,416	1,360	574	-	1,791	3,133	25,199
Lazio	3,567	11,672	1,283	2,825	2,060	33	13,157	17,111	4,040	509	9,287	8,510	74,053
Abruzzo	2,338	2,921	2,629	2,866	666	57	7,378	3,503	2,699	2	1,895	3,043	29,995
Molise	2,073	1,319	61	1,747	303	-	1,573	619	2,509	-	884	723	11,812
Campania	2,804	7,447	4,028	269	50	1	18,608	17,066	1,573	1,717	19,141	13,711	86,414
Puglia	30,057	238	2,388	7,967	1,221	48	31,971	2,607	68,717	7,614	9,045	86,941	248,814
Basilicata	9,089	845	332	718	47	-	5,984	2,653	1,987	7,777	7,304	5,590	42,325
Calabria	6,178	1,869	4,256	1,204	18	1	7,869	3,949	1,326	24,195	4,318	11,801	66,983
Sicilia	9,976	227	2,572	6	125	1	16,887	3,090	38,298	67,039	7,433	15,389	161,044
Sardegna	3,244	736	491	3,208	371	-	10,654	21,460	3,833	4,747	2,884	10,686	62,314
ITALY	**99,636**	**623,155**	**26,461**	**81,532**	**14,259**	**78,617**	**191,012**	**267,560**	**182,694**	**113,651**	**189,175**	**603,624**	**2,471,378**
North-west	**12,988**	**366,797**	**2,367**	**17,651**	**2,352**	**38,368**	**16,249**	**129,335**	**2,679**	**46**	**19,142**	**336,447**	**944,422**
North-east	**11,174**	**204,356**	**5,561**	**29,498**	**960**	**39,925**	**48,202**	**58,666**	**52,472**	**-**	**103,122**	**84,665**	**638,600**
Centre	**9,716**	**36,399**	**1,775**	**16,397**	**8,147**	**217**	**25,637**	**24,613**	**6,601**	**515**	**14,007**	**34,630**	**178,655**
South	**52,539**	**14,639**	**13,694**	**14,772**	**2,303**	**106**	**73,383**	**30,396**	**78,810**	**41,305**	**42,588**	**121,808**	**486,343**
Islands	**13,220**	**963**	**3,063**	**3,214**	**496**	**1**	**27,542**	**24,550**	**42,131**	**71,786**	**10,317**	**26,075**	**223,358**

TABLE 5 continued **Irrigated surface per crop, region and geographical area - Year 2000** *(absolute data in hectares)*

REGIONS GEOGRAPHICAL AREAS	Crop												
	Wheat	Grain maize	Potato	Sugar beet	Sunflower	Soybean	Vegetables	Rotational forage	Vine	Citrus	Fruit trees	Other crops	Total
						% COMPOSITION							
Piemonte	1.7	33.3	0.2	1.8	0.2	2.9	1.7	10.1	..	-	4.2	43.7	100.0
Valle d'Aosta	..	0.1	0.4	..	-	-	..	..	1.2	-	1.4	96.9	100.0
Lombardia	1.2	44.5	0.2	2.0	0.3	5.0	1.7	16.7	0.3	..	0.6	27.5	100.0
Trentino-Alto Adige	..	0.1	0.5	..	..	-	1.0	1.8	16.2	-	50.5	29.8	100.0
Veneto	2.5	43.6	0.5	4.0	0.2	9.2	4.1	7.2	8.6	-	7.5	12.6	100.0
Friuli-Venezia Giulia	0.7	65.1	0.2	1.9	..	9.6	0.7	3.6	9.6	-	3.2	5.3	100.0
Liguria	0.4	1.4	3.6	..	..	..	15.4	1.7	6.7	0.6	6.7	63.6	100.0
Emilia-Romagna	1.6	18.8	1.5	7.0	0.2	3.7	14.4	14.3	5.7	-	20.6	12.1	100.0
Toscana	5.8	19.0	0.8	7.8	6.6	0.1	14.4	9.7	3.2	..	5.2	27.3	100.0
Umbria	5.5	31.7	0.1	11.7	7.8	0.1	3.9	4.9	1.5	-	1.4	31.4	100.0
Marche	6.6	22.0	0.2	24.2	1.9	0.4	17.5	5.4	2.3	..	7.1	12.4	100.0
Lazio	4.8	15.8	1.7	3.8	2.8	..	17.8	23.1	5.5	0.7	12.5	11.5	100.0
Abruzzo	7.8	9.7	8.8	9.6	2.2	0.2	24.6	11.7	9.0	..	6.3	10.1	100.0
Molise	17.5	11.2	0.5	14.8	2.6	-	13.3	5.2	21.2	-	7.5	6.1	100.0
Campania	3.2	8.6	4.7	0.3	0.1	..	21.5	19.7	1.8	2.0	22.2	15.9	100.0
Puglia	12.1	0.1	1.0	3.2	0.5	..	12.8	1.0	27.6	3.1	3.6	34.9	100.0
Basilicata	21.5	2.0	0.8	1.7	0.1	-	14.1	6.3	4.7	18.4	17.3	13.2	100.0
Calabria	9.2	2.8	6.4	1.8	..	..	11.7	5.9	2.0	36.1	6.4	17.6	100.0
Sicilia	6.2	0.1	1.6	..	0.1	..	10.5	1.9	23.8	41.6	4.6	9.6	100.0
Sardegna	5.2	1.2	0.8	5.1	0.6	-	17.1	34.4	6.2	7.6	4.6	17.1	100.0
ITALY	**4.0**	**25.2**	**1.1**	**3.3**	**0.6**	**3.2**	**7.7**	**10.8**	**7.4**	**4.6**	**7.7**	**24.4**	**100.0**
North-west	**1.4**	**38.8**	**0.3**	**1.9**	**0.2**	**4.1**	**1.7**	**13.7**	**0.3**	**..**	**2.0**	**35.6**	**100.0**
North-east	**1.7**	**32.0**	**0.9**	**4.6**	**0.2**	**6.3**	**7.5**	**9.2**	**8.2**	**-**	**16.1**	**13.3**	**100.0**
Centre	**5.4**	**20.4**	**1.0**	**9.2**	**4.6**	**0.1**	**14.3**	**13.8**	**3.7**	**0.3**	**7.8**	**19.4**	**100.0**
South	**10.8**	**3.0**	**2.8**	**3.0**	**0.5**	**..**	**15.1**	**6.2**	**16.2**	**8.5**	**8.8**	**25.0**	**100.0**
Islands	**5.9**	**0.4**	**1.4**	**1.4**	**0.2**	**..**	**12.3**	**11.0**	**18.9**	**32.1**	**4.6**	**11.7**	**100.0**

TABLE 5 continued **Irrigated surface per crop, region and geographical area - Year 2000** *(absolute data in hectares)*

REGIONS GEOGRAPHICAL AREAS	Crop												
	Wheat	Grain maize	Potato	Sugar beet	Sunflower	Soybean	Vegetables	Rotational forage	Vine	Citrus	Fruit trees	Other crops	Total
						% COMPOSITION							
Piemonte	6.1	19.0	2.9	8.0	4.2	13.3	3.1	13.4	0.1	-	8.0	25.8	14.4
Valle d'Aosta	..	..	0.3	..	-	-	..	..	0.2	-	0.2	3.8	1.0
Lombardia	6.9	39.8	4.7	13.6	12.3	35.5	4.8	34.8	1.0	..	1.7	25.4	22.6
Trentino-Alto Adige	..	..	1.0	..	..	-	0.3	0.4	5.1	-	15.4	2.9	2.3
Veneto	6.6	18.6	5.1	13.1	3.2	31.1	5.7	7.2	12.5	-	10.5	5.5	10.7
Friuli-Venezia Giulia	0.5	6.6	0.4	1.5	0.2	7.7	0.2	0.8	3.3	-	1.1	0.6	2.6
Liguria	..	..	1.0	..	..	..	0.6	..	0.3	..	0.3	0.8	0.3
Emilia-Romagna	4.1	7.6	14.5	21.6	3.4	12.0	19.0	13.5	7.8	-	27.5	5.1	10.2
Toscana	2.7	1.4	1.5	4.6	21.9	0.1	3.6	1.7	0.8	..	1.3	2.1	1.9
Umbria	1.8	1.6	0.2	4.6	17.5	..	0.7	0.6	0.3	-	0.2	1.7	1.3
Marche	1.7	0.9	0.2	7.5	3.3	0.1	2.3	0.5	0.3	..	0.9	0.5	1.0
Lazio	3.6	1.9	4.8	3.5	14.4	..	6.9	6.4	2.2	0.4	4.9	1.4	3.0
Abruzzo	2.3	0.5	9.9	3.5	4.7	0.1	3.9	1.3	1.5	..	1.0	0.5	1.2
Molise	2.1	0.2	0.2	2.1	2.1	-	0.8	0.2	1.4	-	0.5	0.1	0.5
Campania	2.8	1.2	15.2	0.3	0.3	..	9.7	6.4	0.9	1.5	10.1	2.3	3.5
Puglia	30.2	..	9.0	9.8	8.6	0.1	16.7	1.0	37.6	6.7	4.8	14.4	10.1
Basilicata	9.1	0.1	1.3	0.9	0.3	-	3.1	1.0	1.1	6.8	3.9	0.9	1.7
Calabria	6.2	0.3	16.1	1.5	0.1	..	4.1	1.5	0.7	21.3	2.3	2.0	2.7
Sicilia	10.0	..	9.7	..	0.9	..	8.8	1.2	21.0	59.0	3.9	2.5	6.5
Sardegna	3.3	0.1	1.9	3.9	2.6	-	5.6	8.0	2.1	4.2	1.5	1.8	2.5
ITALY	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
North-west	**13.0**	**58.9**	**8.9**	**21.6**	**16.5**	**48.8**	**8.5**	**48.3**	**1.5**	**..**	**10.1**	**55.7**	**38.2**
North-east	**11.2**	**32.8**	**21.0**	**36.2**	**6.7**	**50.8**	**25.2**	**21.9**	**28.7**	**-**	**54.5**	**14.0**	**25.8**
Centre	**9.8**	**5.8**	**6.7**	**20.1**	**57.1**	**0.3**	**13.4**	**9.2**	**3.6**	**0.5**	**7.4**	**5.7**	**7.2**
South	**52.7**	**2.3**	**51.8**	**18.1**	**16.2**	**0.1**	**38.4**	**11.4**	**43.1**	**36.3**	**22.5**	**20.2**	**19.7**
Islands	**13.3**	**0.2**	**11.6**	**3.9**	**3.5**	**..**	**14.4**	**9.2**	**23.1**	**63.2**	**5.5**	**4.3**	**9.0**

Source: Istat, Agricultural Census - Year 2000

TABLE 6 **Irrigated surface per irrigated surface classes and crop - Year 2000** *(surface in hectares)*

CROPS	Irrigated surface class								
	Less one hectare	1-2	2-5	5-10	10-20	20-50	50-100	100 and more	Total
				ABSOLUTE DATA					
Maize	9,015	14,734	34,577	38,026	44,118	48,877	20,784	12,621	222,752
Rotational forage	2,311	3,766	10,941	14,663	20,341	21,108	8,073	4,982	86,185
Vine	11,460	15,014	28,247	17,705	10,994	8,076	2,840	1,191	95,527
Fruit trees	8,939	11,480	28,649	22,813	14,485	8,640	2,906	956	98,867
Vegetables	14,988	10,591	19,052	13,773	11,570	8,752	3,779	2,847	85,353
				% COMPOSITION					
Maize	4.0	6.6	15.5	17.1	19.8	21.9	9.3	5.7	100.0
Rotational forage	2.7	4.4	12.7	17.0	23.6	24.5	9.4	5.8	100.0
Vine	12.0	15.7	29.6	18.5	11.5	8.5	3.0	1.2	100.0
Fruit trees	9.0	11.6	29.0	23.1	14.7	8.7	2.9	1.0	100.0
Vegetables	17.6	12.4	22.3	16.1	13.6	10.3	4.4	3.3	100.0

Source: Istat, Agricultural Census - Year 2000

TABLE7 **Irrigated surface per irrigation method, region and geographical area - Year 2000** *(absolute data in hectares)*

REGIONS GEOGRAPHICAL AREAS	Irrigation method						
	Superficial flowing water and lateral infiltration	Flood	Aspersion	Micro irrigation	Dripping	Other system	Total
			ABSOLUTE DATA				
Piemonte	211,453	111,284	35,789	1,124	4,454	2,091	366,195
Valle d'Aosta	14,996	41	8,649	21	110	240	24,057
Lombardia	343,685	89,440	141,911	1,443	1,655	3,479	581,613
Trentino-Alto Adige	2,741	52	45,908	2,132	7,434	250	58,517
Veneto	86,194	4,933	157,445	5,392	4,448	11,694	270,106
Friuli-Venezia Giulia	17,036	8	44,653	1,116	637	640	64,089
Liguria	2,260	2	2,467	134	1,186	1,624	7,673
Emilia-Romagna	45,308	8,074	162,522	6,198	31,476	7,021	260,599
Toscana	4,082	519	33,686	768	8,207	1,048	48,310
Umbria	2,820	-	27,701	262	1,519	246	32,548
Marche	3,515	22	20,831	286	1,100	159	25,912
Lazio	5,897	15	53,075	4,342	11,297	1,340	75,966
Abruzzo	4,577	..	22,932	400	2,280	353	30,541
Molise	406	1	8,595	81	2,638	286	12,006
Campania	39,221	19	38,744	2,742	8,195	1,121	90,042
Puglia	13,293	66	81,698	12,526	130,676	14,337	252,596
Basilicata	4,275	2	21,328	8,983	7,238	1,133	42,959
Calabria	22,236	419	28,291	5,392	10,583	1,463	68,383
Sicilia	21,251	475	75,939	18,122	43,668	3,971	163,425
Sardegna	5,316	2,165	39,038	3,871	11,905	1,178	63,472
ITALY	**850,561**	**217,536**	**1,051,201**	**75,332**	**290,706**	**53,674**	**2,539,011**
North-west	**572,394**	**200,767**	**188,816**	**2,721**	**7,406**	**7,434**	**979,538**
North-east	**151,279**	**13,067**	**410,528**	**14,836**	**43,995**	**19,606**	**653,311**
Centre	**16,315**	**556**	**135,294**	**5,657**	**22,123**	**2,793**	**182,737**
South	**84,007**	**506**	**201,587**	**30,124**	**161,610**	**18,693**	**496,527**
Islands	**26,567**	**2,640**	**114,976**	**21,993**	**55,572**	**5,149**	**226,897**

TABLE 7 continued **Irrigated surface per irrigation method, region and geographical area - Year 2000**
(absolute data in hectares)

REGIONS GEOGRAPHICAL AREAS	Irrigation method						
	Superficial flowing water and lateral infiltration	Flood	Aspersion	Micro irrigation	Dripping	Other system	Total
			% COMPOSITION				
Piemonte	57.7	30.4	9.8	0.3	1.2	0.6	100.0
Valle d'Aosta	62.3	0.2	36.0	0.1	0.5	1.0	100.0
Lombardia	59.1	15.4	24.4	0.2	0.3	0.6	100.0
Trentino-Alto Adige	4.7	0.1	78.5	3.6	12.7	0.4	100.0
Veneto	31.9	1.8	58.3	2.0	1.6	4.3	100.0
Friuli-Venezia Giulia	26.6	..	69.7	1.7	1.0	1.0	100.0
Liguria	29.4	..	32.2	1.7	15.5	21.2	100.0
Emilia-Romagna	17.4	3.1	62.4	2.4	12.1	2.7	100.0
Toscana	8.4	1.1	69.7	1.6	17.0	2.2	100.0
Umbria	8.7	-	85.1	0.8	4.7	0.8	100.0
Marche	13.6	0.1	80.4	1.1	4.2	0.6	100.0
Lazio	7.8	0.0	69.9	5.7	14.9	1.8	100.0
Abruzzo	15.0	..	75.1	1.3	7.5	1.2	100.0
Molise	3.4	..	71.6	0.7	22.0	2.4	100.0
Campania	43.6	..	43.0	3.0	9.1	1.2	100.0
Puglia	5.3	..	32.3	5.0	51.7	5.7	100.0
Basilicata	10.0	..	49.6	20.9	16.8	2.6	100.0
Calabria	32.5	0.6	41.4	7.9	15.5	2.1	100.0
Sicilia	13.0	0.3	46.5	11.1	26.7	2.4	100.0
Sardegna	8.4	3.4	61.5	6.1	18.8	1.9	100.0
ITALY	**33.5**	**8.6**	**41.4**	**3.0**	**11.4**	**2.1**	**100.0**
North-west	**58.4**	**20.5**	**19.3**	**0.3**	**0.8**	**0.8**	**100.0**
North-east	**23.2**	**2.0**	**62.8**	**2.3**	**6.7**	**3.0**	**100.0**
Centre	**8.9**	**0.3**	**74.0**	**3.1**	**12.1**	**1.5**	**100.0**
South	**16.9**	**0.1**	**40.6**	**6.1**	**32.5**	**3.8**	**100.0**
Islands	**11.7**	**1.2**	**50.7**	**9.7**	**24.5**	**2.3**	**100.0**

TABLE 7 continued **Irrigated surface per irrigation method, region and geographical area - Year 2000** *(absolute data in hectares)*

REGIONS GEOGRAPHICAL AREAS	Irrigation method						
	Superficial flowing water and lateral infiltration	Flood	Aspersion	Micro irrigation	Dripping	Other system	Total
	% COMPOSITION						
Piemonte	24.9	51.2	3.4	1.5	1.5	3.9	14.4
Valle d'Aosta	1.8	..	0.8	..	..	0.4	0.9
Lombardia	40.4	41.1	13.5	1.9	0.6	6.5	22.9
Trentino-Alto Adige	0.3	..	4.4	2.8	2.6	0.5	2.3
Veneto	10.1	2.3	15.0	7.2	1.5	21.8	10.6
Friuli-Venezia Giulia	2.0	..	4.2	1.5	0.2	1.2	2.5
Liguria	0.3	..	0.2	0.2	0.4	3.0	0.3
Emilia-Romagna	5.3	3.7	15.5	8.2	10.8	13.1	10.3
Toscana	0.5	0.2	3.2	1.0	2.8	2.0	1.9
Umbria	0.3	-	2.6	0.3	0.5	0.5	1.3
Marche	0.4	..	2.0	0.4	0.4	0.3	1.0
Lazio	0.7	..	5.0	5.8	3.9	2.5	3.0
Abruzzo	0.5	..	2.2	0.5	0.8	0.7	1.2
Molise	..	..	0.8	0.1	0.9	0.5	0.5
Campania	4.6	..	3.7	3.6	2.8	2.1	3.5
Puglia	1.6	..	7.8	16.6	45.0	26.7	9.9
Basilicata	0.5	..	2.0	11.9	2.5	2.1	1.7
Calabria	2.6	0.2	2.7	7.2	3.6	2.7	2.7
Sicilia	2.5	0.2	7.2	24.1	15.0	7.4	6.4
Sardegna	0.6	1.0	3.7	5.1	4.1	2.2	2.5
ITALY	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
North-west	**67.3**	**92.3**	**18.0**	**3.6**	**2.5**	**13.8**	**38.6**
North-east	**17.8**	**6.0**	**39.1**	**19.7**	**15.1**	**36.5**	**25.7**
Centre	**1.9**	**0.3**	**12.9**	**7.5**	**7.6**	**5.2**	**7.2**
South	**9.9**	**0.2**	**19.2**	**40.0**	**55.6**	**34.8**	**19.6**
Islands	**3.1**	**1.2**	**10.9**	**29.2**	**19.1**	**9.6**	**8.9**

Source: Istat, Agricultural Census - Year 2000

TABLE 8 **Irrigated surface per irrigated surface class and irrigation method - Year 2000** *(surface in hectares)*

IRRIGATION METHODS	Irrigated surface class								
	Below one hectare	1-2	2-5	5-10	10-20	20-50	50-100	100 and more	Total
ABSOLUTE DATA									
Superficial flowing water and lateral infiltration	51,834	36,858	69,814	77,171	117,650	154,457	75,849	50,426	634,060
Aspersion	44,025	54,568	132,362	143,104	152,355	168,422	72,036	53,133	820,005
Microirrigation and dripping	23,474	30,013	61,628	50,823	40,665	34,138	14,909	8,812	264,460
% COMPOSITION									
Superficial flowing water and lateral infiltration	8.2	5.8	11.0	12.2	18.6	24.4	12.0	8.0	100.0
Aspersion	5.4	6.7	16.1	17.5	18.6	20.5	8.8	6.5	100.0
Microirrigation and dripping	8.9	11.3	23.3	19.2	15.4	12.9	5.6	3.3	100.0

Source: Istat, Agricultural Census - Year 2000

TABLE 9a

Farms with irrigation per type of source, region and geographical area - Year 2000

REGIONS GEOGRAPHICAL AREAS	Surface water	Aqueduct	Underground water	Treated waste water	More than one source	Total
			ABSOLUTE DATA			
Piemonte	21,501	1,455	7,746	12	7,400	38,114
Valle d'Aosta	4,368	415	199	-	514	5,496
Lombardia	23,454	4,986	4,020	17	3,810	36,287
Trentino-Alto Adige	9,252	5,734	7,145	12	3,731	25,874
Veneto	39,760	5,136	8,600	65	4,081	57,642
Friuli-Venezia Giulia	5,381	897	2,792	11	1,689	10,770
Liguria	6,217	8,916	5,018	12	3,289	23,452
Emilia-Romagna	19,534	868	10,154	76	3,423	34,055
Toscana	7,249	2,440	11,828	24	2,811	24,352
Umbria	3,952	935	5,371	12	951	11,221
Marche	3,996	897	4,742	17	837	10,489
Lazio	10,601	8,423	20,940	64	4,045	44,073
Abruzzo	5,712	7,117	3,815	14	935	17,593
Molise	1,010	2,290	555	4	176	4,035
Campania	18,764	10,985	40,110	83	5,901	75,843
Puglia	9,110	16,398	67,752	283	4,136	97,679
Basilicata	5,732	10,385	2,805	16	1,540	20,478
Calabria	27,293	11,003	16,126	96	4,571	59,089
Sicilia	21,586	23,702	51,747	63	7,461	104,559
Sardegna	4,469	8,797	13,106	54	3,555	29,981
ITALY	**248,941**	**131,779**	**284,571**	**935**	**64,856**	**731,082**
North-west	**55,540**	**15,772**	**16,983**	**41**	**15,013**	**103,349**
North-east	**73,927**	**12,635**	**28,691**	**164**	**12,924**	**128,341**
Centre	**25,798**	**12,695**	**42,881**	**117**	**8,644**	**90,135**
South	**67,621**	**58,178**	**131,163**	**496**	**17,259**	**274,717**
Islands	**26,055**	**32,499**	**64,853**	**117**	**11,016**	**134,540**

TABLE 9a continued Farms with irrigation per type of source, region and geographical area - Year 2000

REGIONS GEOGRAPHICAL AREAS	Surface water	Aqueduct	Underground water	Treated waste water	More than one source	Total
		% COMPOSITION				
Piemonte	56.4	3.8	20.3	..	19.4	100.0
Valle d'Aosta	79.5	7.6	3.6	-	9.4	100.0
Lombardia	64.6	13.7	11.1	..	10.5	100.0
Trentino-Alto Adige	35.8	22.2	27.6	..	14.4	100.0
Veneto	69.0	8.9	14.9	0.1	7.1	100.0
Friuli-Venezia Giulia	50.0	8.3	25.9	0.1	15.7	100.0
Liguria	26.5	38.0	21.4	0.1	14.0	100.0
Emilia-Romagna	57.4	2.5	29.8	0.2	10.1	100.0
Toscana	29.8	10.0	48.6	0.1	11.5	100.0
Umbria	35.2	8.3	47.9	0.1	8.5	100.0
Marche	38.1	8.6	45.2	0.2	8.0	100.0
Lazio	24.1	19.1	47.5	0.1	9.2	100.0
Abruzzo	32.5	40.5	21.7	0.1	5.3	100.0
Molise	25.0	56.8	13.8	0.1	4.4	100.0
Campania	24.7	14.5	52.9	0.1	7.8	100.0
Puglia	9.3	16.8	69.4	0.3	4.2	100.0
Basilicata	28.0	50.7	13.7	0.1	7.5	100.0
Calabria	46.2	18.6	27.3	0.2	7.7	100.0
Sicilia	20.6	22.7	49.5	0.1	7.1	100.0
Sardegna	14.9	29.3	43.7	0.2	11.9	100.0
ITALY	**34.1**	**18.0**	**38.9**	**0.1**	**8.9**	**100.0**
North-west	**53.7**	**15.3**	**16.4**	**..**	**14.5**	**100.0**
North-east	**57.6**	**9.8**	**22.4**	**0.1**	**10.1**	**100.0**
Centre	**28.6**	**14.1**	**47.6**	**0.1**	**9.6**	**100.0**
South	**24.6**	**21.2**	**47.7**	**0.2**	**6.3**	**100.0**
Islands	**19.4**	**24.2**	**48.2**	**0.1**	**8.2**	**100.0**

TABLE 9a continued Farms with irrigation per type of source, region and geographical area - Year 2000

REGIONS GEOGRAPHICAL AREAS	Surface water	Aqueduct	Underground water	Treated waste water	More than one source	Total
			% COMPOSITION			
Piemonte	8.6	1.1	2.7	1.3	11.4	5.2
Valle d'Aosta	1.8	0.3	0.1	-	0.8	0.8
Lombardia	9.4	3.8	1.4	1.8	5.9	5.0
Trentino-Alto Adige	3.7	4.4	2.5	1.3	5.8	3.5
Veneto	16.0	3.9	3.0	7.0	6.3	7.9
Friuli-Venezia Giulia	2.2	0.7	1.0	1.2	2.6	1.5
Liguria	2.5	6.8	1.8	1.3	5.1	3.2
Emilia-Romagna	7.8	0.7	3.6	8.1	5.3	4.7
Toscana	2.9	1.9	4.2	2.6	4.3	3.3
Umbria	1.6	0.7	1.9	1.3	1.5	1.5
Marche	1.6	0.7	1.7	1.8	1.3	1.4
Lazio	4.3	6.4	7.4	6.8	6.2	6.0
Abruzzo	2.3	5.4	1.3	1.5	1.4	2.4
Molise	0.4	1.7	0.2	0.4	0.3	0.6
Campania	7.5	8.3	14.1	8.9	9.1	10.4
Puglia	3.7	12.4	23.8	30.3	6.4	13.4
Basilicata	2.3	7.9	1.0	1.7	2.4	2.8
Calabria	11.0	8.3	5.7	10.3	7.0	8.1
Sicilia	8.7	18.0	18.2	6.7	11.5	14.3
Sardegna	1.8	6.7	4.6	5.8	5.5	4.1
ITALY	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
North-west	**22.3**	**12.0**	**6.0**	**4.4**	**23.1**	**14.1**
North-east	**29.7**	**9.6**	**10.1**	**17.5**	**19.9**	**17.6**
Centre	**10.4**	**9.6**	**15.1**	**12.5**	**13.3**	**12.3**
South	**27.2**	**44.1**	**46.1**	**53.0**	**26.6**	**37.6**
Islands	**10.5**	**24.7**	**22.8**	**12.5**	**17.0**	**18.4**

Source: Istat, Agricultural Census - Year 2000

TABLE 9b Irrigated surface per source type, region and geographical area - Year 2000 *(absolute data in hectares)*

REGIONS GEOGRAPHICAL AREAS	Surface water	Aqueduct	Underground water	Treated waste water	More than one source	Total
			ABSOLUTE DATA			
Piemonte	196,712	11,679	52,929	102	94,395	355,817
Valle d'Aosta	17,604	996	389	-	4,634	23,623
Lombardia	403,762	42,262	33,857	132	77,740	557,752
Trentino-Alto Adige	22,767	8,914	12,839	29	13,218	57,768
Veneto	187,910	12,960	24,632	160	39,590	265,253
Friuli-Venezia Giulia	31,175	4,005	13,344	10	14,668	63,202
Liguria	1,466	2,820	1,584	4	1,356	7,230
Emilia-Romagna	148,684	2,941	49,544	300	50,908	252,377
Toscana	16,096	1,427	17,911	39	11,813	47,286
Umbria	12,968	1,305	6,924	4	10,917	32,117
Marche	9,486	1,952	9,139	29	4,591	25,199
Lazio	17,488	11,298	36,056	43	9,167	74,053
Abruzzo	12,908	10,174	2,977	17	3,919	29,995
Molise	1,069	9,835	358	9	541	11,812
Campania	18,129	17,670	40,776	159	9,680	86,415
Puglia	12,295	39,733	169,908	572	26,306	248,814
Basilicata	8,428	24,965	2,991	43	5,898	42,325
Calabria	19,903	14,205	21,713	99	11,064	66,983
Sicilia	33,469	30,912	73,085	65	23,514	161,044
Sardegna	7,734	20,311	18,094	121	16,053	62,314
ITALY	**1,180,054**	**270,365**	**589,049**	**1,938**	**429,973**	**2,471,379**
North-west	**619,544**	**57,757**	**88,758**	**238**	**178,125**	**944,422**
North-east	**390,537**	**28,820**	**100,360**	**498**	**118,385**	**638,600**
Centre	**56,038**	**15,983**	**70,029**	**116**	**36,489**	**178,655**
South	**72,733**	**116,581**	**238,723**	**899**	**57,408**	**486,344**
Islands	**41,203**	**51,224**	**91,179**	**186**	**39,567**	**223,358**

TABLE 9b continued **Irrigated surface per source type, region and geographical area - Year 2000** *(absolute data in hectares)*

REGIONS GEOGRAPHICAL AREAS	Surface water	Aqueduct	Underground water	Treated waste water	More than one source	Total
			% COMPOSITION			
Piemonte	55.3	3.3	14.9	..	26.5	100.0
Valle d'Aosta	74.5	4.2	1.6	-	19.6	100.0
Lombardia	72.4	7.6	6.1	..	13.9	100.0
Trentino-Alto Adige	39.4	15.4	22.2	..	22.9	100.0
Veneto	70.8	4.9	9.3	0.1	14.9	100.0
Friuli-Venezia Giulia	49.3	6.3	21.1	..	23.2	100.0
Liguria	20.3	39.0	21.9	0.1	18.8	100.0
Emilia-Romagna	58.9	1.2	19.6	0.1	20.2	100.0
Toscana	34.0	3.0	37.9	0.1	25.0	100.0
Umbria	40.4	4.1	21.6	..	34.0	100.0
Marche	37.6	7.7	36.3	0.1	18.2	100.0
Lazio	23.6	15.3	48.7	0.1	12.4	100.0
Abruzzo	43.0	33.9	9.9	0.1	13.1	100.0
Molise	9.1	83.3	3.0	0.1	4.6	100.0
Campania	21.0	20.4	47.2	0.2	11.2	100.0
Puglia	4.9	16.0	68.3	0.2	10.6	100.0
Basilicata	19.9	59.0	7.1	0.1	13.9	100.0
Calabria	29.7	21.2	32.4	0.1	16.5	100.0
Sicilia	20.8	19.2	45.4	..	14.6	100.0
Sardegna	12.4	32.6	29.0	0.2	25.8	100.0
ITALY	**47.7**	**10.9**	**23.8**	**0.1**	**17.4**	**100.0**
North-west	**65.6**	**6.1**	**9.4**	**0.0**	**18.9**	**100.0**
North-east	**61.2**	**4.5**	**15.7**	**0.1**	**18.5**	**100.0**
Centre	**31.4**	**8.9**	**39.2**	**0.1**	**20.4**	**100.0**
South	**15.0**	**24.0**	**49.1**	**0.2**	**11.8**	**100.0**
Islands	**18.4**	**22.9**	**40.8**	**0.1**	**17.7**	**100.0**

TABLE 9b continued **Irrigated surface per source type, region and geographical area - Year 2000** *(absolute data in hectares)*

REGIONS GEOGRAPHICAL AREAS	Surface water	Aqueduct	Underground water	Treated waste water	More than one source	Total
		% COMPOSITION				
Piemonte	16.7	4.3	9.0	5.3	22.0	14.4
Valle d'Aosta	1.5	0.4	0.1	-	1.1	1.0
Lombardia	34.2	15.6	5.7	6.8	18.1	22.6
Trentino-Alto Adige	1.9	3.3	2.2	1.5	3.1	2.3
Veneto	15.9	4.8	4.2	8.2	9.2	10.7
Friuli-Venezia Giulia	2.6	1.5	2.3	0.5	3.4	2.6
Liguria	0.1	1.0	0.3	0.2	0.3	0.3
Emilia-Romagna	12.6	1.1	8.4	15.5	11.8	10.2
Toscana	1.4	0.5	3.0	2.0	2.7	1.9
Umbria	1.1	0.5	1.2	0.2	2.5	1.3
Marche	0.8	0.7	1.6	1.5	1.1	1.0
Lazio	1.5	4.2	6.1	2.2	2.1	3.0
Abruzzo	1.1	3.8	0.5	0.9	0.9	1.2
Molise	0.1	3.6	0.1	0.5	0.1	0.5
Campania	1.5	6.5	6.9	8.2	2.3	3.5
Puglia	1.0	14.7	28.8	29.5	6.1	10.1
Basilicata	0.7	9.2	0.5	2.2	1.4	1.7
Calabria	1.7	5.3	3.7	5.1	2.6	2.7
Sicilia	2.8	11.4	12.4	3.4	5.5	6.5
Sardegna	0.7	7.5	3.1	6.2	3.7	2.5
ITALY	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
North-west	**52.5**	**21.4**	**15.1**	**12.3**	**41.4**	**38.2**
North-east	**33.1**	**10.7**	**17.0**	**25.7**	**27.5**	**25.8**
Centre	**4.7**	**5.9**	**11.9**	**6.0**	**8.5**	**7.2**
South	**6.2**	**43.1**	**40.5**	**46.4**	**13.4**	**19.7**
Islands	**3.5**	**18.9**	**15.5**	**9.6**	**9.2**	**9.0**

Source: Istat, Agricultural Census - Year 2000

TABLE 10a **Farms per kind of supply, region and geographical area - Year 2000**

REGIONS GEOGRAPHICAL AREAS	One form of supply				More than one form of supply	Total
	Self supply	Consortium	From other farm	Other form		
ABSOLUTE DATA						
Piemonte	8,188	19,580	678	5,066	4,602	38,114
Valle d'Aosta	799	3,814	5	222	656	5,496
Lombardia	3,906	25,876	322	3,001	3,182	36,287
Trentino-Alto Adige	5,155	16,404	638	529	3,148	25,874
Veneto	10,472	39,921	243	4,281	2,725	57,642
Friuli-Venezia Giulia	2,224	7,190	47	808	501	10,770
Liguria	9,743	4,549	124	8,347	689	23,452
Emilia-Romagna	12,108	17,124	358	2,489	1,976	34,055
Toscana	15,939	1,855	156	6,033	369	24,352
Umbria	7,250	1,202	128	2,369	272	11,221
Marche	5,417	2,148	114	2,520	290	10,489
Lazio	20,263	11,562	201	10,569	1,478	44,073
Abruzzo	5,146	8,609	148	3,402	288	17,593
Molise	1,052	2,170	7	756	50	4,035
Campania	36,535	14,962	4,388	17,772	2,186	75,843
Puglia	35,346	24,455	12,114	20,934	4,830	97,679
Basilicata	5,302	11,017	43	3,715	401	20,478
Calabria	23,761	15,048	989	17,999	1,292	59,089
Sicilia	34,923	34,987	8,293	22,100	4,256	104,559
Sardegna	12,812	10,083	149	4,747	2,190	29,981
ITALY	**256,341**	**272,556**	**29,145**	**137,659**	**35,381**	**731,082**
North-west	**22,636**	**53,819**	**1,129**	**16,636**	**9,129**	**103,349**
North-east	**29,959**	**80,639**	**1,286**	**8,107**	**8,350**	**128,341**
Centre	**48,869**	**16,767**	**599**	**21,491**	**2,409**	**90,135**
South	**107,142**	**76,261**	**17,689**	**64,578**	**9,047**	**274,717**
Islands	**47,735**	**45,070**	**8,442**	**26,847**	**6,446**	**134,540**

TABLE 10a continued Farms per kind of supply, region and geographical area - Year 2000

REGIONS GEOGRAPHICAL AREAS	One form of supply				More than one form of supply	Total
	Self supply	Consortium	From other farm	Other form		
	% COMPOSITION					
Piemonte	21.5	51.4	1.8	13.3	12.1	100.0
Valle d'Aosta	14.5	69.4	0.1	4.0	11.9	100.0
Lombardia	10.8	71.3	0.9	8.3	8.8	100.0
Trentino-Alto Adige	19.9	63.4	2.5	2.0	12.2	100.0
Veneto	18.2	69.3	0.4	7.4	4.7	100.0
Friuli-Venezia Giulia	20.6	66.8	0.4	7.5	4.7	100.0
Liguria	41.5	19.4	0.5	35.6	2.9	100.0
Emilia-Romagna	35.6	50.3	1.1	7.3	5.8	100.0
Toscana	65.5	7.6	0.6	24.8	1.5	100.0
Umbria	64.6	10.7	1.1	21.1	2.4	100.0
Marche	51.6	20.5	1.1	24.0	2.8	100.0
Lazio	46.0	26.2	0.5	24.0	3.4	100.0
Abruzzo	29.3	48.9	0.8	19.3	1.6	100.0
Molise	26.1	53.8	0.2	18.7	1.2	100.0
Campania	48.2	19.7	5.8	23.4	2.9	100.0
Puglia	36.2	25.0	12.4	21.4	4.9	100.0
Basilicata	25.9	53.8	0.2	18.1	2.0	100.0
Calabria	40.2	25.5	1.7	30.5	2.2	100.0
Sicilia	33.4	33.5	7.9	21.1	4.1	100.0
Sardegna	42.7	33.6	0.5	15.8	7.3	100.0
ITALY	**35.1**	**37.3**	**4.0**	**18.8**	**4.8**	**100.0**
North-west	**21.9**	**52.1**	**1.1**	**16.1**	**8.8**	**100.0**
North-east	**23.3**	**62.8**	**1.0**	**6.3**	**6.5**	**100.0**
Centre	**54.2**	**18.6**	**0.7**	**23.8**	**2.7**	**100.0**
South	**39.0**	**27.8**	**6.4**	**23.5**	**3.3**	**100.0**
Islands	**35.5**	**33.5**	**6.3**	**20.0**	**4.8**	**100.0**

TABLE 10a continued Farms per kind of supply, region and geographical area - Year 2000

REGIONS GEOGRAPHICAL AREAS	One form of supply				More than one form of supply	Total
	Self supply	Consortium	From other farm	Other form		
	% COMPOSITION					
Piemonte	3.2	7.2	2.3	3.7	13.0	5.2
Valle d'Aosta	0.3	1.4	..	0.2	1.9	0.8
Lombardia	1.5	9.5	1.1	2.2	9.0	5.0
Trentino-Alto Adige	2.0	6.0	2.2	0.4	8.9	3.5
Veneto	4.1	14.6	0.8	3.1	7.7	7.9
Friuli-Venezia Giulia	0.9	2.6	0.2	0.6	1.4	1.5
Liguria	3.8	1.7	0.4	6.1	1.9	3.2
Emilia-Romagna	4.7	6.3	1.2	1.8	5.6	4.7
Toscana	6.2	0.7	0.5	4.4	1.0	3.3
Umbria	2.8	0.4	0.4	1.7	0.8	1.5
Marche	2.1	0.8	0.4	1.8	0.8	1.4
Lazio	7.9	4.2	0.7	7.7	4.2	6.0
Abruzzo	2.0	3.2	0.5	2.5	0.8	2.4
Molise	0.4	0.8	0.0	0.5	0.1	0.6
Campania	14.3	5.5	15.1	12.9	6.2	10.4
Puglia	13.8	9.0	41.6	15.2	13.7	13.4
Basilicata	2.1	4.0	0.1	2.7	1.1	2.8
Calabria	9.3	5.5	3.4	13.1	3.7	8.1
Sicilia	13.6	12.8	28.5	16.1	12.0	14.3
Sardegna	5.0	3.7	0.5	3.4	6.2	4.1
ITALY	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
North-west	**8.8**	**19.7**	**3.9**	**12.1**	**25.8**	**14.1**
North-east	**11.7**	**29.6**	**4.4**	**5.9**	**23.6**	**17.6**
Centre	**19.1**	**6.2**	**2.1**	**15.6**	**6.8**	**12.3**
South	**41.8**	**28.0**	**60.7**	**46.9**	**25.6**	**37.6**
Islands	**18.6**	**16.5**	**29.0**	**19.5**	**18.2**	**18.4**

Source: Istat, Agricultural Census - Year 2000

TABLE 10b **Irrigated surface per form of supply, region and geographical area - Year 2000** *(absolute data in hectares)*

REGIONS GEOGRAPHICAL AREAS	One form of supply				More than one form of supply	Total
	Self supply	Consortium	From other farm	Other form		
			ABSOLUTE DATA			
Piemonte	46,531	202,971	3,102	25,350	77,863	355,817
Valle d'Aosta	2,886	13,719	10	864	6,144	23,623
Lombardia	51,734	388,014	3,439	26,913	87,653	557,752
Trentino-Alto Adige	10,462	31,859	1,561	1,202	12,683	57,768
Veneto	36,529	184,448	448	13,359	30,469	265,253
Friuli-Venezia Giulia	12,154	40,404	155	3,243	7,247	63,202
Liguria	3,003	1,596	36	2,179	416	7,230
Emilia-Romagna	58,189	142,955	1,816	10,570	38,847	252,377
Toscana	30,979	3,222	322	10,697	2,066	47,286
Umbria	17,843	3,536	380	5,168	5,190	32,117
Marche	12,544	5,202	121	5,733	1,600	25,199
Lazio	37,281	20,128	344	12,309	3,991	74,053
Abruzzo	9,240	13,302	140	5,814	1,500	29,995
Molise	905	9,943	29	749	185	11,812
Campania	36,724	27,978	2,220	13,786	5,707	86,415
Puglia	97,435	63,189	14,683	41,960	31,548	248,814
Basilicata	3,444	32,566	75	2,373	3,867	42,325
Calabria	24,046	20,241	394	16,086	6,216	66,983
Sicilia	62,812	50,735	5,488	26,249	15,761	161,044
Sardegna	19,406	25,416	88	5,515	11,890	62,314
ITALY	**574,145**	**1,281,424**	**34,849**	**230,118**	**350,843**	**2,471,379**
North-west	**104,153**	**606,300**	**6,586**	**55,305**	**172,077**	**944,422**
North-east	**117,333**	**399,666**	**3,979**	**28,375**	**89,246**	**638,600**
Centre	**98,646**	**32,089**	**1,167**	**33,907**	**12,847**	**178,655**
South	**171,795**	**167,218**	**17,540**	**80,768**	**49,023**	**486,344**
Islands	**82,217**	**76,151**	**5,576**	**31,763**	**27,651**	**223,358**

TABLE 10b continued **Irrigated surface per form of supply, region and geographical area - Year 2000** *(absolute data in hectares)*

REGIONS GEOGRAPHICAL AREAS	One form of supply				More than one form of supply	Total
	Self supply	Consortium	From other farm	Other form		
		% COMPOSITION				
Piemonte	13.1	57.0	0.9	7.1	21.9	100.0
Valle d'Aosta	12.2	58.1	..	3.7	26.0	100.0
Lombardia	9.3	69.6	0.6	4.8	15.7	100.0
Trentino-Alto Adige	18.1	55.2	2.7	2.1	22.0	100.0
Veneto	13.8	69.5	0.2	5.0	11.5	100.0
Friuli-Venezia Giulia	19.2	63.9	0.2	5.1	11.5	100.0
Liguria	41.5	22.1	0.5	30.1	5.8	100.0
Emilia-Romagna	23.1	56.6	0.7	4.2	15.4	100.0
Toscana	65.5	6.8	0.7	22.6	4.4	100.0
Umbria	55.6	11.0	1.2	16.1	16.2	100.0
Marche	49.8	20.6	0.5	22.8	6.3	100.0
Lazio	50.3	27.2	0.5	16.6	5.4	100.0
Abruzzo	30.8	44.3	0.5	19.4	5.0	100.0
Molise	7.7	84.2	0.2	6.3	1.6	100.0
Campania	42.5	32.4	2.6	16.0	6.6	100.0
Puglia	39.2	25.4	5.9	16.9	12.7	100.0
Basilicata	8.1	76.9	0.2	5.6	9.1	100.0
Calabria	35.9	30.2	0.6	24.0	9.3	100.0
Sicilia	39.0	31.5	3.4	16.3	9.8	100.0
Sardegna	31.1	40.8	0.1	8.8	19.1	100.0
ITALY	**23.2**	**51.9**	**1.4**	**9.3**	**14.2**	**100.0**
North-west	**11.0**	**64.2**	**0.7**	**5.9**	**18.2**	**100.0**
North-east	**18.4**	**62.6**	**0.6**	**4.4**	**14.0**	**100.0**
Centre	**55.2**	**18.0**	**0.7**	**19.0**	**7.2**	**100.0**
South	**35.3**	**34.4**	**3.6**	**16.6**	**10.1**	**100.0**
Islands	**36.8**	**34.1**	**2.5**	**14.2**	**12.4**	**100.0**

TABLE 10b continued **Irrigated surface per form of supply, region and geographical area - Year 2000** *(absolute data in hectares)*

REGIONS GEOGRAPHICAL AREAS	One form of supply				More than one form of supply	Total
	Self supply	Consortium	From other farm	Other form		
	% COMPOSITION					
Piemonte	8.1	15.8	8.9	11.0	22.2	14.4
Valle d'Aosta	0.5	1.1	..	0.4	1.8	1.0
Lombardia	9.0	30.3	9.9	11.7	25.0	22.6
Trentino-Alto Adige	1.8	2.5	4.5	0.5	3.6	2.3
Veneto	6.4	14.4	1.3	5.8	8.7	10.7
Friuli-Venezia Giulia	2.1	3.2	0.4	1.4	2.1	2.6
Liguria	0.5	0.1	0.1	0.9	0.1	0.3
Emilia-Romagna	10.1	11.2	5.2	4.6	11.1	10.2
Toscana	5.4	0.3	0.9	4.6	0.6	1.9
Umbria	3.1	0.3	1.1	2.2	1.5	1.3
Marche	2.2	0.4	0.3	2.5	0.5	1.0
Lazio	6.5	1.6	1.0	5.3	1.1	3.0
Abruzzo	1.6	1.0	0.4	2.5	0.4	1.2
Molise	0.2	0.8	0.1	0.3	0.1	0.5
Campania	6.4	2.2	6.4	6.0	1.6	3.5
Puglia	17.0	4.9	42.1	18.2	9.0	10.1
Basilicata	0.6	2.5	0.2	1.0	1.1	1.7
Calabria	4.2	1.6	1.1	7.0	1.8	2.7
Sicilia	10.9	4.0	15.7	11.4	4.5	6.5
Sardegna	3.4	2.0	0.3	2.4	3.4	2.5
ITALY	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
North-west	**18.1**	**47.3**	**18.9**	**24.0**	**49.0**	**38.2**
North-east	**20.4**	**31.2**	**11.4**	**12.3**	**25.4**	**25.8**
Centre	**17.2**	**2.5**	**3.3**	**14.7**	**3.7**	**7.2**
South	**29.9**	**13.0**	**50.3**	**35.1**	**14.0**	**19.7**
Islands	**14.3**	**5.9**	**16.0**	**13.8**	**7.9**	**9.0**

Source: Istat, Agricultural Census - Year 2000

ANNEX 5
OVERVIEW ON CONSORTIA NETWORK STRUCTURAL DATA

1. Introduction

Data on water network characteristics and related area served by consortia are available from different sources. Three different studies have been carried out during the last decades on such matter.

The experience of the Land reclamation and irrigation consortia national association (Anbi survey) is at national level. The other two projects, worthy to be mentioned, have been carried out at multiregional level: one by the Po RB authority (Po RB authority project) in Italy and the other one by the National institute of agriculture economics (Anbi - Mop project), referring to the southern area of the former Objective 1 regions identified by Regulation 2081/93/Eec.

2. Anbi survey

Anbi conducted - among the associated consortia - a survey in year 2001 aimed at collecting data on their structure and related water management systems. Data were collected on water diverted or pumped by the consortia and delivered to final users and on water diverted directly from final users from water canals managed by consortia (Anbi, 2003).

The consortia interviewed resulted to be 138, irrigable area was around 3,250,000 hectares, 66.3 percent of which is actually irrigated. In fact the area irrigated with water delivered directly by consortia accounts for 1,464,541 hectares, whereas the remaining 692,522 hectares were irrigated with water diverted from final users. Irrigable land refers to land served by abstraction water irrigation infrastructure, but not necessarily irrigated in relation to the specific crops grown in the specific reference period.

The mentioned survey provided information with reference to:

- system of delivering (on demand, in turn, continuos flow, etcetera) organised by the consortium;
- water quantity delivered or directly abstracted;
- typology of water source (share of volume abstracted per kind of source);
- irrigation methods adopted (share of area irrigated per type of method).

Very small consortia still active in Piemonte were not encountered.

TABLE 1 **Irrigable and irrigated area per region – Year 2001** (a) *(surface in hectares)*

REGIONS GEOGRAPHICAL AREAS	Irrigable Area	Irrigated Area		
		Through consortia	Trough divertion of water by final users	Total
Piemonte	291,785	294,534	21,693	316,227
Valle d'Aosta	-	-	-	-
Lombardia	583,336	350,834	78,514	429,348
Trentino-Alto Adige	-	-	-	-
Veneto	599,915	204,945	248,012	452,957
Friuli-Venezia Giulia	74,941	40,341	12,000	52,341
Liguria	-	-	-	-
Emilia-Romagna	514,068	122,823	214,292	337,115
Toscana	20,000	5,297	3,120	8,417
Umbria	16,067	5,401	1,170	6,571
Marche	20,153	13,862	61,834	75,696
Lazio	99,211	51,268	27,951	79,219
Abruzzo	59,000	30,356	500	30,856
Molise	49,750	19,525	-	19,525
Campania	128,860	45,321	8,918	54,239
Puglia	214,401	93,423	1,880	95,303
Basilicata	85,465	43,280	-	43,280
Calabria	113,974	21,239	100	21,339
Sicilia	190,589	60,658	988	61,646
Sardegna	192,455	61,434	11,550	72,984
ITALY	**3,253,970**	**1,464,541**	**692,522**	**2,157,063**
North-west	**875,121**	**645,368**	**100,207**	**745,575**
North-east	**1,188,924**	**368,109**	**474,304**	**842,413**
Centre	**155,431**	**75,828**	**94,075**	**169,903**
South	**651,450**	**253,144**	**11,398**	**264,542**
Islands	**383,044**	**122,092**	**12,538**	**134,630**

Source: Anbi, 2003
(a) Provisional data.

3. Po RB authority project

Po River Basin authority carried out the project on irrigation activity managed by consortia. Published data refers to period 1991-1996 and to consortia actives in 10 different areas. These areas were identified according to specific features related to cropping pattern, water network and irrigation methods that resulted to have higher homogeneity in each specific area. The project provided also cartography of the 10 areas, showing that most of the plain area was covered, accounting for the majority of the irrigation activity practised in the River Basin. Regions involved are Piemonte, Lombardia, Emilia-Romagna and Veneto.

The consortia analysed were selected on the basis of water flow volume recorded in different existing lists: only consortia with a *permission of water abstraction* higher than $1m^3$/sec were included in the study. At the end the list, updated during the survey phase, accounted for 41 entities in Piemonte, 49 in Lombardia, 13 in Emilia-Romagna and 2 in Veneto regions. For each consortium data on territorial area (area under consortia administration), irrigable and irrigated area have been collected. Furthermore some information on structural variables related to ways of delivering (in turn, on-demand) and infrastructure characteristics are available. Figures, reported in Table 2 and analysed per region, reveal that over the 2,294,962 administrated hectares only 49.8 percent is watered. Water is delivered slightly more on-demand than in turn (54.2 and 45.8 respectively). The infrastructure is dominated by open canals, which serve 94.3 percent of total irrigable land.

TABLE 2 **Consortia and related structural characteristics per region** *(surface in hectares)*

REGIONS	Consortia territorial area (a)	Irrigable UAA	Irrigated UAA (b)	Ways of delivering (% of irrigable UAA)			Delivering infrastructure (% of irrigable UAA)			
				In turn	On-demand	Total	Open canal	Gravity pipeline	Pressure pipeline	Total
Piemonte	511,318	360,287	354,535	38.1	61.9	100.0	99.3	-	0.7	100.0
Lombardia	835,282	570,265	534,466	72.9	27.1	100.0	90.3	0.1	9.6	100.0
Veneto	56,460	44,884	38,460	-	100.0	100.0	91.3	5.4	3.4	100.0
Emilia Romagna	891,902	487,165	214,669	23.9	76.1	100.0	95.5	1.0	3.5	100.0
TOTAL	**2,294,962**	**1,462,601**	**1,142,129**	**45.8**	**54.2**	**100.0**	**94.3**	**0.5**	**5.2**	**100.0**

Source: Po River Basin authority
(a) Including surfaces under the competence of consortia with water diversion over $1m^3$/sec.
(b) Average for years 1991-1997.

Other available variables available are:

— water abstraction features (validity, location, volume of water, etcetera) and destination;

— volumes abstracted per type of source;
— irrigated land per type of irrigation method adopted.

Due to time variation on juridical nature of consortia involved and related areas, sometimes data declared from consortia itself were corrected on the basis of field trips and geographical discrepancies. Consortia might in fact have declared an area which wasn't anymore under their competence.

4. Inea - Mop project

The National institute of agriculture economics (Inea) carried out a project on water resources and uses for agriculture purposes, involving eight regions (Abruzzo, Molise, Campania, Basilicata, Calabria, Puglia, Sicilia and Sardegna) of the former Objective 1 area identified by Regulation 2081/93/Eec, funded by the European union through the Multiregional operative programme (Mop) initiative from 1994 until 1999 (Inea - Mop)[1].

Among other activities, Inea project consisted in a survey conducted on consortia, in order to collect several kind of data. Main aim of the study was to increase knowledge on water use for irrigation purpose, mainly in relation to the need of maintenance work of water networks and to the need of a more efficient planning of new works to extend the network.

Due to the objective of the project, a wide range of information has been collected on structural characteristics of the water network and on typology of management. 65 consortia have been investigated among the 8 regions included in the study area (Table 3). Those consortia manage 245 *comprensori*, in turn divided into *distretti*, so that the unit named *distretti* is the smallest one.

Consortia were thus required to answer questionnaire on the consortium itself (anagraphycal questions on management and on area of administrated land), on *comprensorio* (area of land with water works), on *distretto* (area of land with water works, total irrigated land, irrigated land by irrigation method).

[1] Results are published at *http://www.inea.it/irri/index.cfm.*

Furthermore partial information is available on water sources and characteristics of works to abstract water, together with water destination and uses. Data on scheme of the water network, number of farms served, method of irrigation applied, irrigated area by crops, modality of water distribution, volume of water abstracted, fees paid to the network management for water distribution services have been collected. Cartography with geo-referenced irrigation network scheme has been produced.

TABLE 3 **Consortia and related surfaces per region** *(surface in hectares)*

REGIONS	Consortia	Comprensorio	Administrated land			
			Total	% of regional territorial area	Of which with delivering system	Of which irrigated
Abruzzo	5	14	760,159	70.4	65,826	60,543
Molise	3	4	94,754	21.4	22,428	11,502
Campania	11	34	449,594	33.1	59,605	56,863
Puglia	6	66	1,743,591	90.1	191,259	68,369
Basilicata	3	11	636,873	63.7	82,339	34,024
Calabria	16	57	953,725	63.2	82,335	33,694
Sicilia	10	40	2,392,361	93.1	156,299	70,716
Sardegna	11	19	928,597	39.0	169,994	59,529
TOTAL	**65**	**245**	**7,959,654**	**64.8**	**830,085**	**395,240**

Source: Inea - Mop project

Nevertheless, questionnaires were incomplete for the required information, leading the project management to choose remote sensing in order to estimate irrigated surface area.

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This publication reports the results of a project co-financed by Eurostat carried out in Istat with the aim to promote harmonisation of water statistics requested by Inland Waters, one of the nine Joint Oecd/Eurostat questionnaires on the state of the environment. A focus on methodological aspects and on data sources for the assessment of the main variables of hydrological cycle is presented together with a description of the links existing between water flows. Estimations are given mainly for precipitation, evapotranspiration, total actual outflow to the sea, water exchanges between neighbouring territories. Furthermore, analyses on the phenomena related to water use in agriculture, that is the most relevant one among all uses, are reported. Aspects faced are water abstraction by sources and water supply by categories. Diverse methodologic approaches and data sources have been reviewed in order to calculate such variables.

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