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ISTITUTO NAZIONALE
DI ECONOMIA AGRARIA

Atlas of Italian Irrigation systems

Edited by Raffaella Zucaro

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April 2014

"Not everything that counts can be counted
and not everything than can be counted, counts"

(Albert Einstein)

Atlas of Italian Irrigation systems 2014.
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Introduction of the President of INEA

The agricultural development of different areas in Italy has been closely associated with access to water. Crop Irrigation systems have always been an asset in terms of revenue and employment. These are the main reasons why in 1961, on the occasion of the 100th anniversary of the Italian Unification, the Italian Ministry of Agriculture started up a specific survey entrusted to INEA on Italian irrigation and the possible developments of the sector in the different Italian regions, which led to the publication of the 'Map of Irrigation in Italy'.

Although, the present historical, socio-economic and agricultural scenario has deeply changed compared to the sixties, particularly with relation to European and national policies and to globalization of agricultural markets, water still plays a pivotal role, and indeed the importance of irrigation management has acquired a strategic value in the scenarios that are evolving at European and global levels.

In such a framework, the new 'Atlas of Italian Irrigation systems' edited and revised by INEA in 2011 appears to be even more significant and provides and important insights on the development of the sector, its criticalities and potentials for years to come. Considering that irrigation represents one of the major national issues that has always been prioritized by the Italian Government since the early years of the Italian Unification, it is not accidental that the publication of the Atlas coincided with the 150th anniversary of the Italian Unification as it was also the case for the Atlas of 1965.

This study also results from the awareness regarding the strategic importance of having available surveys on water use in agriculture, which meet the complex and multifaceted nature of the sector and its integration needs together with further studies aiming to provide information and evaluative elements directed to support decision making. In fact, since the nineties INEA, on the base of precise guidelines received from the European Commission and the Italian Ministry of Agriculture, has resumed its research on these issues through specific surveys. The surveys, starting from portraying the need for general knowledge updating related to water use in agriculture (irrigated crops, irrigation schemes, economic and managerial aspects etc.), delve into new research issues, such as public sector's policies and planning. Also their integration with environmental and energy policies, together with the identification of the most suitable financial instruments for an effective management of water resources are further surveyed. Furthermore, a new approach has been adopted which emphasizes the 'territorial component' and thereby involves local governments and authorities responsible for the management of irrigation water.

Thanks to the research work carried out over the last decades, the Institute has now available reservoir of information, studies and expertise, which constitute a benchmark for researchers as well as for local, regional and national institutions.

The Atlas of Italian Irrigation systems of 2011 was conceived as an updated edition of the Atlas published in 1965. It aims consequently to enhance the research conducted so far by re-launching diverse issues related to water resources, through a historical comparison embracing the fifty years following the first survey and through the dissemination of the results achieved. Besides, it aims at providing food for thought and new insights on issues, which are considered to be strategic for the primary sector as a whole. In such ever-changing environment that keeps on generating a recurrent demand for research, the National Institute of Agricultural Economics, intends to continue to provide its contribution.

Tiziano Zigiotto

Introduction of the General Director of Competitiveness for Rural Development of the Ministry of Agricultural, Food and Forestry Policies (MiPAAF)

Enhancing the EU environmental performance and agricultural policy through a mandatory "greening" component of direct payments and prioritizing actions that pursue both climate and energy goals are among the major challenges Italian agriculture has to face over the next few years, as indicated by the Communication from the Commission to the European Parliament 'The CAP towards 2020'.

In this context, water resources will gain ever more importance and irrigation will have to respond to agricultural sector needs by both implementing new efficient practices as to water savings and by increasing, among other, environmental benefits. The identification of measures that reward virtuous behaviours of farmers in water use will allow Italy to progress and demonstrate Italian capability to take up and respond to such challenge.

And, in fact, as already set in the Work Programme 2005-2009[1]*, among the main priorities of the Common Policy is a strong interaction between agriculture and the Water Framework Directive 2000/60/CE and how the strategies of a Common Policy may contribute to meet the directive's objectives and related implementing procedures. More specifically, a very topical issue is the current implementation of the provisions of Art. 9 of the Water Directive in compliance with Member States water pricing policies aiming at both saving water resources and contributing to an appropriate cost recovery in water services that encumbers different employment sectors including agriculture.*

To this end, the Ministery is committed to coordinate and standardize the flux of information that from water management authorities (Reclamation Consortia and other Irrigation agencies) are to be transmitted to the Authorities of River Basin District for economic analysis as provided by the Directive. As regards these aspects, INEA carried out both technical support and analysis by implementing the National Information System for water management, which also includes managing and collecting economic data and executing specific analyses and surveys related to the cost of water in agriculture.

There are several knotty problems concerning, in particular, context definition and grouping of (service) pricing that have to be evaluated to reckon the current recovery percentage of costs for water services. MiPAAF (the Ministry of Agricultural, Food and Forestry Policies) through its representatives who are within the Technical Committees of District Authorities, upholds the striking feature of the agricultural sector, as the cost of services tallies with the payment of the fixed rates (due contributions), which aim to cover only management costs (licensing costs, irrigation and operational costs of agencies). Another feature of the irrigation sector is related to the environmental costs generated by the implementation of good practice (of irrigation). It should be considered that costs and benefits might be well balanced by implementing good practice of irrigation, such as return to water bodies, replenishment of groundwater or protection of biodiversity and wetlands, as well as preserving historical agricultural landscape in many areas of Italy.

Equally significant, productivity of the Italian irrigation system is essential to provide 'value added' to the agricultural industry, and it is required by the same markets that are oriented to not only quality and safety, but also consumption of Italian agricultural and food products.

Operating, managing, and investing decisions, that certainly are to be taken to enable sustainable management of water resources shall, therefore, at the same time promote enterprises competitiveness and productivity on the market as well. In this way, biases and lack of sector's detailed knowledge shall prevent from undermining agriculture ability to survive and develop.

The complexity of this system, also from an economic outlook, is such that in substance it reflects, on the one hand, the complexity of present dynamic interactions between agriculture and environment and, on the other, between irrigation management and markets, as

1. The *Common Implementation Strategy* is the common strategy which Member States of the European Union and the EU Commission have developed to implement [the above mentioned] Directive aiming to facilitate a consistent implementation across European Member States.

shown by the statements reported in this study. It also highlights well sector features of irrigation management in different areas. The study provides an in-depth analysis of history, development and current structure (and distribution) of the Italian Irrigation systems helping to individuate vulnerable spots that need to be improved and in parallel to disseminate and enhance the long and valuable agricultural history of Italy.

Giuseppe Blasi

Acknowledgments of the President of the National Association for Land Reclamation and Irrigation

I commend INEA for editing the Atlas of Italian Irrigation systems, which, in my view, is a useful support to improve the knowledge of a specific subject as irrigation. In fact, given the world dynamics concerning land use, the availability of arable lands and the consequent availability of food leading to social cohesion, it is a valuable tool for providing information to all the experts, including reclamation operators who, as to irrigation, are the front-office of farms and agricultural holdings.

Water is a basic need for human life in all its different uses: drinking water and water intended for civil use, food production, industrial development, energy production and the environment. Water shortage, which concerns more than one billion people, causes natural disasters and conflicts between nations and it is doomed to become increasingly serious. Therefore, in the future, the exponential demographic growth will lead to water shortage and to shortage of the land necessary for food production. It is then quite natural to wonder how it will be possible to increase food production without being able to expand arable areas.

Consequently, irrigation is due to play increasingly an important role to ensure a sustainable growth of agricultural production, hence food and social cohesion. In order to make sure that food will always be available and safe, China and Japan are buying irrigable lands in Africa and South America. Water represents a basic resource for Italian agriculture, with irrigable areas accounting for more than 40% in flat lands, 10% in middle-mountain and 5% in mountain areas. Unfortunately, in the years to come, water availability will be dramatically reduced even in Italy, owing to climate change, pollution, its conflicting uses as well as apparently endless land consumption, which is likely to put a big question mark on the quality of life for future generations. Furthermore, considering that more than 83% of the value of Italian agricultural production comes from irrigated areas, water availability appears to become even more relevant. It is also worthwhile mentioning that agriculture and rural landscape are the pillars of the so-called Made in Italy and as a result attract a large number of tourists coming to our country. In this respect it is equally worth pointing out the excellence of Italian products, especially agricultural ones that are typical of Italy: wine, olive oil, fruit, vegetables, cheese, sausage products, etc. This produce makes Italian enterprises competitive in world markets thanks to its significant intrinsic value of typical origin (geographical indication) which cannot be changed or cloned. It is precisely through available water resources that it is possible to get this authentic Italian value. Water is also of vital importance for the environment and the conservation of the rural landscape (groundwater replenishment, limiting saline intrusion and the upstream penetration of salt-wedge into the rivers, mitigating subsidence, maintaining natural reserves).

It is in this context that Land Reclamation and Irrigation Consortia operate. The area equipped for irrigation works is around 3.3 million hectares and is managed by 158 Consortia that are members of the National Association for Land Reclamation and Irrigation (ANBI). Only collective irrigation, which has been highly beneficial to Italian agriculture, can enable water to be used in the most rational manner through the establishment of consortia that, abiding by the principle of subsidiarity, ensure consumer involvement also from a financial perspective. Consumers, in fact, are very much interested in an ever more correct management of water capable of satisfying both different needs of crops and those of most members of the Consortia.

Massimo Gargano

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Abstract

In the last decade the need of planning and implementing sustainable water policy has grown in the International, European Community and National political milieu. The awareness of applying the concept of sustainability to water resources - according to the ecological, economical, financial and ethical principles - has implied the development of a complete knowledge framework of the complex National water system.

Since the second postwar period, the National Institute of Agricultural Economics (INEA) has contributed to design the irrigation water policy in Italy by supporting the Italian Ministry of Agricultural, Food and Forestry Policies (MiPAAF) through the provision of technical studies about the issues and development opportunities of the irrigation sector. In particular, in 1965 a specific study produced the publication "Carta delle irrigazioni d'Italia" (Map of irrigation in Italy), realized on provincial scale through the analysis of data collected at municipal level. The work reported also the historical aspects of irrigation in Italy, the main collective irrigation infrastructures and the irrigated agricultural productions.

After the 1990's, the need for more accurate programming of irrigation investments induced the Ministry of Agricultural, Food and Forestry Policies to improve the state of knowledge about the irrigation sector through the technical support provided by INEA. Indeed, the recent research activities have been carefully designed in order to capture all relevant aspects of the irrigation sector such as the establishment of a modern and complete, centralized information system. Since 1994, starting from the Southern territories, INEA collected data and information on the irrigation sector and built up the *Information System for Water Management in Agriculture* (SIGRIA), focusing on territorial, structural, economical and managerial aspects. Since 2000, the information system has been implemented also for Northern and Central Italy by INEA and Regions.

The stabilization of the research activities about the irrigation sector led to the definition of a specific research area inside INEA, called '*Water Resources Management*' devoted to research and institutional support. In agreement with the Ministry of Agricultural, Food and Forestry Policies, INEA completed the organization and the updating of collected data in a National geo-database, called the National Information System for Water Management in Agriculture (the SIGRIAN). It is the most complete and updated instrument that supports Governmental Institutions in both efficiently allocating financial resources for investments and optimizing planning and management of water resource at a river basin level.

The analysis of data and information collected in the SIGRIAN is the base of the present '*Atlas of Italian Irrigation systems*' finalized in 2011 to celebrate the 150th Anniversary of the Italian Unification.

The Atlas provides a thorough presentation of the current situation of the irrigation sector in Italy and its evolution in relation to the former study of 1965, by illustrating main collective irrigation systems and the use of water in agriculture on the base of the River Basin Districts defined by the Water Framework Directive. The Atlas focuses on the principal aspects regarding the evolution of the irrigation sector from 1965 at different levels, such as the regulatory framework, the governance at central and District level, the organization of water management at local level, the issues related to water charges and water management, the description of the condition of main infrastructures.

Introduction

It might pose some puzzling questions the choice of Albert Einstein's saying to introduce 'the National Information System for Water Management in agriculture' (the SIGRIAN), whose data the Atlas of Italian Irrigation systems is based upon. Actually, the real message, intended to be transmitted by this study, is that, the real benefit does not lie in the data as such; rather, it is to be found in various and different responsibilities and competencies that have become diversified and stratified through the activities over the years and ended in the publishing of the INEA Irrigation Series, of which the Atlas is the very final effort.

The experience of INEA in the survey field of the Italian irrigation sector is to date back to the first half of the 60s. The Director of the Institute of those days, Prof. Giuseppe Medici through his scientific research related to agricultural issues, land reform and land reclamation, started the setting up of the project of Map of Irrigation in Italy and greatly contributed to develop the primary national sector. The project in real terms was later on set up by the Director Prof. Mario Bandini, who succeeded him and published the study in 1965.

The drafting of the Map of Irrigation in Italy required a lot of work and involved several regional and provincial operating Inspectors who participated to the compilation of the regional monographic studies. The activity required, indeed, 4-years work and, above all, triggered off an innovative approach in the field of agriculture-economic research with the production of a broad range of documents: surveys, regional irrigation maps (1:750,000 scale), a national summary map (1:2,500,00 scale) and projected the Institute into new issues' surveys.

Similarly, the stream of research concerning the analyses of the irrigation sector began in the late 1990s through the first survey of the Southern Regions and the Islands. It was funded by the EU Commission (MOP, the Irrigation Multiregional Operative Programme – CSF, Community Support Framework 1994-1999) and was carried out between 1997 and 2000. The survey kicked off a series of research and technical support activities provided to central and regional Authorities responsible for water resources planning and management. Most important it enabled the training of professionals with complementary skills (such as agronomists, geologists, engineers, economists, biologists, sociologists) who represent today the real asset and wealth of the Institute. This is so, because they conceived the SIGRIAN, which has become a useful tool, at a national, regional and sub-regional level, to support not only management and planning of policy interventions in the field of managing water resources for irrigation purposes. But primarily because they contributed to start a new trend in surveying and investigating economics and environment and land policies mostly thanks to the support requests received from various international, national and regional authorities, also by creating a special technical service and two specific homogeneous areas of research to manage water resources for irrigation, environment and agriculture policies.

The setting up of the SIGRIAN enabled to develop detailed territorial, regional and national surveys concerning the characteristics of irrigation. It managed to match region-wide data referred to irrigation network, climate, pedological, environment characteristics and agricultural soil conditions of the land, as well as to structure competencies in water sector, carrying out cross-sectional analyses of conditions and characteristics of the land, where irrigation was practiced. How the Information System was conceived and organized permitted to overlap multiple layers of information according to geographical data, and to process data by directly selecting and mining information that were linked according to variables, such as type of processing to be carried out and map-making as result of carried out compilations.

The setting-up of the SIGRIAN required a considerable effort, as it was necessary to support all Regions and Autonomous Provinces involved in the project from the very beginning. In fact, more than 200 technical meetings took place in different Regions, and about 40 meetings at the MiPAAF's and/or INEA's offices. Also about 250 technical notes for specifications, clarifications for better understanding and intermediate validation of information were produced. In the last phase, INEA in addition to constant support provided to Regions, Autonomous Provinces and for intermediate verifications entered the validation phase of the SIGRIA's projects finalized at a regional level. To this end, validation groups were set up. They included various professional human resources who

have been already involved in the project according to their specific skills, such as regional managers, agronomists, engineers, and one representative of the National Association for Land Reclamation and Irrigation (ANBI). The monitoring and implementing activity of the SIGRIAN concerned irrigation carried out by consortia and managed by approx. 500 irrigation agencies on the national territory corresponding to local authorities' surface area of more than 19 million hectares. The large number of authorities is proportional to the wide variety of water agencies (from Irrigation and Reclamation Consortia and to Consortia for land improvement and from 'Mountain Communities' to Provinces and private water agencies). The large number of stakeholders involved required sustained efforts to interpret and mutually exchange technicalities with the experts of the Regions to understand different situations and expertise better in the irrigation sector.

Describing water resources for irrigation, accounted for the largest workload. As the water network, which provides services, is so vast and complex, that the Regions themselves have sometimes become aware in progress of the knowledge gaps relating water use and have started further in-depth surveys. Assignment work and hence validation and interpretation of different situations of irrigation areas concerned an equipped area for irrigation of over 3 million hectares with approx. 1,400 irrigation schemes, 10 of which have inter-consortia and/or inter-regional relevance. Information (concession data, abstracted volumes) from 5,000 water supply structures were collected, evaluated and processed. More than 23,000 km of primary and secondary irrigation network were identified.

These factors implied huge interpretation problems of complex schemes — 45% of the network serves as multiple function of land reclamation and irrigation —. Schemes are mixed from a structural standpoint (some of them are huge and provide service to several areas, however most of them are of small-scale schemes and scattered throughout the land) and from a managing standpoint, (many private Consortia manage them, whereas Consortia manage irrigation). Each important element concerning the study of water use was collected and registered: partitioning points of the primary and secondary irrigation network, structural works (water storage tanks and lifting facilities), points of water returns to the irrigation network (interconnection of irrigation systems with natural networks).

In the end, remarkable efforts were made to classify cultivation systems recipient of water resource and related water volumes (irrigated crops practiced, irrigation season, specific volumes used and irrigation needs). Although the SIGRIAN reveals substantial information regarding the afore-mentioned aspects, it still has considerable basic knowledge gaps at Water agencies and Regions level. Therefore, the analysis of this data was not reported in the present study.

In view of the background described above, I, therefore, would like to express my most sincere thanks to my INEA colleagues, as well as to those colleagues of the Regions, Ministry and of irrigation agencies who all contributed to achieve these important results.

Raffaella Zucaro

Chapter 1

Overview of Irrigation in Italy

1.1 Regulatory and Institutional Framework

In Italy irrigation has ancient origins. Since the time of the Etruscans, in the central regions of the country irrigation practices were implemented in agriculture frequently (INEA, 1965). The Romans utilized irrigation extensively in arable land and viticulture using fresh water resources and groundwater. However, available historical evidence suggests that irrigation practices were individual farmers' initiatives. The first joint irrigation works were set in Southern Italy, mainly in Sicily, during the Arab domination. Some regions along the coast, such as Calabria, Puglia and Campania shared the same history.

Later on around 1000, AD and mostly thanks to some religious orders collective irrigation works were initiated in the North of Italy (Piedmont, Lombardy, Veneto and Emilia). After the Italian Unification, during the Cavour Government (the Kingdom of Savoy and the Kingdom of Italy) a public structural conversion of water use for irrigation was carried out, during which channels became state-owned.

The development of irrigation laws took place especially in the period following the Italian Unification, when it was acknowledged the importance of irrigation practices for the economic development of the country. One of the first important regulation is the law, dated June 18, 1889, which was merged later on into the Consolidation Act No. 195 of 22 March 1900. It concerned land reclamation and the renewal of the irrigation system needed to eradicate malaria in order to enable human settlements in rural areas. In the South of Italy and the Islands, the most extensive water-managed policies were implemented in the years after the Second World War.

Other norms and regulations have been followed and gradually covered several important issues of our history. The evolution of the irrigation regulatory framework, therefore, has been established according to the public interest recognition of the importance of collective irrigation and then it has slowly embraced more and more concepts related to environment protection.

The modern regulatory framework of water resources is based, in effect, upon the Royal Decree No. 1775 of the year 1933 (INEA, 2001a). It began to undergo regulatory changes already in the 70s (with the issuing of the so-called 'Merli Law' concerning the protection of waters against pollution, Law No. 319/76). Compared to the context described in 1965, during the 1990s and through the 2000s a profound evolution took place. Several framework laws were issued governing soil protection (Law No. 183/89), integrated management of water resources (Law No. 36/94, the so-called 'Galli Law') and environment protection of water authorities (Legislative Decree No. 152/99) completing in many ways the regulatory framework that governs today's use of water resources. Subsequently, decentralization laws and Legislative Decree No. 300/99 followed and reorganized functions redistributing competences within the State, Regions and Administration of the Central Government[2].

Cardinal rules — issued by Law No. 183/89 and by the 'Galli Law', both still in force — are: planning water use on river basin scal[3] and managing integrated water cycle in enhanced territorial areas. In particular, with Law No. 183/89 the national territory was divided into national River Basin with a multi-level structure composed of 3 levels of Authorities at national, interregional and regional levels. As for the national and interregional River Basins the law sets up the Basin Authorities. A further important step came with Legislative Decree No. 152/99, which reiterates the principle of indivisibility between qualitative protection and quantitative protection of water authorities. In the last few decades, a number of profound changes have transformed the entire legal frame-

2. In particular, Italian authorities and local water agencies which have various kinds of expertise concerning water resources and irrigation are: Ministry of Agricultural, Food and Forestry Policies; Ministry of Economy and Finance; Ministry of Infrastructure and Transport; Ministry of the Environment and Protection of Land and Sea; The Regions and Autonomous Provinces; Local Authorities, Irrigation and Reclamation Consortia and other agencies with competencies in irrigation; The River Basin Authority; Presidency of the Council of Ministers – the Italian Civil Protection Department (through Prefects or Special Commissioners).

3. River Basin stands for territorial unit in which different surface water such as, streams, rivers and possibly lakes may run through and by entering a single river mouth, either an estuary or delta flow into the sea.

work and redistributed competences in the water sector. The main innovative factor came from the definition of Community Policies on environment protection and natural resources that mostly from the 1990s has led to the issuing of Community Directives adopted in different national legal frameworks. Initially the attention focused on the protection of waters resources against pollution, but over time integration policies of this sector have raised a lot of discussion. There was a shift toward the promotion of integrated water resources management for different uses and enhanced coordination and integration among environment policies, common agriculture and energy policies.

As regards relations between the State and the Regions, pursuant to the Constitution's revised text[4] and the 'Bassanini Law'[5] the State shall dictate the principle rules with which Regions are required to comply. State's specific competencies shall remain: public waters identification, stating and regulating uses and concessions for huge water branches, national census of water bodies, amendments to the General Plan of waterworks, implementation of water resources for power generation, responsibilities related to national and sector planning of water resources intended use. Functions transferred to the Regions may be grouped into three large partitions: a) water protection, including the safeguard of coastal areas and coastal residents, b) multiple use of waters, c) different use of the soil and of beaches facing or directly along inland waters. In addition, the following responsibilities shall be fully transferred: design, implementation and management of water works concerning soil protection.

As last and essential step of this evolution, it is worth mentioning the issuing of the Directive 2000/60/CE that represents the latest directive in terms of water resources management and protection (Zucaro, 2008). The Framework Directive implemented in Italy by Legislative Decree 152/06 (the so-called *Environment Code*), aimed to set up a community framework to protect waters in order to safeguard and enhance the quality of the environment, water bodies and sustainable use of water resources[6]. The special innovative features of the directive lie in the definition of the River Basin Districts, as basic territorial unit[7] that plans use and protection of resources. A close link between quality and quantity protection of water resources[8]; programmatic indications of the policy of the Management Plan of the River Basin District defined and implemented by the River Basin Authority, which includes all types of uses of resources and hence, also, irrigation. Finding water price policies aimed to increase water saving and to contribute in an appropriate manner to the cost recovery of water services that would burden different sectors of water use.

From the North to the South of Italy, Eight River Basin Districts (RBDs) were identified, namely:

- the RBD of the Po River
- the RBD of the Eastern Alps
- the pilot RBD of the Serchio River
- the RBD of the Northern Apennines
- the RBD of the Central Apennines
- the RBD of the Southern Apennines
- the RBD of Sicily
- the RBD of Sardinia

Figure 1.0 in the map annex to this chapter shows the distribution of the River Basin Districts.

Pending the transposition [into the Italian legislation] of the EU regulation that defines and implements River Basin Authorities in the River Basin Districts, today in Italy the River Basin Authorities, established by Law No. 183/89, operate at a national level.

At a management level except for the planning carried out at a River Basin District level, irrigation water use remains within the scope of local water agencies (Consortia, associations, etc.). In the following section it will be described the evolution of irrigation water use in the years following 1965, the reference year of the previous study.

From this brief summing-up regarding the legislative and institutional framework emerges a complex and articulated system that despite the regulatory reorganizational efforts shows a certain degree of fragmentation and sometimes of overlapping of competences and functions both at central and local level. In this respect, over the last few years a proneness to wider integrated planning of the land has been observed, but there are still several steps to be taken to seize the opportunity presented by the re-definition of the Management Plans of the River Basin Districts.

4. Amendment of Title V of Constitutional Law No. 3 of October 18, 2001. Previously, public waters unlike thermal and mineral waters were not included among the subjects Constitution devolved to the authority of the regions.

5. Legislative Decree No. 112 of 1998, on the implementation of Law No. 59 of 1997, the so-called 'Bassanini Law'.

6. The rule is based upon the definition of 'sustainable use of water' as formulated in many and important international documents, ranging from Chapter 18 of Agenda 21 (on water protection) to the 1992 Dublin Conference (where it was, inter alia, enshrined the principle of water as a good of social and economic significance), to the fifth Environmental Action Programme of the UE, until the recent joint declarations of the Johannesburg Summit (2002) and the World Water Fora held in Kyoto (2003) and Mexico City (2006).

7. Area of land and sea, made up of one or more bordering catchment reservoirs and relating groundwater and coastal waters.

8. The status of water and its related (good) conservation is assessed in terms of ecological, chemical and quantitative protection by taking into account a number of criteria laid down in the annexes of the directive.

Likewise, it has emerged the ever-growing need of integrated policies across different sectors in order to increase effectiveness and efficiency of public spending with particular reference to common environment, energy and agricultural policies. In this context, a first and important step forward has been made with the recognition of the thematic importance of the management of water resources that is among the 4 new challenges of the *Health Check* as indicated in 2009 by CAP (reg. (EC 73/09).

In addition the recent European Commission Communication on the CAP towards 2020 (European Commission, 2010) establishes the strengthening of the environment policies' performance aiming at enhancing a more sustainable and multifunctional development of agriculture within the European Union.

Following the current regulatory, planning-programming framework of the irrigation sector, the study describes by comparison with the 60s the development of water use for agriculture and the irrigation schemes implementing the River Basin Districts (RBDs) as the basic territorial reference (territorial unit) established by legislative Decree No. 152/06 (Figure 1.1 of annex of this chapter). The Districts are the referential territorial and administrative units for planning in a consistent manner all kind of water use and investments within the sector according to water needs and availability.

See below the table that summarizes the most important norms and regulations, issued since 1965, governing water resources.

Box 1.1 – Major regulations on water resources since 1965

LEGISLATIVE FRAMEWORK	
Law No. 319 of 10th May 1976 'Water protection against pollution' (Merli Law)	The law is the first Italian legislative norm on pollution and reclamation of water bodies. The principles, objectives and instruments of the law are related predominantly to: • Protection of waters from pollution due to intense human and industrial activities affecting the land; • Guidelines relating to all kind of wastewater, discharged into surface water, groundwater, inland and marine waters; • General criteria for the use of water in settled areas; • Organization of public services pertaining waterworks, sewage and wastewater treatment; The law, furthermore, establishes preparatory criteria to develop a general Restoration Water Plan for the Regions, whereby the quantitative and qualitative characteristics of water bodies are measured after systematic monitoring of waters, and actions identified to preserve and prevent destruction of the environment. The Merli Law was repealed by Legislative Decree No. 152/99.
Law No. 183 of 18th May 1989 'Norms for organizational and functional readjustment of soil protection'	The Law seeks to ensure soil protection, water restoration, organization and the use and management of water resources for economic and social development and environmental conservation. The fundamental innovation of the law consists in the establishment of the river basin as the basic Territorial reference (territorial unit). New public authorities responsible for water managing are identified. The national, regional and inter-regional District Basin Authorities and basic planning instruments were established to protect the soil and the Basins Plans. A competent Authority was established as a planning and programming Body to overcome the problem of the fragmentation of responsibilities among the existing Bodies and to ensure the coordination of all actions nationwide. Through the Basin Plans soil protection measures are planned and coordinated together with national, regional and sub-regional plans for economic development and land use and conservation.
Low No. 36 of 5th January 1994 'Provisions relating to Law Water resources' (Galli Law)	In keeping with the law objectives, water use must be regulated to reduce water consumption and modernize resources without jeopardizing water resources (which are part of our environmental heritage) sustainability of the environment, agriculture, aquatic flora and fauna, geo-morphological processes and the hydrological balance. The law furthermore identifies certain natural habitats as areas of special conservation interest, and therefore, under complete protection, excluding any capturing of spring waters, run-off waters and groundwater necessary to the preservation of ecosystems. It prioritizes the use of water for human consumption above all other uses of the same water bodies, which may be surface water, running water or groundwater. Water use in agriculture is prioritized, as secondary to the use for human consumption. In particular, the law aims to overcome: • excessive fragmentation of management that leads to inefficient productive structures andinsufficient level of specialization with consequences in terms of adjustment to technological progress of services; • water pricing system aiming to guarantee rates which can finance the investment necessary to modernize infrastructures and provide higher levels of services; • institutional set-up with a clear separation of responsibilities related to activities of guidance and supervision from management with the main objective of protecting consumers. The law provides for new processes and institutional players to achieve these objectives. At a decentralized level, law enforcement requires some fundamental steps, such as • the approval of implementing rules by the Regions • the regional establishment of territorial boundaries and institutional forms of integrated water services called '*Optimal Territorial Areas*' (OTA) (*Ambiti Territoriali Ottimali*, ATO); • the setting-up of the Plan and related compliance of infrastructures and the achievement of objectives to improve the service by each OTA Authority; • entrusting Integrated Water Service (*Servizio Idrico Integrato*, SII) to providers on the basis of conventions; • the development of monitoring activities by each OTA over the provider related to Plan implementation

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Legislative Decree No. 59 of 1997 (Bassanini Law); Legislative Decree No. 112 of 1998 (Bassanini Law bis); Legislative Decree No 267 of August 18, 2000 'Consolidated Legislation on the structure of the local government system'	Decentralization of powers and responsibilities from the State to the Regions. With regard to water resources, the state coordinates policies and legislating on national and EU regulations.
Legislative Decree No. 152 of May 11, 1999 'Provisions concerning the protection of waters against pollution and transposition of Directive 91/271/ EEC concerning urban waste water treatment and Directive 91/676/ EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources', subsequently amended and supplemented by Legislative Decree No. 258 of August 18, 2000	The main objective of the Decree is to set up general rules to protect marine, surface waters and groundwater, in order to: • prevent and reduce pollution, implement the restoration of polluted water bodies; • achieve better water quality and protect waters intended for specific uses; • pursue sustainable and long-lasting uses of water resources prioritizing potable waters; • maintain the natural self-purifying capacity of water bodies, as well as sustain a wide diversity of flora and fauna. The law introduces a series of obligations based on the principle of integrated conservation of quality and quantity of resources. Quantity conservation of resources contributes, in fact, to achieving quality standards and, therefore, the quality of waters cannot disregard controls over water abstraction and use. The decree provides for and strengthens actions established by Law No. 36/94 aiming to "save, recycle and reuse water". It reduces concession limits subordinating them to water budget planning and qualitative conservation of waters. General principles relating to the use of water resources for the water sector are: • opting, among different competitors, for the one offering the best guarantees for the environment, namely as to the quantity and quality of return waters; • banning the use of water intended for human consumption from other uses, unless abundance of the resource is verified or there is a grave deficit of alternative sources of supply. This serves as a deterrent against preciuos water resources being squandered or utilized where a high quality of water is not required. In such case fees shall be tripled; • curbing concession limits that shall not exceed 30 years (40 for irrigation use). At a regional level, the enforcing instrument of the legislative decree 152/99 is the Plan for Water Conservation, considered a 'master plan' of the River Basin Plan
Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy	Directive 60/2000/ CE aims to establish a Framework Programme for all Member States, which provides for complementary and joint actions based on the principle that 'water is a not a commodity, but rather a heritage that must be protected, safeguarded and treated as such'. The directive intends to maintain and enhance the aquatic environment within the European Community focusing mainly on water quality and gradual reduction of hazardous substances. The achievement of objectives depends on the close cooperation and consistent interactions at local, European Community and Member States levels. It also aims to disseminate information, foster consultation and spur participation of public opinion, including users. The objectives of the water directive are part of a larger environmental policy of the Union, which pursues conservation and enhancement of the environment together with a rationalization of natural resources and rely on the following: a) Principles of precaution and prevention; b) Reduction above all at source, of the triggering causes that damage the environment and people; c) The basic principle 'the polluter pays' d) Disseminate information and cooperation among all stakeholders. The enhancement of the aquatic environment of the Territory of the Union should be achieved through integrated measures concerning qualitative and quantitative aspects at the level of each River Basin District. Apart from the conservation of water under Art.1 one of the other objectives is that of saving water, (quantity) through which a sustainable use must be guaranteed based on long-term conservation of available resources. This principle also referred to in Art. 9, where it is established that the future water-pricing policies shall act as an adequate incentive for consumers to use water resources efficiently. Member States identify River Basin District as territorial units of reference incorporating one or more Water Catchment Areas and establish Basin Authorities as designated Managing Authorities. The established environmental objectives are to be achieved through the definition and implementation of the River Basin Management Plans.
Legislative Decree No. 152, April 3, 2006 'Environmental Regulations'	The Legislative Decree provides for a rearrangement of the Italian regulations governing environmental issues and, in fact, is known as the "Environment Code". With reference to the regulations on water resources, the Decree transposes European Directive 2000/60/CEE and repeals the Legislative Decree 152/99 and Law No. 183/89. The decree identifies 8 River Basin Districts in Italy.

Source: Elaboration with data provided by INEA

1.2 Development of the irrigation sector at a national level

The geomorphological characteristics of the hydrographic network in Italy are extremely varied and are among the most diversified in Europe with different typologies of water resources ranging from large water river basin in the North, water bodies of medium and variable size in the Centre to irregular stream-like water bodies in the South and in the Islands. The areas that may be potentially used in agriculture for production and irrigation purposes are concentrated along the coasts and in valleys of small and medium size with the exceptions of some extensive valleys, such as the Po River, the plain of *Agro Pontino* and the plains of Foggia, Catania, and Oristano.

The survey published by INEA in 1985 showed that

the greatest growth in irrigation has been in the Northern part of the Country, also due to the extent of surface area and the propagation of cooperation management[9]. This data is ascribable to the great availability of water in the North as well as to the historical events that characterized Italy prior to the Unification. In the North and in some locations of the centre there has been a growing tendency to 'collective forms of associations' and to the expansion of agricultural and irrigated areas by irrigation and land reclamation works dating from the Middle Ages and, subsequently through the periods of the Municipalities and *Signorie* (Lordships). In the South and in the Islands, apart from very few exceptions, the political and historical situation limited, if not prevented, similar activities. It was only with the Italian Unification and the national policies endorsed by the 'Cavour Government' that the principle of public interest in irrigation was definitely established. Public funding for irrigation and land reclamation works were granted nationwide. However, in the following decades, the South had scarce access to funds due to a lack of collective forms of associations representing different situations and the fact that funds were mainly intended for Consortia. From the data reported in the INEA survey of 1965, potential irrigation areas (i.e. the area equipped with irrigation systems) increased from 1.5 to 3.1 million hectares between 1875 and 1961 with an increase of over 70% in the North of Italy. Irrigation development in the South and in the Islands has been fully implemented only through investment policies carried out in the post-war period, from the '50s and the '60s. In this new historical phase investments were directed to modernizing agriculture through the development of collective irrigation, increasing crop production and the specialization of agriculture production (orienting it towards more profitable crops and new crop productive combinations), in short to make Italian agriculture more competitive and market-driven. One of the conclusions drawn from the survey, in fact, asserted a possible expansion of the irrigation areas to over 4 million hectares.

In 1965, new elements emerged that were taken into consideration and these required a more far-reaching vision and new State reforming measures. In particular, the needs were identified as follows:

- to plan integrated investments in line with areas' natural potential and storing capacity (productive capacity) in order to ensure cost-effective public spending;
- to support both investments and innovation in irrigation practices and techniques to increase efficiency and reduce waste of resources on agricultural farms;
- to reclassify water points in use to overcome old habits and customs, (for example, the old system of granting concessions and payments) that were no longer considered compatible with the need to modernize agriculture. Unfortunately, it has to be acknowledged that many of these points, albeit with different nuances, are still part of today's objectives, in particular, those aspects concerning integrated management and system rearrangement of granting concessions. In the last few decades, because of the profound changes occurring on political, social and economic fronts, policies themselves have been profoundly affected and redirected by the CAP. More specifically, the success of environmental policies has played a pivotal role among the elements that most strongly influenced the development of irrigation and water management in agriculture. Since the '70s, a long and lively debate has already been underway worldwide regarding the need to protect natural resources from pollution and consequent depletion, which has also lead in subsequent decades to a redefinition of the development models, reasserting the cardinal principles of sustainable development. In this context, agriculture played a key role in favour of an environmentally friendly management and protection of natural resources.

The adjustment of the European agriculture policies responded to the requests and needs of civil society that were increasingly oriented towards a land protection policy, benefit from environmental asset, and the quality of agricultural products and food. It is a well-known fact that the reclassification of objectives under the PAC reform, started in 1993, and became even more evident with the Agenda 2000 and the Reform of 2003[10] witnessing a gradual shift of focus in policies and aid from production and price control to rural development. Furthermore, liberalization of markets together with food preferences of European citizens led to new strategic decisions in favour of typical, controlled and high quality products, especially in those countries bordering on the Mediterranean

9. There are two modes of carrying out and organize irrigation practices: collective and self-supplying irrigations. Farmers may independently supply themselves by following a specific procedure of granting licences to abstract water applying to the relevant licencing Authority. In this case water withdrawal, in terms of time and methods of irrigation practices, is free. In the case of collective irrigation, water distribution and supply are ensured by a jointly managed service, organized in Consortia or associations of users (farmers). They generally manage the supply of resources (intake structures on water bodies), water schemes ensuring resource distribution (irrigation network) and define water supplying procedures to users (irrigation practice). According to the most recent data available, 53% of irrigated farms supply from Consortia, 18% has a two-tier supplying procedure: Consortium and self-supply irrigation (ISTAT, 2000).

10. The Mc Sharry Reform of 1993 introduces accompanying measures (agri-environment, forestry and early retirement); Agenda 2000 introduces rural development measures; the Fischler Reform of 2003 introduces the decoupled scheme and eco-conditionality and consolidates rural development.

Basin. The new trends had a strong impact on irrigated agriculture, as this produce thanks to irrigation succeeded in meeting national and international market needs, i.e. requiring a quality standardization of products that remains constant and stable over time.

In recent decades there have been profound structural changes in the national policies for irrigation infrastructures, in irrigation planning (fund size has been an important issue), in the European structural and agricultural policies for research and innovation, and in the operational programmes of the Regions that promote and support infrastructures together with maintenance and services available to enterprises. In addition, over the last 50 years socio-economic dynamics have profoundly changed consumption patterns, lifestyles and the per capita consumption of drinking water, which has increased for industrial and tourist use.

For these reasons, irrigation has continued to adapt and specialize both at the level of agriculture farms and cooperative forms of resource management in the North of the Country as well where irrigation has become a regular practice, rather than a 'supplementary' one. Many Consortia that in the past focused on land reclamation activities have reorganized their irrigation practices accordingly.

At the same time, however, because of a wider implementation of environment objectives also promoted by the Agricultural Policy, water conservation has become a top priority and the expansion of irrigation areas is strongly discouraged, unless accompanied by a sharp reduction in water distribution in the same area and replaced by more efficient irrigation systems. At the same time, in the last century water demand and consumption have constantly increased. The trend today continues to grow creating considerable problems in supplying water, and also resulting in a form of competition among diverse water uses in different sectors, in particular water consumption in the energy, agriculture and tourism industries. Hence, the principle of an integrated use of water has become predominant with water planning and scheduling aimed to ensure civil use first, as a priority, then the use in agriculture in accordance with environmental objectives. In Italy this principle resulted in the setting up of the integrated water cycle, managed under OTA, *Optimal Territorial Areas* (*Ambiti Territoriali Ottimali*, ATO) (Law No 36/94), from which, however, the use for irrigation remains excluded.

All this led over time to a reduction of the irrigated UAA (Utilized Agricultural Area) which according to the data of the *National Institute of Statistics*, ISTAT was around 2.5 million ha in 2000 (in 1990 it was equivalent to 2.7 million ha).

Finally, a further critical issue worth mentioning is climate change that is, by now, on the Italian scientific and political agenda and well documented in all projected scenarios. It is expected an overall reduction in water availability as well as an increased incidence of extreme events, such as droughts and floods. Postulated scenarios seem to be confirmed by the events over the last decade (drought in the North throughout the years 2003-2005, trends towards winter and spring drought and more frequent extreme rainfalls in the North, Centre and South) (Zucaro and Pontrandolfi, 2007). Consequently, in the political, economic and environmental context, described above, the availability of water resources has become an ever more decisive factor in agriculture development.

1.3 Structural characteristics

The different irrigation characteristics in diverse areas of Italy, outlined by the INEA study of 1965, are still much the same today as they are caused by intrinsic hydrogeological, topographic, environmental and as well as historical factors. In the North, an impressive distribution network of drainage channels (called 'hybrid network') has developed over the years and it is used during the irrigation season. Water resources supplying for irrigation are, in most cases, direct outlets from water bodies or springs. To a large degree, irrigation is managed jointly in a collective form. There are substantial differences between the subalpine area, characterized by a sort of 'patchwork-like' irrigation that is scattered and concentrated in valleys, and the areas of the Po River and the Veneto Valley, where irrigation is widespread and capillary on the flood plains.

In the Centre of Italy, the land reclamation network is moderately developed and collective irrigation is limited to specialized areas of medium and small size, but it can guarantee the quality and quantity of high-income agricultural production (for instance, the agriculture areas along the Tuscany Coast, the *Valtiberina* or the plains of *Agro Pontino* and *Agro Romano*, the countryside around Rome). A self-regulated irrigation system prevails in inland hilly areas.

In the South and in the Islands reclaimed areas are restricted to floodplains along the coasts. In the years after the Second World War, reservoirs and jointly managed irrigation schemes were established, but the chronic problem of imbalance between availability and irrigation needs persists. In any case, self-regulated irrigation is very widespread and predominant in some areas (notably Apulie and Calabria). A further aspect that lustrates the complexity of the irrigation practice is the territorial unit responsible for the planning and management of water resources. Under the Community and national legislations, planning is implemented on a River Basin scale (see Paragraph 1.1) while irrigation management identifies the administrative areas as the reference territorial

units for approximately 500 irrigation agencies[11] which were resulting from regions' shuffles occurred in the last few decades (Figure 1.1). The bodies are heterogeneous in size, functions, and as regarding legal aspects (for further discussion see Paragraph 1.5). The vast majority of them are Irrigation and Reclamation Consortia, but it is worth emphasising that in some regions not every consortium carries out irrigation practices, such as, for instance, a significant part of the consortia located in Tuscany, the Consortium at *Pratica di Mare* in the Lazio Region and the 4- Reclamation Consortium in *Caltanisetta*, Sicily. This consideration is important to clarify that the decision to include Irrigation agencies in the SIGRIAN was taken in liaison with the Regions depending on the real irrigation practice carried out by several Consortia present in the area. General objectives of the Regional Regulations' reclassification are to rationalize irrigation management within the Regions and to define competencies that respond more adequately to territorial needs (for further information see Chapters from 2 to 9). Specifically, rationalization led to unifications of agencies that in the past were very numerous in some parts of the North because they were set up on farmers' own initiatives and regarded small portions of the land. In these areas, reordering required an overall use reclassification of irrigation in the new plans (Lombardy, Veneto, Piedmont). Through restructuring, in addition to agriculture, agencies have also been given the functions of pursuing environmental objectives, such as multi-functionality and conservation of the land. Finally, it should be noted that in central and southern regions the reordering tends to ensure that limits of Irrigation agencies coincide with the boundaries of the River Basin Districts. In some cases, in the reordering of consortia under regional regulations territorial boundaries have tended to coincide with the provinces.

The administrative area corresponds to a legal jurisdiction concerning the irrigation of the land, however it does not always reveal much about the irrigation feature, as it also tends to include territories and areas with no irrigation equipment (Table 1). This is mainly due to the different tasks of the agencies, which may also carry out other practices that are prevailing over irrigation, primarily land reclamation, land amelioration/property enhancement and agro-forestry practices (Mountain Communities). 49% of agencies operate in the District of the Po River, which is proportional to the high number of small agencies operating in the sub-alpine regions (the Valle d'Aosta and the Region of *Trentino-Alto Adige*) which are characterized by a high level of territorial fragmentation. Mainly medium-large sized Bodies operate, instead, in the plains and foothills in the North, South and Islands.

A better understanding of the irrigation feature can be achieved by considering the equipped areas, which represent the portion of land where Irrigation Bodies have irrigating infrastructures upon which water services organization are based (in the INEA study of 1965, it was referred to as irrigable areas). In Italy, the areas equipped with irrigation cover approximately over 3.1 million hectares. They are grouped as follows: 43% in the Po River, 19% in the Easter Alps and 13% in Southern Apennines. It must also be taken into account that already in the 60's

Table 1 - Areas of Irrigation agencies in River Basin Districts (RBD)

River Basin Districts (RBDs)	Operative Irrigation agencies (n.)	Area in Hectares (ha)		
		Administrative Area	Equipped Area	Irrigated Area
Po River basin	240	4,270,356	1,325,907	983,867
Eastern Alps (*)	157	1,371,351	598,711	586,700
Eastern Alps - Po River basin (1)	5	278,780	169,954	148,198
Northern Apennines	12	2,082,213	135,725	49,168
Northern Apennines - Serchio River basin (2)	2	95,507	1,054	…
Central Apennines - Northern Apennines (3)	5	619,446	24,433	14,073
Central Apennines	9	1,881,176	92,909	74,547
Central Apennines - Southern Apennines (4)	2	337,897	25,177	1,020
Southern Apennines	37	4,951,099	413,068	207,537
Sicily	10	2,382,307	142,965	74,248
Sardinia	10	937,363	161,540	59,303
ITALY	489	19,207,495	3,091,443	2,198,661

(*) Autonomous Province (AP) of Bolzano not included
(1) Eastern Alps - Po River basin: Verona province, Fossa di Pozzolo, the Po Adige Delta,Terlago, Ronzo-Chienis
(2) Norhern Apennines – Serchio River basin: Bientina, Versilia Massacciuccoli
(3) Central Apennines - Northern Apennines: Valtiberina, Tuscany, Northern Umbria, Val di Chiana Romana and Val di Paglia,High Val di Paglia, Etruscan Maremma
(4) Central Apennines - Southern Apennines: South, West
Source: Data Elaboration provided by INEA, SIGRIAN Data 2010

11. As regards irrigation there is no structural data available yet from the Autonomous Province (AP) of Bozen. In any case the number of Irrigation agencies practising irrigation in the area is estimated at more than 100.

FIGURE 1.1 - IRRIGATION AGENCIES IN RIVER BASIN DISTRICTS SIGRIAN – INEA

the old INEA study referred to 3.1 million hectares of irrigable area. This confirms that large parts of the irrigation investments of significant importance (without considering secondary or tertiary networks) are to be traced back to those years. If the number of Bodies is compared with the areas equipped with irrigation, each Body manages, on average, approx. 6,300 hectares. However, the data is distributed very homogeneously as it ranges from about 100 hectares managed by the Consortia in the Aosta and Trentino-Alto Adige Regions to over 30,000 hectares of the Consortia in the Veneto and Puglia Regions. On average the Authorities with the largest irrigated areas are in the middle and lower reaches of the Po River while in absolute terms the Authority with the largest irrigated area in Italy is that of East Sesia, with over 137,000 hectares.

An interesting aspect emerging from a comparison of the outcomes of the study of 1965 is that at that time the idea of an irrigation area / equipped area corresponded substantially to the water use on the same areas, therefore, to the irrigated areas. Today, instead, there is a clear distinction between the areas with irrigation infrastructures and areas actually irrigated in that some areas with irrigation infrastructure may not be irrigated for a variety of reasons, such as production choices, lack of water availability and infrastructures built out of proportion to productivity of the area. Today the rate of utilization of irrigation infrastructures (ratio between irrigated surface and equipped area) at national level is 71% with significantly higher values in the Eastern Alps (98%) and in the Central Apennines (80%) and far lower in the South and in the Islands (between 50% and 31%). In absolute values, the area under irrigation covers 2.2 million hectares, 80 % of which is in the North. Such differences depend on various factors (production choices of farmers, economic convenience, self-sufficiency), but historically the most important factor is water availability. Its abundance in the North encouraged the spreading of irrigation in agriculture also through irrigation drainage channels. On the other hand, in the South and in the Islands, although there were large infrastructure investments, problems concerning water availability still persist and prevent full utilization of the network.

Summarizing the structural characteristics of collective irrigation, the aspects of the survey concerning irrigation systems implemented by the irrigation consortia are of particular interest, especially because in the last few decades, also resulting from environmental objectives on water conservation set by European and national policies, there has been a marked tendency to convert to irrigation systems with reduced water consumption and with a more efficient use of water (sprinkler and localized irrigation systems). As early as 1965, a gradual increase of areas implementing the sprinkler irrigation system has emerged, mostly in central regions, even if there is still a predominance of channels and infiltration (flowing and later infiltration irrigation systems) corresponding to 74% of the irrigation systems nationwide in both the Northern and Southern regions. These irrigation systems are almost exclusively implemented (with an average fluctuating between 95% and 83%) in some regions, such as the Valle d'Aosta, Puglia, Basilicata, Campania and Emilia Romagna.

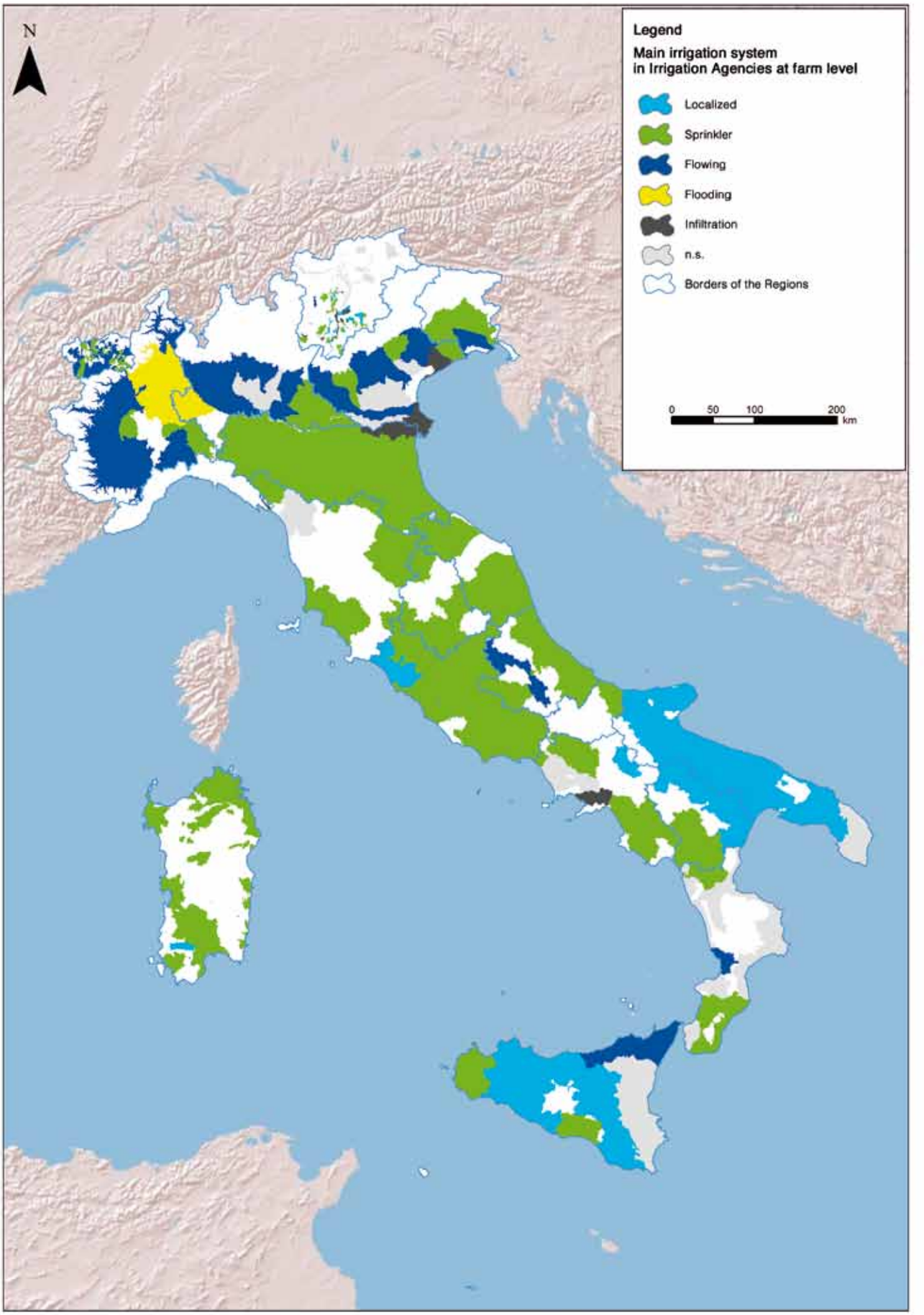
Today's data comparison confirms the trend to technical and technological modernization at farm level, also due to farming investments in recent years and also thanks to access to EU funding made available by the Communities Policies for Rural Development. Today sprinkler systems prevail in most of the irrigated areas (Table 2 and Figure 1.2) and sprinkler and flowing systems amount to 37% of the equipped areas followed by localized (12%). The data, however, varies greatly in the North, Centre and South: in the Po River District and Eastern Alps flowing irrigation systems prevail, whereas the Northern Apennines register an inverted trend (70% sprinkling and 24% local-

Table 2 - Irrigation Systems at farm level in River Basin Districts (RBD)

River Basin Districts (RBDs)	Irrigation Systems in percentage (%)					
	Flowing	Sprinkler	Flooding	Lateral infiltration	Sub-irrigation	Localized
Po River basin	51.9	29.1	13.5	2.1	0.1	3.3
Eastern Alps	41.2	38.0	1.5	13.7	3.3	2.3
Eastern Alps – Po River basin	38.9	30.3	4.8	25.8	0.0	0.1
Northern Apennines	0.0	69.1	3.8	1.9	1.3	23.8
Northern Apennines – Serchio River basin	….	….	….	….	….	….
Central Apennines - Northern Apennines	_	72.8	_	8.2	_	19.0
Central Apennines	17.1	79.0	_	_	_	3.9
Central Apennines - Southern Apennines	10.3	76.7	_	_	_	12.9
Southern Apennines	3.4	39.3	0.3	3.6	_	53.3
Sicily	5.5	20.6	0.5	_	_	73.3
Sardinia	0.2	70.0	5.6	_	_	24.1
ITALY	37.5	37.3	8.3	4.8	0.5	11.6

Source: Data Elaboration provided by INEA. SIGRIAN Data 2010

FIGURE 1.2 - MAIN IRRIGATION SYSTEMS IN IRRIGATION AGENCIES AT FARM LEVEL SIGRIAN – INEA



ized). In the South and in the Islands localized irrigation prevails, with the single exception of Sardinia because of its types of cultivation (70% sprinkling irrigation). In addition, localized irrigation is the method mostly used in 6 regions (Trentino-Alto Adige, Emilia-Romagna, Veneto, Lazio and Puglia), besides it is the most implemented irrigation system in Basilicata and Sicily. Lastly, it should be noted that flooding irrigation, even if used only in rice areas, is however equal to 8% of the total national use, because of the vast areas located in the North of Italy (Eastern Sesia, between Lombardy and Piedmont, the lower Po River between Emilia Romagna, Veneto and the areas near Grosseto in Tuscany).

The analysis of structural data reveals the existence of different models that have evolved in the regions and shows a concentration of collective irrigation practices in the Northern territory of Italy, specifically in the Valleys of Po and Veneto. In contrast with the Centre and South, collective irrigation show small-medium sized equipped areas that are often concentrated along the coastal plains, such as the Versilia, the plain of *Agro Pontino*, and the countryside around Rome (plain of *Agro Romano*), the Sele Valley, the Metapontino, the Capitanata and the plain of Catania. All these areas share a particular propensity for high-income agriculture (horticulture, fruit-farming, floriculture). In addition, there are very characteristic areas of the sub-alpine chain where irrigation is very scattered and patchwork-like.

In conclusion, although the historical context has changed since 1965 and irrigation has played an important role in the development of several areas of Italy and in particular in the South and in the Islands, substantial differences between the North and the South remain and are dictated for certain by the natural abundance of water in the Northern Plains. The imbalances, however, may also be explained by the difficulties of bridging the gap in few decades between development divide, stratified over prior to the Italian Unification, and public investments in agriculture.

1.4 Characteristics of irrigation schemes

The importance played by collective irrigation schemes at a national level was also evident in the survey carried out in 1965, which illustrated the areas equipped with irrigation on a municipal level and thereby included both self-supplying and collective irrigation.

The reference Units of the SIGRIAN are the irrigation Schemes managed in collective forms, i.e. the total of water works, which transfer water from natural and man-made water bodies to the final consumers of the resource (see map annexes at the end of chapters). Today, in Italy, approximately 1,400 schemes of different sizes are in use. Sizes range from very small to very large with very different hydraulic and structural characteristics (see Chapters from 2 to 9 and pertaining map annexes). Schemes with high development potential --some of them are interregional schemes-- are to be found in the Regions of Lombardy, Emilia-Romagna and Veneto. Important interregional schemes are in the Southern Regions of Italy, such as Campania, Basilicata, Puglia and Calabria. The irrigation scheme of *Jonico Sinni* in the *Metapontino* Plain is of particular importance.

The survey carried out in the year 1965 concerning water supply systems clearly showed a prevailing use of surface irrigation to supply the irrigation network system, which was serving 78% of the national irrigation area, followed by groundwater (20% from wells and springs). However, it showed large differences among areas. More specifically, important features were revealed, such as

- the importance of the line of spring waters (22%) along Piedmont and Veneto;
- the almost prevalent use of water from rivers in the Centre of Italy;
- the importance of groundwater in the South and the Islands due to a less developed irrigation surface network,
- and also water supplied from tanks in the islands, which was already important in the 60s.

It is not possible to directly compare the SIGRIAN data with that of the study carried out in 1965, because the data refers to the territorial units resorting to water supplied surface, including autonomously-irrigated areas (self-supplying irrigation), and do not specify the quantity of water collection. As regards current data concerning water supply used for irrigation, in different areas of Italy, no countertendencies or significant structural changes compared to the study of the 60s are shown.

From the SIGRIAN it should be noted that Irrigation agencies, currently supplying and distributing water, have over 5,000 water supply systems (abstracting from water bodies) approx. 1,900 of the latter are located along water bodies and over 500 along an channels (Table 3 and Figure 1.3).

At a territorial level, 54% of water supply concerns the River Basin Districts of the Po River and Eastern Alps. Water bodies mostly involved in water collection are the main Po Tributaries in Piedmont and Lombardy, the Po itself and the Adige River. In the South and the Islands 580 out of 881 sources/abstraction points are ground water tables. Compared to the rest of the country, natural and artificial reservoirs (66, of which 27 are in Sicily alone) are also important. Groundwater is irreplaceable in many Southern areas of Italy, especially in those areas with a less developed surface network (wells census showed in the survey that 72% of the total wells in the South are in Puglia).

In terms of water availability, water bodies and, in general, surface networks guarantee the best coverage. As

regards real availability, the benchmark is the volume abstracted for the agriculture sector and is numerically expressed as cubic m/year. Limited cover of data at national level (approx. 33%) is one of the most critical factors in the irrigation sector and the topic has very often been the subject matter for debate on several occasions. In addition, it has been a cause for open criticism of agriculture and its modes of planning and managing water resources. Trying to give at least an order of magnitude of the taken volumes and considering as "minimum" volume the one taken from the partial data available in the SIGRIAN, the volume is quantified as 15-20 m^3 billion yearly nationwide. More than half of this volume (approx. 10 billion) refer to water abstracted from water bodies which is highly concentrated in the North of Italy, whereas in the South and in the Islands most of the availability results from reservoirs.

Another critical issue already highlighted in the study carried out in 1965, remains the concession system of water abstraction that shows a lack of standardization as regards criteria and evaluation of technical and economic aspects. In some cases, customs that may be described as archaic persist, when allocating water concessions. In other cases, the monitoring system is substantially still incomplete or yet to be developed. From this perspective, several regional bills have contemplated a number of changes, still under discussion today, regarding the granting systems of concessions that permit water abstraction at national and regional levels. It is worth mentioning that during the SIGRIAN implementation work a series of information gaps emerged regarding permit issuing with responsibilities transferred from the State to the Regions and, in some cases, from the latter to the Provinces. These responsibilities transfer for permits is not yet completed, and monitoring and checking mechanism of permits is not yet fully operational at a regional level. In very many cases (approx. 50-60% of the surveyed permits) agencies are licensed with permits for abstraction that are in a 'transient state', i.e. expired permits under renewal. Some of the requests for permit renewals were submitted over 20 years ago or concessions are still under review pending and in compliance with the requirements of the Water Protection Plans and/or Water Basins Plans especially as regards the application of the minimum vital flow[12]. In some cases, the first permits granted (continuously extended) are very outdated with some even dating back to 19th century, making it therefore impossible to trace back to documentation. These situations are typical of the North of Italy. The frequent cases concern the recognition of 'ancient water rights' in the regions of the Valle d'Aosta, Lombardy and Veneto.

Abstraction permits are widely diversified even within the same Regions, and apart from very few exceptions, at a regional level the system is not systematized yet. In general, permits report the volume granted for abstraction, seldom specifying the time range during which abstraction is licensed. This prevents the evaluation of potential availability of water resources (yearly volume licensed). Some refer to specific abstraction points of the water body, other instead are cumulative, i.e. indicate an overall volume that the Granting agencie may take from different water bodies, impeding, therefore, a survey of abstractions carried out at river basin level. In some cases, the permit registers the total volume that may be taken from several Granting agencies resorting to the same water body, also rendering it impossible to show data separately.

To conclude, therefore, nearly 20 years after the is-

Table 3 - Types of water supply structures (number and percentage)

River Basin Districts (RBDs)	Type of water supply											
	Channel		Spring		Groundwater		Lake/Reservoir/ Dams		River		Others	
	n.	%	n.	%	n.	%	n.	%	n.	%	n.	%
Po River basin	271	10.0	310	11.4	588	21.6	32	1.2	1,394	51.3	122	4.5
Eastern Alps	194	15.3	63	5.0	511	40.3	15	1.2	282	22.2	204	16.1
Northern Apennines	-	-	2.0	2.7	21.0	28.0	8.0	10.7	31.0	41.3	13.0	17.3
Serchio River basin	-	-	-	-		0.0	1.0	33.3	1.0	33.3	1.0	33.3
Central Apennines	11	8.1	2	1.5	45	33.1	19	14.0	54	39.7	5	3.7
Southern Apennines	30	3.8	57	7.3	567	72.1	21	2.7	99	12.6	12	1.5
Sicily	-	-	10.0	14.7	13.0	19.1	27.0	39.7	13.0	19.1	5.0	7.4
Sardinia	1	3.7	-	-		-	18.0	66.7	8	29.6		-
ITALY	507	10.0	444	8.7	1,745	34.3	141	2.8	1,882	37.0	362	7.1

Source: Data Elaboration provided by INEA, SIGRIAN Data 2010

12. Pursuant to Law 183/89 "programming of activities, planning and implementation of interventions [...] focus in particular on [...] the rational use of groundwater and surface water resources through an efficient water and irrigation hydraulic network. They ensure that all uptakes do not affect the constant '*Minimum Vital Flow*' (MVF) in the substrate of streambeds and water treatment". *Minimum Vital Flow* or MVF" refers to the minimum quantity of water required after the uptake for the plant to ensure that the natural ecological integrity is maintained, albeit with reduced population, with particular reference to the protection of aquatic life.

FIGURE 1.3 - WATER SUPPLY SYSTEMS IN IRRIGATION AGENCIES SIGRIAN – INEA

suing of the Galli Law (Law No. 36/94) and 5 years after the issuing of the Legislative Decree 152/06 (see Paragraph 1.1) and in the prospective of finalizing proper planning of different uses of water resources at a river basin level, as required by both European and national Legislations, the lack of a comprehensive framework concerning abstractions to be granted to water bodies remains one of the most critical aspects of irrigation.

Shifting to supplying and delivery irrigation infrastructures, the primary and secondary Italian irrigation network accounts for 23,000 km in length (Table 4). In particular, the network of the Po River (over 11,000 km) in the North followed by that of the Southern Apennines (approx. 4,000 km) are worthy of note. The irrigation network of the central Apennines is less developed (approx. 900 km) and it is smaller than that of the Island regions (Sicily 1,100, Sardinia roughly 1,200 km).

The most modern networks prevail in the southern and central regions (79% and 72% respectively of pipes), whereas in the North open channels (81% in the Po River, 65% in the Eastern Alps) prevail (Table 4 and Figure 1.4). Most of the multiple network is in the Po River, 49% of which is utilized for both reclamation and irrigation. The network of channels shares common problems, with some exceptions, related to the segments of open channels and their conservation status (maintenance of beds and banks). The sections of pipes, in contrast, share common problems of needed modernization; in particular, with reference to the network that was built in the '70s (metallic material was mostly used). A final issue worth considering, that is also important for the multi-functionality played by irrigation in the territory, concerns the reservoirs in the South and in the Islands and the impressively large number of water networks, which run through the areas of Piedmont, Lombardy, Veneto and Emilia. Over the years various external factors have caused reservoirs to gain new ecological and recreational functions ranging from the conservation of protected migratory species to biodiversity, to cultural and recreational purposes; in some cases some of them are now defined as natural conservation areas. Likewise, Northern large networks of channels together with closely related structural works provide an ecological function by replenishing groundwater, re-vitalizing natural networks, playing a historical and landscape function, providing an architectural and cultural heritage that is recognized at an institutional level. The historical-agricultural landscape of many regions is, in fact, subject to specific enhancement programmes and historical and architectural regeneration.

Approaching the end of the paragraph, it is worth pointing out that the evolution of the functions of the irrigation network on the territory has been strictly bound to the financial resources that were available over the last decades and were implemented to modernize and/or upgrade schemes and irrigation works.

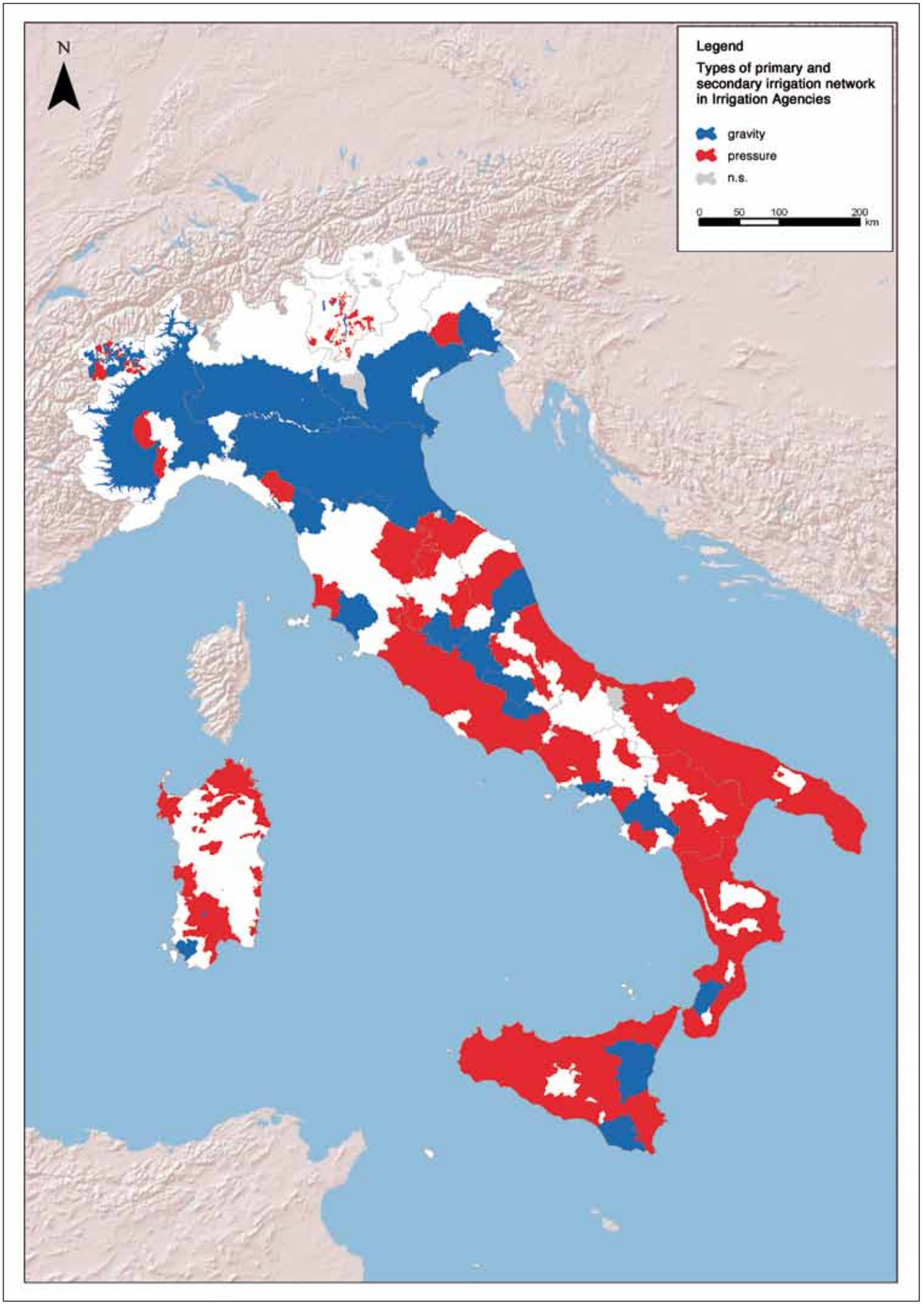
In the last few years, infrastructure investment planning for the irrigation sector shows that a mechanism for coordination and consultation activities became increasingly marked among the numerous relevant Authorities responsible for the integrated Water Cycle (see Paragraph 1.1). In particular, initiatives of scheduled activities for the irrigation sector abandoned those sectorial approaches that in the past primarily featured the Italian *Cassa del Mezzogiorno* (it is a Fund for development of the South of Italy) and very often led to the setting up of operations that did not really respond to the natural potential of the land and environment criticalities, consequently squandering financial aid. Consequently conforming to the guidelines dictated by European policy, there was a switch towards a more modern planning approach called 'integrated planning', which aimed to evaluate investments more in a territorial and cross-sectorial perspective.

Table 4 - Characteristics of the primary and secondary irrigation network in River Basin Districts (RBD)

River Basin Districts	Type of use			Types of network (km)						Total length (km)
	Irrigation	Multiple	Not specified	Open channels	Closed channels/ gravity	Tunnels	Pipes	Section of water course (Reg. 41/00)	Not specified	
Po River basin	5,727	5,605	-	9,188	697	53	784	189	421	11,332
Eastern Alps	2,397	735	-	2,042	84	1	950	-	55	3,132
Eastern Alps – the Po River basin	232	149	-	347	17	-	11	-	7	381
Northern Apennines	301	427	0	449	76	26	101	75	0	728
Northern Apennines - Po River basin	44	94	-	125	13	-	1	-	-	138
Northern Apennines - Serchio River basin	28	0	0	28	0	1	0	0	0	28
Central Apennines - Northern Apennines	183	-	-	-	-	-	183	-	-	183
Central Apennines	823	23	-	195	89	18	545	-	-	846
Central Apennines - Southern Apennines	162	-	-	8	13	-	141	-	-	162
Southern Apennines	3,631	-	405	621	80	40	3,189	-	106	4,036
Sicily	1,007	-	61	300	39	17	712	-	-	1,068
Sardinia	1,208	-	-	286	14	59	849	-	-	1,208
ITALY	15,744	7,034	466	13,589	1,121	215	7,467	265	589	23,244

Source: Data Elaboration provided by INEA, SIGRIAN Data 2010

FIGURE 1.4 - TYPES OF PRIMARY AND SECONDARY IRRIGATION NETWORK IN IRRIGATION AGENCIES SIGRIAN – INEA



In this field the planning instruments that are defined and implemented (or under implementation) in the irrigation sector are the following:

- National Programme for irrigation Water Supply and Irrigation Development set up by MiPAAF (Ministry of Agricultural, Food and Forestry Policies) in 2002;
- Framework Agreements between the State and the Regions concerning Water Resources;
- Rural Development Plans 2000-2006 and 2007-2013;
- Some regional regulations related to financial intervention measures in favour of irrigation;
- National Irrigation Plan, which MiPAAF set up in 2004 in liaisons with the Regions.

The Irrigation Plan of 2004 that is still today under the implementation phase, deserves special attention. It was set up following Art. 4 of the Finance Law of 2004 (Law No. 350/03). The Plan is an integral part of the National Water Plan "aiming to ensure the coordination needed for the development of works in the whole irrigation sector". It represents the first cross-sectorial planning instrument covering completely the national territory and involving all relevant sectorial, central and regional authorities coordinated by the Ministry of the Environment and Protection of Land and Sea. The establishment and implementation of the Plan represent one of the most important challenges of the irrigation sector.

Another planning regulation is the Law No. 443/01 (the so-called 'Objective Law') endorsed by the Ministry of Infrastructure and Transport, with the aim of speeding up the implementation of some large structural works through a review of decision-making and licensing processes of the projects. The law also identifies public and private infrastructures and industrial sites 'of huge national interest'. Although the measures listed in the Law were considered priority objectives, they did not benefit from full financial backing, therefore throughout the years resources were allocated as soon as they were made available.

Finally, the Regional Emergency Plans[13] were prepared in those Regions where the state of emergency was declared.

1.5 Management and economic characteristics

The management and economic description of the characteristics of Irrigation agencies responsible for the management of available water resources starts from defining the irrigation practice in terms of responsibilities of the relevant Irrigation agencies, methods of carrying out irrigation activities (management) and subsequent relations with water users. In particular, the organization of water distribution (irrigation practice in use), together with the cost coverage associated with services of water delivery are surveyed (water pricing). It is noteworthy that the Map of Irrigation in Italy of INEA, drafted in 1965, did not portray these critical issues. They became increasingly important in the last decades, especially as a result of the modern philosophy described in Paragraph 1.1, which ascribed to water management the role of both developing the primary sector and protecting the environment. In fact, the efficient management and planning of water resources is the very starting point to achieve such important objectives.

As described above in Paragraph 1.1, the evolution of the legal and institutional framework of the irrigation sector has been radical and quite remarkable in the last decade. **Responsibilities of collective** irrigation remained, at a managerial level, under different jointly management forms of irrigation, with different legal status. In general, Irrigation agencies are those bodies that by statute have a territorial jurisdiction (administrative surface) related to management and water distribution to water users. In Italy, operative Irrigation agencies have different legal structures and land characteristics. In addition to irrigation and reclamation consortia, Mountain Communities, Provinces, and Consortia for Property Enhancement operate managing the irrigation network and water users' service. Consortia for Property Enhancement also coexist in most places with consortia and replace them in those areas not covered by their management. Irrigation functions tend to be equally distributed, although, in the case of the Provinces the situation is clearly much more complex. In the Northern Plains, in central regions of Marche, Abruzzo, and Lazio and in the Southern and Islands regions, irrigation and reclamation Consortia operate almost solely. Types of Consortia for Property Enhancement are to be found for the most part in sub-alpine areas (Valle d'Aosta, Autonomous Provinces (AP) of Trento and Bolzano), while Mountain Communities share irrigation functions operating mainly along the Apennines Ridge of Umbria and Tuscany. The only provinces managing irrigation network and services cooperatively are Arezzo and Siena. The overlapping of competencies increases the complexity of water resource management, as well as their planning and scheduling at River Basin District and river basin levels.

Under a purely managerial aspect, it should be emphasized that Irrigation agencies generally also **manage schemes**, ranging from the sources of supply to the abstraction and distribution networks. In some more complex cases, schemes are managed by several agencies having no responsibility for the organization of ir-

13. 'State of water emergency' was declared in 2002 in Puglia, Sardinia, Basilicata and Campania, whereas in Sicily, Campania and Calabria was declared the 'state of waste emergency' (sewage-treatment industry).

rigation (hence, they are not Irrigation agencies) they instead manage and maintain the network solely. The most frequent cases are secondary Consortia, such as the Emilian-Romagna Channel in the Emilia Region, the *Lessino-Euganeo-Berico* Channel in the Veneto Region) which manage schemes serving areas governed by different Irrigation agencies. In Piedmont, on the other hand, the so-called 'shared uses' emerged, resulting from associating different users, also unrelated to irrigation. The best example known comes from the shared user managing the Cavour Channel. In addition, there are, some cases where, due to old habits and customs still in use, agencies manage one single Channel or one scheme within the area of Irrigation agencies and 'sell' water to private individuals and to Irrigation agencies as well (e.g., the *Naviglio Civico* of Cremona in the land of the Consortium *Naviglio Vacchelli* in the Lombardy Region). There is no doubt that such a complicated situation is of no help during the planning stage of water use.

1.5.1 Irrigation management

Moving on to the stage of distribution to users a significant degree of variety of **irrigation practices**[14] in the organization of water distribution emerges. At a general level, different irrigation practices coexist within Irrigation agencies and take into consideration different requirements of users, the requirements of different crops grown (overall, seasonal, various phases of the cycle) and the specific time of watering in each area (soil, hydrological conditions, amounts of water, etc.). Different irrigation practices adopted in one common area are, often, associated with agriculture practice and with the structural characteristics of agricultural holdings. In the locations where greater crop diversification and high-income farming (e.g. the Liguria Region) procedures tend to be extremely variable also in circumscribed areas where one type of crop (e.g. corn) clearly prevails. There are medium-large farms in which the procedures adopted tend to be far more standardized. Most of the management problematic issues occur generally when the method adopted is more rigid or, in any case, when the agricultural/farming structure is fragmented. Conversely, when a more flexible method is possible, or when networks are serving an area with a predominance of large land ownerships, the problems concerning satisfaction with irrigation service are mitigated.

In Italy, therefore, different areas do not adopt one exclusive type of irrigation practice, it is also possible to find different coexisting models. It is worth mentioning that a certain predominance of turns in water delivery and supply during the irrigation season (24%) is recorded, followed by water delivery based on demand of irrigation present in all regions, except for the Lazio Region, city of Trent and prevailing in the Emilia-Romagna Region. In the South of Italy and in some Central areas irrigation based on water booked is also widespread and enables the consumer to plan the use of water at the beginning of the season (37% in Sardinia).

The mode of delivery procedure prevailing in the Veneto Region is quite particular and is, defined as unstructured irrigation (see Chapter 3). It is a mode of irrigation with no organization of irrigation delivery and, therefore, without a stable irrigation practice. In many Northern areas, this practice is called 'emergency irrigation'. Historically it refers to the occasional watering of crops that generally are not irrigated through channels of reclamation consortia used to channel off water to which farmers resort to water freely. From an agronomic standpoint, in these areas irrigation is a stable and consolidated practice; hence it is no longer considered as emergency irrigation to crops but rather remains a mode of resorting to channels freely. In view of these considerations, it may be more correct to talk of 'unstructured irrigation'. This case is mostly present in areas located in Lombardy, Friuli and Emilia-Romagna. The diffusion of this mode is deemed as a critical factor of the irrigation in the Centre and North of Italy, especially if the effects of climate change that are taking place are considered. Vast areas also effectively escape both organization of proper management of water resources and monitoring of use (in many cases these areas are not even subjected to water charges). In fact, following the 2003 drought, today many of these Northern areas are subject to irrigation reclassifications.

It is also true that, occurring climate changes imply considerable change of resource availability, especially in water distribution over time, and further complicate water management, forcing, at times, Irrigation agencies to change the procedure during the irrigation season and in some extreme cases to stop or limit it to emergency situations (A.A.vv., 2008; Zucaro and Pontrandolfi, 2007). Climate change represents, therefore, a new challenge, which Irrigation agencies have to confront with by proposing increasingly innovative forms of management.

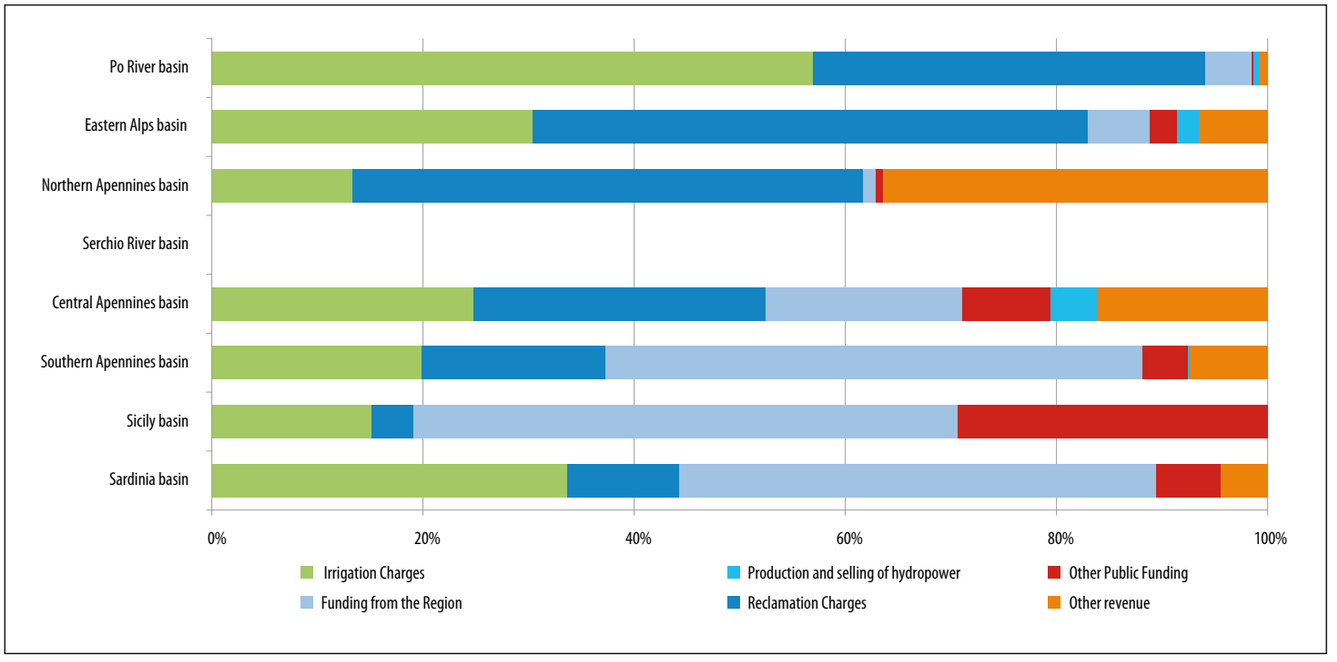
14. The most common organizational arrangements of water distribution and supply are: rotational supply; according to a request/application; continuous operation over 24 hours; intermittent operation over 24 hours; demand-based. In rotational supply the water is distributed to each user (or user groups) at predetermined intervals or shifts, which can be constant or changeable during the irrigation season. The demand-based supply is organized at the beginning of the irrigation season, with the possibility of variations during the same season; detailed water supply programmes are organized according to irrigation areas, schedules of volumes and shifts in water delivery. During the provision of demand-based services, it is taken into account users cultural needs and neither schedule, nor set shifts are expected, each user is permitted to abstract the quantity of water considered to be more appropriate in a given time. For this type of service, it is essential to have a great availability of flowing water.

1.5.2 *Financial Aspects*

There has been an ever-going debate on the environmental "costs" and "benefits", raised by the presence of irrigation channels . In this respect, it is worth to be noted that, in many Northern regions, the dry season of 2003 increased the need for water use in irrigation (including also for dry crops) and for more efficient water management. Farmers themselves started in some areas (especially in Lombardy and Friuli) a reorganization of consortia water points in use of and/or irrigation practices and water charges. It is also true, that irrigation channels are necessary to ensure groundwater replenishment and to maintain the agricultural eco-system of surface irrigation as well as the natural ecosystem and the historical agricultural landscape. Therefore, the **economic aspects**, namely the revenue covering the costs of the activities of Irrigation agencies concerning irrigation, reclamation and power generation, should be further investigated. Water service costs as described in Paragraph 1.1 are considered to be of paramount importance to a rational utilization of water and a controversial issue at both European level and national levels. Pursuant to EU regulations on water costs, the core issue lies in providing an ongoing and efficient service the costs of which are 'satisfactorily' covered by the consumers and this issue is, in fact, complex, delicate and multifaceted and involves a wide variety of aspects and sectors. Relating to irrigation, it is necessary to specify that, rather than 'rates' and 'tariffs' the term 'water charges' are more appropriate, since consumers are obliged to pay the operating costs of the service according to regulations stating that maintenance and operating costs of irrigation works shall be charged to the consortia members who benefit from them. To that end, Irrigation agencies are entitled to exercise specific tax powers and through consumer cost-sharing they can recover irrigation operating costs proportionally to the benefits[15] attainable through irrigation. To analyze operating costs changing each year, the following key factors are considered. These are: water access licences to be paid to the relevant Region, any possible participating share in the management of the resources, ordinary repairs of networks, as well as distribution (especially energy costs for lifting water), labour, pump maintenance activities (energy, fuel, lubricants etc.), administration costs and general and sundry costs attributable to irrigation. This variability stems from the availability of the resource and the extent of the service provided. However, contributions obviously vary since water use, water benefits and operating costs differ from area to area.

On the other hand, Irrigation agencies may benefit from **revenue** that is not only limited to irrigation contributions, and thus it is important to examine the different types of activities and receipts of the agencies as well as the importance water charges played in the general budgetary balance. As shown in Graph 1, irrigation contributions are particularly important for the revenue of the agencies located in the Po District, followed by those

Graph 1 - Percentage of irrigation agencies revenue in River Basin Districts (RBD)



Source: Data Elaboration provided by INEA, SIGRIAN Data 2010

15. Irrigation benefit is assessed on the basis of indices that individual agencies must determine with appropriate agreement that consortia call Classification Plan.

in the north-east regions, and specifically in those areas where land reclamation activities prevailed as a result of the scarcity or even absence of public funding. It also shows the greater relative importance of contributions for reclamation activities in the Northern Apennines of the limited areas equipped with irrigation as compared to the whole area falling under the administration of the agencies. In contrast, in the South and Islands, the budget of the agencies is mainly supported by public funding (primarily regional funds) aimed at supporting both operating costs (energy, personnel, etc.) and the relative responsibilities of agencies on a given area.

1.5.3 Types of Water Charges

The system of **water charges** is highly complex and varied, with at least around 20 methods of calculation. Some of the calculation methods in the North date back to the Middle Ages (for example, the "Piedmontese day" and payment by "vegetable gardens" ['orti'] or by the "Cremonese ounce" [*oncia Cremonese*]). Data analysis of the SIGRIAN pointed out that there are marked differences between Regions and agencies as well as among Irrigation Districts managed by the same agencies. This variability combined with the obsolete system of concessions for water abstraction (see Paragraph 1.4) were often identified as among the main causes of low efficiency in water management and as an obstacle to reforming the charge system of the sector as provided for by the Water Framework Directive 2000/60/CE.

At a general level, relating to the calculation methods of charges in practice, there are two types of water charges: an 'single charge' (*monomio*) and an 'double charge' (*binomio*)[16], with a slight prevalence of the former in the northern areas. This is because of the important parallel reclamation activity in the area and the fact that networks serve multiple purposes (reclamation and irrigation). Consequently, there is no need to differentiate the operating costs covered by reclamation charges from the costs of irrigation service. Such managerial choices are to be found in the reclaimed land of the River Basin of the Po River in Veneto and Friuli Venezia Giulia. The flat rate is also largely used in the Central areas of Italy, where reclamation is less common (such as, Abruzzo and some Consorzia in the Lazio Region) or completely absent (Marche). However, as already pointed out, in many regions Irrigation agencies benefit from regional contributions compensating for costs incurred for network system maintenance, irrigation or environmental works.

The 'double charge' of charges prevails in the South and Islands and in some Central and Northern areas (such as Northern sub-Alpine areas, Tuscany, Umbria and Lazio), where irrigation is practiced in specific localized areas.

Regarding the method of calculation of the 'single charge' (firm price) (*monomiale*) or the 'double charge'[17] (cost-plus basis) (*binomiale*), the calculation of Euro per equipped or irrigated hectare (euro/ha) is generally used (Figure 1.5) with equal importance in southern and northern areas. Especially areas where reclamation activities are also carried out, this method of calculation is often considered the most efficient means of dividing the costs with the charges paid for reclamation, which partially or fully cover management and maintenance costs. The applied unit values for irrigation are very variable. They range from a minimum value of euro 0.62 per hectare used in Valle d'Aosta to euro 787 per irrigated hectare in the plain of *Agro Pontino* in the Lazio Region, up to maximum water charges of euro 2,000 per irrigated hectare (euro/ha) applied in the Province of Trento. In general, it emerges that the charge are higher in those areas mostly affected by energy costs for lifting water.

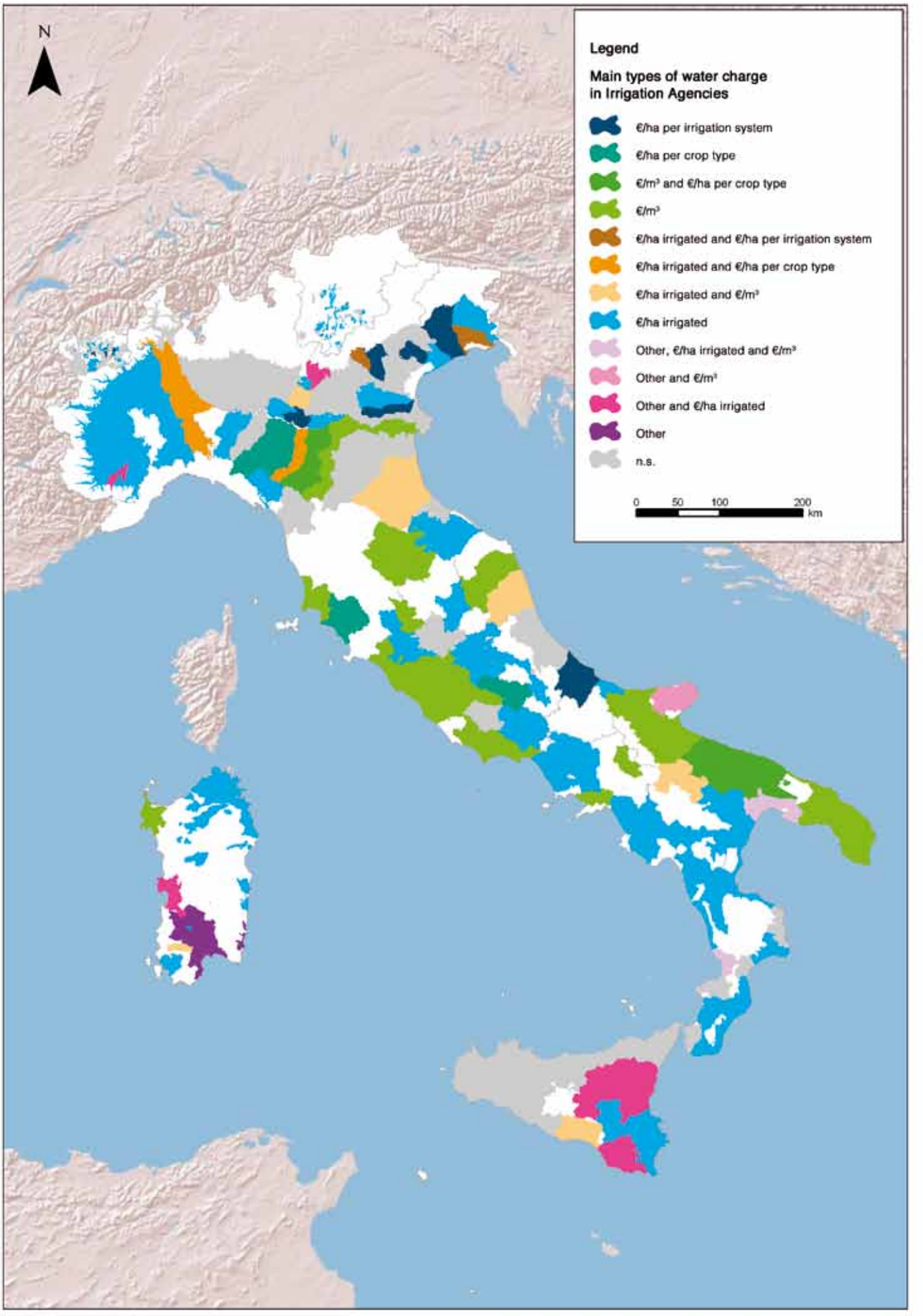
Water charges which are always calculated per hectare and yet adjusted according to type of irrigation system are widespread in the North-East (*Navarolo* in Lombardy, *Pedemontano Brenta* and eastern Veneto in Veneto, *Cellina Meduna* in Friuli) and in the Region of Valle d'Aosta. Also here water charges vary very much ranging from a minimum of euro 5 per hectare to a maximum of euro 1,100 per hectare (applied to sprinkler irrigations only in the *Consorzio di Terreblanche* in Valle d'Aosta). Irrigation systems using large volumes of water such as flowing irrigation prevail in these regions. In general, the water charges for sprinkler irrigation are always higher than the water charges applied to practices that are very water demanding (on average almost doubled), as the applied principle refers to the cost/benefit ratio of irrigation. Sprinkler irrigation is more efficient; it requires higher pressure for water distribution and produces larger irrigation benefits.

Charges based on irrigated hectares per type of crop guarantee better costs allocation among users as to crops irrigation needs. They are more widespread in the North (East *Sesia*, *Alessandrino*, *Bonifica Parmense* and *Bonifica dell'Emilia Centrale*, *Trentino*) and they

16. There are two types of water charges associated with the benefits users draw from the reclamation and irrigation services: a 'single charge' or a 'double charge'. In the first case, the charge is an 'all inclusive flat rate', with no differentiation of specific rates for irrigation practice. In the case of 'an integrated rate', instead, there is a differentiation between a firm price that users pay for overheads (ordinary plant maintenance) and a variable rate calculated in accordance with the irrigation practices.ed in accordance with the irrigation practices.

17. Calculation of Euro per hectare (euro/ha) irrigated. Euro per crop quality — the rates are higher for idro-demanding and high-income agriculture productions —; euro per irrigation system — rates are generally lower for low-efficiency systems which guarantee lower irrigation benefits; euro/m^3 of water supplied — this system is used when available measuring instruments calculate consumption at water distribution and enterprise levels.

FIGURE 1.5 - TYPES OF WATER CHARGE IN IRRIGATION AGENCIES SIGRIAN – INEA



are also present with other modes of charging for water in Tuscany (*Grossetana*) and in southern Puglie (*Terre d'Apulia*). Maximum Values have been registered in some regions of the North they peak euro 420 per hectare for rice crop (*Est Sesia*) and euro 467 per hectare in *Emilia Romagna* (permanent grassland in the area of *Parma*). The highest average values are to be found in the province of Trent, where the water charges for blueberries and vegetables are equal to euro 670 per hectare; for grapes are between euro 340 and euro 700 per hectare; for kiwi fruit up to euro 965 per hectare. Lower water charges --although significant -- are equal to approx. euro 300, and applied to produce quality apples entrusted to a group of cooperatives and consortia. Among their most famous brands there are "*la Trentina*" and "*Melinda*". The water charges in these areas tend to be higher in agencies whose only revenues derive from irrigation.

Compared to other methods and from a technical standpoint, the method of collecting water charges by m^3 of water supplied to the user is considered the most efficient as it is calculated based on consumption and is prevailing in diverse irrigation areas:

- Emilia-Romagna (*Ferrara*, *Burana*, *Renana*, *Renana*, *Romagna Occidentale*) in the North;
- Umbria (Upper Tevere and in *Chiana Romana* Valley and *Val di Paglia*), Tuscany (Mountain Community of *Valtiberina Toscana*, in the province of *Arezzo* and in the *Cornia* Valley), Marche (Musone and Tenna Valley) and Lazio (*Agro Pontino*, *South Pontino*, *Etrusca Maremma*) in the Centre;
- In the South, in most of the irrigation agencies in Puglia and some in the Campania Region (*Ufita* and *Sarno*);
- In the Islands, in some areas of Sardinia (*Nurra* and Low *Sulcis*) and Sicilian areas (*Gela*).

In terms of unit **values by consumption** the range goes from euro 0.04 per m^3 to a maximum of euro 6.3 per m^3 (both water charges are present in Emilia Romagna). The average rate reported in the Databank of INEA equal to euro 0.54 per m^3.

Furthermore, some special types of irrigation charges must be briefly mentioned. They are mostly used in the North of Italy and date back from ancient customs still in use. Besides the modes of charging water by liter per second, by liter per hour or referred to the year (in Lombardy) and by minute and by irrigation 'turn' (East Sesia), there are also calculating methods based upon the 'Tourinese day' (*giornata torinese*), 'Piedmontese day'[18] (*giornata piemontese*) (*Canavese* in Piedmont) and 'vegetables gardens' (*orti*) also in Piedmont.

Particular methods of calculations are also 'double managements', namely shared among different agencies (irrigation and non-irrigation agencies). In Lombardy many consortia have artificial channels (called *rogge*) of the distribution network managed by private companies and consequently the user pays directly these companies and the Irrigation Body. In the Consortium Muzza Bassa Lodigiana there are still two water charges, a summer charges (euro/liters per second) and a winter charges. In the reclamation Consortia of *Naviglio Vacchelli* and *Naviglio* of the city of Cremona, a 'mixed rate' is applied. It combines both the so-called 'waterway charges' for all users alike calculated by euro/Cremonese Ounce[19] and the so-called 'charges on irrigation ditches'. This is a rate for distribution of expenses calculated according to the length of ditch that supplies users and to watering cycle and also for capacity in the case water might be also supplied through CIIC, the Management Body, namely *Consorzio per l'Incremento dell'Irrigazione nel Territorio Cremonese* (Consortium for incrementing irrigation in the area of Cremona).

When the management body of the network is not the same as the Irrigation Body using and supplying water to users, a double rate is calculated.

A classic case of a second-degree consortium is CER, the *Consorzio Canale Emiliano Romagnolo*, which manages the channel (see Chapter 4). The Consortium collects charges from associated consortia of first-degree with the aim of collecting those water charges connected to the management of irrigation system calculated on the base of land (equivalent) coefficients. A situation similar to the second-degree Consortium of CER is to be found in Veneto at LEB, the Consortium of second-degree of *Lessinio Euganeo Berico*, which manages a channel supplying 4 Consortia (see Chapter 3). The Second-degree Consortium collects water water charges from Reclamation Consortia, water charges are listed in the *Piano di Riparto Consortile* (Plan for Consortia Allocation), which calculates the ratio between the supplied average flow charges and the allocated average flow charges.

On the other hand, the multi-functionality of irrigation is acknowledged in those cases where water charges inherent to the replenishment of groundwater, which is considered one of the greatest environmental benefits of irrigation practices, are somehow calculated. In Emilia-Romagna, for instance, the Reclamation Consortium of Reno Palata requires an additional rate from users for en-

18. The '*giornata Piemontese*', the 'Piedmontese day' is an old measurement unit of the land used in the Piedmont Region. It corresponds with the size of the arable land ploughed with a pair of oxen on average in a day. The 'Piedmont day' stands for to 3,810 m^2 (a square of about 62 m) " (from http://it.wikipedia.org/).

19. The term 'ounce' is used in Cremona to indicate an old capacity unit, which refers to the capacity of 'delivery inlets' shaped according to Cremona customs, namely they were one ounce wide and 10 once high. It corresponds more or less to 16-20 l/s flow capacity (Loffi, 1969)..

vironmental benefits — recharge and replenishment of wetland or grassland, and replenishment of reservoirs for different uses, up to euro 565 per hectare — and this is an indication of the level of multi-functionality of agriculture in these areas of Italy. In Lombardy, the *Consorzio Est Ticino Villoresi* collects a rate for irrigation related to groundwater that is equal to one-third of total annual water charge. This rate is calculated in proportion to the volumes abstracted and measured by water meter and applied to all buildings where groundwater withdrawal is carried out for any purpose and it is in relation to the benefit resulting from consortia activities of groundwater replenishment.

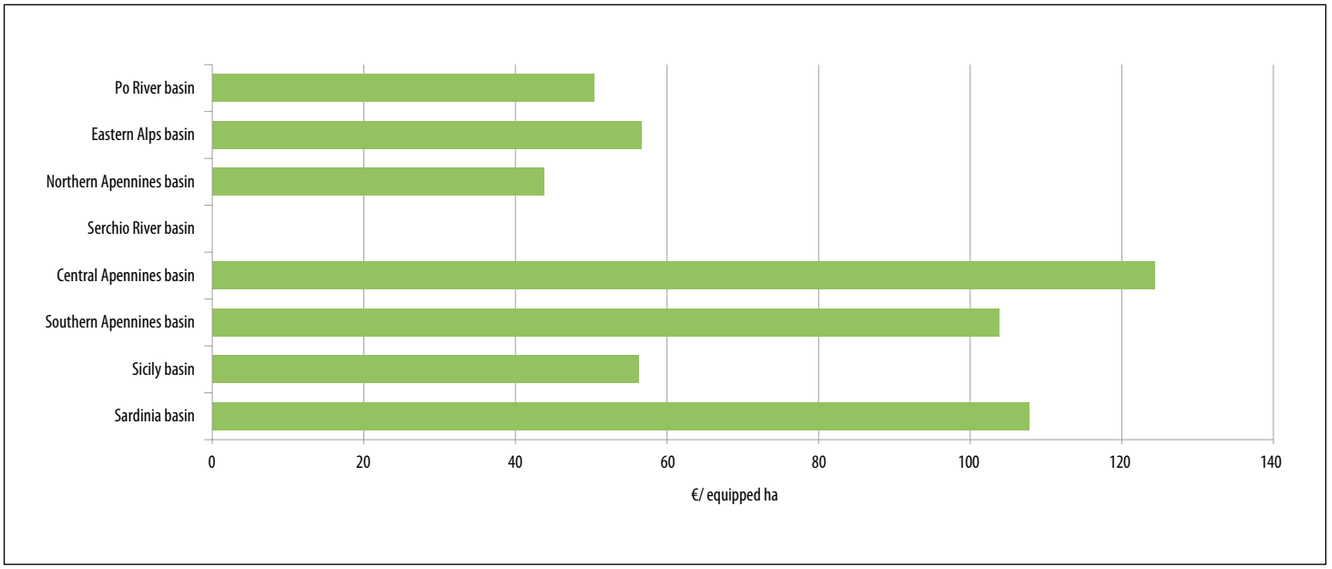
Finally, it should be noted that there are areas where water charges are not collected, for example Puglia, where the problem is only partially solved or in areas with unstructured irrigation (Veneto and Lower Friuli in Friuli Venezia Giulia). Another distinguishing feature is represented by the fact that some users do not pay any water charges pursuant to the so-called "ancient rights" of water use gained when the private channels of major landowners became publicly-owned (Lombardy and Valle d'Aosta). In general, however, the absence of water charges with respect to service provided to users across large areas of Consortia, such as Veneto, Friuli and Puglia may be a critical factor as regards planning activities of water use. In the region of Valle d'Aosta there are few Irrigation agencies where standard water charges are calculated. In the case of Friuli and Valle d'Aosta, it must be taken into account that being regions under special statutes they benefit from a larger Local Autonomy regarding budgeting and policy objectives. In addition, as mentioned, in Valle d'Aosta many agencie do not collect water charges also because there is a direct participation of consortia members in management activities (*corvée*).

In view of the huge variability, already highlighted related to water pricing system, and with the aim of mining data, which sums up and provides indications about the approximate cost of water service comparable in different cases, an index was calculated. It is given by the ratio between the overall annual charges for irrigation and the equipped area at a regional level (Graph 2). The choice for an equipped area is linked to the consideration that management costs are mostly fixed, namely they do not vary according to the real service provided from year to year.

The index has an overall average value of euro 77.56 per equipped hectare, with very high variations fluctuating from the euro 124.32 of the agencies of Central Apennines to euro 50.41 of the Po River. The receding figures of the northern areas are ascribable to the previously mentioned recovery of management costs through water charges for reclamation, to the larger availability of the resource and to the presence of areas in which no charges are collected. Especially in the case of Sicily, where despite issues and irrigation management are as problematic as in other regions, figures are objectively lower than the rest of the South. Such situation is also due to the support of large public funding.

In conclusion, the analysis of management characteristics and the economic organization of irrigation areas of consortia certainly provide very useful food for thoughts in particular in the light of the positions required by the Water Directive 2000/60/CE on the economic instruments to recover costs of irrigation services. Account should be taken about the specific nature of the irrigation sector and about the needs to address key issues at stake to improve the efficiency of the pricing system.

Graph 2 - Irrigation charges and Rates per Hectare (ha) of Equipped Area in River Basin Districts



Source: Data Elaboration provided by INEA, SIGRIAN Data 2010

Map annex
of Chapter 1

Legend of
Annex Maps to Chapters

ATLAS OF ITALIAN IRRIGATION SYSTEMS

SIGRIAN

River Basin Districts

Irrigation agencies (different colours)

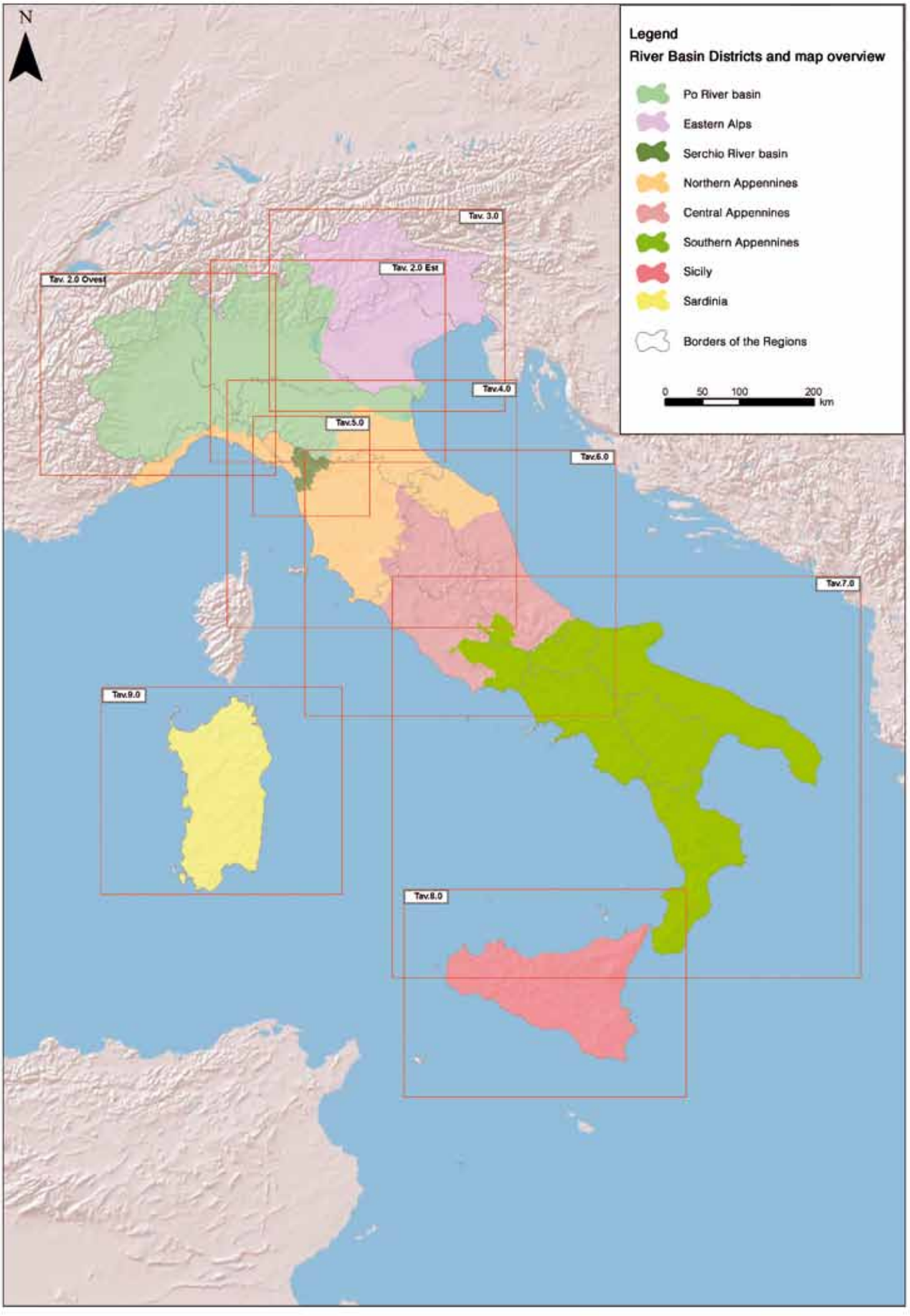
Primary and secondary Irrigation Network

Types of water supply

- River
- Lake/Resevoir/Dams
- Spring
- Channel
- Groundwater
- Other Structures

- Provincial Capitals
- Borders of the Regions
- Hydrography
- Lakes

FIGURE 1.6 - MAP OVERVIEW OF THE RIVER BASIN DISTRICTS SIGRIAN – INEA



Chapter 2

River Basin District (RBD) of the Po River

2.1 Overview

The River Basin District (RBD) of the Po River coincides with the borders of the river basin of the Po River, the longest Italian river by extension (it winds from the Alps to the Adriatic Sea for approx. 74,000 km²), by length of its main channel line and by extent of runoff. Its surface accounts for 23% of the entire national territory and includes 3,210 municipalities distributed along 7 regions. In particular, it includes the whole Piedmont and Valle d'Aosta, most of the Lombardy Region and a portion of Liguria, Veneto and Emilia Romagna, small parts of Tuscany and the Province of Trent (Basin Authority of the Po River, 2010). The medium altitude of the RBD of the Po River accounts for less than 900 metres above sea level (ASL), its highest point, 4,810 metres, is in the Valle d'Aosta (the Mont Blanc massif) and its lowest point is few metres below sea level in the Veneto Region (area of Polesine and the Po delta). More than half of the river basin is in middle-mountain and mountain areas guaranteeing high runoff.

The hydrographic network of the RBD of the Po River represents, in Italy by far, the most important water supply for all sectors and in particular for the agricultural one. This brought about an expansion, in the area, of the largest Italian areas equipped for irrigation and the setting up of complex and large schemes for irrigation. The very developed natural and artificial network (with an overall length of 55,700 km) comprises 37 major subbasins. A predominant feature of the Po River is the cluster of artificial irrigation and reclamation channels, while large lakes are important reservoirs of fresh water and were adjusted long ago to respond better to the different needs of users (RBD of the Po River, 2010).

Two different areas, the High and the Low Plains, fall within the RBD. The High Plains, also known as dry plains stretch along the foot of the Pre-Alps and the foothill of the Apennines. They are featured by permeable soil and spring waters from groundwater tables (called "Fontanili"). The irrigated Low Plains stretch from the line of the spring waters. They have impermeable or little permeable soils which become waterlogged and easily originate marshes and swamps (INEA, 2011; INEA, 2009c).

Within the RBD there are other three macro-areas with flow regimes that are well defined: a) the High River Basin in the Regions of Valle d'Aosta Region, Piedmont and Liguria with some important tributaries of the Po River (Dora Baltea, Tanaro, Scrivia). b) the Middle River Basin, with a system of flow regime control exercised mainly by the large lakes of Lombardy (such as Maggiore, Como, Iseo, Idro and Garda) and by the sub-basins of the Emilia Romagna Region. c) the Law River Basin located between the areas of Ferrara and Polesine (the lower Po River) in Veneto featured by a widespread cluster of channels widely interconnected with the hydrological network.

The use of water in irrigation is an old-age custom and as for other areas of Italy dates back to the Roman Empire. However, the largest canalization works used today were built in the 18th century and 19th century. In Piedmont and Lombardy, the first water abstraction for irrigation, are known from the late Middle Ages (14th century) with systems mostly built from religious orders. In the following centuries many works of canalization were built by (upper) middle-class landowners families, whose names are today still in use to name channels , irrigation ditches and waterways. In the second half of the 17th century, in some areas of the North of Italy the first landowner associations were set up. They shared more opened approaches concerning the use of the resource and aimed to manage jointly irrigation. Over the years, these cooperative forms of associations led to the establishment of the first irrigation Consortia.

Following the Italian Unification network and channels became state ownership and an intense phase of law enactment began mainly aiming at reordering responsibilities within the land (INEA, 2009c, INEA, 2009d, INEA, 2009f, INEA, 2011). Following the transfer of network and channels under the state jurisdiction landowners often maintained their original rights over water use taking advantage of a granting system, known as 'ancient water rights', which guaranteed profitable State concession.

There have been several historical stages of development of agencies, their merging and reordering led to the today's RBD of the Po River with almost 240 agencies providing irrigation management (Figures 2.0 East and 2.0 West). Most of them concern Valle d'Aosta, which has a large management fragmentation due to its geomorpho-

logical, land and productive characteristics typical of the sub-alpines areas (several small-size agencies) (Figure 2.1). The largest administrative areas are concentrated in the regions of Piedmont, Lombardy and Emilia-Romagna. There are three interregional agencies, the water association East *Sesia* (Figure 2.0 West), the reclamation Consortium *Terre di Gonzaga*[20] (Figure 2.0 East) and *Burana*[21] (Figure 2.0 East). Moreover, it is necessary to add to the list other five agencies that from an administrative prospective fall within the jurisdiction of the RBD of the Po River and the RBD of the Eastern Alps, such as Fossa di Pozzolo, Veronese, Delta del Po, Ronzo-Chienis and Terlago (Figure 2.0 Est)[22].

The equipped area, which is the portion of the land of the Irrigation agencies, on which irrigation infrastructures are to be found, accounts for 31% of the administrative area, it exceeds the national average of 16% and hits the highest figures in Lombardy, Veneto and in those agencies provided with interregional schemes between Lombardy and Piedmont.

The ratio between irrigation area and equipped area is equal to 74% for the entire District. This figure does not diverge much from the national figure of 71% and hits high figures in Piedmont and Lombardy (above 87%). Lower figures are in Emilia- Romagna and Valle d'Aosta (below 43%). These are regions where in addition to the multipurpose use of the network, reclamation activities prevail in very large areas. There are many irrigation infrastructures in these regions, however, irrigated agriculture is not practiced in all areas (*Emilia Romagna*) (Figure 2.10), or the irrigation area might be underestimated (*Valle d'Aosta*) .

Irrigation development led over time to more efficient irrigation systems thereby reducing the systems more obsolete (INEA, 1965). Currently 'flowing irrigation' is the predominant system adopted by most of the farms and used in 52% of irrigation areas. A percentage that is much higher than the national average (37%). This system is characterized by high water consumption and due to historical and technical reasons (good availability of water) is largely used and it prevails in the network of open channels with dual functions, reclamation and irrigation.

The SIGRIAN data registered a substantial spreading of sprinkling irrigation (29%) compared to the modest data of the 60s concentrated in limited areas, such as those around Mantova, Cremona and Como. Sprinkling irrigation is currently widespread in different areas with recently erected irrigation infrastructures and is matched with more efficient irrigation systems, such as localized irrigation. This is found to a larger extent in the province of Trent and in Emilia Romagna. Flooding irrigation is a more hydro-demanding system. It is found only in largely rice-growing areas (East Sesia between Lombardy and Piedmont and the agencies *Pianura di Ferrara* and *Delta del Po* between Emilia Romagna and Veneto). It produces positive effects for the environment, because this type of irrigation system contributes to replenish groundwater by approx. 40% by later returning to the resource use cycle of resources for irrigation (INEA, 2009c).

2.2 Characteristics of irrigation schemes

The first abstraction works and the first channels were concentrated in the High River Basin and mostly in Piedmont; lately following a series of diversion works from *Dora Baltea* and from *Sesia* enabled to build the Cavour Channel (1863-1866), which manages to supply areas of the Lombardy. To replenish the outflow of the mentioned channel other three channels were built, the most important are the *Canale Farini*, which abstracts water from *Dora Baltea* and the *Canale Regina Elena*, which abstracts water from Ticino. The complex system of channels still supplies today an area that is very important for agriculture, namely the rise-growing area pertaining the provinces of Vercelli and Novara. It is also worth mentioning, both for historical reasons and for overall capacity, the *Canale Villoresi* which withdraws water from the Ticino river and the net of Navigli, the *Canale Vacchelli* which abstracts water from the River Adda and the *Canale Virgilio* which abstracts water from the Mincio River.

In Lombardy in addition to water abstractions, capturing systems of percolating waters and spring waters were

20. The regional council decreed on January 27 2005 the d.g.r 7/20345, which ruled the establishment of the Consorzio Terre of Gonzaga on the Right bank of the Po River by merging the Agro Mantovano-Reggiano Consortium and the Consortium Revere. Part of the administrative area of that Consortium is in the Emilia-Romagna region. The Consortium extends from the provinces of Mantova to Reggio-Emilia and it is supplied by waters from the Po River running through the joint inter-consortia and interregional scheme of Boretto, which also supplies other 3 irrigation agencies. The peculiarity of this area lies in the irrigated agriculture practiced, as there is a clear majority of maize and alfalfa for livestock (production of milk for Parmigiano Reggiano).

21. The Consortium Burana extends between the provinces of Modena (82%) and Mantova (10%) and small portions of territory are in the provinces of Bologna, Ferrara and Pistoia; Consortia equipped areas are served by the interregional schemes of Boretto and Pelješac.

22. 65% of the Fossa di Pozzolo is in the administrative area of the Eastern Alps, there are many irrigation schemes largely interconnected with the natural and artificial network system. The Veronese Body develops mainly in the Eastern Alps. The Delta of the Po is a collection of Islands divided by the river beds of the Po River and its delta branches and is mainly in the River basin District (RBD) of the Po River. Ronzo-Chienis the and Terlago are 2 agencies of Trentino-Alto Adige. 60% of the administrative area of the first one stretches to the Eastern Alps, while the second is distributed equally between the two Districts.

23. Data entered in the SIGRIAN from the region are partial (INEA, 2009*f*)

developed to storage resources, so that water availability would increase during times of greater need. They were built also for environmental reasons as they play a pivotal role for natural habitats and as cultural and historical heritage. Spring waters were widespread and well known and they have been widely documented on the Map of irrigation in Italy (INEA, 1965) (see historical Annex sheets 1 and 2), which localized wide areas of the Low Po River affected by this phenomenon. In the last few years, several springs shrank their resurgences, while others have disappeared. The main reasons for these occurrences are ascribable to the spread of urbanization and lowering of the water table due to intense water pumping for irrigation and industry uses and, to a lesser extent, to the lack of maintenance (AA.V.v, 2008).

The soil of Emilia Romagna is morphologically flatter and following reclamation works witnessed rising irrigation practices. Initially milling practices were preferred to irrigation practices. The areas of the Emilia benefitted from diversions from the Po River and its tributaries, whereas the areas of Romagna were characterized by a historic water scarcity due to the distance from the Po River and the reduced summer outflows typical of the Apennine rivers (INEA, 2009d). In fact, the first major diversions works of the Po River (Boretto) and the first reservoirs (Mignano) began in the 20's. They were followed by the setting-up of remarkable lifting facilities from the Po River (*Pilastresi, Sabbioncello, Palantone*), which allowed to implement major hydraulic works (the emiliano-romagnolo Channel) and extent irrigated agriculture in areas lacking in water resources.

The classification of water availability and uses in the RBD of the Po River is particularly complex because of the specific land characteristics and historical conditions, in which agriculture ad irrigations have evolved. In this area of Italy, it was necessary to carry out land reclamation, reduce exceeding water and protect the soil form hydrological imbalance/instability. Consequently, this led to develop a huge channeling and reclamation network that with irrigation channels typified the agricultural landscape of the Po River. Over time, water availability began to run out and the irrigation practice stabilized at the level of farms and collective water management. Therefore, as it was previously, irrigation became a stable practice rather than a supplementary one. This affected the evolution of irrigation agencies, which from carrying out exclusively reclamation activities moved on to an organization based on irrigation activities.

Over the last 50 years, the evolution of irrigation within the RBD has been a slow but steady process. There was a shift from irrigation systems mainly relying on flowing irrigation, and largely concentrated on areas with exceeding water resources, to more efficient irrigation systems, which allowed to extend irrigation practices to land with scarce water resources.

Substantial improvements were observed in those areas with collective irrigation systems mainly in the Emilia-Romagna Regions, where the development of the *emiliano-romagnolo* Channel enabled a constant upgrading of the main irrigation and distribution network. From the 70s, in Valle d'Osta, a series of programmatic interventions were carried out primarily concerning the upgrading of supplying channels (named Ru) and completion of pressurized irrigation systems to spread sprinkling irrigation. In Lombardy, and most of all in the irrigation downstream areas of the Great Lakes the irrigated areas increased over time by utilizing part of the water resources stored in artificial reservoirs or coming from effluents.

Today within the whole RBD collective irrigation is guaranteed by 600 irrigation schemes, 320 of which are in the Region of Valle d'Aosta (Figure 2.1) and consist of small-scale networks supplying small and yet numerous, irrigated areas, as a consequence of the land morphology of the Valle d'Aosta that is typical of Sub-alpines areas. There is a similar situation in the Region of Trentino (Alto-Adige) where 37 irrigation schemes supply areas of highly fragmented landed properties and hence organized in small single crop irrigable areas. In Piedmont there are 81 irrigation schemes of variable size, most of them are distributed along the left side bank of the Po River and range from the impressive interregional irrigation scheme of the Cavour Channel, in-between Lombardy and Piedmont, to the small well-fields in the areas nearby Turin and Cuneo.

Over 95 schemes are in the Lombardy, each having different characteristics depending on the specific historical and environmental features of the supplied areas. Small schemes, supplying restricted areas coexist in the region, with large and developed irrigation schemes, which include historical channels important for irrigation purposes, such as the Canale Vacchielli, Canale Villoresi and the net of the Navigli. In addition, there are other two important interregional schemes the Boretto and Sabbioncello between Lombardy and the Emilia-Romagna. There are 42 irrigation schemes in Emilia-Romagna mainly distributed along the right side bank of the Po River. In the end, it is worth mentioning the 24 irrigation schemes falling within the Veneto Region.

Although the SIGRIAN data concerning abstracted volumes are partial, all resources in the RBD abstract, for irrigation purposes, water volumes equal to approx. 10 billion m^3 yearly.

Water supply of irrigation schemes of the RBD of the Po River is ensured by over 2,700 intake structures, largely consisting of direct intake on the natural and artificial surface network (67%). Withdrawals from groundwater amount to 22% of the total and the remaining 11% is of abstraction points from springs. The vast majority of irrigation withdraws is not directly abstracted from the

Po River, but rather from the large and complex sub-basin system, such as the Dora Baltea, the Dora Riparia and the Sesia in the High Basin. Instead, in the Middle part of the Basin water is abstracted from the system of the great lakes of Lombardy and related effluents. They are the Ticino river (controlled by the Lake Maggiore), the Adda River (controlled by the Lake of Como), the River Oglio (controlled by the Lake Iseo) and the Mincio River (controlled by the Lake Garda) (INEA, 2009c).

Analyzing the number of water abstractions from the surface irrigation agencies, the Dora Baltea has the largest number of abstractions. There are also other numerous small irrigation schemes in the Region of *Valle d'Aosta*, many sources are also in the secondary river water supplies of the Po River, the *Tanaro* River, the *Stura di Lanzo* River and the *Mincio* River.

Water supplies in the Emilia Romagna Region are guaranteed by the intakes along the Po River. The main abstraction points are the intakes of *Boretto* and *Sabbioncello*, which originate the schemes having the same names (Figure 2.11) and the intake of the *emiliano-romagnolo* Channel, which arises from the lifting facility of *Palantone*, and now supplies the land of the RBD of the Northern Apennines (see Chapter 4).

In addition to the Great Lakes of Lombardy, there are some reservoirs along the Apennines tributaries of the Po River in the Emilian area. The most significant are the reservoir of Molato along the stream of Tidone (3.5 million of available storage capacity) (INEA, 2009d).

The main irrigation network supplies the agencies falling within the RBD and considering its primary and secondary components, it develops a total of approx. 11,600 km, 51% of which with irrigation purpose only and 49% with multiple types of land utilization (reclamation and irrigation). That is a much higher percentage than the national average (approx. 30%) and indicative of the significant spread of this type of network in this area of Italy. The areas with a prevailing irrigation purpose, namely where irrigation is newer and/or related to type of crop, are the province of Trent (100% of the surveyed network has irrigation purposes only) (Figure 3.2), the Valle d'Aosta Region (97%) (Figure 2.1) and the Piedmont Region (85%) (Figures 2.4, 2.5, 2.6, 2.7 and 2.8), instead, slightly lower figures are found in Veneto (70%).

Analyzing the main network distribution of the RBD, 51% of it develops in Lombardy and 24% in Piedmont, while in Emilia-Romagna is the 17% of the total network. As regards the type of network, on the whole, open channels develop for over 9,120 km (about 81%) and are present in almost all regions with different percentages, much lower figures were registered for closed channels (6%). At a regional level in *Valle d'Aosta* the different types of networks, such as open, closed channels and pipes are almost equivalent. In Piedmont, open channels account for approx. 70% of network types and such percentage rises to 98% in the interregional area of East Sesia. Higher figures, above 90%, are also in Lombardy, where there has been a modest rise in pipes (5%), most of all for those schemes that were recently developed. In Emilia-Romagna the network of the two interregional authorities consists of open channels, however in the remaining land the kilometres of pipes and closed channels have increased.

Worth to be mentioned and different matter, is the practice of using natural water bodies as irrigation carriers, typical of the Region of Emilia-Romagna, where the cluster of the network and interconnection with the natural network do not enable a precise definition of the water flows and origin of waters. This led to adopt a regional regulation (Reg. 41/01), which provides for and rules the so-called 'water transfer', enabling the use of natural waterways to convey and distribute irrigation water (INEA, 2009d). At present, waterways used as carriers are approx. 190 km. To conclude, the main network of the province of Trient as part of the RBD consists of 84% of pipes and 10% of closed and/or gravity channels.

2.2.1 Interregional irrigation schemes

As part of the RBD of the Po River, the most important interregional scheme — the longest in Italy as for development and volumes — is the Cavour Channel, which stretches from Piedmont to Lombardy. It is managed by a joint use established on purpose (an association among end-user agencies, irrigation and non-irrigation agencies). Main water supplies of the scheme are in Piedmont and water is abstracted from the Rivers: Po, Dora, Baltea, Ticino and Sesia. The irrigation agencies benefitting from the water resource supplied by this scheme are four: East *Sesia*, West *Sesia*, *Baraggia Biellese – Vecellese* and *Canavese*. The Cavour Channel, set up in the second half of the ninetheenth century (between 1863 and 1866) originates from the water supply structure on the Po River, nearby Chivasso (Figure 2.2). In its entire route of approx. 86 km runs from West to East through the West and East Sesia up to the point where it meets the Ticino river nearby Galliate. It is fed by the channels of Naviglio di Ivrea, De Petris and Sussidiario Farini which abstract water form Dora Baltea and from the Channel of Regina Elena diverting form the Ticino river (downstream of the dam of the *Miorina*). The Regina Elena Channel (Figure 2.2) runs through the land of East Sesia and in the end, after running for almost a total of 25 km, flows into the Cavour Channel in the proximity of the city of Novara. The overall water capacity is estimated at 200 m^3/s, it reaches 270 m^3/s together with spring waters and water harvesting. Other hydraulic works, which constitute different subsystems of the scheme refer to the land of East Sesia and to the Ticino river. Main diversion works con-

sist of irrigation ditches, artificial channels, whose oldest excavation dates back to the Middle Ages. They were initially used for reclamation purposes and currently are used for irrigation purposes. Waters were diverted from Sesia (Figure 2.2) through several irrigation ditches, such as the Roggia Mora that with a length of over 50 km reaches Lomellina, the Roggia Bisca (54 km long; the Roggia Biraga (51 km long). The Roggione di Sartirana, that with a total length of 27 km, is the southernmost branch of the Sesia and whose waters are intended to irrigate the areas of Lomellina. The two most important channels abstracting water from the Ticino river are: the *Navoglio Langosco* (Figure 2.2), with a total length over 43 km, has an water supply structure nearby the city of *Galliate* and the *Naviglio Sforzesco*, (Figure 2.2) which abstracts water from the Ticino river between Trecate and Galliate and extends for almost 27 km (INEA, 2009; INEA, 2011). The 77% of the main network system of the scheme, besides fulfilling irrigation requirements, serves also drainage purposes. Moreover, several reaches are used to return water to the natural hydrographic network and 96% of the net consists of open channels.

Another important interregional scheme is the scheme of Boretto (Figure 2.11), which originates from the infrastructures on the Po River, nearby Borretto and it extends for approx. 405 km along the main network. It supplies areas that are among the richest agricultural soils in Europe and placed within the Regions of Lombardy and Emilia Romagna. It supplies the consortia of the *Terre dei Gonzaga* in Lombardy and the *Emilia Centrale* in the land of Emilia. The scheme is very complex and rich in points where channels joint and like a cluster draws a sort of thick-meshed net. It is important the multiple function of the network (almost 70%), **as 92% of open channels flows in the ground**. The water volume abstracted from source has been estimated at 214 million m^3, supplied mostly the areas of Emilia. Waters that are not used for irrigation purposes return to the Po River and in other eight points return to the artificial network (INEA, 2009c).

The scheme of Sabbioncello, which stretches from Lombardy to Emilia-Romagna, is linked to Boretto (Figure 2.11) through a water supply of the Po River and is over 270 km long. An agreement between the Consortia, located in the aforementioned regions, of the Terre di Gonzaga and of the Consorzio Burana rules that a portion of the flow concerning the first consortium abstracted from the Borretto facility should be actually withdrawn from the Sabbioncello farther North. The overall capacity, then, is returned downstream in different points of the network (water returning from the Borretto facility). The total capacity, subject to irrigation swaps between the two agencies is of 2 m^3/s. Instead, with regard to the source along the Po River, the consortium Burana owns concessions to withdraw 20 m^3/s and abstract a volume of 76 million m^3. 90% of the scheme primary and secondary network consists of open channels the remaining portion consists of pipes.

Map annex
of Chapter 2

FIGURE 2.0 – WEST

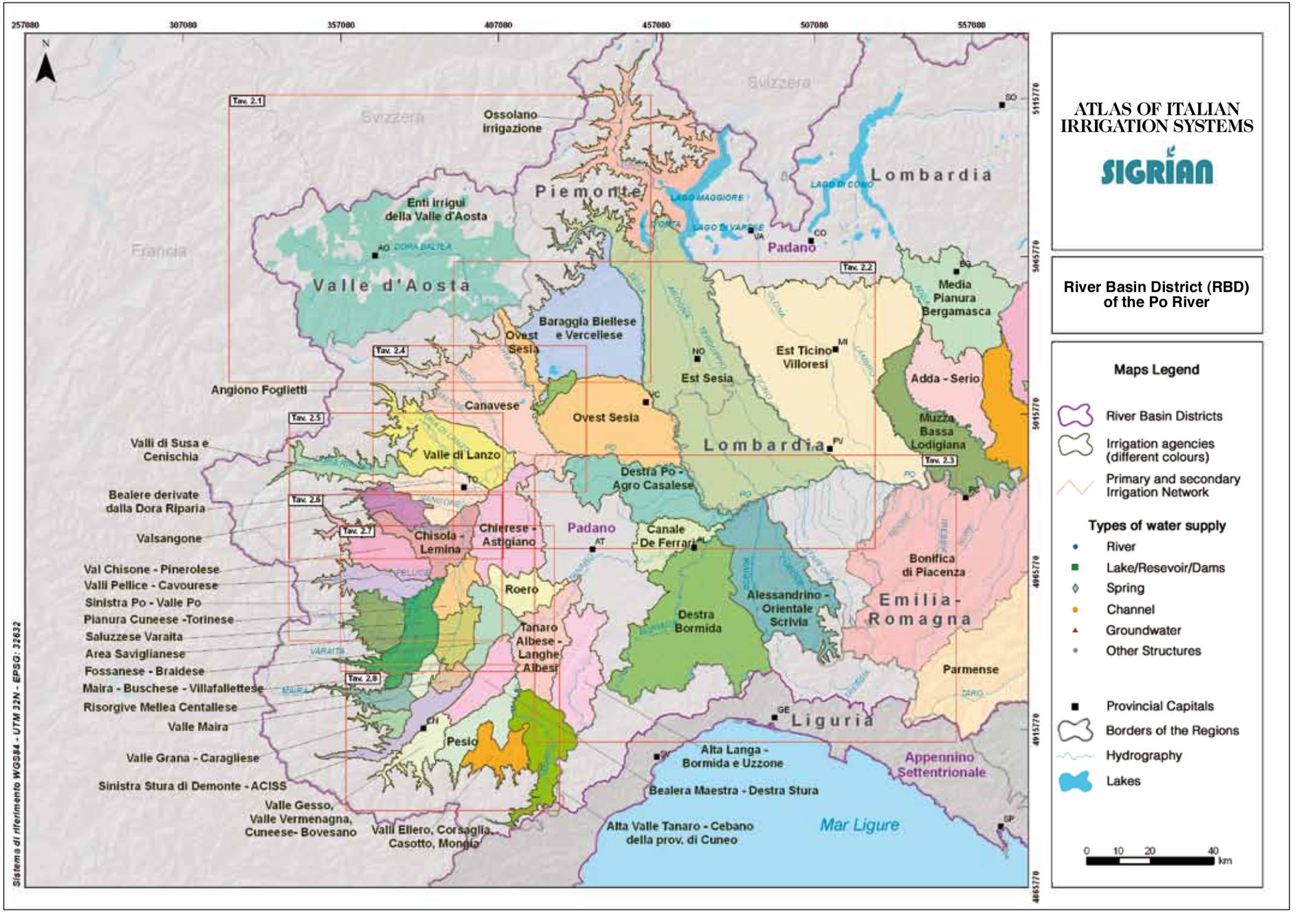


FIGURE 2.0 – EAST

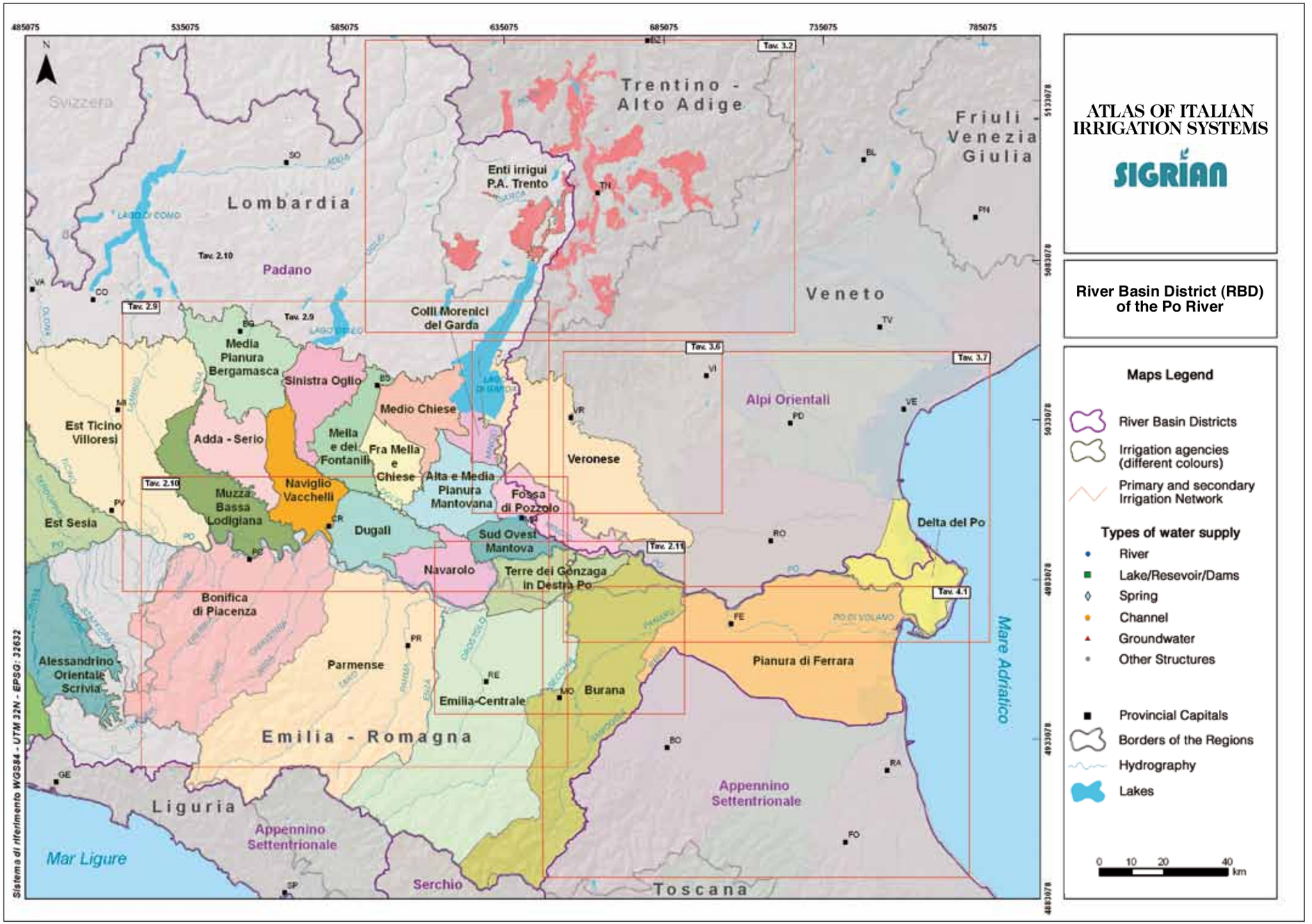
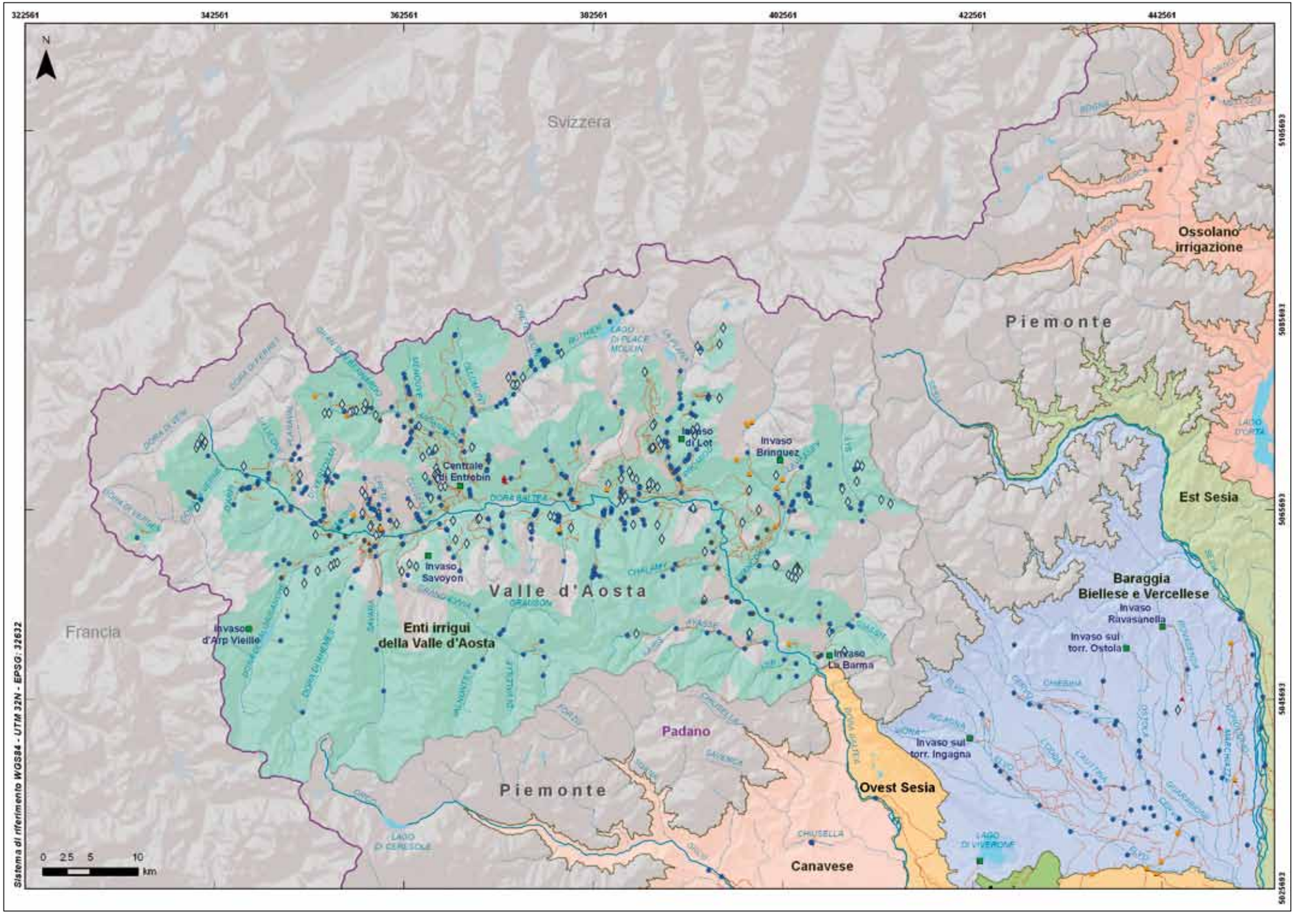


FIGURE 2.1

SIGRIAN – INEA

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Valle d'Aosta
Baraggia Biellese e Vercellese
Invaso Ravasanella
Invaso sul torr. Ostola
Invaso La Barma
Invaso sul torr. Ingagna
Presa della Roggia Mora
Presa della Roggia Busca
Presa della Roggia Biraga
Presa del Canale Regina Elena sul f. Ticino
Lombardia
Presa del Naviglio Langosco
Presa del Naviglio Sforzesco
Invaso Baccarino
Ovest Sesia
Presa del Naviglio di Ivrea sul f. Dora Baltea
Canale Cavour a Ponte Cervo
Est Ticino Villoresi
Fontanili Naviglio Grande
Fontanili Area Lambro
Angiono Foglietti
Chiusa di Arro
Canavese
Est Sesia
Presa del Roggione di Sartirana
Presa del Canale Farini sul f. Dora Baltea
Ovest Sesia
Invaso di cava
Valle di Lanzo
Presa del Canale Cavour sul f. Po
Destra Po - Agro Casalese
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Piemonte
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FIGURE 2.3

SIGRIAN – INEA

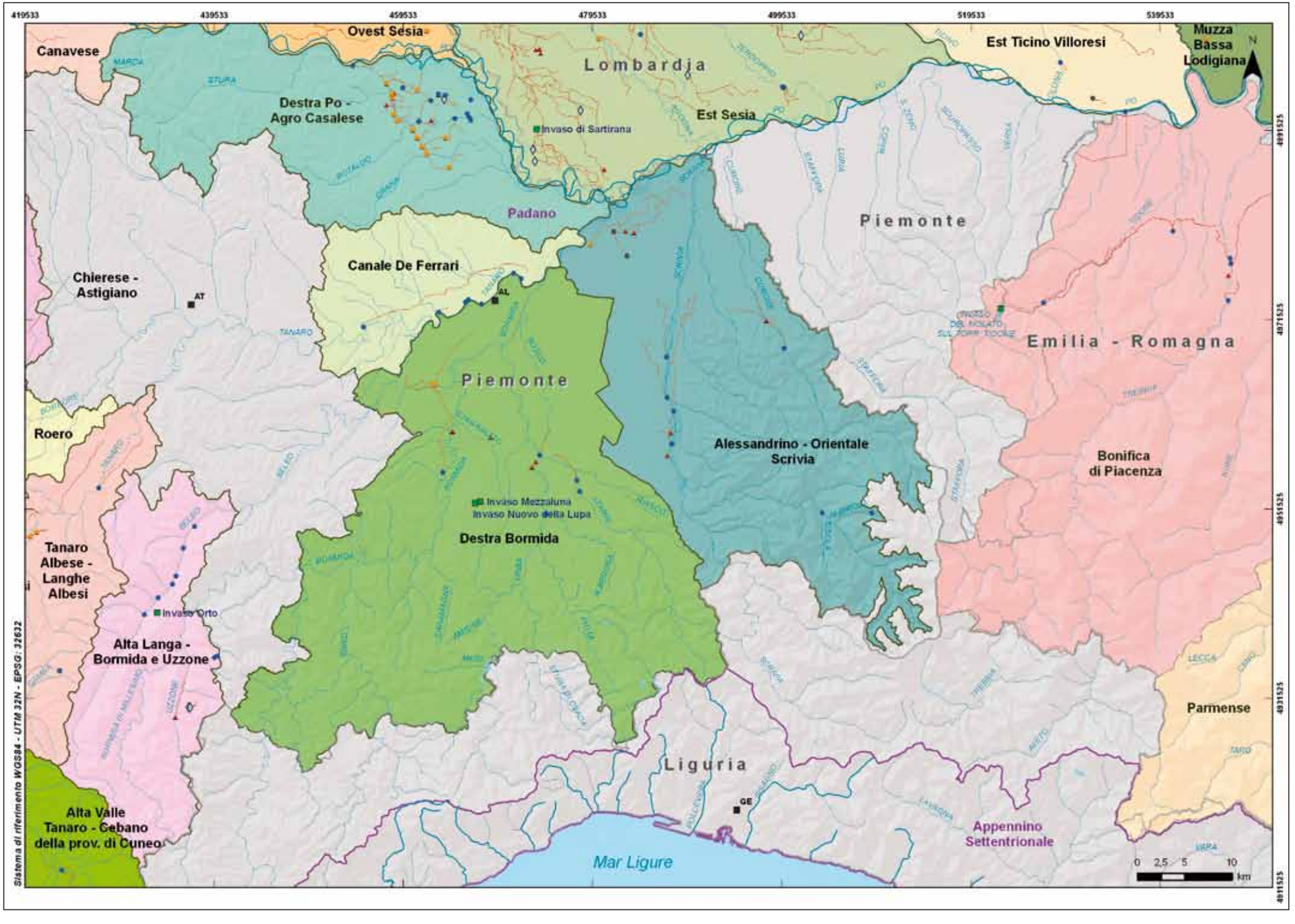
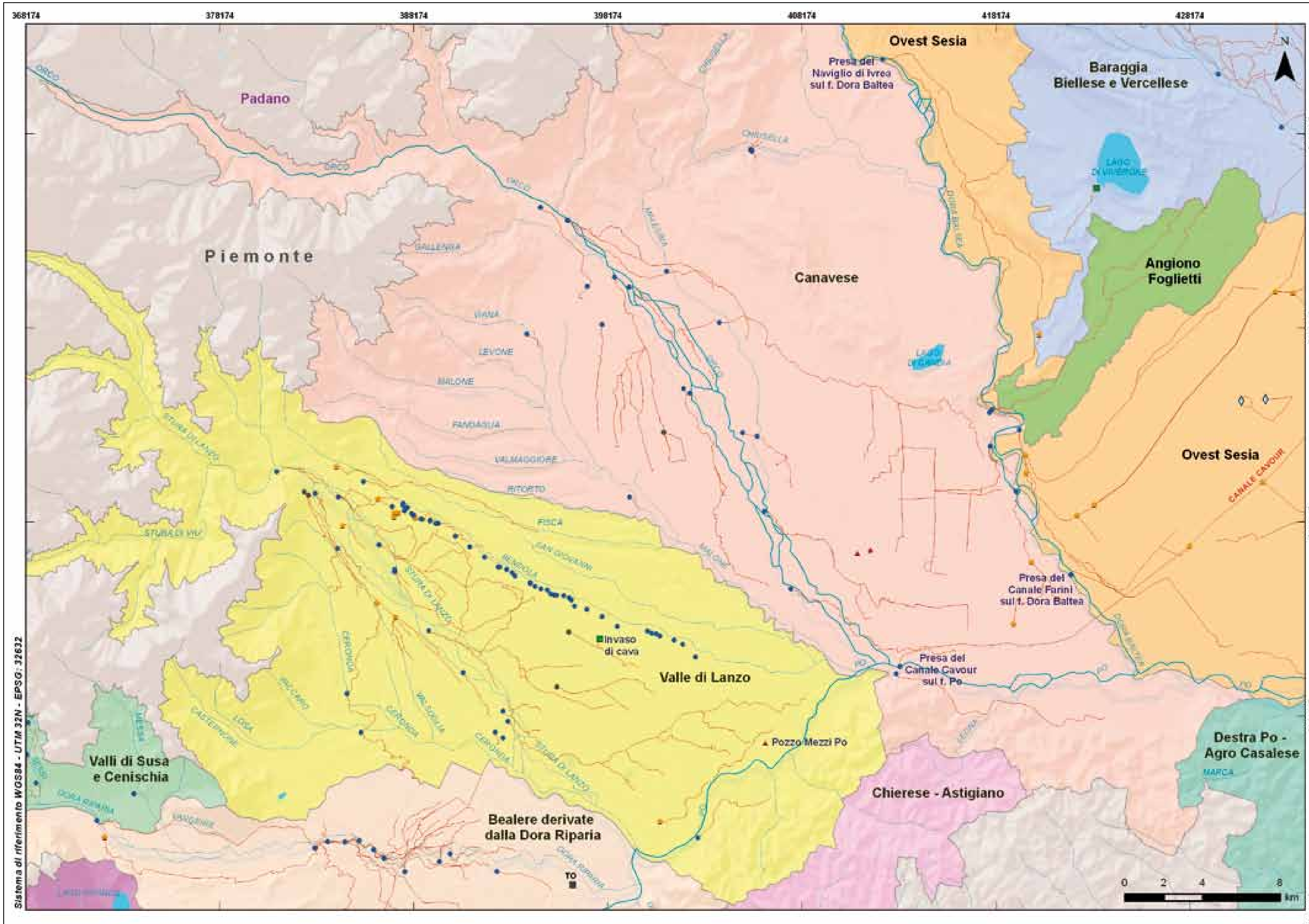


FIGURE 2.4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Baraggia
Biellese e Vercellese
Presa del
Naviglio di Ivrea
sul f. Dora Baltea
Padano
Piemonte
Canavese
Angiono
Foglietti
Ovest Sesia
CANALE CAVOUR
Presa del
Canale Farini
sul f. Dora Baltea
Presa del
Canale Cavour
sul f. Po
Invaso
di cava
Valle di Lanzo
Pozzo Mezzi Po
Valli di Susa
e Cenischia
Bealere derivate
dalla Dora Riparia
Chierese - Astigiano
Destra Po -
Agro Casalese
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FIGURE 2.5

SIGRIAN – INEA

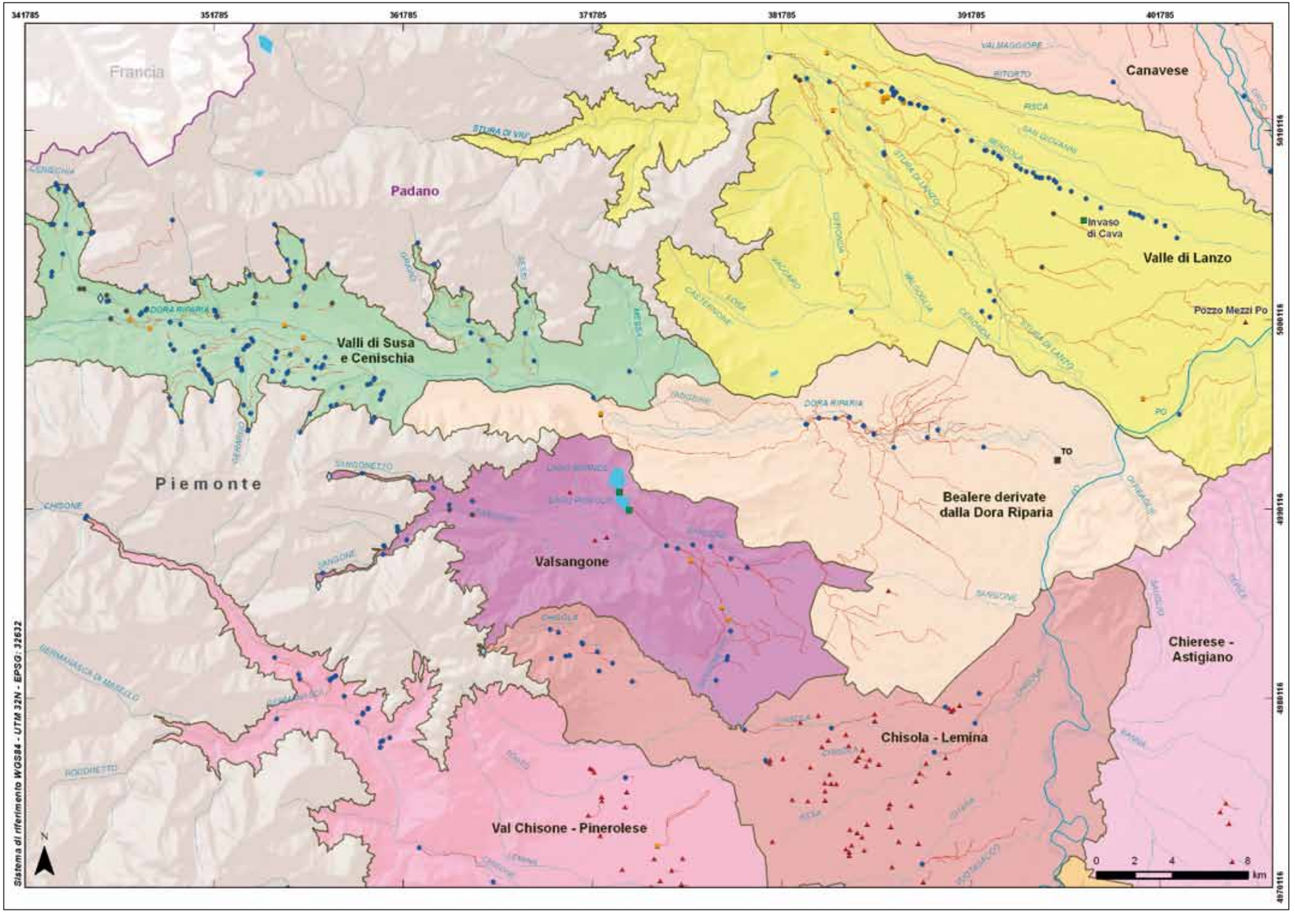

FIGURE 2.6

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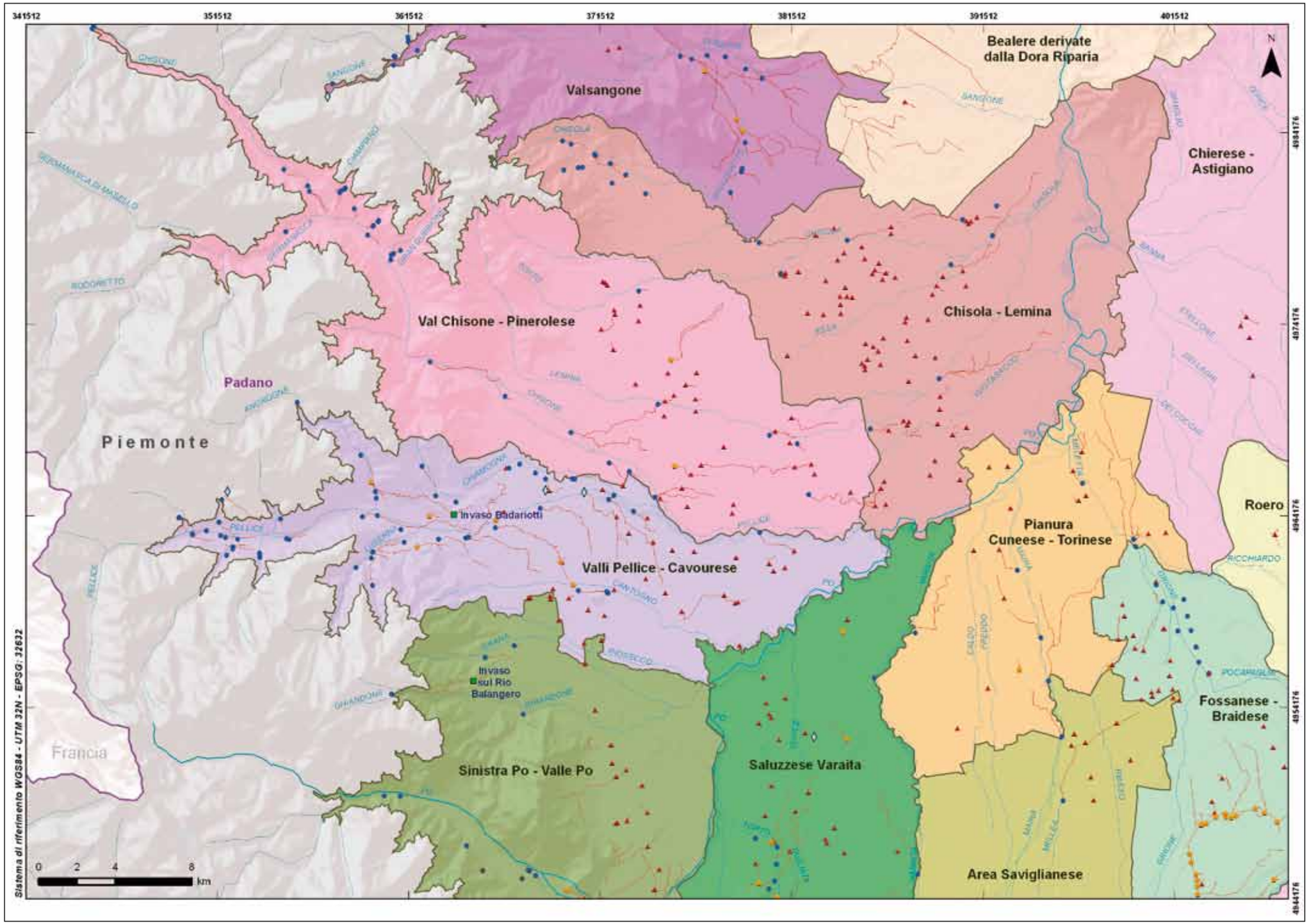

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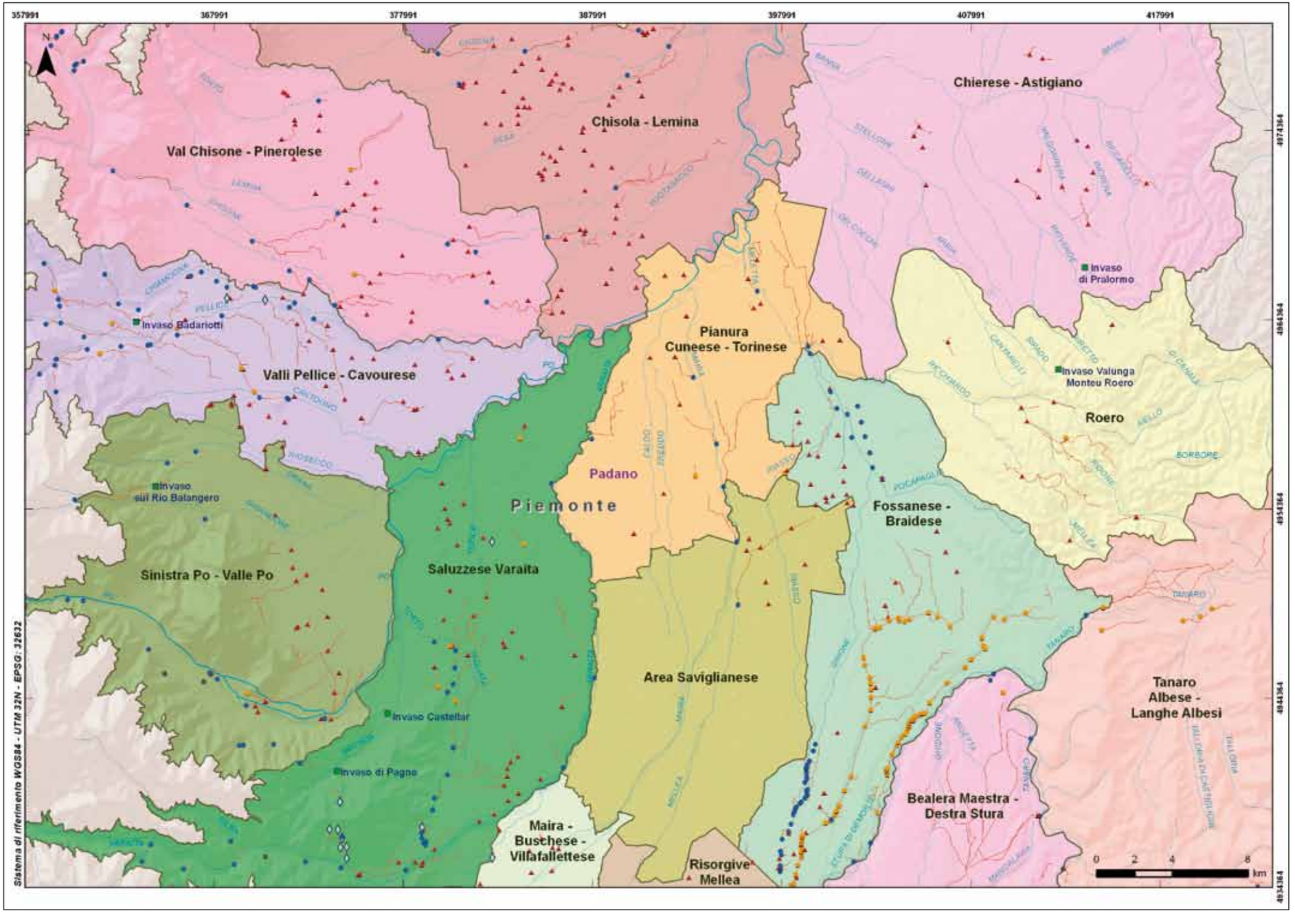

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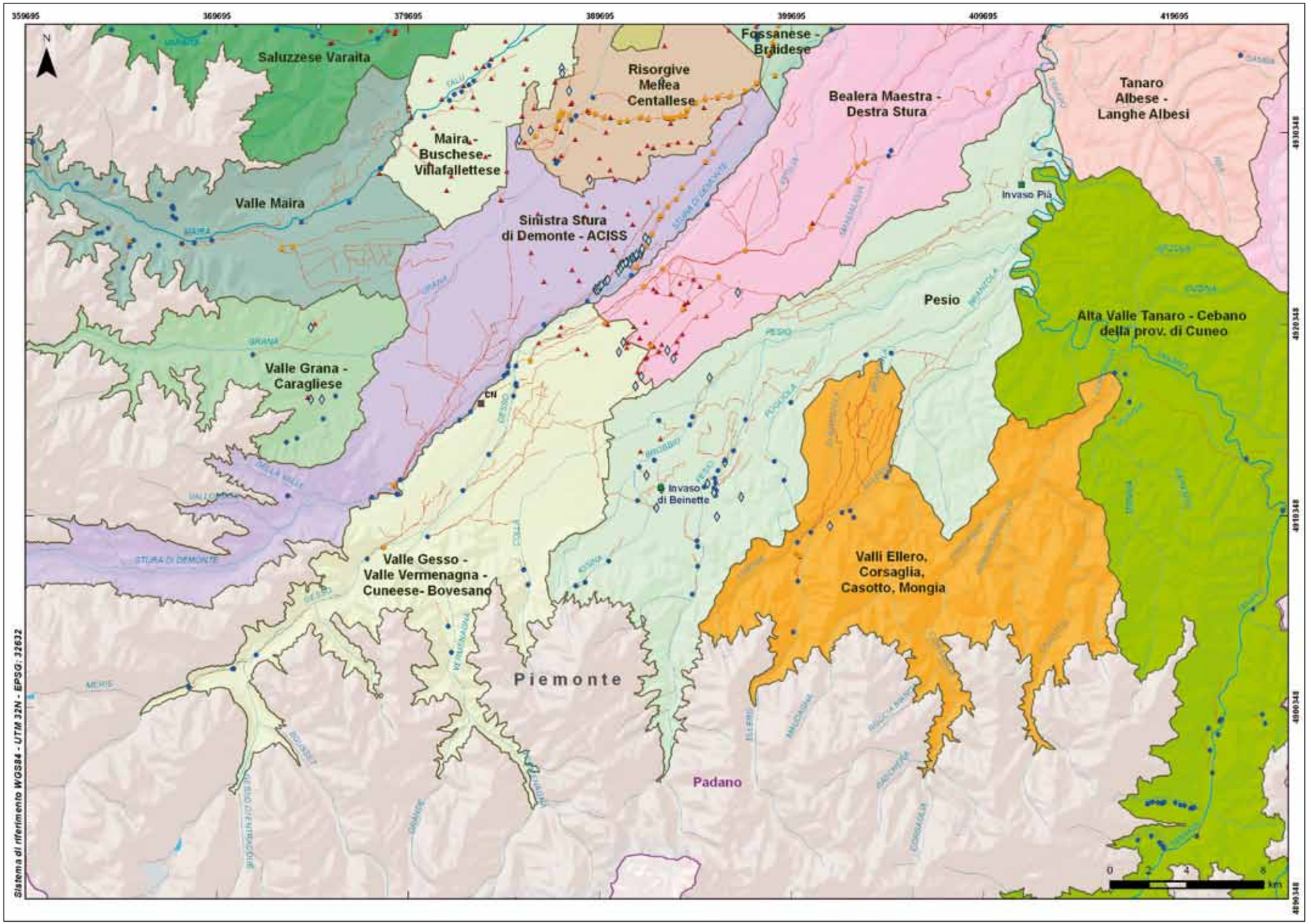


FIGURE 2.9

SIGRIAN – INEA

FIGURE 2.10

SIGRIAN – INEA

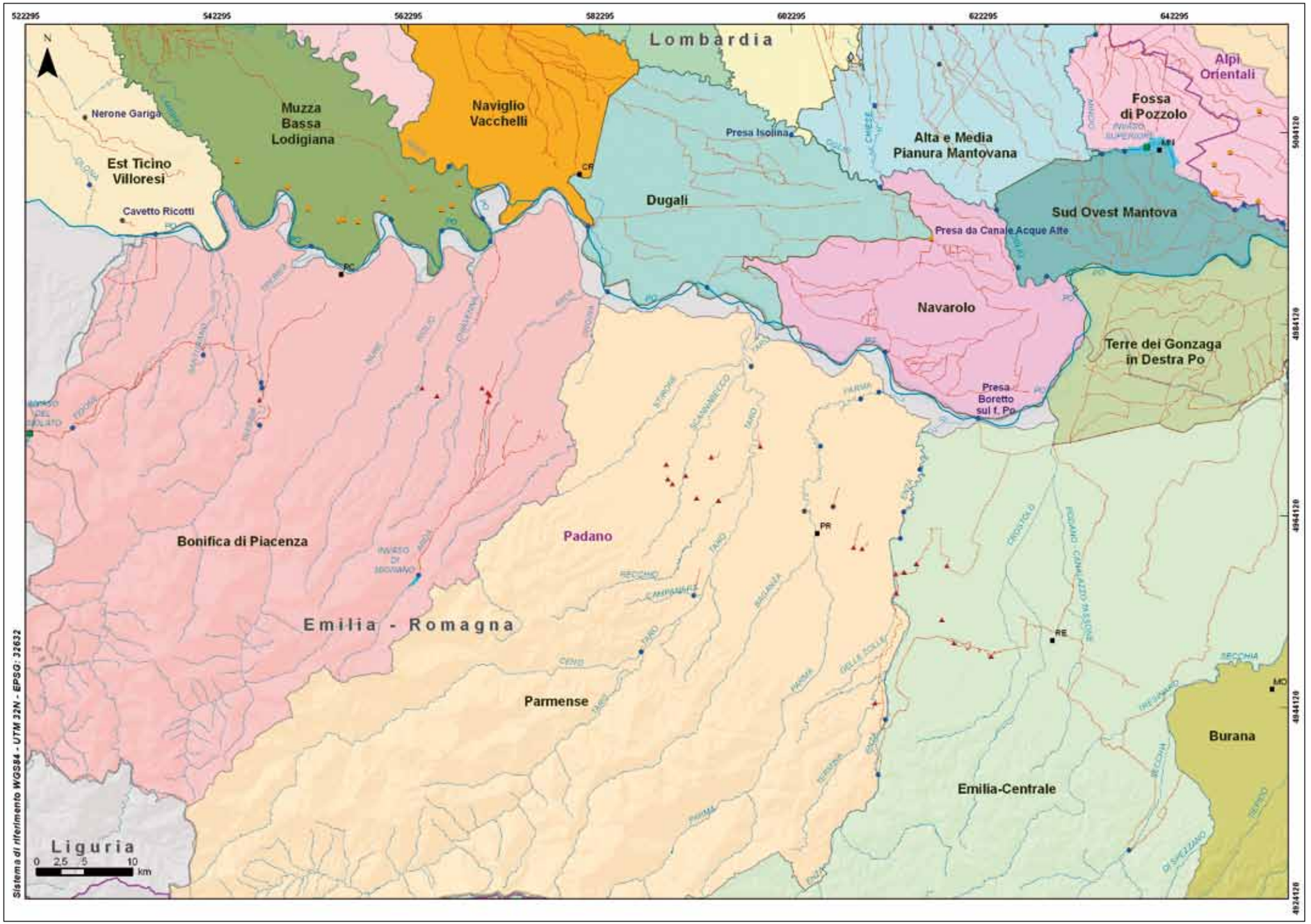


FIGURE 2.11

SIGRIAN – INEA

Chapter 3

River Basin District (RBD) of the Eastern Alps

3.1 Overview

The River Basin District (RBD) of the Eastern Alps covers an overall surface area of approx. 39,385 km^2 (Basin Authority of the Adige River and of the Upper Adriatic, 2010), including the following significant basins:

- national basin of the *Adige River*;
- national basin of the Upper Adriatic (*Isonzo, Tagliamento, Livenza, Piave and Brenta-Bacchiglione*);
- inter-regional basins of the *Lemene* and *Fissero -Tartaro-Canalbianco*;
- regional basins of the Friuli-Venezia Giulia and of the Veneto.

This includes, also, the Venice Lagoon and its river basin (pursuant to Law 798/84).

A majority of the Veneto Region and of the province of Trento and a small portion of Lombardy are completely included in the District of the Friuli-Venezia Giulia Region and the province of Bolzano. Some of the river basin of the Eastern Alps are of international relevance; precisely the basin of the *Levante* and the basin of the *Isonzo* also fall into Slovenian area, while the river basin of the Adige River extends beyond the national borders in Swiss area. The District borders the RBD of the Po River to the West and with that of the Danube to the North (Basin Authority of the Adige and of the Upper Adriatic, 2010). The average altitude of the entire district is approx. 800 m. above sea level, reaching the maximum value of 3,900 meters in Alto Adige (Group Ortles-Cevedale) and the minimum, a few meters below sea level, in some sections of the Veneto coast.

From a morphological perspective, the basin may be divided in three major areas: mountain and foothills, high plateau and low plains. The mountain area consists, proceeding from East toward West, of the relief of the Giulia Alps and of the Carnic Alps, the Dolomite mountain groups of the *Bellunese*, of the *Trentino-Alto Adige* to the Group Ortles-Cevedale that indicates the border with the drainage basin of the *Adda*; here is found primarily land with high permeability, where the complex river-water table relationship is evident. The southern limit of the high plateau consists of the line of spring waters and involves the entire upper alluvial area of the plain of Veneto and of the Po River, extending from Friuli-Venezia Giulia to Lombardy.

From this limit onward originates the minor irrigation network characterized by constant and fluid capacities. The hydrographic system includes six main water bodies that flow into the Adriatic: proceeding from West toward the East are found the rivers Isonzo, Tagliamento, Livenza, Piave, Brenta-Bacchiglione and Adige. Also, there is a smaller hydrographic system consisting of river from water groundwater emergencies present in the low plains, fed by the dispersion of the main water bodies (Basin Authority of the Adige and of the Upper Adriatic, 2010).

From a historic perspective, the irrigation that was performed in the regions within the District has held a very important role from the earliest times; initially it was a work of containment with the exclusive function of reclamation with the purpose of regulating excess water, but over time the need emerged to use the resource also for irrigation purposes. In Veneto the first owner associations arose, the Consortia, including rather extensive property, but with the need to solve important hydraulic and irrigation problems that prevented real expansion. In Trentino-Alto Adige, the construction of the first irrigation waterworks, serving productive areas in Non Valley and Sole Valley dates back to 1700 and 1800, when important and significant forms of association arose with the goal of performing work for common use. In Friuli-Venezia Giulia there were various problems, linked especially to the dissemination of the irrigation on primarily arid land; however, the practical irrigation had more recent origins compared with the other regions. The oldest district was that of the Agro *Monfalconese*, which used water from Isonzo through the channel de' Dottori, while the largest Consortium has always been that of the Ledra-Tagliamento, initially serving more than 50,000 hectares, that brings water from the rivers of the same name. Later, starting in the 30's, the establishment of the second-degree Consortium of Lower Friuli allowed extending irrigation practice using water from springs and from wells (INEA, 1965).

Over the years various reorganizations involved the Consortia, especially land improvement, of very ancient origin and also having irrigation purposes, the activity of which often overlapped the action of the Consortia of rec-

lamation determining an increase in contribution fees. In Veneto, in particular, there was first the dissolution of agencies with the sole purpose of land improvement and then entrusting the functions to the reclamation consortia. The last reorganization dates back to 2009 (INEA, 2009e). The Irrigation agencies in the RBD of the eastern Alps are approx. 157 (Figure 3.0), consisting of irrigation and reclamation Consortia and Consortia for Property enhancement; are concentrated numerically in both the provinces of Trento and Bolzano (95%), the territorial morphology of which generated a definite fragmentation of the property and of the cooperative irrigation organisation in small specialised areas and connected to the presence of high-yield agricultural production (apples and grapes) (INEA, 2009b).

In Friuli-Venezia Giulia there are 4 of irrigation and reclamation Consortia that operate regarding irrigation: Lower *Friulana* in the South-Central area, *Cellina Meduna* to the West, North-Central *Ledra Tagliamento* and *Pianura Isontina* to the East (Figure 3.4). The irrigation activities of the Consortia are carried out in the river basin of national relevance of the *Isonzo*, *Tagliamento* and *Livenza* rivers.

The Veneto Region has 10 Irrigation agencies consisting of irrigation and reclamation Consortia that perform a fundamental role especially for the reclamation of the area, revealing high amounts of irrigated over equipped area (97%). There is also a second-degree reclamation Consortium, the Lessino-Euganeo-Berico (LEB) that manages the channel of the same name (described later), the main purpose of which is that of supplying water primarily for irrigation use to 5 first-degree reclamation Consortia withdrawing water from the Adige River (INEA, 2009e).

The agencies with larger administrative surfaces are Piave, the high plateau of Veneto, Veronese, Adige Po and Adige Euganeo in Veneto, while in Friuli-Venezia Giulia the Ledra-Tagliamento and the Cellina Meduna. It is necessary to add that 5 agencies, from an administrative perspective, fall between the Po River and Eastern Alps Districts: these are, in particular, Fossa of Pozzolo, Veronese, Po Delta, Ronzo-Chienis and Terlago (Figure 2.0 East)[24].

The equipped areas that represent the portion of Irrigation agencies areas on which the irrigation infrastructures persist, represent 44% of the administrative areas, a value more than double compared with the national average of 16%, representing a good degree of coverage of the area with irrigation infrastructures, reporting high levels in Veneto (69%), very much lower in Friuli-Venezia Giulia and Trentino (approx. 22%).

The relationship between irrigated areas and equipped area is equal to 98% (at the national level it is 71%), a value that indicates a high level of use of the infrastructure for irrigation purposes and shown widely and homogeneously on all the agencies belonging to the District. The development of the irrigation in the District from 1965 to today has seen the conversion from irrigation systems using flowing irrigation, which reached high levels in some provinces of Veneto, to more efficient systems, such as sprinkler and lateral infiltration. This process of modernisation and of expansion of the irrigation network took place also in Friuli, where it may be considered nearly complete in the area of the Plain Isontina and in that supplied by the Ravedis Dike scheme (*Cellina Meduna*). Currently the irrigation system primarily adopted in most of the farms in the basin is represented by irrigation using flowing irrigation, approx. the 41% of the irrigated areas, mostly networks with open channels with double functions, both reclamation and irrigation; the Venetian agencies Piave, Veronese and Brenta have very high values of irrigation using flowing irrigation. Sprinkler system, approx. 38% of the irrigated areas, is spread to a lower extent in various areas with more recent irrigation infrastructures; high levels are reached in Friuli-Venezia Giulia (*Cellina Meduna* and *Ledra Tagliamento*) and in the Fossa of Pozzolo in Veneto. Irrigation systems with low consumption and greater efficiency (localised) are found especially in Trentino Alto-Adige. This involves the dissemination of the irrigation for percolation (26%) compared with the national average of the 5%, which is practiced on large areas in Eastern Veneto and Po Delta agencies.

A special and widespread phenomenon in nearly all the Venetian agencies and in some of the Friuli, is the so-called non-structured irrigation (known as 'emergency irrigation'), not organised in terms of distribution and granting to the consumers (irrigation practice) but based on volumes the farmers can directly and freely abstract from the channels of the consortia without any type of organisation and control. In general, in Northern Italy, this terminology is utilised to indicate the presence of occasional supplying system of sources in areas that present great availability of resources and a well-developed reclamation network. In the current situation, what is normally called emergency irrigation is now a form of stable irrigation, and the presence of these means of irrigation is often considered an index of less than efficient management, as it escapes activities of planning and con-

24. 65% of the Fossa di Pozzolo is in the administrative area of the Eastern Alps, there are many irrigation schemes largely interconnected with the natural and artificial network system. The Veronese Body develops mainly in the Eastern Alps. The Delta of the Po is a collection of Islands divided by the streambeds of the Po River and its delta branches and is mainly in the River basin District (RBD) of the Po River. Ronzo-Chienis the and Terlago are 2 agencies of Trentino-Alto Adige. 60% of the administrative area of the first one stretches to the Eastern Alps, while the second is distributed equally between the two Districts.

trol. The dissemination of this supply practice involves approx. 36% of the entire irrigated areas of the District, with high levels in Veneto and much lower in Friuli-Venezia Giulia (INEA, 2009e; INEA, 2008a).

3.2 Characteristics of irrigation schemes

The first water control works within the area of the District can only refer to the regional context of Veneto, described in literature as "the civilisation of the waters" thanks to the performance of many water controls interventions, especially in defence of the city of Venice, from the risk of silting up, but also from reclamation interventions in wetland areas.

Even today there are evident sections of past interventions: of the mesh of narrow channels with which the Romans subdivided the area to then proceed with the assignment of the land to colonies, to major reclamation and diversion works of the water operating during the Serene Republic (INEA, 2009e).

A different situation concerns Friuli-Venezia Giulia where in some areas important interventions were performed to allow the agricultural irrigation on poor, arid and permeable soil of the central plains; in the *Isontino* area the reclamation activities evolved in the broadest hydraulic and health and hygiene concept, reclamation, the so-called comprehensive reclamation, to then expand into the bordering areas of Friuli, Trieste and Istria.

The entire RBD is supplied by approx. 402 irrigation schemes, of which 209 are in Veneto alone, most with various dimensions in terms of surfaces supplied and of development of the major networks; three consortia schemes supply several agencies: *Fener*, *Mordini* and *Lessinio-Euganeo-Berico*. In Friuli-Venezia Giulia there are approx. 25 schemes, of which the most important are serving the agencies *Cellina Meduna* and *Ledra Tagliamento* that alone constitute 90% of the main regional irrigation network; the underground water abstraction has particular importance in areas supplied by wells of the consortia between the *Ledra Tagliamento* and the Lower Friulana (Table 3.3).

According to the coverage of the SIGRIAN data, although partial concerning the volumes, all of the sources present in the River District abstract a volume of water for irrigation demonstrated to be around 4 billion of m^3/year.

Today the irrigation supply system in the River Basin District of the Eastern Alps is guaranteed by 1,270 water supply structures, mostly from superficial natural and artificial networks (39%) and withdrawals from the water table (40%). The greatest withdrawal sources, mainly in terms of volumes derived for irrigation purposes, are located in Veneto. Both provinces and both regions of the District have no abstraction points to the water of the basin of the Po for irrigation purposes, with the exception of some areas in the southern part of the Veneto.

Water availability for irrigation is ensured by the Adige River and the Isonzo, Tagliamento, Livenza, Piave, Brenta-Bacchiglione, Lemene, Fissero-Tartaro-Canalbianco rivers and from a series of minor regional basins. Among the most important withdrawal sources of Veneto are noted the off-taking channels on the Biffis Channel from which many irrigation schemes originate, the Fener and Nervesa dams on the *Piave* giving rise to the *Fener Interconsortia* irrigation scheme and the Bova dam of *Belfiore* on the Adige River that feeds the *Lessinio-Euganeo-Berico* scheme.

The development of irrigation through withdrawals from the water table in the area between the *Ledra Tagliamento* and the Lower Friulana is connected to its particular geomorphological conformation characterized by a very superficial level of the water table. This situation is becoming increasingly critical as it is experiencing, during recent years, a constant decrease in the underground draining strata. Medium-sized schemes, in addition to drawing from smaller water bodies, or from so-called 'spring waters', integrate the water resources with dam projects for irrigation on reclamation channels (irrigation ditches), indicating that also in the Friuli area the irrigation system shows a strong level of interconnection, determining continual water exchanges with the artificial network and definite direct benefits on the environment. (INEA, 2009b).

The technical characteristics of the irrigation network are associated with the historic development of the irrigation in the various areas of the consortia, as it has been affected by the passage from infrastructures essentially of reclamation to multiple functions, to a specialised irrigation network, especially in contexts in which network modernisation policies were enacted with construction or replacement of the channels with pipes networks. The main irrigation network of approx. 3,100 km was developed within the River Basin District, 77% exclusively for irrigation purposes, while 23% is for multiple uses.

Trentino-Alto Adige is the only area in which there is the type of irrigation use where the system, from a structural perspective, is the most recent and specialised; in the remaining regions are present both types (irrigation and multiple) with different percentages but with prevalence (greater than 70%) solely for irrigation purposes. This indicates that the irrigation most widespread systems are represented by flowing irrigation, for the regions with significant availability of water (especially Veneto) and mixed irrigation systems with more (sprinkling) and less efficiency (flowing) (part of the Veneto and Friuli-Venezia Giulia); there are areas in which efficient systems prevail, both from a perspective of distribution network and irrigation system type (*Trentino-Alto Adige*).

The main network was developed especially in Veneto (52%) and in Friuli-Venezia Giulia (22%). Overall, open

channels are prevalent everywhere and constitute 65% of the entire development of the network, followed by approx. 30% pipes. At a regional level in Friuli-Venezia Giulia the type primarily consists of open channels, 71%, and pipes, 28%.

Trentino-Alto Adige, where the high structural efficiency was most often cited pipes were developed for more than 92% of the regional irrigation network and finally, in Veneto, 84% consist of open channels and approx. 10% of pipes.

Among the main schemes of the District, the Lessinio-Euganeo-Berico irrigation scheme (LEB) (Figure 3.7) originates from the Bova dam of Belfiore on the Adige River and was developed in the central Veneto plain, on approx. 141,000 hectares. The execution of the scheme, completed in the early 1990s, has allowed the agricultural reclamation of a large area of Central Veneto characterized by water supply problems.

The scheme currently supplies 3 Consortia and the derived concession capacity is 24.8 m^3/s, with a capacity volume estimated in 2011 at approx. 315 million m^3. The scheme is managed by the second-degree Consortium of Lessinio Euganeo Berico, originating in 1958 from the association of various reclamation consortia, with the role of administration and maintenance of the scheme from dam-building to the consortium network and planning the use of the water during irrigation seasons. The overall irrigation network composing the scheme was developed on more than 72 km and shows predominantly irrigation use (63%) compared with the multiple use of reclamation and irrigation. A majority of the network consists of open channels (62%) (INEA, 2009e).

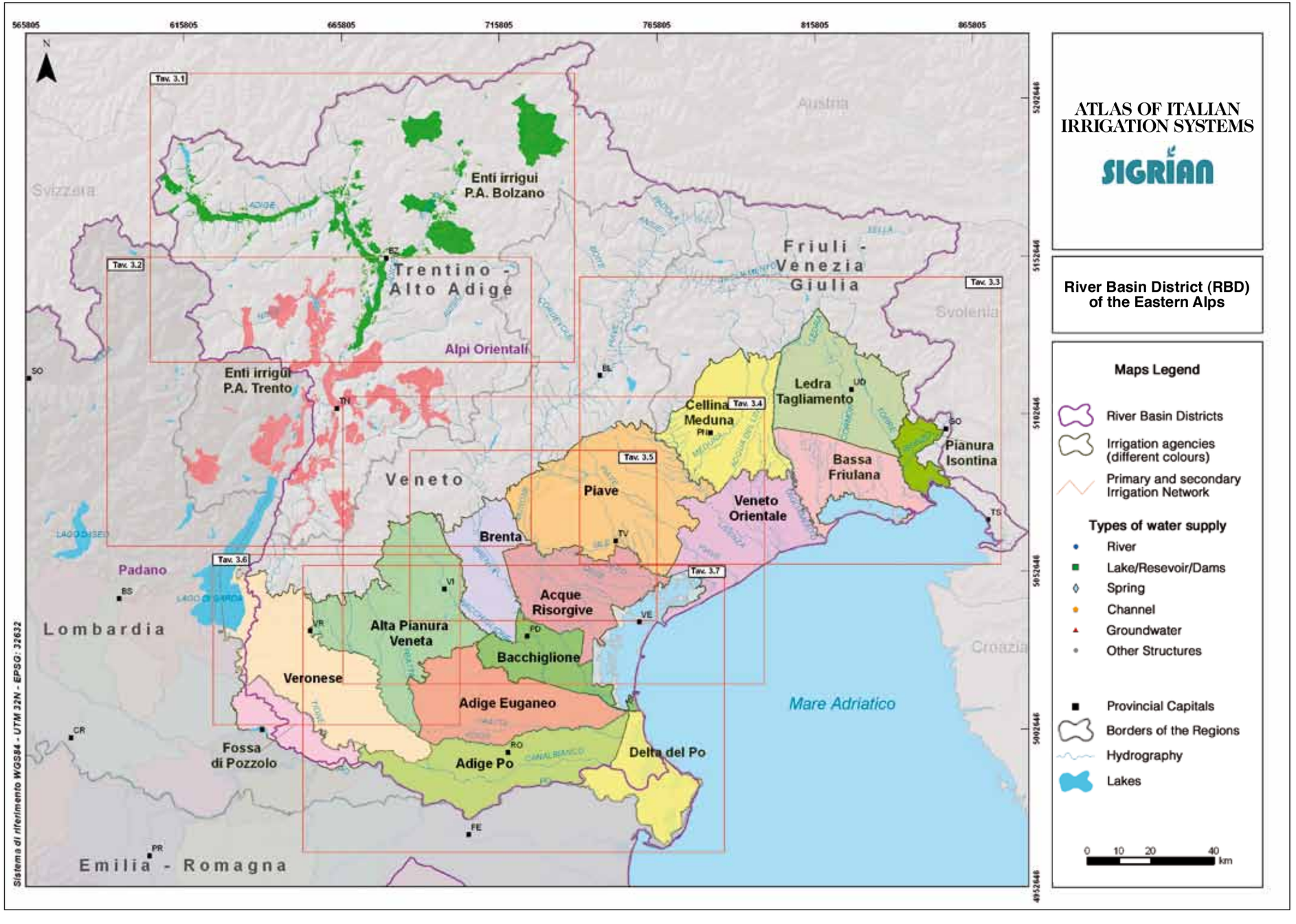
The *Fener interconsortia* irrigation scheme (Figure 3.4) is serving Irrigation agencies Piave and spring waters, given the complexity of the network, is a very important Interconsortia scheme at a regional level. The volumes are withdrawn through two dam projects, the Fener and the Nervesa Dams, both on the Piave river; regarding first the capacity volume in the year 2011 was approx. 553 million m^3, nearly a fifth of the overall capacity volume at a regional level, while for the Nervesa Dam a withdrawal volume was granted equal to 150 million m^3.

The capacities granted for irrigation use vary during the year, with increases of the capacity in the period of greatest need for irrigation of the crops, between mid-June and the end of August. The main network, primary and secondary, extend more than 276 km, with a clear prevalence of the secondary network and performs 56% a purely irrigation function and the remaining part, however, also works f, or reclamation (INEA, 2009e).

The Mordini interconsortia irrigation scheme (Figure 3.4), serving two agencies, the High plateau of Veneto and the Brenta, originates from a water supply on the Astico stream that feeds the Channel Mordini and along the development of the scheme, for integration of the resources, there are 6 wells and 5 water sources that fall within the Brenta Entity. The source of the Channel Mordini abstracts approx. 38 million m^3 while the integrations from the wells amount to approx. 1.1 million m^3. The scheme was developed in approx. 85 km of main network and 53% functions primarily for irrigation while the remaining part also works for reclamation. The open channels constitute the predominant type, followed by pipes, equal to approx. 30% of the main network.

Map annex
of Chapter 3

FIGURE 3.0


ATLAS OF ITALIAN IRRIGATION SYSTEMS
SIGRIAN
River Basin District (RBD) of the Eastern Alps
Maps Legend
River Basin Districts
Irrigation agencies (different colours)
Primary and secondary Irrigation Network
Types of water supply
River
Lake/Resevoir/Dams
Spring
Channel
Groundwater
Other Structures
Provincial Capitals
Borders of the Regions
Hydrography
Lakes
0 10 20 40 km
Enti irrigui P.A. Bolzano
Trentino - Alto Adige
Alpi Orientali
Enti irrigui P.A. Trento
Friuli - Venezia Giulia
Cellina Meduna
Ledra Tagliamento
Pianura Isontina
Bassa Friulana
Veneto
Piave
Veneto Orientale
Brenta
Padano
Acque Risorgive
Alta Pianura Veneta
Bacchiglione
Veronese
Adige Euganeo
Fossa di Pozzolo
Adige Po
Delta del Po
Lombardia
Emilia - Romagna
Mare Adriatico
Austria
Svizzera
Slovenia
Croazia
Tav. 3.1
Tav. 3.2
Tav. 3.3
Tav. 3.4
Tav. 3.5
Tav. 3.6
Tav. 3.7
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715805
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FIGURE 3.1

SIGRIAN – INEA

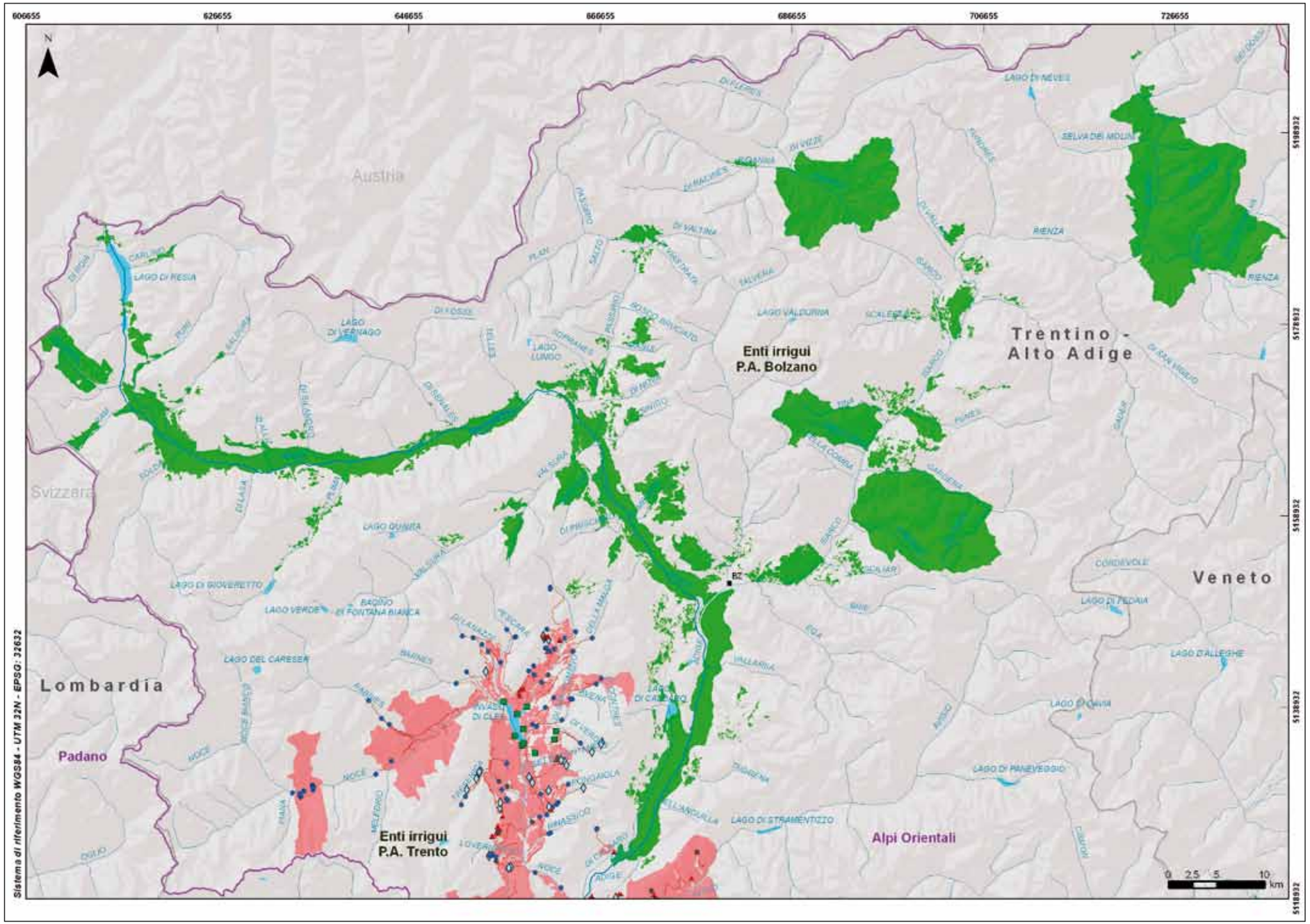


FIGURE 3.2

SIGRIAN – INEA

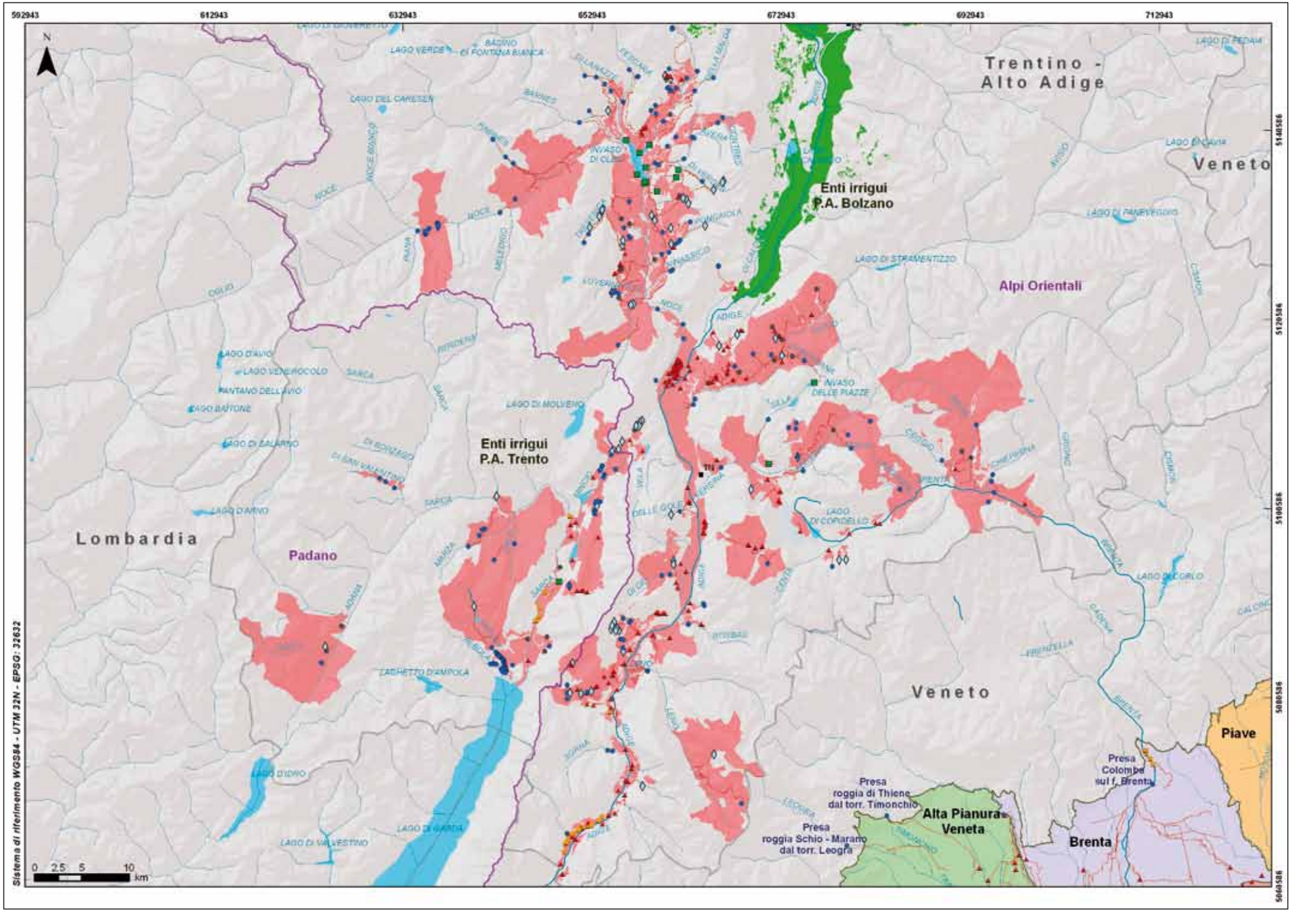


FIGURE 3.3

SIGRIAN – INEA

FIGURE 3.4

SIGRIAN – INEA

FIGURE 3.5

SIGRIAN – INEA

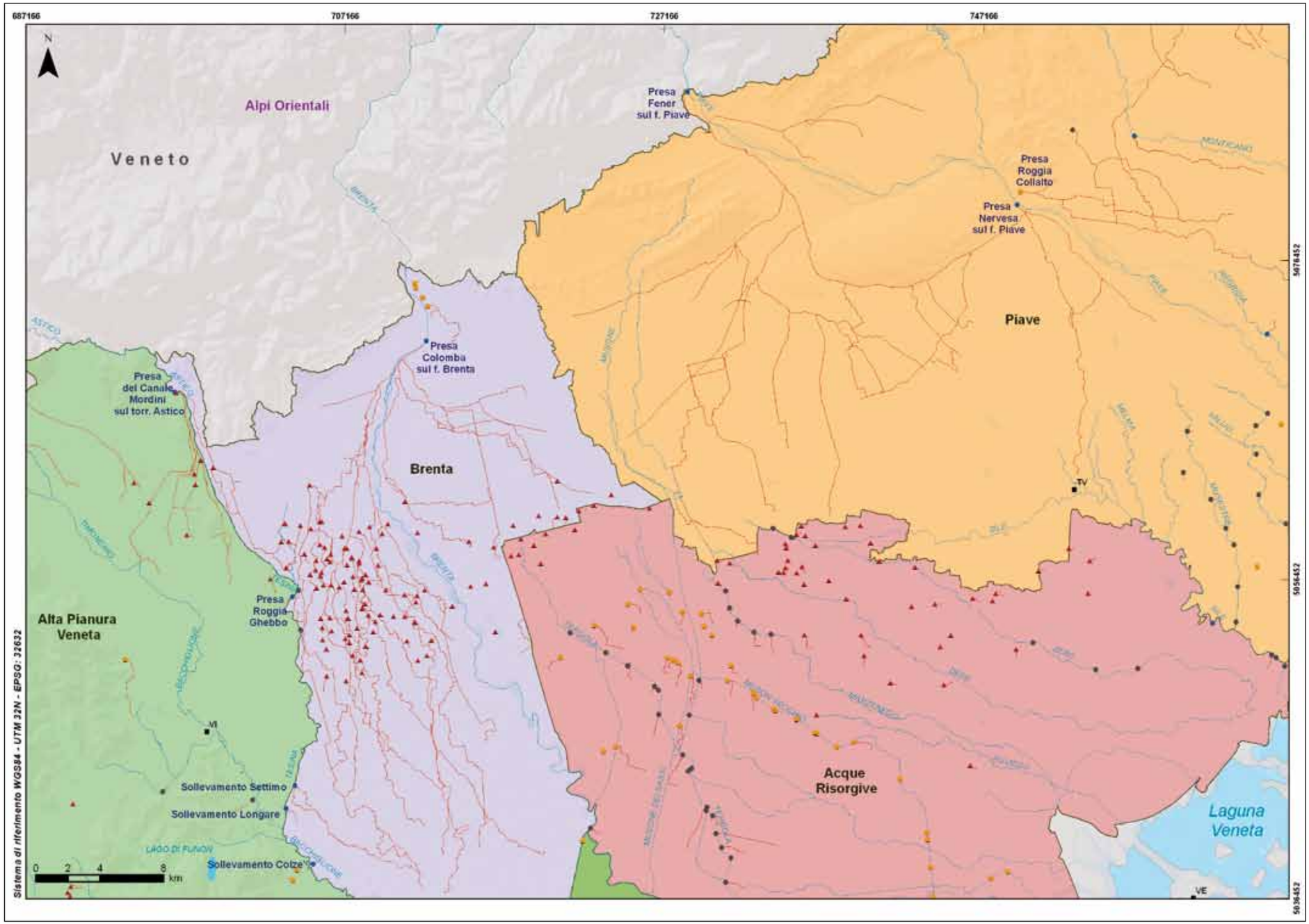


FIGURE 3.6

SIGRIAN – INEA

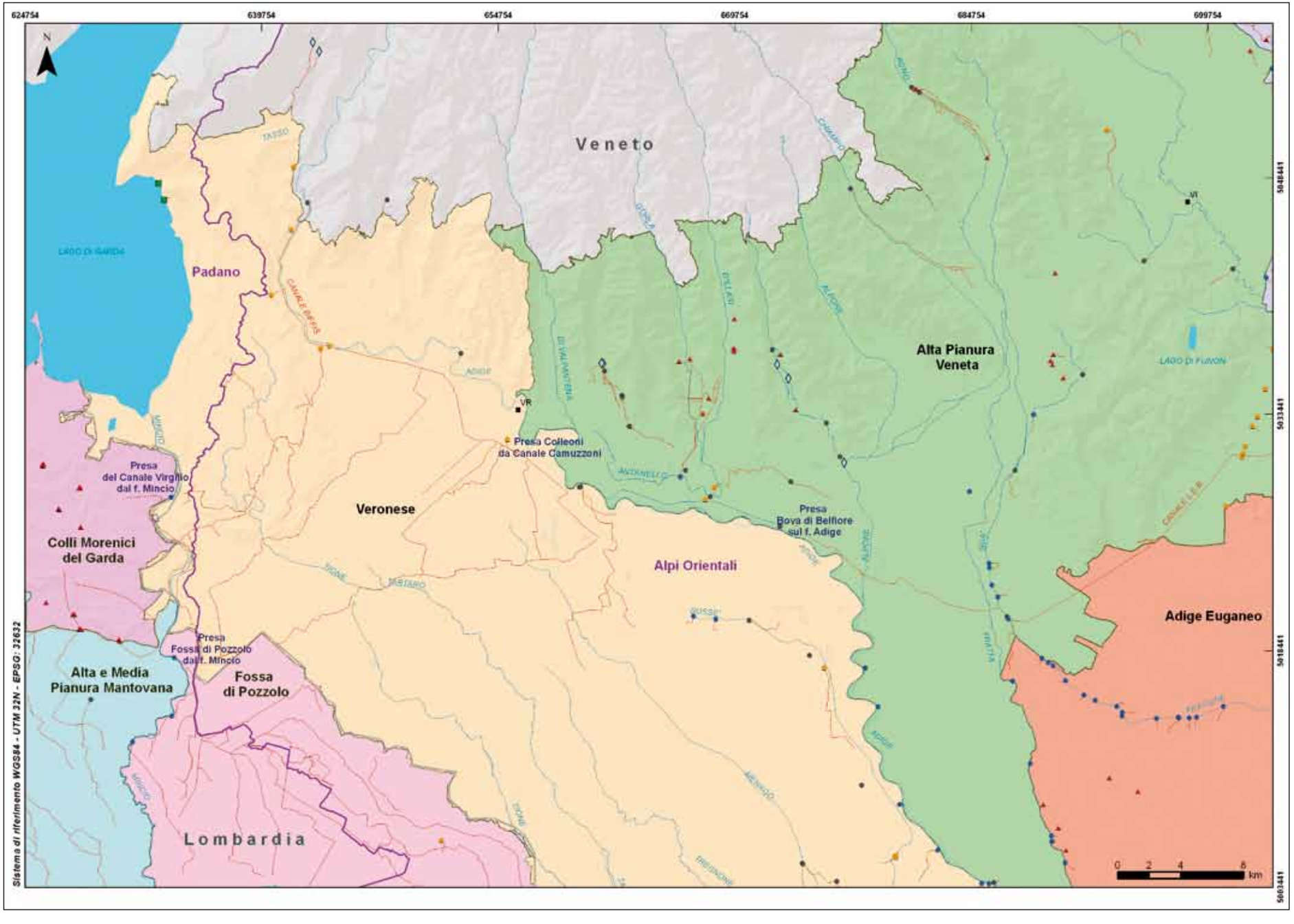


FIGURE 3.7

SIGRIAN – INEA

Chapter 4

River Basin District (RBD) of Northern Apennines

4.1 Overview

The River Basin District (RBD) of the Northern Apennines is located geographically in the system of the central Mediterranean Alpine chain and extends from Liguria to Marche, occupying a surface area of 38,131 km² (Administrative Authority of the River Basin District of the Northern Apennines, 2010). The area of the District includes mainly the regions:

- Liguria (in all its provinces);
- Tuscany (in all the provinces);
- Emilia-Romagna (primarily in the provinces of Bologna, Forlì-Cesena, Ravenna and Rimini and only marginally Reggio-Emilia, Modena and Parma);
- Marche (in the provinces of Pesaro-Urbino, Macerata and Ancona);
- Piedmont (marginally included);
- Umbria (in the province of Perugia);
- Lazio (in the province of Viterbo).

The River Basin District shares a border to the West with the District of the Po River, to the South with the Central Apennines District, to the West with the French Rodano District, and is divided in two parts by the Pilot River District of the Serchio River that intersects the area near the province of Lucca to the river basin of the Lake Massaciuccoli. The main river basins included in the District are those of the rivers *Magra*, *Arno*, *Ombrone*, *Reno*, *Marecchia*, *Fiora*, and the minor regional river basins of Liguria, Tuscany, Romagna and Marche.

The hydrography of the District is very diverse, characterized by a significant lack of homogeneity of the river basins and by distinct final receiving bodies of water such as that of Liguria and Tyrrhenian Sea on the western side and The Adriatic Sea in that eastern (Administrative Authority of the RBD of the Northern Apennines, 2010).

The Tyrrhenian side is affected by average density of the hydrographic network, in particular in the portion of Liguria, significantly higher compared with the rest of the area of the entire District. The basins are of limited extent and nearly all of the first order (opening into the sea). Among the most important are indicated the river basin of the Arno river (9,149 km²), the area of which was developed to the South of the mouth of the Serchio river (not included in the area of the district).

The Arno, with 241 km of main water course, is the longest river of the RBD. The main tributaries are the Sieve and the Bisenzio on the right bank, the Chiana, the Elsa and the Era on the left bank. The inter-regional basin of the Magra River (1,694 km²) extends between Liguria and Tuscany. The Magra River has a course of approx. 62 km and, along its route toward the sea, it receives water directly from the Vara River and many minor tributaries.

Continuing along the Tyrrhenian Coast there are the *Ombrone Grossetano* river basin (3,539 km²) and the inter-regional river basin of the Fiora (825 km²), the mouth of which falls into the Lazio area.

The lakes of the Tyrrhenian side of the River Basin District are the *Montepulciano* (1.9 km²), Chiusi (3.9 km²) and the Orbetello lagoon (27 km²). In the Tuscan area there are two important artificial reservoirs: the reservoirs of *Montedoglio* (7.7 km²) on the River Tevere, originating for irrigation serving areas in the River Basin District of the central Apennines (see Chapter 6), and the reservoirs of Bilancino (5 km²) in the province of Florence, on the Sieve River, to retain flood lamination and for potable water (INEA, 2007a). The Canino dike is of interest for irrigation; located in *Viterbo* province, it feeds the irrigation scheme of the same name (INEA, 2008c).

On the Adriatic side, leaving from the North, the District includes the inter-regional basin of the Reno River (4,361 km²), extending from the Tosco-Emiliano Apennines to the Ravenna coast, and the Romagna regional river basins (3,419 km²), the most extensive of which is the river basin of the United Rivers (Ronco, Montone and Rabbi, 1,239 km²). The Reno, with a course of 212 km, is the District's second longest river after the Arno. Its main tributaries are the Boverchia River, the Rio Maggiore, the Silla and the Samoggia-Lavino on the left bank; the Limentra of Sambuca and the Limentra Eastern, the Idice, the Sillaro, the Santerno, the Senia and the Riolo-Botte reclamation channel on the right bank.

Overlapping with the Marche Region, follow the Marecchia-Conca inter-regional basin (774 km²), that includes some portions of the provinces of Arezzo and Pesaro-Urbino, the entire province of Rimini and a limited part of Forlì-Cesena province. The Marche slope extends from the Foglia basin (705 km²) to the Musone basin (652 km²), including the Metauro basin (1,392 km²);

the most extensive portion of this area (Inea, 2009d; Inea, 2009a). The Marecchia (70 km) and Conca Rivers (47 km) originate in Romagna and flow into the Adriatic of Marche.

Common characteristics of the rivers that flow into the area of Marche are the scarcity of tributaries, the mainly parallel water bodies and the asymmetry of the shorelines.

The Adriatic network of rivers falling into the level lands of the River Basin District over the years has experienced significant changes due to the need for hydraulic reclamation of the areas. For this reason, the network often acquires characteristics of complete artificiality (Administrative Authority of the River Basin District of the Northern Apennines, 2010).

On the Adriatic side there are two artificial reservoirs for hydroelectric use, the Lake Suviana on the Eastern Limentra (1.47 km^2) and the Lake of Brasimone on the stream of the same name (0.40 km^2) in the inter-regional basin of the Reno; one used for drinking purposes, the Reservoirs of Ridracoli on the Bidente River (0.93 km^2) in the area of the Romagna regional basins; one for irrigation purposes, the reservoirs of Castreccioni (or Lake Cingoli) (90 km^2) on the Musone River, serving the same irrigation area (INEA, 2009d; INEA, 2009a).

In the District, 12 Irrigation agencies are currently present and operating (Figure 4.0). The most significant, in terms of extent of irrigation schemes and of volumes withdrawn, are the Lunense Channel and Grossetana agencies, in the Tyrrhenian areas, and the Renana agencies, Reclamation of the Romagna and Comprehensive Foglia, Metauro and Cesano rivers on the Adriatic side. All the agencies, overall, present equipped area of approx. 136,000 hectares, for irrigated areas of approx. 50,000 hectares (ratio of irrigated/equipped area near 37%). Although collective irrigation has experienced considerable development, especially post-World War II, the River Basin District is still affected by significant autonomous irrigation practices, spread especially in the minor river basin of Liguria, in Tuscany and Romagna. Withdrawals are primarily from wells and, also given the autonomous nature of the administration, usage data are unknown.

The development of irrigation over the years has led to abandoning inefficient irrigation systems, such as flowing -very widespread in the past- (INEA, 1965), flooding and lateral infiltration, and the adoption of modern practices that guarantee significant water savings.

The SIGRIAN data, in fact, indicate widespread irrigation by sprinkling (69%) and increasing adoption of localised irrigation, reached 24% in the past years, compared with a trivial percentage in the 1960's. In the past, in the river Basin District irrigation practices were spread especially over the Romagnole plains after the execution of various hydraulic reclamation works.

4.2 Characteristics of irrigation schemes

In the past, the irrigation practice in the area of the RBD of the Northern Apennines was concentrated in the areas of the plain characterised by good availability of underground water. Over time, following hydraulic reclamation works, irrigation spread as a stable practice in various parts of the RBD, especially in the Romagnole and Tuscan plains (INEA, 2008c; INEA, 2009d; INEA, 2009a). Following the industrial era and with the introduction of motors, reclamation and diversion works of water from the rivers became very widespread, expanding the arable land and encouraging the adoption of innovative crops and irrigation practices. The most recent interventions of modernisation and expansion of irrigation schemes concern primarily the river basin of Foglia and Musone rivers in Marche, affected respectively by investments for the execution of the Mercatale reservoirs, on which the primary and secondary network is not completed yet, and the Castreccioni reservoirs that require structural upgrading (Figure 4.3). There were also significant interventions of expansion of the Emiliano Romagnolo Channel (CER) with the goal of extending cooperative forms of irrigation in Romagna, historically characterised by private withdrawals from the water table.

Although cooperative irrigation was supported over the years with enormous availability of public financing, the potential of development of the agricultural irrigation of the District was sometimes limited due to problems of political and environmental nature. The development of Tuscan irrigation schemes supplied by the reservoirs of Montedoglio, for example, has experienced significant delays due to the growing demand for water for civil and industrial purposes and changes in agricultural policies and the community markets: the reduction of volumes available for irrigation and the adaptation process in the agricultural sector to new political arrangements have made the benefits of expanding irrigation networks uncertain (INEA, 2008c).

The increase of climate variability, shown with greater intensity in the recent years, has emphasized the need to adapt the existing irrigation network to the new irrigation needs and to expand cooperative irrigation in the area of the RBD with the goal of guaranteeing continuity in the irrigation water supply and to limit excessive use of the water of water table that, especially in periods of strong lack of water or of drought, contributes to feeding the phenomenon of the intrusion of the salt- wedge in the agricultural seacoast areas.

The important reclamation work taking place in particular in Sarzanese, Lunigiana and Romagna has profoundly characterised the hydrography of the area. Open channels, even today essential for reclamation, were created with complete integration into the hydrographic

network and have contributed to the reclamation of the areas.

In the River basin district collective irrigation is guaranteed by 45 irrigation schemes, 24 of which are concentrated in Romagnolo, 6 in Marche and 15 on the Tyrrhenian side. Annually the irrigation schemes of the District, overall, remove approx. 420 million m^3 from 80 sources. The supplies from the river are prevalent with 39 dam projects, concentrated especially in the Romagna Irrigation complexes in which are also present 9 sources represented by wastewater purification plants[25] (Figure 4.1). The most important sources of withdrawal from the lake (reservoirs) in terms of abstraction points are on the Lake of Castreccioni (Table 4.3), in the area of Marche. The overall capacity granted for irrigation use is approx.100 m^3/s. The individual capacities granted are very modest, excluding the CER that reaches 68 m^3/s.

The main irrigation network supplies an equipped area of approx. 136,000 hectares. Considering the primary and secondary components, it extends 341 km overall and primarily consists of open channels, especially in areas historically dedicated to irrigation.

The schemes developed on the Tyrrhenian side annually draw approx. 24 million m^3 through 16 sources, located primarily on the natural networks of Tuscany.

The main network reaches a dimension of approx. 86 km (25% of the total), serving equipped area of approx. 7,000 hectares (3% of the total area) and shows an average relationship between irrigated areas and equipped areas equal to approx. 60%, higher compared with the rest of the District. The main network consists of approx. 58% channels, while the remaining 42% is composed of pipes, which characterize schemes of recent execution.

The Adriatic side is characterised by a complex integration between hydrographic network and a cluster of irrigation schemes, some of which are also interconnected to the CER (see Paragraph 2.2), which withdraws approx. 393 million m^3 from 48 sources. The main network was developed for approx. 255 km and abstracts water from 42 sources from the main rivers of the area, such as the *Reno*, the United Rivers and the *Marecchia*. The basins of the Reno and of the United Rivers are crossed by the CER, along which are present 5 sources that replenish many Romagnolo irrigation districts. The irrigation network supplies approx. 129,000 hectares of equipped area with an average relationship between irrigated areas and equipped area of the 45%. Considering the Romagna, the relationship irrigated areas/equipped equal to 35%, while reaches 100% in Marche. The main network that extends in Romagna is completely consisting of channels, some of which were used for water distribution, while those of Marche, of recent execution or modernisation, are all developed with pipes.

Among the most important irrigation schemes of the District are the Channel Lunense, the Ombrone and the CER. The Lunense Channel irrigation scheme (Figure 5.1) was planned in 1856 for irrigation and reclamation; the work began in 1891 and lasted approx. forty years. The scheme supplies the reclamation and irrigation Consortium of the same name that currently manages approx. 1,000 hectares of equipped and irrigated surfaces. The irrigation resource comes from a dam built on the Magra River in the municipality of Aulla (Ms) for which the Entity has a concession issued by the province of Massa Carrara of 2.73 m^3/s and estimated annual withdrawal of approx. 15 million m^3. The scheme is characterised by a single primary and secondary tract (approx. 24 km long) from which departs the distribution network consisting of open channels (INEA, 2007a).

The Ombrone irrigation scheme (Table 4.4) supplies the Grossetana Consortium reclamation and equipped area of approx. 3,354 hectares. The main network was made in the period of 1958-1963 and in 1978 the Consortium launched restructuring and modernisation for the conversion of the open channels with pipes. The scheme is by natural gravity, with derivation from the Ombrone River in the Steccaia region of Poggio Cavallo, in the Municipality of Grosseto. The water is held by a fixed dike with a capacity of 2 m^3/s and annual withdrawal of approx. 7.5 million m^3. The main network measures approx. 19 km and consists primarily of open channels (INEA, 2008c).

The irrigation scheme that was developed along the CER (Figures 4.1 and 4.2) is among the important irrigation work of Italy, serving 9 Irrigation agencies for an overall equipped area of approx. 119,000 hectares between the River Basin Districts of the Po River and Northern Apennines. The CER, planned since the 17th century, with various design revisions, to date has not been completed yet. The construction work began in 1955 and continued with the development of the complex water system in service primarily for irrigation. The administration of the channel, facilities and the main network and the performance of maintenance and expansion interventions are the responsibility of the second-degree Consortium of Emilia-Romagnolo Channel, while the true water distribution phase is requested by the Consortia associated to the second -degree, that are: the *Circondario Polesine* of Ferrara, *Circondario Polesine* of *S. Giorgio* and *Valli di Vecchio Reno*, falling into the Po River (see Chapter 2) and Renana,

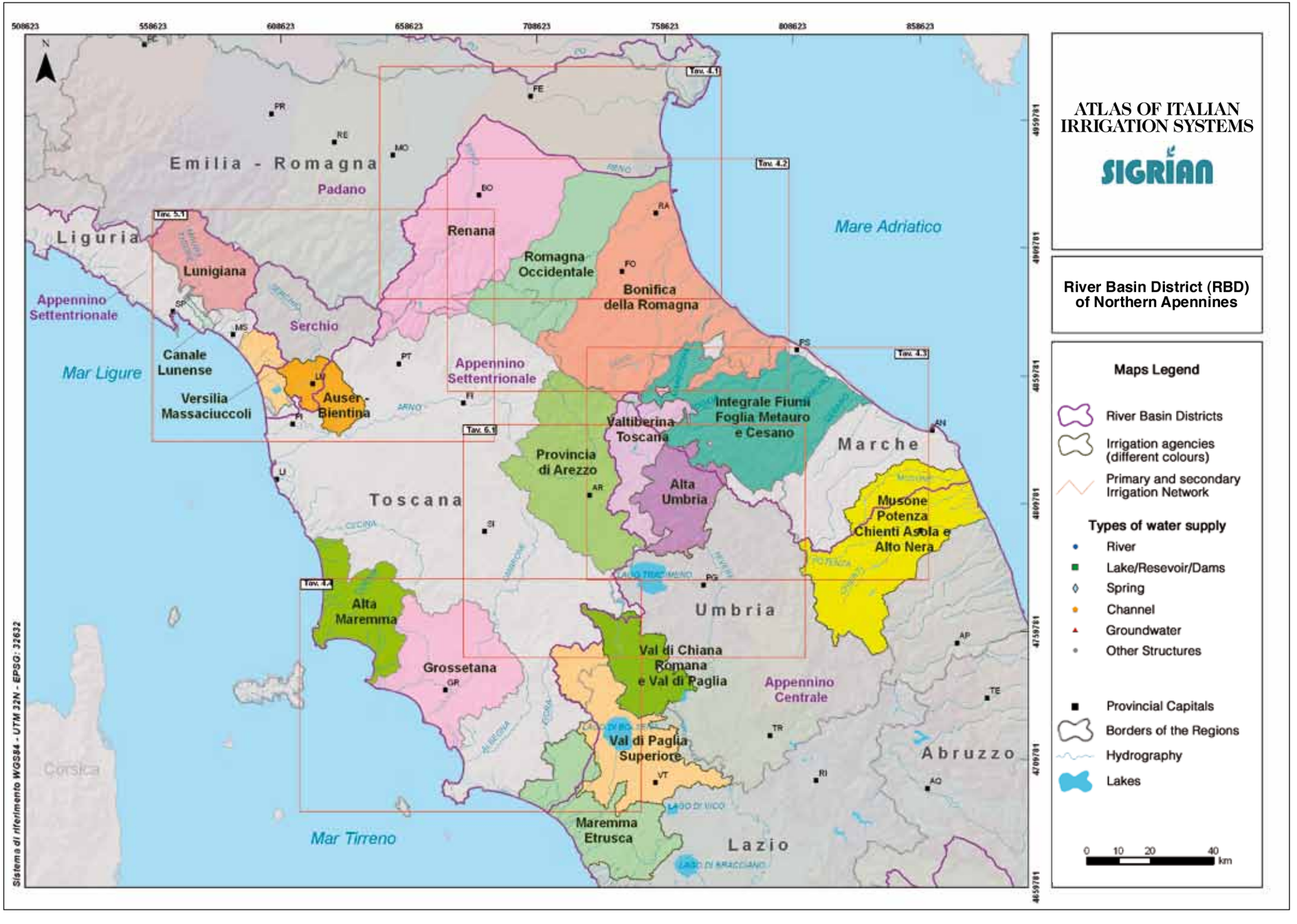
25 The treatment plans of Anzola, Calcara, Calderara di Reno, Ozzano and Castel San Pietro are in the area of the Reclamation Consortium of Renana; the treatment plans of Ravenna, Savio, Cervia and Cesena are in the area of the Reclamation Consortium of Romagna.

Romagnola Occidentale and Bonifica della Romagna[26] in the RBD of the Northern Apennines. The origin of the water for the scheme is in the Po River. The CER, in fact, abstracts water from the Po River through the Palantone lifting facility and transfer it to the Cavo Napoleonico, extending for approx. 18 km in the Po Valley District. The CER proper departs from the left bank of the Cavo Napoleonico, while on the right bank originate the the Derivation Channel Cer. The annual capacity volume is of approx. 200 million m^3 for an overall capacity of 68 m^3/s. The channel currently supplies water to the networks of the associated Consortia, through direct diversions or interconnections with the diverse networks of the consortia, based on the following provisions of water foreseen: Renana: 20.8 m^3/s; Eastern Romagna: 12.9 m^3/s; Reclamation of the Romagna: 23.70 m^3/s. The areas located to right bank of the channel track are those that, most recently, were equipped for irrigation and are created entirely by pressure, in contrast with the network on the left bank, primarily gravity. Overall, the main network is approx. 500 km long (151 of primary and secondary), 67% of which have multiple functions and the remaining 33% are solely irrigation networks. Structurally the scheme is created with open channels (77%) and to a lower extent with pipes (15%) and closed channels (6%) (INEA, 2009e).

26 The region Emilia Romagna, with regional law 5/2009, has reorganized its Reclamation Consortia and relevant Drainage Irrigation agencies. The reclamation Consortium 'New Renana' includes Renana and part of the Water Hydrographic Basin of the Reno-Palata; Reclamation consortium 'the new Romagna Occidentale' includes Romagna Occidentale and some Water Hydrographic Basin of Romagna Centrale. The new Reclamation Consortium of the Romagna Centrale includes the other part of Romagna Centrale as well as the reclamation consortia of Savio and Rubicone Rimini and the province of Rimini.

Map annex
of Chapter 4

FIGURE 4.0


ATLAS OF ITALIAN IRRIGATION SYSTEMS
SIGRIAN
River Basin District (RBD) of Northern Apennines
Maps Legend
River Basin Districts
Irrigation agencies (different colours)
Primary and secondary Irrigation Network
Types of water supply
River
Lake/Resevoir/Dams
Spring
Channel
Groundwater
Other Structures
Provincial Capitals
Borders of the Regions
Hydrography
Lakes
0 10 20 40 km
Emilia - Romagna
Liguria
Toscana
Umbria
Marche
Abruzzo
Lazio
Corsica
Mare Adriatico
Mar Ligure
Mar Tirreno
Padano
Renana
Romagna Occidentale
Bonifica della Romagna
Appennino Settentrionale
Lunigiana
Serchio
Canale Lunense
Versilia Massaciuccoli
Auser - Bientina
Valtiberina Toscana
Integrale Fiumi Foglia Metauro e Cesano
Provincia di Arezzo
Alta Umbria
Musone Potenza Chienti Asola e Alto Nera
Alta Maremma
Grossetana
Val di Chiana Romana e Val di Paglia
Appennino Centrale
Val di Paglia Superiore
Maremma Etrusca
Tav. 4.1
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Tav. 4.3
Tav. 4.4
Tav. 5.1
Tav. 6.1
Sistema di riferimento WGS84 - UTM 32N - EPSG: 32632

FIGURE 4.1

SIGRIAN – INEA

FIGURE 4.2

SIGRIAN – INEA

FIGURE 4.3

SIGRIAN – INEA

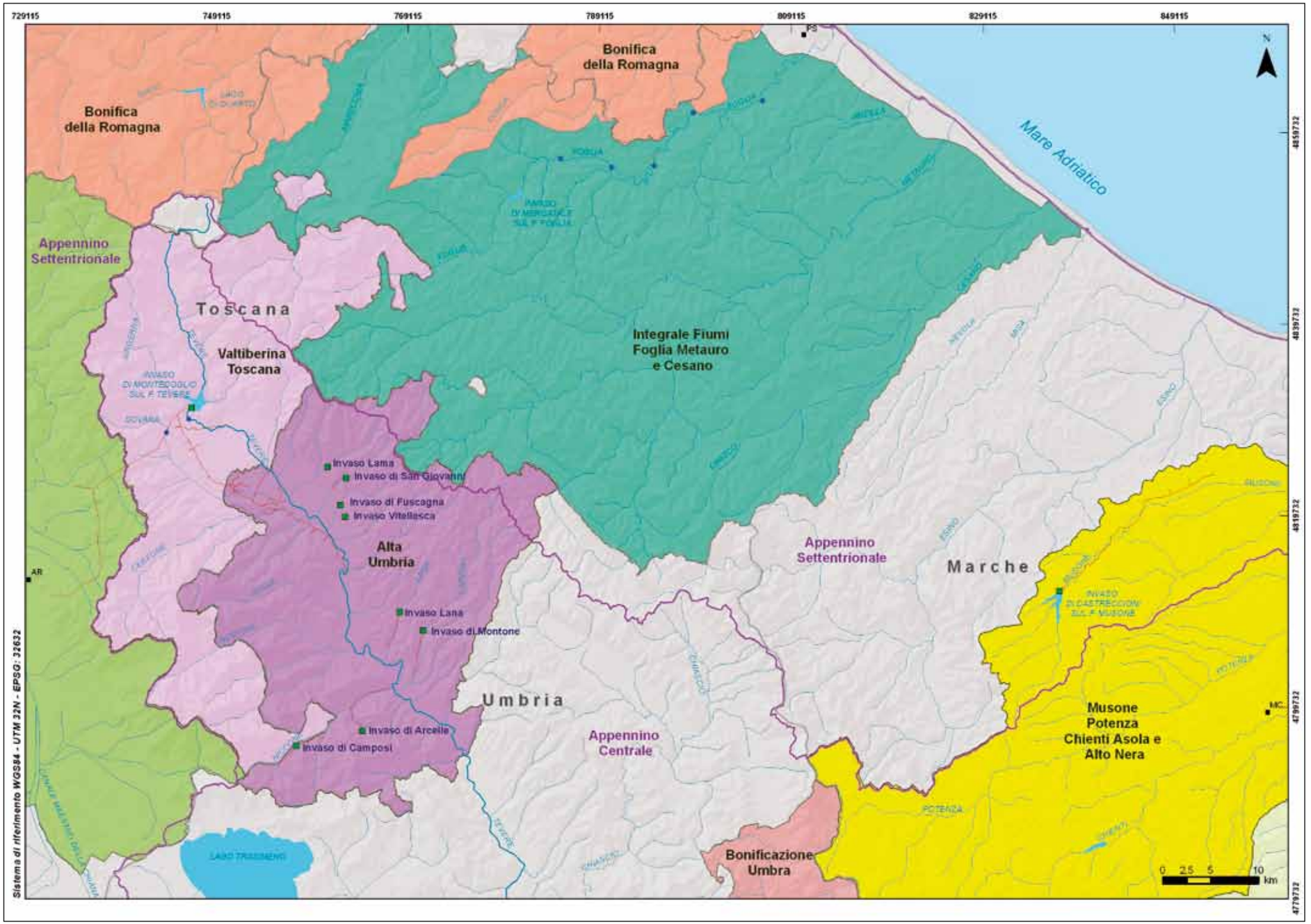


FIGURE 4.4

SIGRIAN – INEA

Chapter 5

Pilot River Basin District (RBD) of the Serchio River

5.1 Overview

The River Basin District (RBD) of the Serchio River was identified as 'Pilot River Basin' by the Water Directive 2000/60/CE through an early transposition into national law, compared to the rest of the national territory, of the requirements of EU directives relating to hydrological preservation and water protection[27]. The Pilot River district is equivalent in all respects to the basins of national interest. However, in the end of the experimental phase, it will be included in the Regional River Basin of the 'Northern Tuscany' and, therefore, it will be part of the River Basin District of the Northern Apennines (Pilot Basin Authority of the Serchio River, 2010).

The area includes the river basin of the river Serchio, the river basin of the Lima Torrent, the coastal area of the river basin of the Lake Massaciuccoli. It encloses for the most part the province of Lucca and, marginally the provinces of Pistoia and Pisa, covering an area of approx. 1,600 km^2. The river basin district borders by the River basin district of the Po Valley to the North and intersects the RBD of the Northern Apennines by the river basin of the Magra River, by the river basin of Liguria in the West, and by the southern-Eastern river basin of the Arno River (Figure 5.0).

The selection as Pilot River Basin District of the River Basin District of the Serchio River is due to its distinctive characteristics and to historical reasons related to surface water management. The abundant surface water resulting from the river basin of the Serchio River and the Lima Torrent flowed into the Serchio River causing frequent floods in the Plain of Lucca, which in the past was a natural waterlogging area of the river. Over time the people from Lucca built several dykes along the river Serchio and related tributaries and develop a natural water distribution network (to use) for agricultural and industrial purposes. The historic implementation of such water control system guaranteed a flourishing development of agriculture and industry, fostering agriculture and industry, and promoting in particular silk production (in the Province of Lucca).

The Hydrological network consists of the Serchio River, and its tributaries and of the Lake Massaciuccoli (7 km^2). The main river originates North of the Tyrrhenian side of the Tuscan-Emilian Apennines. It runs southward and eastward for about 50 km to the confluence, on the left bank, with the Lima River and heads to the South for other 52 km to the outlet in the Tyrrhenian Sea, between the mouth of the Arno River and the port of Viareggio. The Lima Torrent is the most important tributary of the river Serchio extending for 42 km and with a river basin of 315 km^2. The nature of the terrain (orography) of the river basin consists of 301.5 km^2 of lowland (equal to 19% of the total area) and of middle-mountain and mountainous areas.

Irrigation management is entrusted to the Reclamation Consortia of Versilia Massaciuccoli and Auser-Bientina, that exercise their territorial jurisdiction over an area of 95,507 ha, and partially over the River Basin District of the Northern Apennines. In this area there are 3 river basins, the Basin of Pisano Massaciuccoli, the Basin of Moriano and the Plain of Lucca stretching respectively to the south of the Lake Massaciuccoli and along the left and right banks of the Serchio River for approx. 2,435 ha. The overall equipped area is 947 ha, distributed as follows: 58% in the river basin of the Plain of Lucca and the remaining 10% in the river basin of Moriano.

The extension of irrigated surfaces and volumes are unknown.

5.2 Characteristics of irrigation schemes

The irrigation schemes of this River Basin are Massaciuccoli and the left and right bank of the Serchio River, which has a series of channels extending for a total length of 81 km. They were built between the late 1800 and early 1900(s) as reclamation and irrigation channels. The scheme of Massaciuccoli (Figure 5.1) abstracts waters from the Lake Massaciuccoli and also from the Channel of Barra-Barretta. The main network extends for approx. 10 km and consists mainly of earthen channels

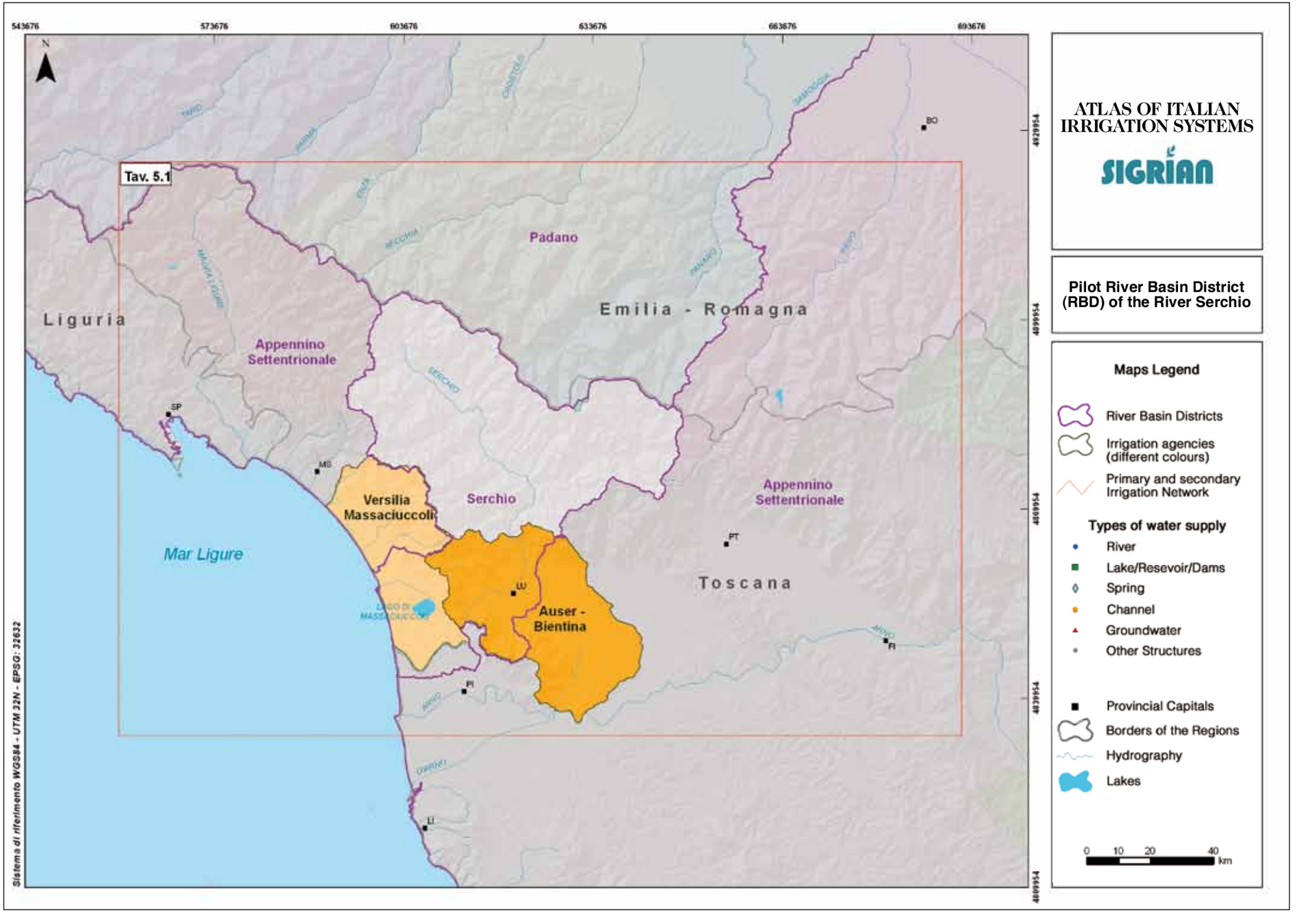
27 Directives EC 2000/60, 2001/42, 2003/4, 2006/118, 2007/60, 2008/105.

with little riparian vegetation. Besides serving irrigation purposes, the Channel of Barra-Barretta and the Channel Allacciatore of Massaciuccoli supply along their course mainly to reclaim and return water to the natural hydrological network (INEA, 2008c).

Right and Left schemes of the Serchio River are directly fed by the Serchio River through 2 different abstraction points displaced respectively, one along the right bank, the other along the left. The main net (primary and secondary network) stretches for approx. 14 km. 84% of the channels extends along the left bank of the Serchio River, suppling the Plain of Lucca, whereas the remaining 16% is along the right bank and supplies the area of Moriano (Figure 5.1). The scheme of the Left bank of the Serchio abstracts waters from bypass discharge channel of a hydroelectric power station called Public Conduit (*Condotto Pubblico*), from which originates a cluster of secondary distribution network (among the major branches are the *Canale Nuovo*, the *Canale Fanuccio* and the *Canale Soccorso*). The conveying network extends for approx. for 7.2 km, followed by 52 km (it is a partial measuring) of a dense distribution network. Along the right bank of the Serchio River it is the *Canale Moriano* that delivers water and the primary and secondary network consists of 5 distribution trenches. Water abstraction is carried out through a fixed barrier along the right side of the River nearby Tofani.

Map annex
of Chapter 5

FIGURE 5.0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Tav. 5.1
Padano
Liguria
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Appennino Settentrionale
Versilia Massaciuccoli
Serchio
Appennino Settentrionale
Mar Ligure
Toscana
Auser - Bientina
SP
MS
LU
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LI
Sistema di riferimento WGS84 - UTM 32N - EPSG: 32632
ATLAS OF ITALIAN IRRIGATION SYSTEMS
SIGRIAN
Pilot River Basin District (RBD) of the River Serchio
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River Basin Districts
Irrigation agencies (different colours)
Primary and secondary Irrigation Network
Types of water supply
River
Lake/Resevoir/Dams
Spring
Channel
Groundwater
Other Structures
Provincial Capitals
Borders of the Regions
Hydrography
Lakes
0 10 20 40
km

FIGURE 5.1

SIGRIAN – INEA

Chapter 6

River Basin District (RBD) of the Central Apennines

6.1 Overview

The River Basin District (RBD) of the Central Apennines consists of the river basin of the rivers Tiber, Tronto, Sangro, Potenza, Chienti, Tenna, Ete, Aso, Menocchia, Tesino and minor basins in the Regions of Abruzzo, Lazio and Marche. Its administrative area is about 2.8 million hectares and includes portions, more or less extensive, of 7 regions (River Basin Authority of the Tiber River, 2010):

- Abruzzo: Provinces of L'Aquila, Pescara, Chieti and Teramo;
- Emilia Romagna: Province of Forlì-Cesena;
- Lazio: Province of Frosinone, Latina, Rieti, Rome and Viterbo;
- Marche: Province of Ancona, Macerata, Fermo and Ascoli Piceno;
- Molise: Province of Isernia;
- Tuscany: Province of Arezzo, Grosseto and Siena;
- Umbria: Province of Perugia and Terni.

The area of the District is crossed by a hydrographic network largely modified by human activities, such as irrigation, reclamation and the development of productive activities, but most of all by modifications for hydroelectric purposes that for decades have affected surface flow. Already in the early years of the last century, a series of hydraulic regulation works were initiated for the production of hydroelectric energy.

In the Tyrrhenian part of the District, the landscape is characterized by the presence of great land reclamation works completed in the 40s in the Pontine and Fondi Plains where marshes stretched, allowing for a solution for the problem of malaria, human settlements of medium size, and the development of consistent irrigation and agricultural activities. For the execution, maintenance and operation of public works reclamation — in addition to the interventions of state authorities — numerous Consortia for water engineering works were operational and once past the first phase in which reclamation activity was directed mainly to rehabilitate and reorganize water works, they were replaced over the years by land reclamation consortia. Following reorganization and mergers and pursuant to current regulations the latter manage irrigation practices with cooperative forms of associations.

Beginning from the second post-war period onward, given the modest efficiency of groundwater and springs — especially found in the northern part of the River Basin District — the Southern Development Fund (the Italian Cassa per il Mezzogiorno) planned numerous works, such as artificial reservoirs and lakes (some of which are still today in the development phase). The works aimed to collected surface water runoff in order to be reuse at times when most needed and to increase the irrigated area in an adequate manner.

In general, therefore, greater water availability currently derives besides from surface network, also from these natural and artificial reservoirs.

Water bodies are evenly distributed in this area, and the most important rivers serving irrigation purposes are Tiber, Liri-Garigliano, Volturno, Tronto, and Sangro. Natural and artificial lakes are different in size and storage capacity. Among those important for agricultural and hydrological exploitation are: in the territory of Abruzzo Region, the Lake Bomba sul Sangro and Lake Penne on the Tavo River; in the Tuscany Region, the Lakes of Montepulciano and Chiusi in the province of Siena, and the Orbetello Lake in the province of Grosseto. The most important irrigation reservoirs in the District include Montedoglio on the Tiber River in the province of Arezzo in the Tuscany Region, and Lake Trasimeno, situated in the central West area of the Umbria Region, that represents another main source of water supply for irrigation in Central Italy.

In the territory of the District and above all in the valleys, there were many underground channels, used for irrigation and for milling wheat and corn through milling practices (INEA, 1965). Overall, irrigation has always been autonomous being mainly self-regulated by individual farmers equipped with supplies largely made up of wells and their own systems and distribution networks. Given the current political and structural framework, this situation represents today one of the most critical factors. In fact, autonomous irrigation is not part of the planning activities for the use of resources at the level of River Basin District (RBD) and remains beyond the control and management and, in the event of inefficient usage, is the cause of environmental concern (such as salinization of waters due to excess withdrawals, loss of soil

fertility) and the inability to better manage water crises. In this area collective irrigation had limited development and, in fact, is concentrated in the downstream areas of the major rivers and along the coastal plains where irrigated agriculture takes on the forms of intensive and single crop agriculture.

Cooperative irrigation is currently managed by 16 irrigation authorities (Table 6.0), most of which are represented by reclamation and irrigation consortia, 2 mountain communities (Valtiberina Toscana and Alto Tevere Umbro) and an irrigation consortium (Aso, Tenna and Tronto Valley). In Marche Region, consortia do not perform remediation activities. There are inter-regional irrigation authorities such as the Val di Paglia Superiore (18% falls within the Tuscany Region and the remaining part in the Lazio Region), the reclamation consortium *Val di Chiana Romana* and *Val di Paglia* (16% falls within the Tuscany Region and the remaining part in the Umbria Region, but irrigation systems are only present in Umbria), and the Tevere-Nera (92% of whose administrative area falls within the Region of Umbria and the remaining part in the province of Viterbo, but irrigation equipment are present only in Umbria). Special cases are made by Marche Consortium *Musone-Potenza-Chienti-Asola-Alto Nera*, that falls partly in the River Basin District, but whose only area equipped for irrigation pertains to the Northern Apennines District (see Chapter 4), and the Water District Arezzo 1, managed by the Province of Arezzo that falls within the limits of the Northern Apennines Water District, but which draws from the Montedoglio scheme in the Tiber basin. Finally, we should highlight that Abruzzo Consortia *West* and *South* fall partially also in the Southern Apennines Water District (see Chapter 7).

The District has an equipped area amounting to approx. 142,000 hectares, while the irrigated area, corresponding to the part of the surface of the equipped area actually irrigated in the reference year, amounts to approx. 89,640 hectares, or 3% of the administrative area.

The coverage of the Water District territory with collective infrastructures, given by the ratio between the surface equipped for irrigation and the administrative area, is equal to a value of about 5%, which is much lower than the national average (16%) and that in all Regions of the District never takes exceeds 8% with the greatest values found in the territories of the agencies present in Abruzzo, in the plain of *Agro Pontino Laziale* and the upper part of the Umbria Region. The use of irrigation infrastructures, instead, that is to say the ratio between surface area actually irrigated and equipped, is equal to 63% (the national level is 71%) and within the River Basin District takes on values below 40% only in some areas between the Regions of Umbria and Marche, in the authorities located in Val di Chiana Romana and Val di Paglia and Musone-Potenza-Chienti-Asola-Nera, with the most irrigated areas located in the Adriatic side of the River Basin District, in Abruzzo Region (reaching 100% within the areas of the Enti Interno and Nord), and the Tyrrhenian coast of Lazio (68% in the *Tevere Agro Romano* and *Agro Pontino* Consortia). The irrigation systems currently adopted in the River Basin District share a certain uniformity in terms of utilized practice. As mentioned, in fact, following the Second World War, the problem of irrigation took on a predominant character in initiatives regarding land improvement for property enhancement, with the confirmation of more effective and efficient irrigation systems; high consumption practices were less and less used (such as flooding and infiltration) in favor of flowing and sprinkler (INEA 1965). To date, among those most used are sprinkler (78%), which constitutes the predominant system of all irrigation organizations, flowing (13%), which is present in the areas between the Regions of Abruzzo and Marche and in the Tevere-Nera, and localized irrigation (8%), present especially in the Umbria Region and in some agencies in the Lazio and Abruzzo Regions.

6.2 Characteristics of the irrigation schemes

The irrigation schemes in the District are medium and small in size both in terms of development and complexity of the irrigation network and in terms of underlying equipped areas (INEA 2008c). Overall, they present uneven structural characteristics depending on the type of water supply structure, the development of the network, the type of use and materials used. The primary and secondary and distribution of the water source for irrigation purposes in the District is guaranteed by 118 consortia schemes serving individual irrigated areas.

In the northernmost portion of the District fall two interregional schemes: Montedoglio (Tuscany and Umbria) and Elvella (affecting the Regions of Lazio and Tuscany).

The region of Umbria has 16 schemes; the sources of the most important Umbrian schemes consist of hydroelectric plants pipelines. Among these are the Marroggia scheme, whose source is the Marroggia stream reservoir managed by the *Bonificazione Umbra* Consortium in the Spoleto valley (Table 6.4), with a total capacity of approx. 6.3 million m^3, of which about 3.4 for irrigation purposes and 2.4 for flood control. The program of interventions foreseen by the Consortium was already cited in the framework described in 1965, and that provided for the creation of this reservoir that at the time was still in process of execution. The source of the Corbara scheme, managed by the Tevere-Nera Consortium, is the reservoir with the same name on the Tiber River completed in the 60s, and with total volume equal to 207 million m^3. In addition, the Nera-Sersimone and Nera-Cervino schemes, managed by the Tevere-Nera Consortium, source from 2

ancient Roman era channels , Cervino and Sersimone, located in the municipality of Terni, which derive the waters of the Nera River (Table 6.4).

In the northeastern part of the District, the river diversions take on a prevailing role. In the territory of Marche Region 10 schemes are present, of which the most important are the Destra and Sinistra Tenna 1, Aso 1 and 4, and Tronto, managed by the interregional Consortium Aso, Valle Del Tenna and Tronto (Figure 6.2). The water structure of the Destra Tenna 1 scheme was built in 1955 (in the map of irrigation in Italy The Map of Irrigation in Italythey were still listed in the development stage). Other two structures on the Tenna River, built out respectively in 1950 and 1990 in the municipalities of Falerone and Rapagnano (AP), constitute the source supply of the Sinistra Tenna 1 scheme. The Aso 1 scheme is fed by the waters of the Aso River; in the municipality of Force (AP), the diversion is accomplished through a structure created in 1979 that feeds the Media Valley of the Aso River. The source of the scheme Aso 4 structure on the river Aso called Guado Carassai, and 5 spring waters built in the 60s are mentioned in the the Map of Irrigation in Italy as irrigation alternatives in the province of Ascoli Piceno. Lastly, the Tronto scheme, powered by a structure on the river by the same name (in the municipality of Ascoli Piceno), was created in 3 construction phases during the period 1950-1993 (INEA, 2009a).

Moving toward the South, 26 irrigation schemes are present in the Lazio Region. In this area the Tiber River feeds various schemes, among which the greater is the Tevere 2, managed by the *Tevere Agro Romano* Consortium (Tables 6.4 and 6.6).

Other important structures on water bodies are located in Abruzzo Region. Here the irrigation schemes are 32 but the most important, in terms of area supplied and diversion channels, are Vomano, the deviation channel by Enel (7), Sangro 1, 2 and 3, Capo D'Acqua Dam 1 and 2, Foro, and Penne Dam on the Tavo River. The Vomano scheme is fed by the river by the same name with an structure near the town of Villa Vomano (Teramo), managed by the Consortium Nord (Table 6.3). The 7 derivation channel schemes of Enel are managed by the Consortium Centro and supply the areas of Vestina-Sx Pescara and Alento-Dx Pescara (Table 6.5) with the waters of the Pescara River taken in by the Enel pipeline. The schemes Sangro 1, 2, and 3 are managed by the Consortium South; they supply the area of Frentana and are fed by three structures: one directly installed on the exhaust pipe of Acea's hydroelectric plant (that exploits the waters of Lake Bomba), and two dikes (Serranella) on the Sangro River (Table 6.5). Lastly, an important role is played by the reservoirs: the Consortium Interno manages the Capo d'Acqua 1 and 2 Dam schemes, sourced by the springs of Capo d'Acqua (Table 6.3). In the Consortium Centro, the Penne Dam is powered by an artificial lake/reservoir on the Tavo River, with a storage capacity of 8.8 million m^3 and whose construction was foreseen within the irrigation possibilities of the Tavo Valley in 1965. The Foro scheme supplies the Val di Foro district: already in the Map of Irrigation in Italy of 1965 the need to extend irrigation practices to the entire valley had been manifested and, therefore, to increase the quantity of water to be used, as the supply through wells and diversions channels from the Foro River was insufficient. The creation of two reservoirs was envisaged that to date has not been built, and the scheme continues to be fed by the sources cited (well field and diversions from the Foro River) (INEA, 2008b).

At the District level, the water bodies reaching significant volumes in terms of withdrawals and areas supplied, from which water availability depends, are characterized by the presence of 136 structures.

Most of these withdrawals are from rivers (39.7%) and capturing groundwater sources (33.1%). There are also several reservoirs for irrigation (19, of which 1, i.e. the Montedoglio reservoir supplies 3 agencies). They constitute 14% of the total of sources, and abstractions from channels of hydroelectricity plants (12%). In terms of volume, the greatest availability in the RBD are concentrated in the regions of Tuscany, Umbria and Abruzzo (the Umbrian-Tuscan structure of Montedoglio, the structure on the Tiber River of the *Tevere Agro Romano* Consortium, the Sangro-Serranella structure in Abruzzo of the South Consortium), and are guaranteed by the water bodies and by channels of hydroelectric plants.

The main network (primary and secondary) is not particularly developed (especially when compared to that of Northern Italy) and, in fact, is characterized by a development of about 1,192 km, all exclusively for irrigation purposes, with the exception of 23.5 km of network in the plain of *Agro Pontino*, used for both reclamation and for irrigation. The irrigation network of the District consists largely of pipes (about 870 km), while the open channels constitute about 203 km of the main network. The network is efficient and modern only in certain areas (the Montedoglio interregional scheme of national importance and, in general, in Abruzzo and Lazio), while there are different situations in need of restructuring, modernization and adapting in the primary, secondary and distribution systems.

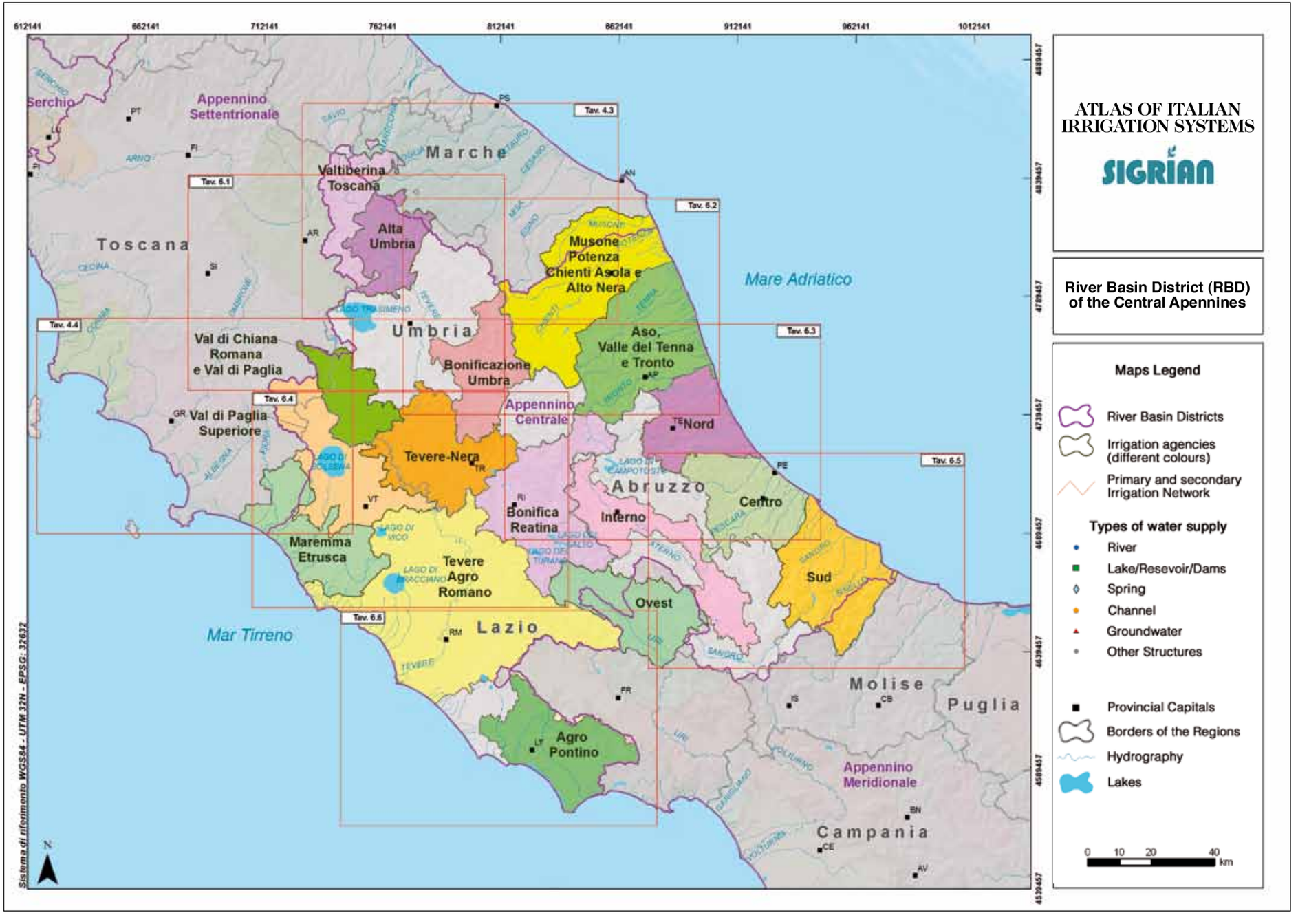
6.2.1 Interregional irrigation schemes

As mentioned, 2 interregional irrigation schemes are in the area of the District, the most important of which is the Montedoglio scheme which supplies the Province of Arezzo Tiber valley and the mountain communities of Valtiberina Toscana and Alta Umbria (Table 6.1). The scheme, together with that of Chiasco (that interests only Umbria), was designed as part of the General Irrigation

Plan drawn up by the Umbrian-tuscan irrigation authority Umbria and Tuscany (EIUT) in 1965. It identified 2 major relief factors of the terrain (orographic areas) of the Tiber basin, falling in both Tuscany and Umbria, considered suitable for irrigation and called "western irrigation system" and "eastern irrigation system". The water supplies of the Montedoglio scheme are represented by the reservoir of Montedoglio on the Tiber River and by the structure on the Sovara stream. The reservoir on the Tiber River was built in the vicinity of Montedoglio in the municipality of Pieve S. Stefano (Arezzo) during the period from 1978 to 1993, and currently has useful capacity of 142.5 million m^3. The reservoir on the Sovara stream was built between 1981 and 1992 in the municipality of Anghiari (Arezzo), where the lake formed by dam-building has a surface area of 25,000 m^2 and a useful capacity of 167,000 m^3. The reservoir on the Tiber and the small abstraction on the Sovara stream/ are connected through a tunnel at the Plain of Arezzo where the irrigation network has origin and which supplies the *Distretto1-Arezzo*. This last stretch is still being completed and at the conclusion of the work will allow for water to be brought to the Val di Chiana senese and romana Valleys and then in Umbria, and the surrounding area of Lake Trasimeno. Along the network there are 13 compensation tanks, one of which supplies the Province of Arezzo, 3 of the upper Tiber Valley and 9 of the higher portion of the Tiber in Umbria. From these the authorities make withdrawals to supply their respective districts. The length of the principal network detected in the Sigrian is about 96 km, covering both the sections of primary and secondary network. Primary and secondary network develops for the most part in the Tuscan territory (73%), while the secondary and distribution in Umbria (70%) (INEA 2008c; Inea, 2008d). The other interregional scheme of the District develops between the regions of Lazio and Tuscany and uses the waters of the Elvella reservoir in the Tiber basin. It is managed by the interregional Consortium of Val di Paglia Superior (Figure 6.4). The construction of the reservoir, located on the border between Lazio and Tuscany, dates back to the end of the 50s but came into operation the 70s (INEA, 2007b).

Map annex
of Chapter 6

FIGURE 6.0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Appennino Settentrionale
Marche
Valtiberina Toscana
Toscana
Alta Umbria
Musone Potenza Chienti Asola e Alto Nera
Mare Adriatico
Umbria
Aso, Valle del Tenna e Tronto
Val di Chiana Romana e Val di Paglia
Bonificazione Umbra
Appennino Centrale
Val di Paglia Superiore
Nord
Tevere-Nera
Abruzzo
Centro
Bonifica Reatina
Interno
Maremma Etrusca
Tevere Agro Romano
Sud
Ovest
Mar Tirreno
Lazio
Molise
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Agro Pontino
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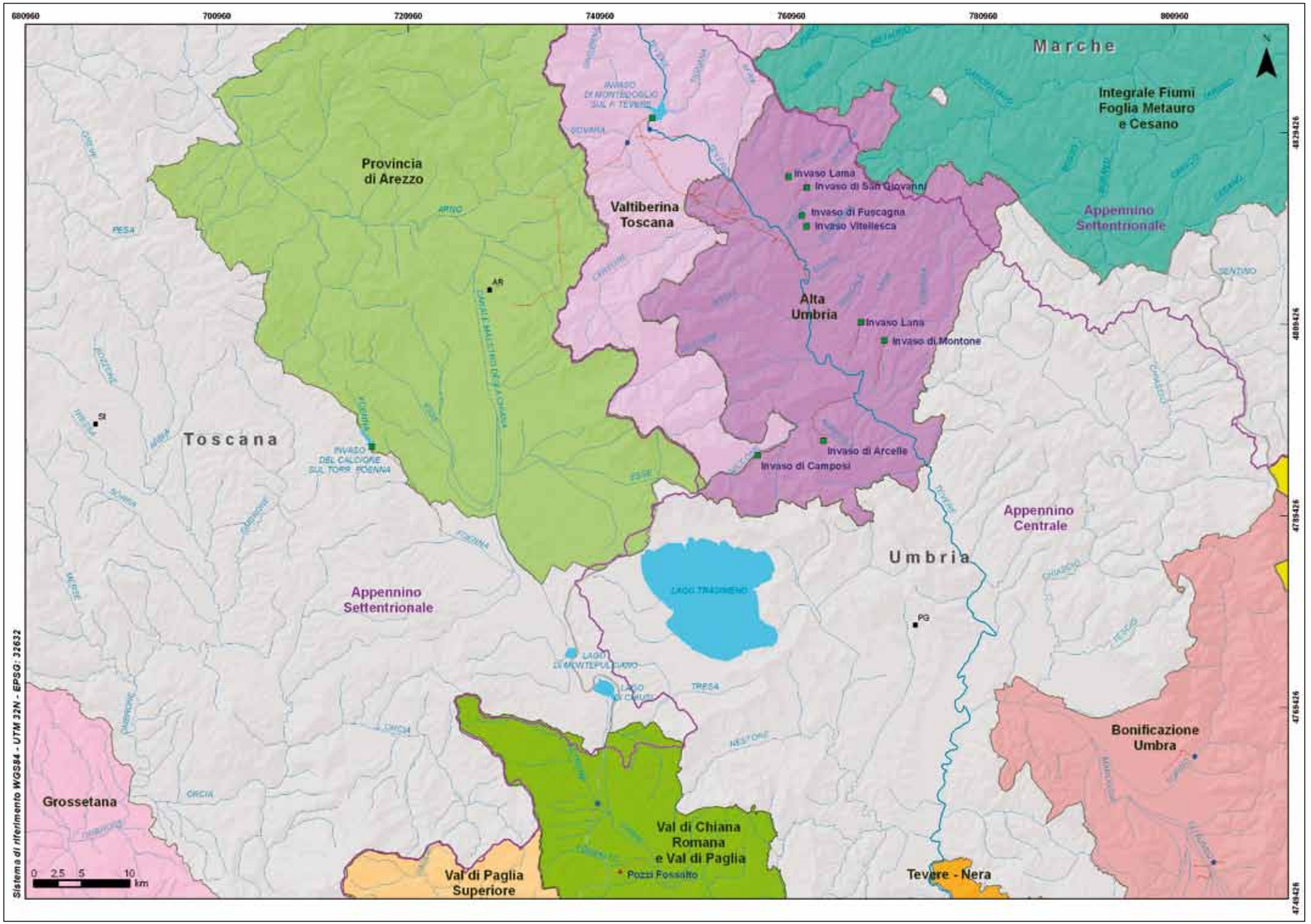
ATLAS OF ITALIAN IRRIGATION SYSTEMS
SIGRIAN
River Basin District (RBD) of the Central Apennines
Maps Legend
River Basin Districts
Irrigation agencies (different colours)
Primary and secondary Irrigation Network
Types of water supply
River
Lake/Resevoir/Dams
Spring
Channel
Groundwater
Other Structures
Provincial Capitals
Borders of the Regions
Hydrography
Lakes
0 10 20 40
km

FIGURE 6.1

SIGRIAN – INEA



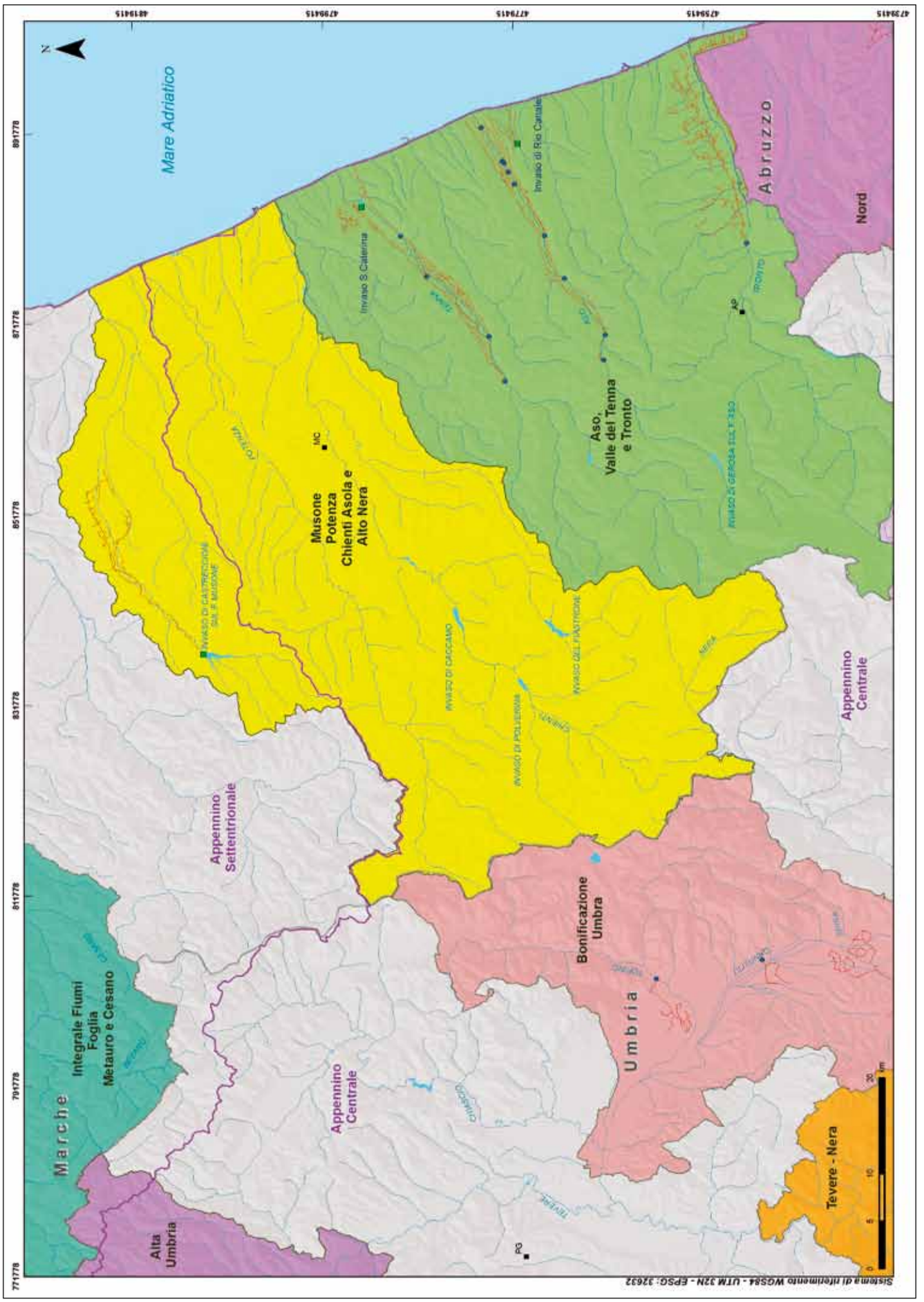
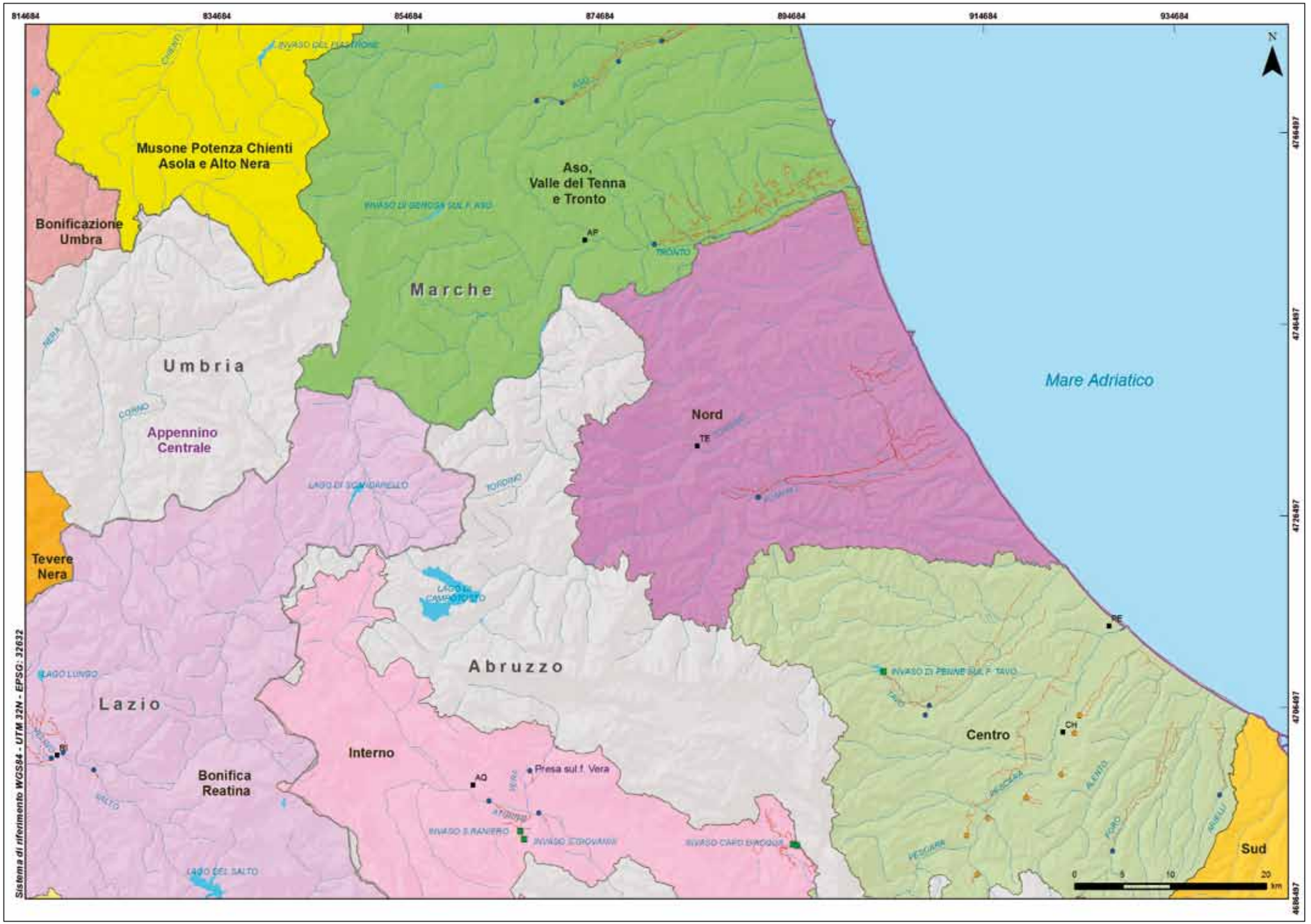


FIGURE 6.2

SIGRIAN – INEA

FIGURE 6.3

SIGRIAN – INEA



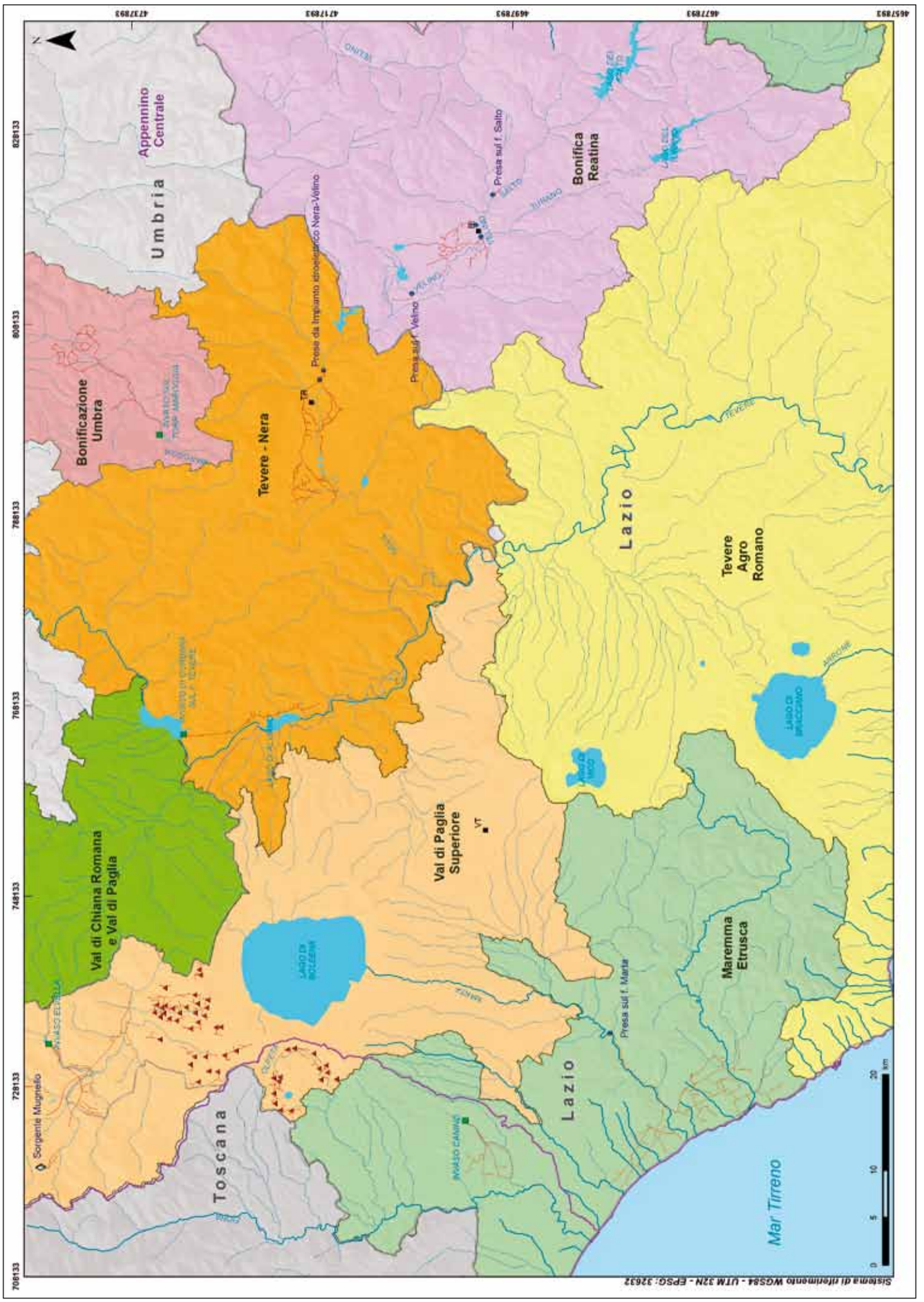
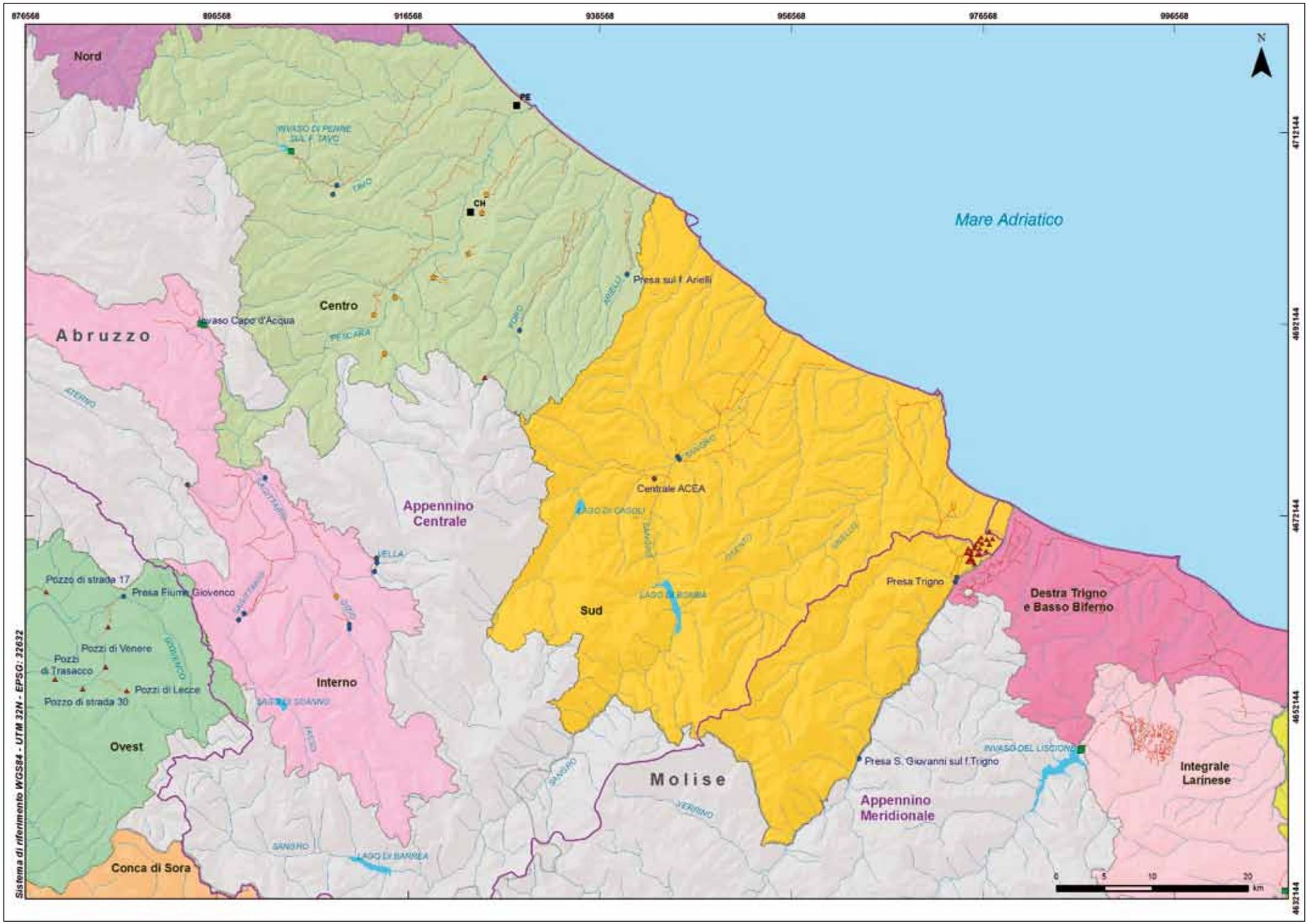


FIGURE 6.4

SIGRIAN – INEA

FIGURE 6.5

SIGRIAN – INEA



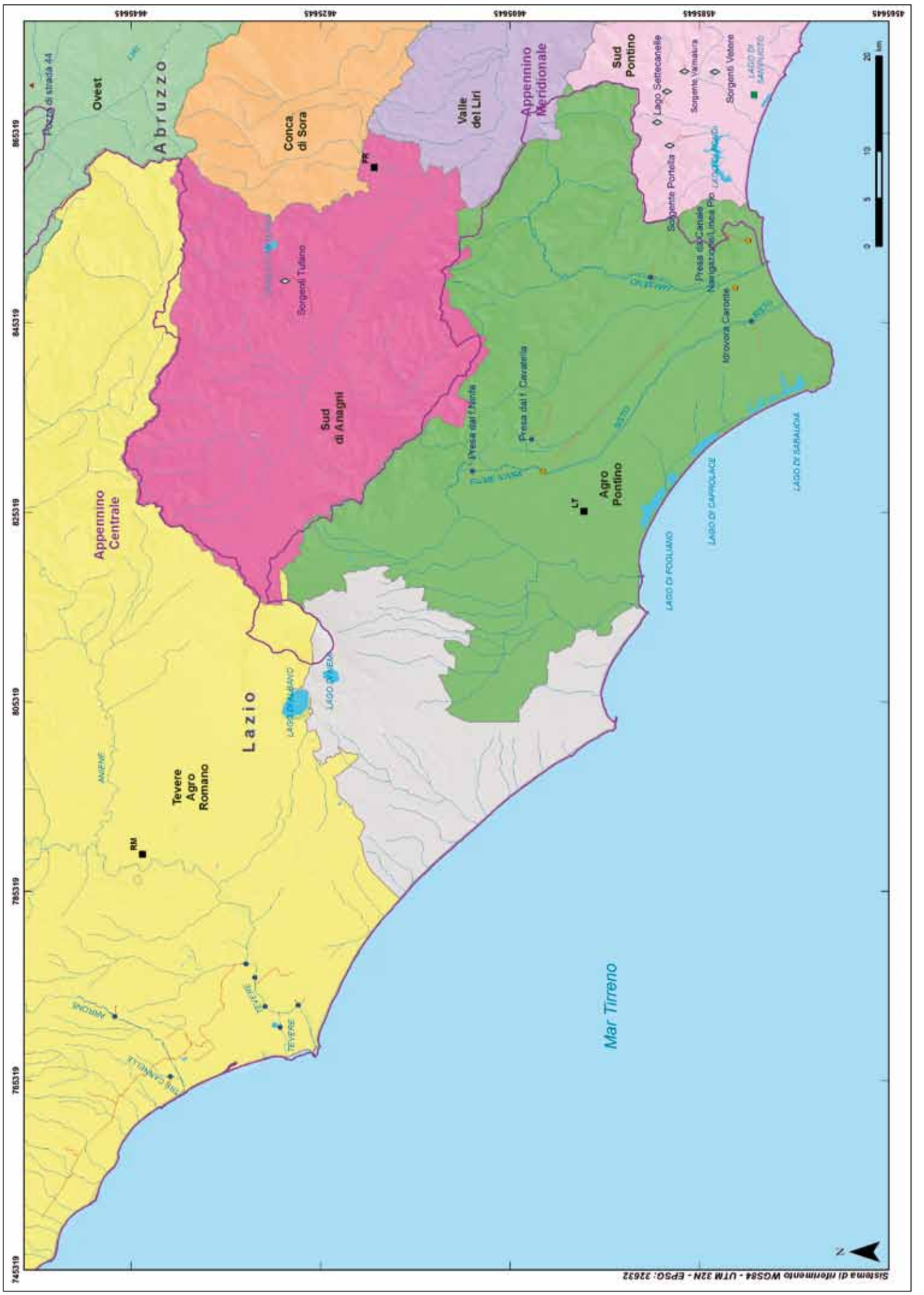


FIGURE 6.6

SIGRIAN – INEA

Chapter 7

River Basin District (RBD) of the Southern Apennines

7.1 Overview

The River Basin District of the Southern Apennines covers an overall surface area of approx. 5.3 million hectares and includes the river basins of the rivers Liri-Garigliano, Volturno, Sele, Noce, Agri, Bradano, Sinni, Saccione, Fortore and Biferno, Ofanto, Lao, Trigno, and the minor basins of Calabria Basilicata, Campania, Puglia, and Molise (Figure 7.0) (Liri-Garigliano and Volturno basin Authority, 2010.)

The District completely includes the following regions:

- Campania;
- Puglia;
- Basilicata;
- Calabria;
- Molise, almost completely (97%)
- Lazio (21%) in the provinces of Frosinone, Latina and Rome;
- Abruzzo (15%) in the provinces of the Aquila and Chieti.

Water availability of the District is in a critical situation due to a series of problems that historically affect the territories in question. Some areas suffer from frequent lacks and water crises that are not always traced to the unfavourable climate characteristics, and the quantity of water resources thus are not sufficient to guarantee the meeting the agricultural needs.

Many factors contribute to this condition of deficit, such as the presence of unauthorized withdrawals, the structural and technological obsolescence of the primary, secondary and distribution networks and the high losses, their failure to be completed, the scarce maintenance and the inadequacy of some accumulation and reserve systems, and finally the low quality of the resource due to abusive withdrawals.

For the purposes of the recovery and of the water reclamation of the territories, beginning in the first years of the century, many interventions were performed, allowing people to stay in the countryside and in the swamp areas, with the creation of residential areas, causing deep and evident changes in the landscape and contributing permanently to form the current scene. The rather serious situation causes the problem of the low availability of resources to be experienced also at the level of the use planning. Already in the early 1900s the transfer of the resources toward Puglia was planned (a region historically suffering from water shortages) and toward the Naples areas, and years afterward, since post World War II, the *Cassa per il Mezzogiorno* began to be occupied with transferring the resources and interconnection of various water bodies systems.

The current assessment of the water systems delivering the water resources (drinking and irrigation) sees Campania at the centre of an articulated system of interregional exchanges of resources superficial and underground with importation and exportation of huge amounts water respectively from Lazio and Molise and toward Puglia, thanks to a series of Draft Program Agreements between the parties, many of which are still being defined (Basin Authorities of the Liri-Garigliano and Volturno rivers, 2010).

Also, to ensure the availability of water during droughts were executed by the Cassa per il Mezzogiorno, still in post-World War II, important projects of damming water bodies and artificial reservoirs intended for the accumulation of water resources intended to meet the water requirements of the various users.

The most important rivers of the River basin district are:

- Lao (Basilicata and Calabria);
- Sinni (Basilicata, Calabria and Puglia);
- Ofanto (Basilicata, Campania and Puglia);
- Bradano (Basilicata and Puglia);
- Agri (Basilicata);
- Sele (Campania);
- Liri-Garigliano (Campania and Lazio);
- Volturno (Campania and Molise);
- Fortore (Molise and Puglia).

The main natural and artificial reservoirs in Abruzzo include San Giovanni Lipioni and of Pietrafracida on the Trigno River, the Lago Saetta, the reservoir S. Pietro on the Osento River (affluent of the Ofanto), the reservoirs San Giovanni, the Fosse and Fabbrica on the Palistro River and that of Piano of the Rocca on the Alento River in Campania, the reservoir of the Liscione on the Biferno River and the reservoir of Occhito on the Fortore in Molise, the reservoir of the Celone on the stream of the same name in Puglia, the Lucania reservoirs of Monte

Cotugno, of the Pertusillo on the Agri, of Abate Alonia on the Rendina, of S. Giuliano on the Bradano and Gannano on the Agri, and finally the of Calabria reservoirs Monte Marello on the Angitola, Tarsia on the Crati, Farneto of the Principe and Cameli on the Esaro, and Passante on the Alli.

A vital role for the irrigation availability of the District territories, in addition to the natural and artificial reservoirs, is finally assumed by the groundwater, given the evident lower development of the superficial river basin network compared with the north-central regions, in particular in the Salento in Puglia. The huge withdrawals from private wells, often uncontrolled and unauthorized, in some areas are the cause of problems of environmental nature, such as the lowering of the groundwater level, intrusion of the sea in the coastal areas and the depletion of the underground and soil water resources, with consequent environmental damage, often irreversible.

The collective irrigation is organised and managed by 39 Reclamation consortia and irrigation, including the Lazio and Abruzzo Consortia that fall partially in the river basin district (South and West in Consortia Abruzzo and Conca di Sora, Valle dei Liri, South Pontino and South Anagni in Lazio) (Table 7.0).

The equipped surfaces of the District, i.e. that part of the administrative surfaces in which there are the projects needed for exercising irrigation practice, amount to approximately 438,000 hectares, while that irrigated is equal to approximately 208,000 hectares, approximately 4% of the administrative surfaces.

The coverage of the territory of the River basin district with collective infrastructures, date of the relationship between the surfaces equipped for the irrigation and the administrative surfaces, arrives at a value equal to 8% approximately, lower than the national average; this is nearly marginal in Campania, that is equipped with consortium networks for a value that does not exceed 3%, assumes slightly higher values (between 7 and 11%) in Basilicata, Calabria, Lazio and Puglia, while they are more significant in the area more to the North of the District, i.e. in Molise (27%).

Finally, the degree of use by the Irrigation agencies, thus the recourse to the irrigation infrastructures, given the relationship between surfaces effectively irrigated and equipped, globally assume a value of 48%; it is quite high in the northwest part of the District, i.e. in Campania and Lazio (more than 65% approximately), and instead assumes average values in the other regions of the District (between 38 and 48%), with a national value of 71%; these values are associated with specific supply problems of some areas or reduced use of the network.

Regarding the irrigation systems adopted in the areas of the District with collective irrigation; among those most used are those with low consumption. Already in the framework of the situation outlined in 1965 by the Irrigation Map of Italy, the high-consumption systems such as flooding and infiltration were practically no longer used, and in the regions of the District the flow and rain methods were much used. The evolution toward high-efficiency systems, thanks to the technical characteristics of the networks created (exclusively for irrigation use and consisting primarily of pipes), as well as investments made, brought localized irrigation at 48%, constituting the system prevalent in all the irrigation agencies, following sprinkler (44%), flowing (4%), and finally infiltration (3%, primarily adopted in Campania).

7.2 Characteristics of the irrigation schemes

The irrigation schemes of the District are of medium dimensions, in general serving individual irrigation areas (districts), and often various among them for territorial value, for available water volume and for intended use of the same water resources (multiple use; i.e. drinking, irrigation or industrial). There are 227 schemes that fall in the territory of the River basin district and pertain to all the regions. Those of larger dimensions, as well as the most significant in terms of pressure capacities and areas served are described below.

The central part of the District is characterized by greater coverage of the territory with collective irrigation schemes; in this area there are two interregional schemes, the Jonico-Sinni (Calabria, Basilicata and Puglia) and the Ofanto (Basilicata, Campania and Puglia).

The Calabria currently presents 51 schemes. The analysis of the situation in the 1965 Irrigation Map of Italy delineated a program of interventions intended to extend the irrigated areas in the regional territory, in part with projects being executed and mostly of future performance (INEA, 2002e). To date these projects, mostly created and functioning, constitute important sources of supply of the Calabria irrigation schemes. Between these recall, in the Plain of Sibari and in the middle Valle dei Crati, both managed by the Northern Reclamation Consortium basins of the Cosentino: the Tarsia reservoir of on the Crati, having capacity of 75 million m^3, that at the time was being executed, and the dike on the Esaro, having a capacity of 38.8 million m^3, of which at 1965 still must begin work (Figure 7.9). Also, in the Plain of S. Eufemia, we recall the Angitola scheme, served by the reservoir of the same name of the capacity of 15,7 million m^3, being executed at the time of the Irrigation Map of Italy of the 1965, and managed by the Jonio Catanzarese Reclamation Consortium (Figure 7.10) (INEA, 2002e).

In the territory of Lucania the irrigation schemes are 38 (INEA, 2002c); of these recall the Basento-Bradano scheme managed by the Bradano Metaponto Consortium, that ha as sources the reservoir of Serra del Corvo, of useful capacity of the reservoir of 25 million m^3, and the

free flow of the Basento River (Figures 7.3 and 7.6), is also characterized by projects such as reservoirs and dike still in execution. Another significant scheme is Agri-Pertusillo, which mostly involves the lower part of the Metapontino, bordering Calabria (Municipalities of Scanzano, Policoro and part of Nova Siri). The scheme is fed by the flow issuing from the Pertusillo reservoir (useful reservoir capacity of 155 million m^3) on the Agri River, managed by the Irrigation body.

The residual flow is intercepted from the Gannano reservoir, of 10 million m^3 capacity, managed by the Consortium Bradano Metaponto (Figure 7.6) (AA.VV., 2002a).

In the Puglia Region there are 80 irrigation schemes (including the interregional Ofanto, Jonico-Sinni, and the Fortore with the Molise Region), while between those that belong exclusively to the Puglia territory there are various smaller water schemes, in execution, prepared in limited areas, in which is used primarily groundwater drawn from wells (INEA, 2000). Among these we recall the Idume scheme, managed by the Reclamation Consortium of Ugento and Li Foggi (Figure 7.8) that would affect the area to the North of Lecce, through the performance of a series of projects: capture projects (from the Idume spring, the maximum design which of was begun in the 1960s, as recorded in the Irrigation Map of Italy of the 1965), annual compensation projects (crown reservoirs) and third party wastewater treatment projects (residential area of Lecce). We also recall the Carapelle scheme, located in the south-central part of the Tavoliere (of the Capitanata Consortium), that would have as its supply source the reservoir on the Carapelle, near the Masseria Tufarelle, and the reservoir on the Cervaro stream (Table 7.1). The aforementioned reservoir was identified as work to be performed, necessary for the extensions of the regional irrigation possibilities, as recorded in the 1965 Irrigation Map of Italy.

In the Adriatic slope of the River basin district, the supply from the rivers assume a prevalent role regarding the rest of the sources, with the important exception of the Puglia, poor in surface network and substantially dependent of the contribution of water from the bordering regions through interregional schemes (see Paragraph 7.2.1).

In Molise, there are 4 district irrigation schemes (INEA, 2002b), among which is recalled the Biferno scheme, that enters exclusively in the Molise territory. The source is the Liscione reservoir, of 258.93 million m^3 capacity (Table 7.1); this was provided in the framework delineated by the 1965 Irrigation Map of Italy, as an additional source of supply to be executed for the irrigation of the lower Biferno valley; was then built in the municipality of the same name, Agro di Larino, and constitutes the primary irrigation resource of the larger irrigation district of the Molise managed in part by the Right Trigno Reclamation Consortium and the Lower Biferno and in part by the Comprehensive Larinese Reclamation Consortium (Inea, 2002b).

Additionally, we recall the Left Trigno scheme in the Abruzzo Region, managed by the South Reclamation Consortium (Table 7.1) (INEA, 2008b). The sources are with wells and the S. Giovanni dam on the Trigno River that allow serving the aforementioned irrigation district of Vasto. Another important source in Abruzzo is the Giovenco River, which feeds the scheme of the same name, managed by the West Reclamation Consortium of the Region Abruzzo (Table 7.2). This scheme falls exclusively in the part in Abruzzo of the River basin district, along with another 3 still managed by the Consortium itself, and one, the Left Trigno scheme, managed by the Consortium South (INEA, 2008b).

In the Campania part of the District, among the 25 regional schemes are recalled those of the Lower Volturno, Right Sele, and Paestum, fed by the Volturno, Sele, Tusciano and Calore Rivers (INEA, 2001b; INEA, 2001c). The Lower Volturno scheme is managed by the Lower Basin Reclamation Consortium of the Volturno, and serves the areas falling in the province of Napoli and Caserta. Serving the municipalities of the province of Salerno there are the Right Sele and Paestum schemes. The first, the Right Sele scheme, is managed by the Right Sele River Reclamation Consortium, and ha as sources the rivers Sele and Tusciano (Figures 7.4 and 7.7).

The second, the Paestum scheme, is managed by the Consortium Paestum Left Sele, the sources of which are the Calore River, and, naturally, the Sele River (Figure 7.7). The dike on the Calore River in Agro di Fellitto (Salerno), is among the projects foreseen for the expansion of the surface irrigation recovery in the 1965 Irrigation Map of Italy.

Finally, still on the Tyrrhenian slope of the District, we find the 23 irrigation schemes of the Lazio Region, among which are the Liri 1 scheme in Frosinone province, that draws the water from the river of the same name, and is managed by the Conca di Sora Consortium (Figure 7.2), while in the south eastern area of the region, the Valle dei Liri Consortium (Figure 7.2), that manages seven schemes, each fed by the water of the rivers Sacco, Cosa, Amaseno, Melfa and Gari (INEA, 2007b). The most relevant irrigation scheme in terms of extension, is the Gari scheme, fed by the Gari River, the dam project of which intercepts the branch of the river in the municipality of Cassino, in Frosinone province.

Regarding the origin of the irrigation resources, the creation of many imposing artificial reservoirs characterises the entire history of southern irrigation, as a factor of agricultural development considered essential to counter the adverse climatic characteristics and the frequent drought events that have always characterized the southern regions. Despite the investments made, in various areas a critical report remains between water avail-

ability and irrigation requirements, in particular in the last twenty years, during which a general and progressive reduction was seen of the resources accumulated in the reservoirs and of the capacities of the water bodies, which was accompanied, simultaneously, by an increase in the civil and industrial requirements.

Especially in some regions (Calabria, Puglia), a certain prevalence of autonomous irrigation is seen compared with collective irrigation, in terms of agricultural irrigation that use independent sources (mostly wells, thus with withdrawals from the underground water).

This situation represents a serious problem, in that the autonomous irrigation does not participate in the activity of planning the use on the scale of the river basin and escapes control and management, giving rise not only to problems of environmental nature, but also limiting the capacity to manage any water crises.

In the RBD of the southern Apennines, significant withdrawals in terms of amounts drawn and areas served, come from 786 sources of supply irrigation (dam projects) on superficial and underground water bodies.

In numerical terms, the withdrawals consist essentially by groundwater capture (72.1%) and water bodies (12.6%), followed by the withdrawals from the spring (7.3%), from channels/conduits of hydroelectric centres (5%), and from the reservoirs (2.7%). To guarantee a majority of the availability, especially in Basilicata, in Puglia and in Molise, there are the reservoirs made since the middle of the past century from which important interregional schemes depart.

The main irrigation network (primary and secondary) covers the territory of the River basin district in a less widespread manner, being developed to a limited extent, with an extension of approximately 4,198.5 km, nearly exclusively for irrigation use. The network consists mostly of pipes (79%), and open channels (approximately 15%). In the last decades there have been significant steps forward both on the structural level (which requires huge additional investments) and technological and administrative adaptation (remote control, contribution to consumption). Overall, it can be affirmed that the irrigation network in southern and insular Italy consists of a good structure, although sometimes deteriorated, and that the pertinent infrastructural investments made to date have allowed improving the level of the water schemes and use of the water at the farm level.

7.2.1 Interregional irrigation schemes

In the territory of the District there are many interregional irrigation schemes.

The interregional scheme mostly developed involves the areas of Calabria, Lucania and Puglia, and the Jonico-Sinni, fed by 3 rivers of the Basilicata, the Sinni, the Agri and the Bradano (INEA, 2000; INEA, 2002c; INEA, 2002e).

This scheme provides for the feeding of a vast territory including the Jonic area of the Basilicata and Puglia, the Salento and in part the Jonic Calabria area. The system originates from the Monte Cotugno reservoir in Basilicata (Table 7.6) having useful capacity of 430 million m^3 and receiving the water of the Agri and Sinni rivers, and of the Sarmento stream. To date there is an agreement in effect between the Basilicata and Puglia Regions for the use of the reservoirs of Lucania, the management of which is entrusted to the Lucania "Water spa" company. Within the territory of Calabria the Jonico-Sinni scheme serves the area between Rocca Imperiale and Trebisacce (and is managed by the Jonio Cosentino basins Reclamation Consortium).

The Pertusillo reservoir is cited among other important projects; the resources of which are involved in withdrawal by the Bradano-Metaponto and Alta Val d'Agri Consortia. This reservoir was provided in the 1965 Irrigation Map of Italy among the projects to be performed to extend the irrigation into the Metapontino area.

Another scheme with interregional impact is the Ofanto scheme that serves the Campania, Lucania and Puglia areas (INEA, 2000; INEA, 2002c; INEA, 2001a and 2001b). It is fed from the reservoir of Conza (Saetta Lake) in Campania, having useful capacity of 4.5 million m^3, managed by the Irrigation body in Puglia Lucania and Irpinia, and the S. Pietro reservoir on the Osento River (useful capacity of 14 million m^3) still in Campania, but managed by the Puglia Reclamation Consortium of the Capitanata (Table 7.4). These two reservoirs, currently functioning, were identified as future projects in 1965. The rainwater scheme also on the functionality of the Santa Venere dam, performed on the branch of the Ofanto River in Rocchetta Sant'Antonio municipality, in the territory currently of competence of the Reclamation Consortium of Lucania of the Voltura Alto Bradano (Table 7.4). the territories served are Lucania and Puglia of the Middle and Lower Ofanto, since the scheme includes the Rendina reservoir (Consortium Voltura Alto Bradano) in Basilicata, having useful capacity of 21.8 million m^3 (Figure 7.3), Lower Marana Capacciotti (Reclamation Consortium of the Capitanata), having useful capacity of 46 million m^3, and Locone (Reclamation Consortium Terre d'Apulia) having useful capacity of 105 million m^3 in Puglia (Figure 7.3).

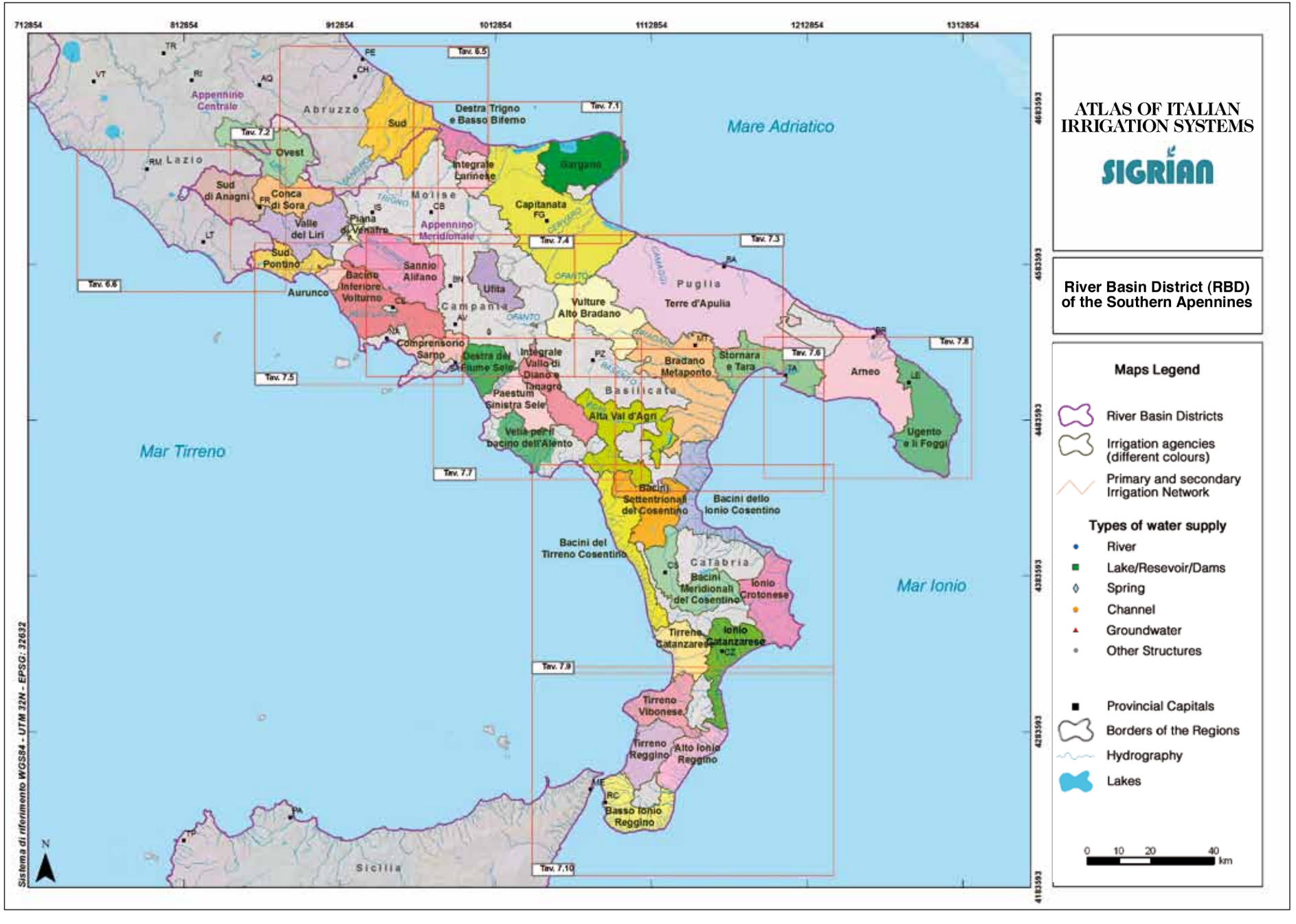
A scheme that involves the territories of Puglia and Molise is the scheme Fortore, that serve the districts irrigation of the Fortore (Consortium of the Capitanata in Puglia) and of the Larinese Consortium (Molise) (INEA, 2000; INEA, 2002b). The sources of supply consist of the Occhito reservoir, on the Fortore River, and of the reservoir of the Celone on the stream of the same name (Figure 7.1). The Occhito reservoir, managed by the Consortium

for the recovery of the Capitanata (Puglia), created in the 1950's, and having useful capacity of 250 million m^3.

Overlapping the Regions Lazio and Campania the Garigliano interregional scheme was developed, fed by the dam on the river of the same name, performed in the period 1933-1941 (INEA, 2001c; INEA, 2007b). The scheme is managed by the interregional Aurunco Reclamation Consortium that serves 4 districts, Right Garigliano, Aurunco, Cellole and the eastern area (Figure 7.5). The water of the Garigliano River, before being used for irrigation purposes passes through turbines for the production of electric energy in the Suio centre. The scheme network was developed for a total length of approximately 54 km, of which 16 km serving the district Right Garigliano falling within the Region Lazio (consisting entirely of conduits), and 37 km serving the other three districts falling within the Region Campania (concrete channels).

Map annex
of Chapter 7

FIGURE 7.0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Mare Adriatico
Mar Tirreno
Mar Ionio
Sicilia
Appennino Centrale
Abruzzo
Lazio
Molise
Campania
Puglia
Basilicata
Calabria
Appennino Meridionale
Destra Trigno e Basso Biferno
Sud
Ovest
Integrale Larinese
Gargano
Capitanata
Sud di Anagni
Conca di Sora
Valle del Liri
Piana di Venafro
Sud Pontino
Aurunco
Bacino Inferiore Volturno
Sannio Alifano
Ufita
Vulture Alto Bradano
Terre d'Apulia
Comprensorio Sarno
Destra del Fiume Sele
Integrale Vallo di Diano e Tanagro
Paestum Sinistra Sele
Bradano Metaponto
Stornara e Tara
Arneo
Alta Val d'Agri
Ugento e li Foggi
Bacini Settentrionali del Cosentino
Bacini dello Ionio Cosentino
Bacini del Tirreno Cosentino
Bacini Meridionali del Cosentino
Ionio Crotonese
Tirreno Catanzarese
Ionio Catanzarese
Tirreno Vibonese
Tirreno Reggino
Alto Ionio Reggino
Basso Ionio Reggino
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Tav. 7.8
Tav. 7.7
Tav. 7.9
Tav. 7.10
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ATLAS OF ITALIAN IRRIGATION SYSTEMS
SIGRIAN
River Basin District (RBD) of the Southern Apennines
Maps Legend
River Basin Districts
Irrigation agencies (different colours)
Primary and secondary Irrigation Network
Types of water supply
River
Lake/Resevoir/Dams
Spring
Channel
Groundwater
Other Structures
Provincial Capitals
Borders of the Regions
Hydrography
Lakes
0 10 20 40
km

FIGURE 7.1

SIGRIAN – INEA

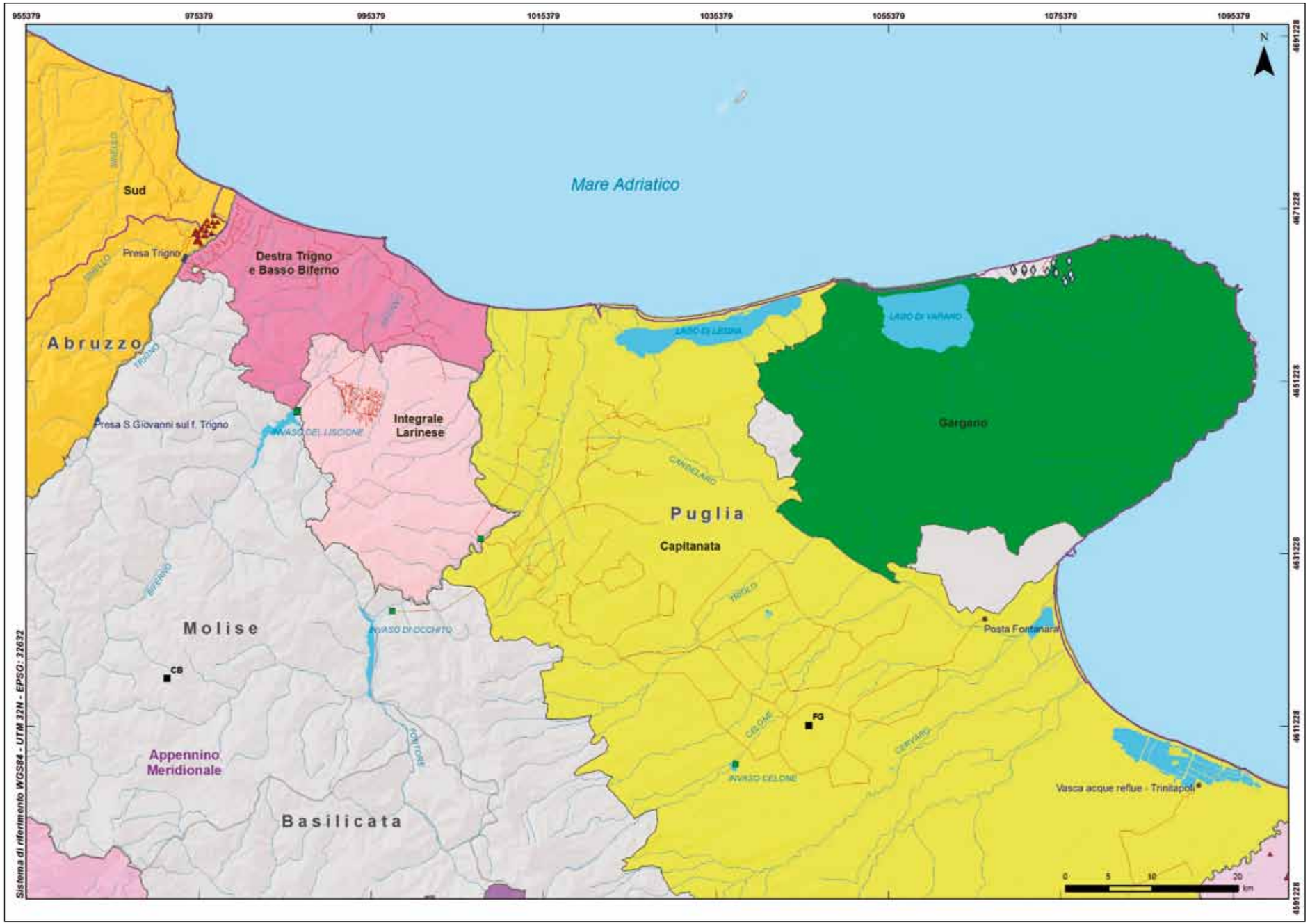
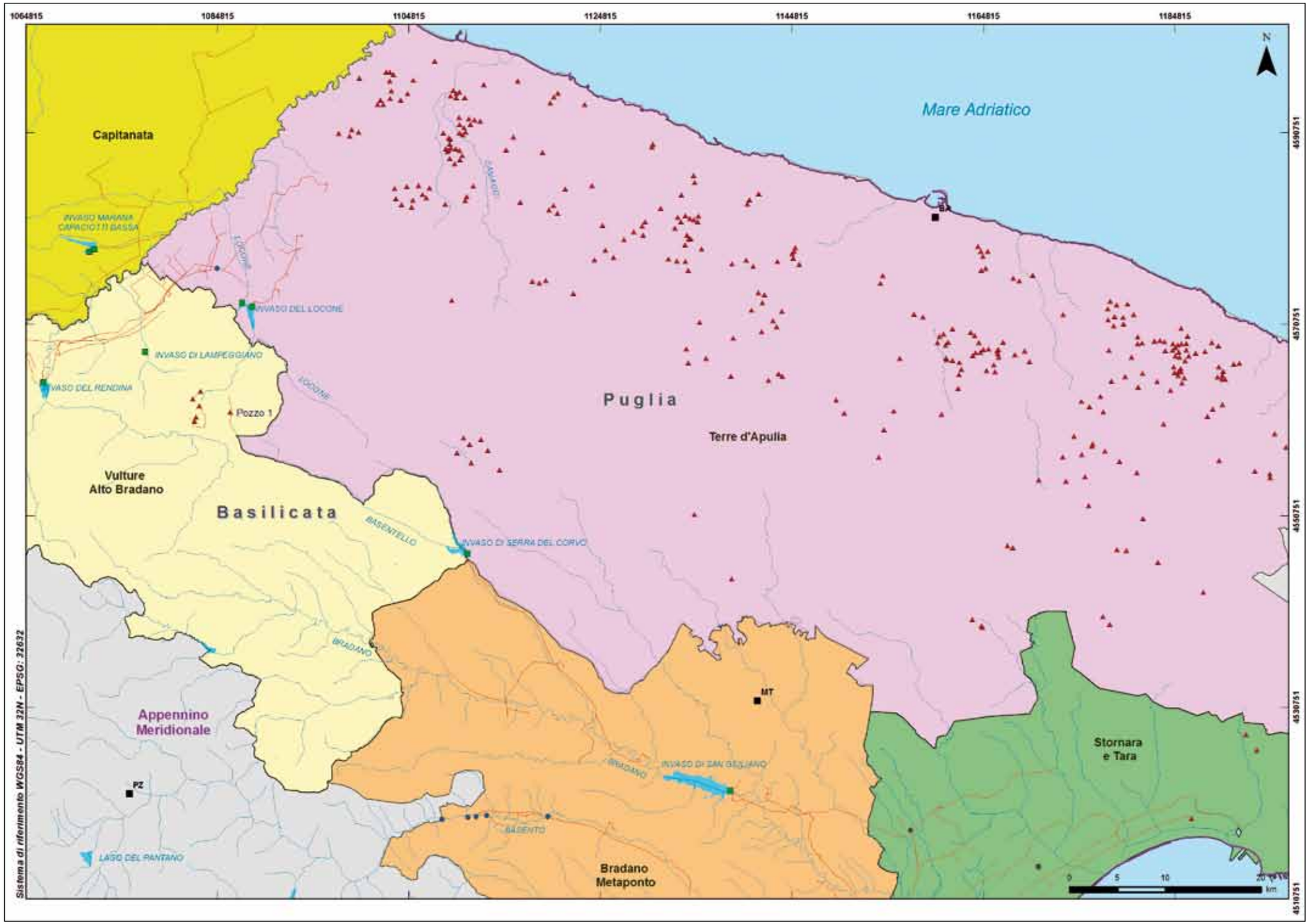


FIGURE 7.2

SIGRIAN – INEA

FIGURE 7.3

SIGRIAN – INEA



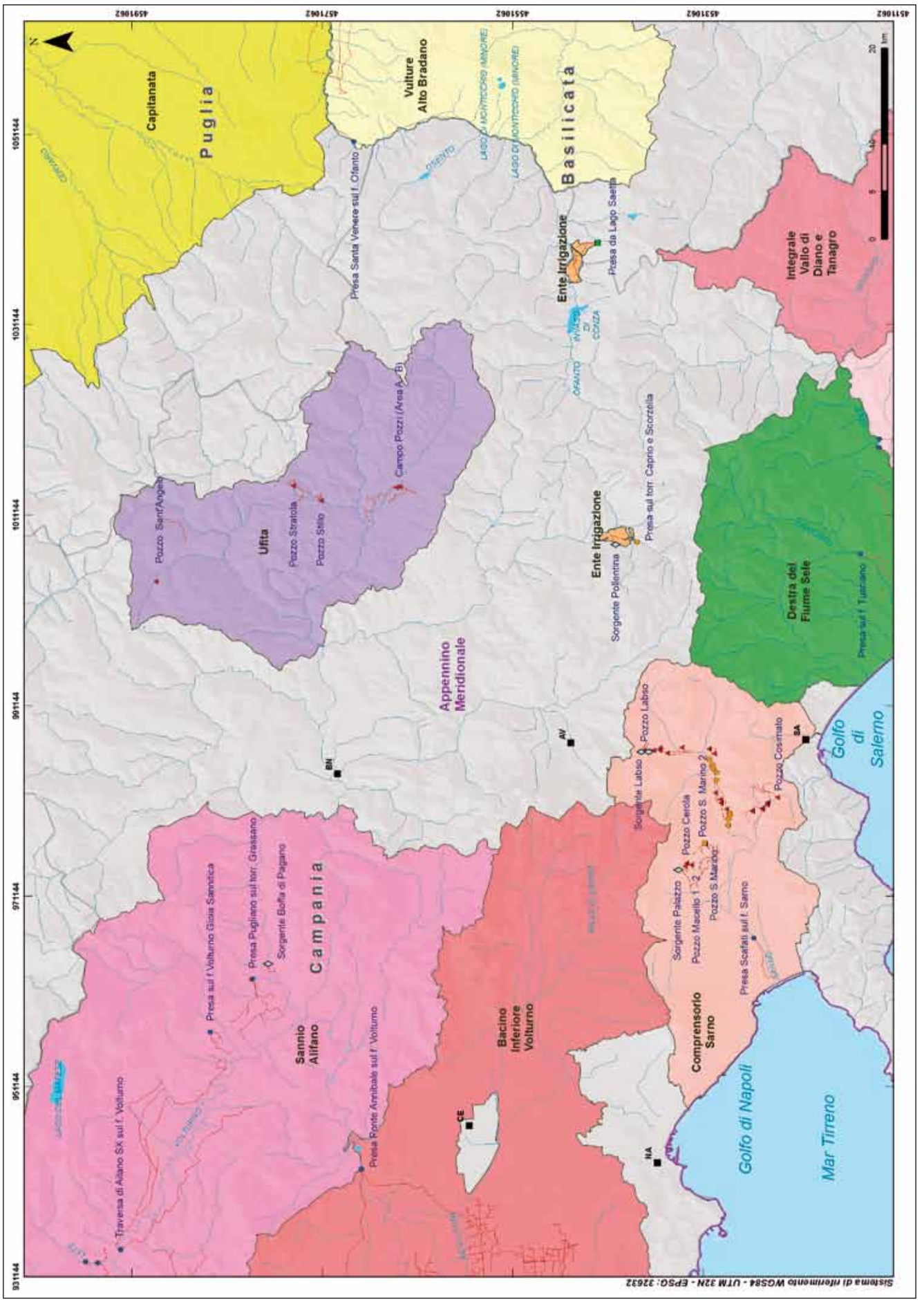


FIGURE 7.4
SIGRIAN – INEA

FIGURE 7.5

SIGRIAN – INEA

FIGURE 7.6

SIGRIAN – INEA

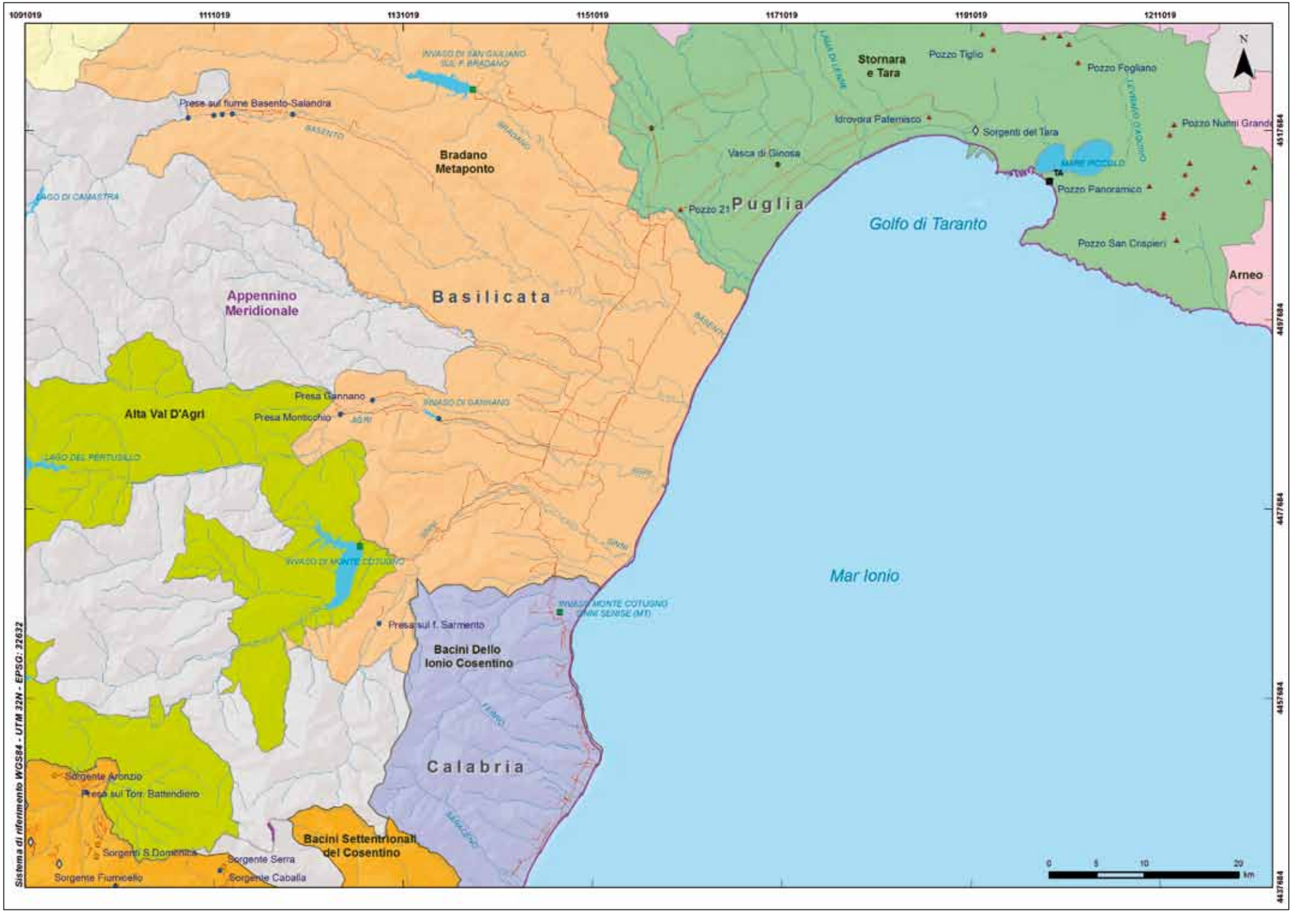


FIGURE 7.7

SIGRIAN – INEA

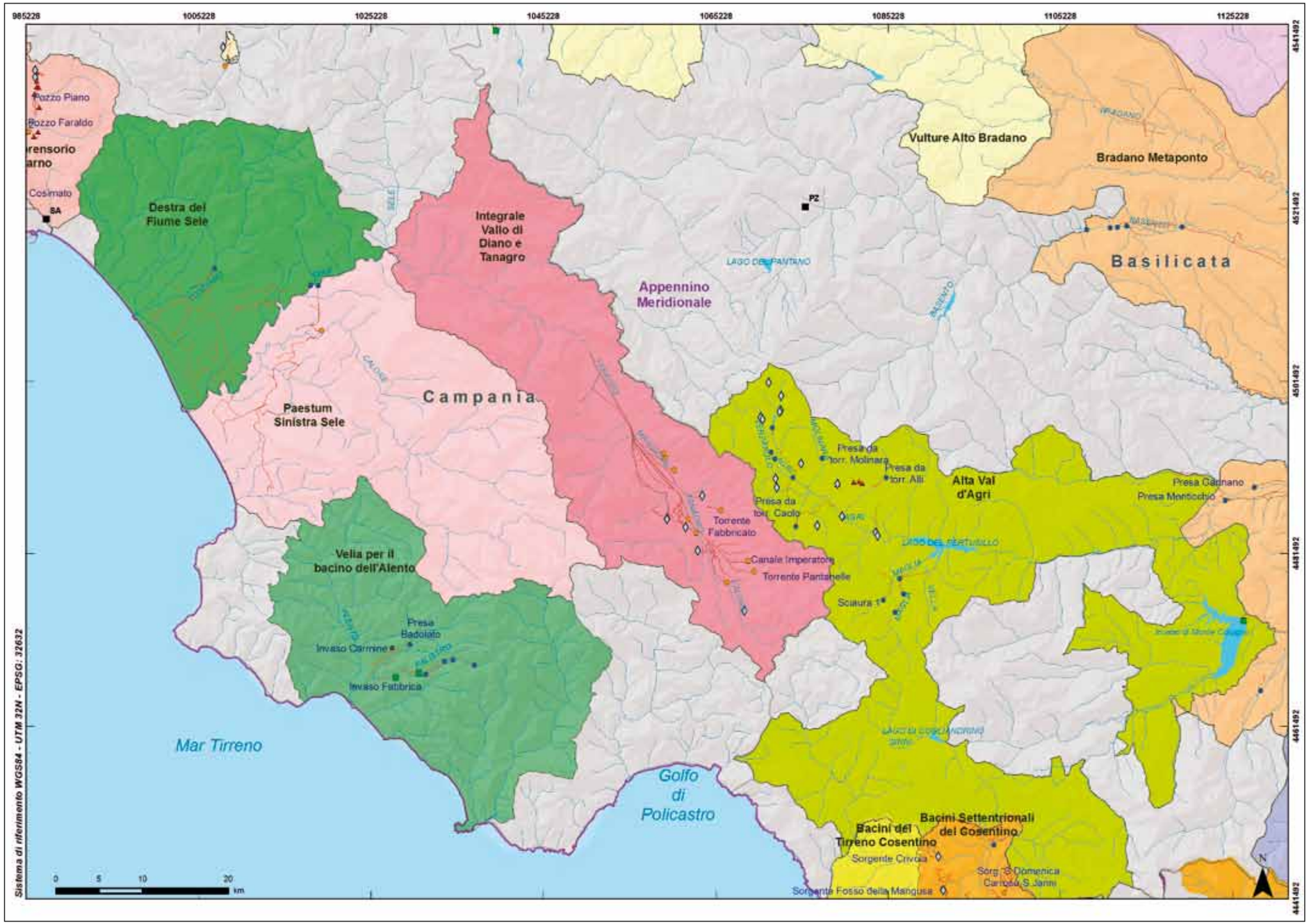


FIGURE 7.8

SIGRIAN – INEA

FIGURE 7.9

Alta Val d'Agri
Golfo di Policastro
Sorgente Crivola
Sorgente Fosso della Mangusa
Sorgente Fiumicello
Sorgente Sambucheto Pantano
Sorgente Caballa
Sorgente Pietà
Sorgente Caldanello
Cafarone
Bacini Settentrionali del Cosentino
Quota 40
Bacini dello Ionio Cosentino
Mar Ionio
Sorgente Malafarina
Sorgente Petroso
Bacini del Tirreno Cosentino
Calabria
Scarichi centrale ENEL
Appennino Meridionale
Lago di Cecita
CS
Mar Tirreno
Sorgente Malpertusa
Bacini Meridionali del Cosentino
Lago Arvo
Lago Ampollino
Ionio Crotonese
Tirreno Catanzarese
Ionio Catanzarese
CZ
Golfo di Sant'Eufemia
Golfo di Squillace
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Sistema di riferimento WGS84 - UTM 32N - EPSG: 32632
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4439396
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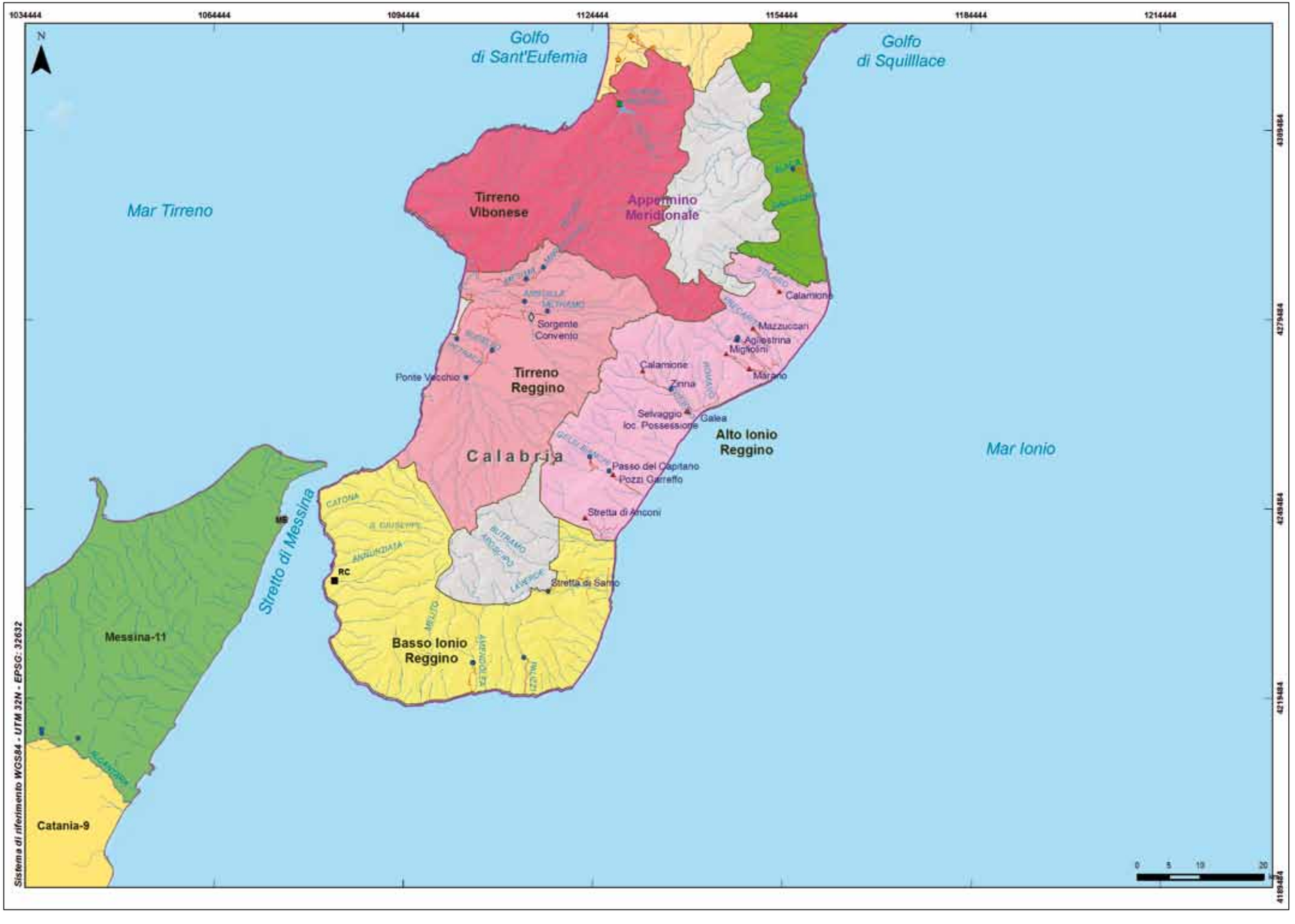
FIGURE 7.10

SIGRIAN – INEA



Chapter 8

River Basin District (RBD) of Sicily

8.1 Overview

The River Basin District (RBD) of Sicily coincides with the Sicilian Region that covers 25,708 km². According to ISTAT data, 14% of the entire area of the region is level ground, 61% middle-mountain and 24% mountainous. Sicily, therefore, is characterized by a significant geomorphological variability and by a complex surface and underground irrigation network (INEA, 2002a). The area is divided, based on the Waters Reclamation Plan of Sicily, into 57 sub-basins (Regione Siciliana 2010). The basins in the Northern side (or Tyrrhenian Sea), although very numerous, are of modest extent due to the nearness to the sea of the mountain chain, from which water bodies originate. By far the most important river basin, for extension and outflows, are those rivers, tributaries of the Channel of Sicily and despite having, sometimes, perennial source are of poor capacity.

The main waterways on the Tyrrhenian side (Figure 8.1) are: the Torto River (50 km long and average annual capacity 1.28 m³/sec) and the San Leonardo River (43 km long and with a capacity of 3.40 m³/sec), the Northern Imera River (32 km long and with a capacity of 0.39 m³/sec) and the Pollina River (30 km long and with a capacity of 0.39 m³/sec).

The main waterways of the southern part or Mediterranean side (Figure 8.2) are: the Platani River (83 km long and with a capacity of 8.40 m³/sec), the Belice River (100 km long and with a capacity of 4.82 m³/sec), the Salso River or the Southern Imera River (111 km long with a capacity of 3.15 m³/sec) and the Dirillo River (52 km long and with a capacity of 0.40 m³/sec).

Regarding the eastern or Ionic side (Figure 8.3) of Sicily the main water bodies are the Simeto River (130 km long and with a capacity of 18.60 m³/sec) and the Alcantara River (48 km long and with a capacity of 8.90 m³/sec).

Many torrential water bodies flow onto the Tyrrhenian side, they are very short and harnessed between embankments). It follows that, because of the sudden and violent autumn storms, waters, benefitting from steep longitudinal gradients (slopes), head from the mountainside of the river basin toward downstream areas at high speed. This phenomenon causes deep soil erosion of the more vulnerable metamorphic rocks. Large masses of think and fine rubble are transported and deposited near the delta, where over time originated more or less extensive alluvial plain.

Natural lakes are few and of little importance. Among the best known are the Lake of Biviere di Gela, the Preola Pond and the Lake Gorgi Tondi near Mazara del Vallo (province of Trapani, TP) and the Pergusa Lake in Enna province. Due to scarcity in water resources, rainfalls are concentrated only in some months of the year and are virtually missing for extended periods. This is also because of the geomorphological characteristics of the island over the last fifty years a very high number of artificial reservoirs have constructed in Sicily for irrigation and drinking (potable) purposes. Currently, there are 26 artificial river basin developed and or nearly to completion, the water of which is used for irrigation purposes. They are among the largest and most important of Italy.

To regulate water use in agriculture and also given the importance that this sector has for the regional economy, the Sicilian Region reorganized the reclamation Consortia with Presidential Decree of the Regional Council of 25/05/1997, limiting them to 11 Authorities with offices in the provincial capitals and municipalities of Gela and Caltagirone (Figure 8.0). There are 10 Reclamation Consortia[28], which manage cooperative forms of irrigations within the River Basin District, either as holders of the service provided to users or as operations managers on behalf of the Region. In fact, unlike other Water Basin Districts, in Sicily the employees of the consortia are employees of the Region of Sicily.

Among the reclamation Consortia of the land, Caltanisetta is characterized by the lack of collective irrigation, while in the land there are several micro reservoirs (hill reservoirs) and water table wells used for irrigation purposes by private individuals (INEA, 2002a). In addition, it should be pointed out also the historical

28. The Sicilian Reclamation consortia, are: Reclamation Consortium 1-Trapani; Reclamation Consortium 2-Palermo; Reclamation Consortium 3-Agrigento; The Consortium 4-Caltanissetta; Reclamation Consortium 5-Gela; Reclamation Consortium 6-Enna; Reclamation Consortium 7-Caltagirone; Reclamation Consortium 8-Ragusa; Reclamation Consortium 9-Catania; Reclamation Consortium 10-Siracusa; Reclamation

importance played in the evolution of land reclamation in this region by the Consortia of Catania and Palermo.

The administrative area of Irrigation agencies is equal to approx. 2.4 million hectares, 6% of which are equipped for irrigation a much lower percentage than the national average (16%); the highest percentage close to that of the national average is found in Catania.

In the whole the Region 74,248 hectares are irrigated, namely 52% of the equipped area, therefore, the ratio of irrigated area and equipped area is lower than the national one (71%). Regarding this data it is usefult to underline the high recourse to irrigation infrastructures higher than the national average in the Consortia of Messina (100%), Caltagirone (98%), Agrigento (84%) and Ragusa (73%). However, the percentage of use of the Syracusan network (12%) is much lower than the national average.

Concerning the historical evolution of irrigation practices, we must point out the crucial role played by the financial assistance of the Southern Development Fund (the Italian *Cassa del Mezzogiorno*), which changed radically the regional and rural landscape. Thanks to it, beginning in the 50s, the hydraulic and sanitary modernization of the island was implemented, the establishment of stable and efficient agriculture; the creation of industrial zones and the development of urban and tourist settlements.

The Map of Irrigation in Italy published by INEA in 1965 indicated that the most used irrigation system was flowing (utilized in 52% of irrigable area), followed by flooding which involved 47% of the regional irrigable area. Sprinkling irrigation was nearly non-existent and involved only 0,8 % of the regional irrigable area (INEA, 1965). Currently, however, the irrigation system mostly used is localized irrigation, which involves 73% of the regional irrigable area, while sprinkling convers 21%.

Regarding this data, it is possible thus to underline that the figure that concerns localized irrigation is much higher than the national average (12%), while sprinkling is lower than this average, equal to 37%.

Furthermore, it is clear by the comparison with data regarding 1965 that high water consumption systems have been nearly completely replaced and this thanks to the important investments made by the Italian *Cassa del Mezzogiorno* in Sicily.

The climatic and geographic characteristics of the region and the evolution of the irrigation practices have led to the development of specific types of cropping in Sicily, characterized primarily by citrus groves and orchards (49%), followed by vineyards (25%), vegetables and greenhouse crops (Regione Siciliana 2010).

Autonomous irrigation managed by private consortia or owner of single farms is quite widespread and prevails in many areas compared with collective irrigation. It abstracts waters from hill reservoirs (tarns), from long earthen ponds/tanks, springs and above all, from wells.

8.2 Characteristics of the irrigation schemes

There are about 30 irrigation schemes in Sicily and the most important ones connect or have been designed to connect in the future, multiple delivery systems of water resources aiming to integrate or make water use management more flexible and respond efficiently to the geographical and climatic issues typical of the Sicilian River Basin District (RBD).

These schemes are: the water scheme of Garcia-Arancio; the water scheme of San Giovanni – Furore; the water scheme of Sosio – Verdura; the water scheme of Platani – Tumarrano; the water scheme of the plain of Gela; the water scheme of the plain of Catania (or of Simeto) (INEA, 2002a).

Regarding the water scheme of Garcia-Arancio (Figure 8.2), this interconnects two reservoirs: *Garcia*, on the *Belice Sinistro* River, and *Arancio* on the Carboj River both in the provinces of Palermo and Agrigento. The two reservoirs are integrated and supplied with water transferred by the Belice Destro River (through duct pipe) and by the Senore torrent (through open channel/conduit) and with an overall capacity respectively of 80 million and 33 million m^3 corresponding to an active storage of 63 million m^3 and 31 million of m^3. The two sources secure to supply irrigation areas in the district of three Reclamation Consortia, 1-Trapani, 2-Palermo, 3-Agrigento. The Irrigated Areas account for 7,979 hectares.

The water scheme of San Giovanni – Furore (Figure 8.1), falls under the relevant area managed by the Consorzio 3-Agrigento, is supplied from the Naro River and Burraito Torrent, the water are flooded by the dams of S.Giovanni on the Naro river and Furore the Bu on the Burraito Torrent. The two reservoirs constitute from the hydraulic engineering perspective a single supplying system being cascade-connected (connected in falls) to each other. The reservoir of San Giovanni has a total capacity of 15 million of m^3 and an effective storage of 12 million of m^3. The reservoir of Furore has a total capacity of 5.5 million of m^3 and an effective storage of 5 million of m^3.

The water scheme of Sosio – Verdura (Figure 8.2) serving the Consorzio of Palermo-2, currently supplies a complex of facilities, managed by ENEL and built in the second half of the 30s, including several multi-purpose minor reservoirs.

Regarding the water scheme of Platani – Tumarrano (Figure 8.2) the irrigation networks extends along the course of the Platani River, below the Fanaco dam, of which total capacity is of 20.5 million of m^3 and with an effective storage of 19 million of m^3. It benefits from the flow of the same Platani River and the waters abstracted from the reservoir of Fanaco through the current hydroelectric power plant of ENEL at a rate of 1.5 million m^3 per year. The scheme supplies the Consorzio Agrigento – 3

and the irrigated area extends for 500 hectares. The water scheme of the plain of Gela lies in the area managed by the Consorzio di Bonifica 5 – Gela (Figure 8.3) and supplies the south eastern part of the coast. It is characterized by minimum annual rainfall and by ancient irrigation practices and supplied through a network of channels in the ground, in part still existing. The first work, built in the past (1563), was the reservoir Grotticelli on the Gela River, while the work carried out in recent times on the same river was the Dam of Disueri, completed in the 50s, with an active storage of 13.3 million m^3 all for agricultural purposes.

Finally there is the water scheme of the plain of Catania (Figure 8.1) which controls stored supplying water of the irrigation areas of the province of Catania, Enna, Siracusa and Messina (irrigated area supplied by this scheme is equal to 19,897 hectares). Water supplies of this scheme are the reservoirs of Pozzillo and Anticipa — which dam the Salso and Troina Rivers respectively — from the barriers of Santa Domenica and Contrasto ad from the water supply of Ponte Barca, all are along the Simeto river and the reservoirs along the Gornalunga river.

Going back to the historical development of irrigation practices within the River Basin District (RBD) of Sicily, in 1965 the type of water diversion from wells and spring emergencies was widely used in the region. In the area of the Alcantara River, between Randazzo and Taormina, as well as in the plain of Catania, along the coast West of Scicli and along the Belice and Verdura Rivers, the prevalent type of diversion implemented was river diversion. While diversion from storage tanks were primarily implemented along the cost between Castelvetrano, Sciacca and Gela (INEA, 1965).

Today the consortia irrigation supply in Sicily is secured by 69 resources, consisting mostly from artificial reservoirs, 27 are lakes. In fact only one of these resources is a natural reservoir, the Lake Biviere in the town of Gela. The use of these resources is for 17 of these of seasonal type. Abstractions from rivers, consisting of 13 resources distributed in nearly the entire region, are largely ongoing. the amount of water withdrawals from groundwater is the same and concentrated essentially in the area of Ragusa and characterized by mostly seasonal use. While supplying from spring is from 10 sources and the rest of the capturing comes from alternative resources.

10 Reclamation Consortia manage more than 100 reservoirs and compensation tanks capable of collecting 400 million of m^3 of water and 11,000 km of delivery and distribution channels annually supplying a volume of water equal to approx. 200 million of m^3. the construction and management of the large collective irrigation networks was the responsibility of the *Sicilian agency for Agricultural Development* (ESA, *Ente di Sviluppo Agricolo*) and by Reclamation consortia. This agency began in the 50s and is still benefitting from the investments made by la *Cassa del Mezzogiorno*, has created a renowned programme of studies and construction artificial tanks intended for hybrid use (agriculture, industrial and domestic) and for irrigation use as the complex of Belice-Carboi (reservoirs of Garcia and Arancio) and the reclamation consortium of Scicli marsh

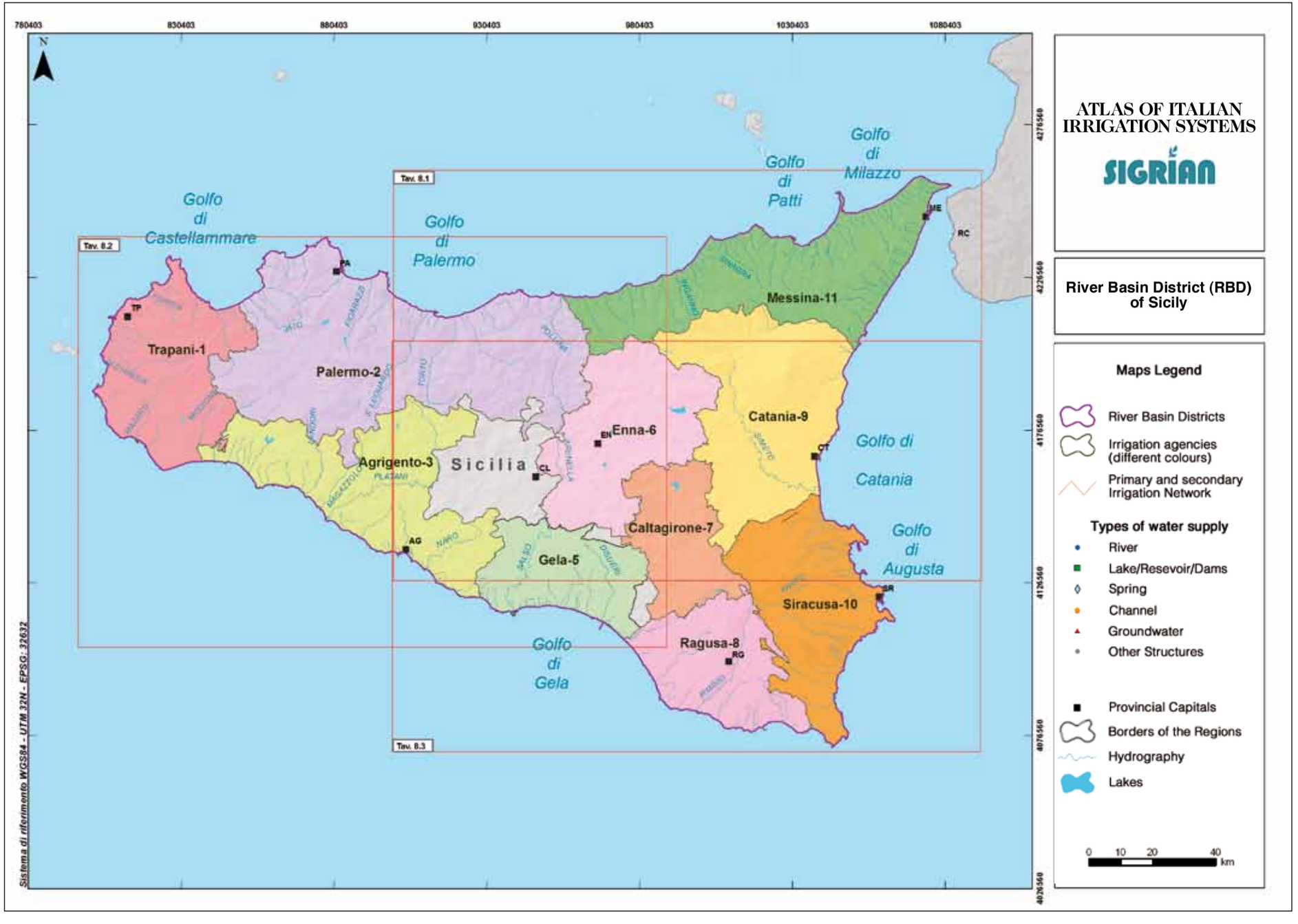
While in the 20s and 30s, some reservoirs were built mainly for hydroelectric use (*Piana degli Albanesi*, *Piano del Leone*, *Prizzi* and *Gammauta*), from the 70s more than 30 tanks were built exclusively for irrigation use.

The distribution network meandering across the areas of the Reclamation Consortia often presents lack of not homogeneity mirroring most of all the construction times of the structures. Nearly everywhere the small ditches (on the embankment) were eliminated, they were made of reinforced concrete and intended for supplying and distribution. The replacement of the remaining small earthen ditches and reinforced concrete conduits are completed, under construction and/or in the planning phase.

To conclude, the irrigation network (primary and secondary) was developed for just over 1,000 km, approx. 67% of which is made of pipes and 28% of open channels. In contrast, closed channels/gravity are very few and even a smaller the number the tunnels, which all together represent the remaining 5%. In particular, pipes are in all the areas of the region. They are more implemented in the following Consortia: Consortium of Agrigento (19%), in which pipes are also the only existing type; Consortia of Trapani (16%), Catania and Ragusa (12%). Also in the irrigated areas of Messina, presenting the lowest extent of the main irrigation network (approx. 9 km equal to 0.9%) pipes are the only existing type. Open channels are mainly in the irrigated areas of Catania (46%) and of Ragusa (30%). By confronting the SIGRIAN data, it is, therefore, possible to say that compared with the national average figures, data related to pipes is much higher than the national one, which is equal to 26%, while percentage of open channels is lower than the national average (58%).

Map annex
of Chapter 8

FIGURE 8.0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Tav. 8.1
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Tav. 8.3
Golfo di Castellammare
Golfo di Palermo
Golfo di Patti
Golfo di Milazzo
Golfo di Catania
Golfo di Augusta
Golfo di Gela
Trapani-1
Palermo-2
Agrigento-3
Sicilia
Enna-6
Messina-11
Catania-9
Caltagirone-7
Gela-5
Siracusa-10
Ragusa-8
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4026560
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Groundwater
Other Structures
Provincial Capitals
Borders of the Regions
Hydrography
Lakes
0 10 20 40
km

FIGURE 8.1

SIGRIAN – INEA

FIGURE 8.2

SIGRIAN – INEA


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986893
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1076893
Palermo-2
Sicilia
Enna-6
Catania-9
Agrigento-3
Caltagirone-7
Gela-5
Siracusa-10
Ragusa-8
Golfo di Catania
Golfo di Augusta
Golfo di Gela
Scarico Enel dal serbatoio Fanaco
Sorgente Gran Fonte
Serbatoio Ancipa
Vasca Serravalle
Vasca Leone
Iqvaso Ancipa
Vasca Maroglio
Sorgente Donna
Pozzi Finocchiara
Fonte Paradiso
Derivazione Foce Fiume Irminio
Sorgente Passolatello
Pozzi Gravina
Sorgenti Mussillo Castelluccio
Sorgenti Gruppo Salto
Pozzi Cassero
Pozza Raddusa
Pozzo Raddusa
Sorgente Giummarra
Pozzi Pezza Filippa
Pozzi Arizza-Spinasanta
EN
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CT
SR
RG
INVASO ANCIPA
INVASO POZZILLO
INVASO NICOLETTA
LAGO DI PERGUSA
INVASO CLEMO
INVASO DON STURZO
INVASO RASOLETO
INVASO SAN GIOVANNI
INVASO DISUERI
INVASO DIVIERI
INVASO COMUNELLI
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Chapter 9

River Basin District (RBD) of Sardinia

9.1 Overview

The River Basin District (RBD) of Sardinia is equivalent to the extension of the Sardinia Region (24,000 km²). The hydrographic system of the island has the classic characteristics of the Mediterranean regions. The only waterways with perennial source are: the Tirso River, which with a course of 153 km long is the most important of the Sardinian Rivers, the Flumendosa River (147 km long), the Coghinas River (64 km long), the Cedrino River (78 km long) (Figure 9.0) (Management Basin District Authority of Sardinia, 2010). The other water bodies are torrential in nature and this is because elevations and coasts are very near. Waterways have steep downward gradients along most of their water bodies. They suffer from natural phenomena of serious flooding in the late autumnal months and significant low fresh water flow and dry periods in summer.

Over the centuries, the hydrographic network of the Island has undergone several changes caused by a wide range of human activities, such as building reservoirs, embankments and, is some cases, diversions of water bodies aiming essentially to protect urban areas from flood risks. Several artificial reservoirs representing significant water primary and secondary networks have been built. There are also several reservoirs interconnection works, which allow integration, guarantee flexibility in water use management and ensure effective response to critical issues featuring this RBD.

Therefore, it is important to highlight that, each lake of the island, with the exception of the Baratz Lake, is an artificial lake, namely waters are impounded by several dams' constructions.

Irrigation is (by far) the largest user of water resource of the island and collective irrigation is managed by 9 Reclamation Consortia (Figure 9) (INEA, 2002d).

These public law entities, which supply the member of the consortia and over which the regional authority exercises control, establishes guidelines for assessment and monitoring (Articles 15 and 16 of Regional Law 6/08), are: *Nurra*; *Nord Sardegna*; *Gallura*; *Sardegna Centrale*, *Ogliastra*, l'*Oristanese*; *Sardegna Meridionale*, *Cixerri*, *Basso Sulcis*.

Within the RBD of Sardinia the area equipped for collective irrigation (169,123 hectares) is equal to 18% of the administrative area and from the SIGRIAN data it is possible to conclude that the extension of land with irrigation infrastructures is a bit higher at a regional level than the national level (16%). Well above the national average is the infrastructure provision in the area of *Oristano* (47%) and mostly the area is managed by ENAS (*Ente acque della Sardegna*), the Governamental Water Agency (82%), while *Gallura* has a very small percentage of areas equipped for irrigation (less than 3%) in contrast to the administrative area.

The extent of use of collective irrigation network, expressed in ratio between irrigated and equipped land, it is instead far lower than the national average (71%). In fact, it is equal to ca. 31% at a regional level and this is surely attributable to the region's water scarcity. The use of irrigation infrastructures is higher than the one at a national level only in the Ogliastra area (78%) and in Gallura is the highest (61%) of the region. Furthermore, it is worth highlighting the case of ENAS, though covering almost most of the areas, uses in a very small extent (14%) irrigation infrastructures.

Concerning the historical evolution of irrigation practices and comparing it with the survey of 1965, the main irrigation system adopted at that time was flowing irrigation, which was used in 78% of the overall irrigated area. Whereas sprinkling irrigation was used, at that time, in 17% of the land and flooding irrigation in 4% of irrigated areas.

Today the most used irrigation system in RBD of Sardinia is sprinkling (70%). This system is used to water cereals and forage crops, which are the main crops in Sardegna. Also localized irrigation is quite used (20%) contrary to the national rate that does not exceed (12%). Flooding irrigation (5%) is concentrated on the Oristano area (*Consorzio Oristanese* and *Consorzio della sardegna Meridionale*) a well-known growing-rice area.

As regards the real supplied water it emerges that almost one third of agencies in Sardinia practices irrigation and the irrigated area is equal to less than 7 % of the overall UAA (Utilized Agricultural Area) (Autorità di Gestione del Distretto idrogafico della Sardegna, 2010). The comparison of the census data means that the number of water supplying agencies for irrigation purposes

increased by 7 %, instead, in terms of irrigated areas, the increase is equal to less than 1 %.

9.2 Characteristics of the irrigation schemes

There are 19 Irrigation schemes in Sardinia (INEA, 2002d). The Scheme Cohinas-Mannu of Pattada- Bunnari (Figure 9.1) operates in the northern part of Sardinia. The scheme supplies important household users, such as the city of Sassari and all other centres in the North of Sardinia, as well as the Industrial users of Porto Torres and the area of Sassary and lastly the irrigation users falling within the OTAs (Optimal Territorial Areas) of the Reclamation Consortium of *Nord Sardegna*. This Scheme captures the flows of the Rio Coghinas River through the reservoirs of Casteldoria and Muzzone and it captures one of its effluents the Mannu di Pattada through the reservoir at Monte Lerno. The multipurpose reservoir along Cohinas at Casteldoria, which also supplies the Reclamation Consortium of *Nord Sardegna*, captures the remaining flows of the Rio Coghinas River.

Also the Liscia Scheme operates in the northern part of Sardinia and supplies water to all users of the *Gallura* area. The main reservoir for this scheme is on the *River Liscia* at *Punta Calamaiu*. The scheme is managed by the Reclamation Consortium of *Gallura*, which has a water access licence equal to 80.5 million m³ of water, 75 million of which are used for irrigation purposes. It has water active storage capacity adjustment equal to 104 million m³ of water.

The schemes of *Posada* and *Cedrino* (Figure 9.1) operate in the eastern part of Sardinia.

The Posada scheme supplies through the reservoir of *Cedrino* at *Pedra 'e Othoni*. This is also managed by the Reclamation Consortium of *Sardegna Centrale*, which has a water access licence equal to 113 million m³ of water, 13 million of which are used for irrigation purposes.

The scheme of *Taloro-Torrei-Tirso-Flumineddu-Mogoro-Montiferru* (Figure 9.1) is in central part of Sardinia. This scheme used by the Reclamation Consortium of *Sardegna Centrale* supplies nearly all typology of water points in use of the plain of *Campidano* and Mid Valley of the Tirso River, where is also significantly practiced hydroelectric use. Since 2000 the new dam on the Tirso River at *Cantoniera di Busachi* (Figure 9.2) replaced the old dam of *S. Chiara*, whose storage capacity was limited to only 143 million m³ of water due to permits issuing bindings. The dam has a maximum storing capacity equal to 792 million m³ of water and an active storage capacity adjustment of 745 million m³ and is used by the Reclamation Consortium of Oristanese.

In conclusion, the scheme of *Flumendosa-Campidano -Cixerri* (Figure 9.2) operates in the southern Sardinia. It is the most important hydraulic scheme as to number of supplied users and scope of reached areas. It supplies ca. 700,000 inhabitants, a variety of industrial activities and water points in use supplied by the reclamation consortium of Sardegna Meridionale. The Autonomous Board of Flumendosa, EAF (*Ente autonomo del Flumendosa*) manages the water resourse of the area, except for the reservoirs of Corongiu and Bau Pressiu. The Bau Pressiu reservoir is grouped as sub-scheme because it is constantly supplied by the EAF system through the lifting from the dam of Cixerri at Genna Is Abis. The reservoir of Simbrizi operates also in this area and is the end point of the junction of the whole system of *Flumendosa-Campidano-Cixerri* is needed to control the remaining flows of the southern part of *Campidano* which are captured from the fixed barrier on the river *Mannu* di *Narcao* at *Bau Pressiu* and it has an adjusting capacity equal to 29 million m³ of water.

Back to the historical evolution of irrigation practices, in 1965 rivers abstraction was limited to the reclamation area of *Arborea* and the North of *Oristano*, whereas wells and springs abstractions were highly concentrated in the plain of *Campidano*, in the plain of *Nurra* and the coastal plain of nearby *San Pietro a Mare*.

While tank abstraction mainly converged on the area of Oristano and Solarussa and in the plain of Carbonia (INEA, 1965).

Today Consortia abstraction sources are 27, 8 of which are river withdrawals and 18 lake withdrawals they concentrate in the provinces of Cagliari (8 water supplies), Sassari (6 water supplies) and Nuoro (4 water supplies). The today's operating reservoirs are multipurpose in use, they supply water for household, agricultural and industrial purposes. In fact, it is well-known that Sardinia is one of the Italian regions suffering from scarce water availability, in some cases this creates problems for a functional distribution of the resources needed for domestic and civil uses. In order to compensate for such problematic issues artificial reservoirs were built throughout the years, so that the mass of water that during autumn and winter times fell in rivers–most of them are torrential water bodies – might be available in moments of needs.

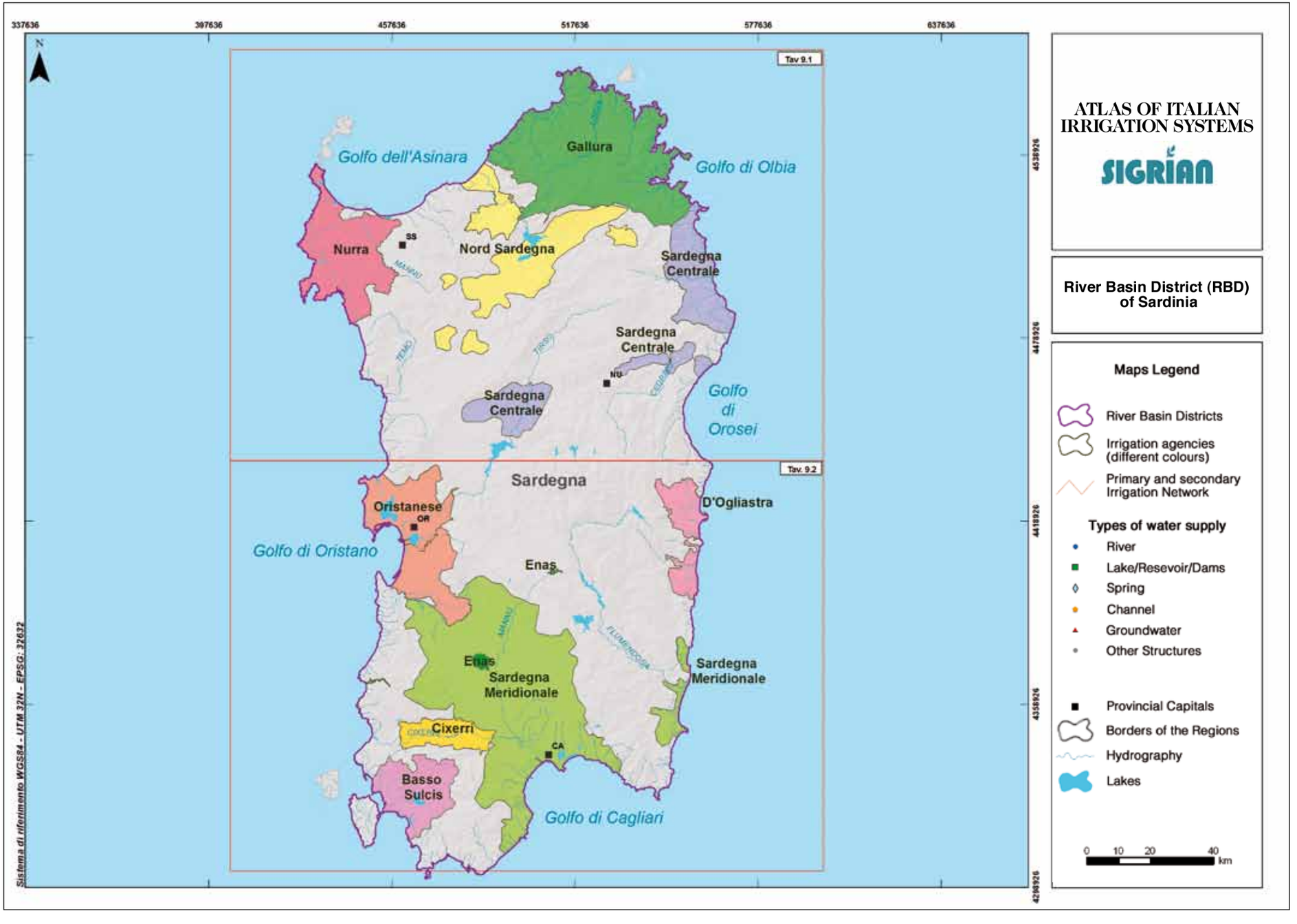
However, as it was mentioned above, the massive presence of reservoirs and dams does not correspond to an efficient water distribution network anywhere in the equipped areas. At the same time, where water schemes are dimensioned adequately, the obsolete facilities and the network lack of maintenance have a bad effect on supplying efficiency. A part some cases where new infrastructures' modernization was carried out most of the network was built following operations implemented after the agrarian reform of the first 50's. Today they are in a dilapidated state causing losses of channeled water that in some cases can reach 50% (INEA, 2002d). According to ISTAT census data of 2000 concerning forms of manage-

ment, most of the farms withdraw water from self-supplying sources. Half of Sardinian farms abstracts water from self-supplying sources, mainly wells. In this context, irrigated agriculture is not functionally developed throughout the regional territory. It is well-represented in those areas where orographic and pedological conditions were more favourable (in lowlands, such as the plain of Campidano or Nurra). Irrigate agriculture had always have to live with (been confronted with) the effects linked to drought, as well as the occurrence with a certain frequency of adverse weather conditions (for example, frosts).

Lastly, the main principal irrigation network (primary and secondary network) stretches for almost 1,200 km and reveals that 70% of conduits are pipes showing a higher figure than the national average. The network is more developed in the central area of the island. Also open channels are rather widespread (24%) even if far below the national average. From a detailed analysis it can, thus, be concluded that, whereas pipes are all over the region close channels and/or gravity are only to be found in the reclamation Consortia of *Nord Sardegna* and *Nurra*, both in the *North of Sardinia*.

Map annex
of Chapter 9

FIGURE 9.0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Golfo dell'Asinara
Gallura
Golfo di Olbia
Nurra
SS
Nord Sardegna
Sardegna Centrale
Sardegna Centrale
NU
Sardegna Centrale
Golfo di Orosei
Sardegna
D'Ogliastra
Oristanese
OR
Golfo di Oristano
Enas
Enas
Sardegna Meridionale
Sardegna Meridionale
Cixerri
CA
Basso Sulcis
Golfo di Cagliari
Sistema di riferimento WGS84 - UTM 32N - EPSG: 32632
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ATLAS OF ITALIAN IRRIGATION SYSTEMS
SIGRIAN
River Basin District (RBD) of Sardinia
Maps Legend
River Basin Districts
Irrigation agencies (different colours)
Primary and secondary Irrigation Network
Types of water supply
River
Lake/Resevoir/Dams
Spring
Channel
Groundwater
Other Structures
Provincial Capitals
Borders of the Regions
Hydrography
Lakes
0 10 20 40
km

FIGURE 9.1

SIGRIAN – INEA

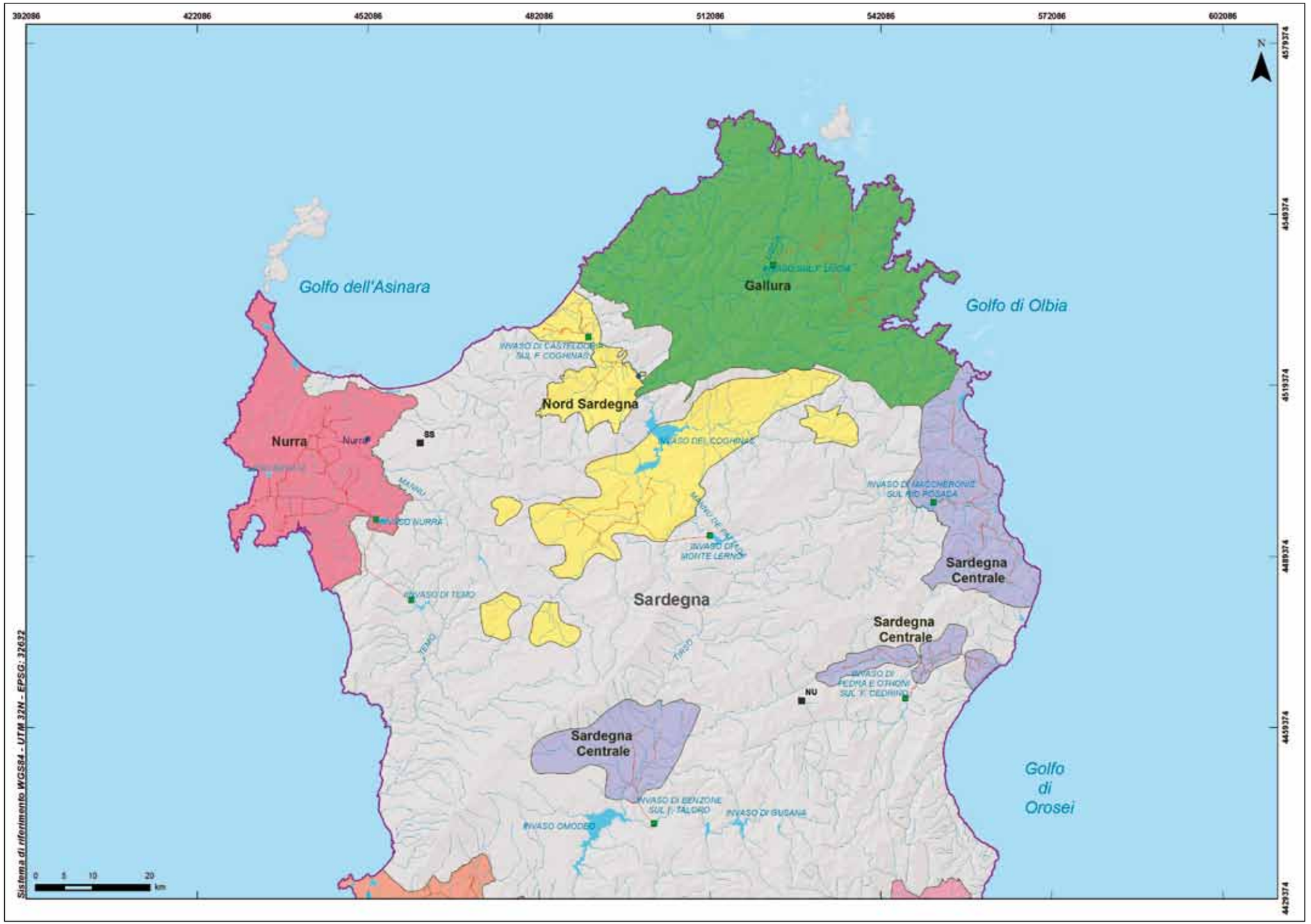


FIGURE 9.2

SIGRIAN – INEA

Annex - Statistical Tables

Table 5 - Areas of Irrigation agencies in Regions in River Basin Districts (RBD)

River Basin Districts (RBDs)	Operative Irrigation agencies (n.)	Area in Hectares (ha)		
		Administrative Area	Equipped Area	Irrigated Area
Emilia Romagna	4	1,156,642	353,864	132,142
Lombardy	14	943,435	349,776	349,118
Lombardy – Emilia Romagna	2	284,068	145,772	87,710
Piedmont	35	1,693,079	315,334	275,180
Piedmont - Lombardy	1	210,000	137,343	127,722
Trentino	25	24,166	2,982	2,926
Valle d'Aosta	159	176,767	20,836	9,069
Po River basin	240	4,488,157	1,325,907	983,867
Veneto	8	948,058	494,494	485,507
Friuli-Venezia Giulia	4	338,562	89,632	86,979
Trentino	145	84,731	14,585	14,214
Eastern Alps	157	1,371,351	598,711	586,700
Lombardy	1	48,488	41,031	31,677
Veneto	2	228,592	128,745	116,370
Trentino	2	1,700	178	151
Eastern Alps – Po River basin	5	278,780	169,954	148,198
Emilia Romagna	3	898,952	123,258	42,708
Liguria	3	3,506	1,018	1,018
Marche	2	543,165	5,457	3,528
Tuscany	4	636,590	5,992	1,914
Northern Apennines	12	2,082,213	135,725	49,168
Northern Apennines	1	38,052	657	….
Northern Apennines – Serchio River basin	1	38,052	657	….
Tuscany	1	57,455	397	….
Serchio River basin	1	57,455	397	….
Lazio	1	159,891	9,965	5,960
Tuscany	1	90,864	1,087	235
Tuscany - Lazio	1	179,925	6,472	3,786
Umbria	1	98,800	6,769	4,072
Umbria - Tuscany	1	89,966	140	20
Central Apennines - Northern Apennines	5	619,446	24,433	14,073
Abruzzo	3	424,495	38,953	38,463
Lazio	3	884,803	33,367	22,523
Marche	1	266,099	14,917	9,898
Umbria	1	128,000	3,122	1,963
Umbria – Lazio	1	177,779	2,550	1,700
Central Apennines	9	1,881,176	92,909	74,547
Abruzzo	2	337,897	25,177	1,020
Central Apennines – Southern Apennines	2	337,897	25,177	1,020
Basilicata	3	863,332	80,204	30,148
Basilicata - Campania	1	1,048	….	….
Calabria	11	1,027,732	75,818	32,788
Campania	8	799,029	24,490	29,589
Lazio	4	410,806	21,553	14,023
Lazio – Campania	1	14,987	2,455	2,022
Molise	3	94,726	25,794	12,274
Apulie	6	1,739,439	182,754	86,693
Southern Apennines	37	4,951,099	413,068	207,537
Sicily	10	2,382,307	142,965	74,248
Sardinia	10	937,363	161,540	59,303
ITALY	489	19,425,296	3,091,443	2,198,661

Source: Data Elaboration provided by INEA, SIGRIAN 2010

Table 6 - Irrigation Systems at farm level in Regions and in River Basin Districts (RBD)

River Basin Districts (RBDs)	Irrigation systems (%)					
	Flowing	Sprinkler	Flooding	Lateral infiltration	Sub-irrigation	Localized
Emilia Romagna	8.6	55.0	4.5	13.7	0.8	17.4
Lombardy	69.5	29.6	0.7	0.0	0.0	0.1
Lombardy – Emilia Romagna	1.5	89.3	1.4	0.5	0.0	7.4
Piedmont	66.6	3.4	29.9	0.0	0.0	0.0
Piedmont - Lombardy	37.8	0.6	61.7	0.0	0.0	0.0
Trentino	0.0	47.2	0.0	30.1	0.0	22.7
Valle d'Aosta	54.1	45.8	0.0	0.0	0.0	0.1
Po River basin	*51.9*	*29.1*	*13.5*	*2.1*	*0.1*	*3.3*
Veneto	47.4	24.5	2.4	20.1	5.2	0.4
Friuli-Venezia Giulia	36.7	63.3	0.0	0.0	0.0	0.0
Trentino	1.0	57.4	0.0	11.3	0.0	30.3
Eastern Alps	*41.2*	*38.0*	*1.5*	*13.7*	*3.3*	*2.3*
Lombardy	23.0	62.6	14.4	0.0	0.0	0.0
Veneto	47.1	14.1	0.0	38.8	0.0	0.0
Trentino	0.0	40.4	0.0	0.0	0.0	59.6
Eastern Alps – Po River basin	*38.9*	*30.3*	*4.8*	*25.8*	*0.0*	*0.1*
Emilia Romagna	0.0	66.8	3.9	0.0	1.6	27.6
Liguria	0.0	3.5	0.0	96.3	0.0	0.2
Marche	0.0	100.0	0.0	0.0	0.0	0.0
Tuscany	0.0	77.9	9.6	0.0	0.0	12.5
Northern Apennines	*0.0*	*69.1*	*3.8*	*1.9*	*1.3*	*23.8*
Tuscany	….	….	….	….	….	….
Northern Apennines – Serchio River basin	….	….	….	….	….	….
Lazio	0.0	41.4	0.0	0.0	0.0	58.6
Tuscany	0.0	100.0	0.0	0.0	0.0	0.0
Tuscany - Lazio	0.0	69.3	0.0	29.4	0.0	1.4
Umbria	0.0	98.4	0.0	0.0	0.0	1.6
Umbria - Tuscany	0.0	100.0	0.0	0.0	0.0	0.0
Central Apennines - Northern Apennines	*0.0*	*72.8*	*0.0*	*8.2*	*0.0*	*19.0*
Abruzzo	21.4	75.9	0.0	0.0	0.0	2.7
Lazio	0.0	92.4	0.0	0.0	0.0	7.6
Marche	47.6	52.4	0.0	0.0	0.0	0.0
Umbria	0.0	100.0	0.0	0.0	0.0	0.0
Umbria – Lazio	41.2	58.8	0.0	0.0	0.0	0.0
Central Apennines	*17.1*	*79.0*	*0.0*	*0.0*	*0.0*	*3.9*
Abruzzo	10.3	76.7	0.0	0.0	0.0	12.9
Central Apennines – Southern Apennines	*10.3*	*76.7*	*0.0*	*0.0*	*0.0*	*12.9*
Basilicata	5.2	39.9	0.0	2.4	0.0	52.5
Calabria	22.3	61.9	5.0	2.0	0.0	8.7
Campania	7.3	69.0	0.2	21.0	0.0	2.4
Lazio	0.0	89.7	0.0	0.0	0.0	10.3
Lazio – Campania	6.6	81.8	0.0	0.0	0.0	11.6
Molise	0.0	95.1	0.0	0.0	0.0	4.9
Apulie	0.2	3.4	0.0	0.0	0.0	96.4
Southern Apennines	*3.4*	*39.3*	*0.3*	*3.6*	*0.0*	*53.3*
Sicily	*5.5*	*20.6*	*0.5*	*0.0*	*0.0*	*73.3*
Sardinia	*0.2*	*70.0*	*5.6*	*0.0*	*0.0*	*24.1*
ITALY	37.5	37.3	8.3	4.8	0.5	11.6

Source: Data Elaboration provided by INEA, SIGRIAN 2010

Table 7 - Types of water supply structures in Regions and in River Basin Districts (RBD) (%)

Regions	Type of water supply					
	Channel	Spring	Groundwater	Lake/Reservoir/Dams	River	Other
Emilia-Romagna	1.0	0.0	28.1	1.0	63.5	6.3
Lombardy	5.5	22.1	39.9	0.7	26.6	5.2
Piedmont	14.8	6.0	27.7	1.2	48.5	1.8
Trentin-Alto Adige	4.3	6.1	11.3	1.7	70.4	6.1
Valle d'Aosta	2.8	24.0	0.8	1.0	67.6	3.9
Veneto	0.0	0.0	0.0	4.4	0.0	95.6
Po River basin	*10.0*	*11.4*	*21.6*	*1.2*	*51.3*	*4.5*
Friuli Venezia Giulia	6.4	0.0	82.4	0.8	10.4	0.0
Lombardy	76.9	0.0	0.0	0.0	15.4	7.7
Trentino-Alto Adige	3.0	12.0	48.5	3.0	29.2	4.3
Veneto	24.4	1.1	27.4	0.0	19.7	27.5
Eastern Alps	*15.3*	*5.0*	*40.3*	*1.2*	*22.2*	*16.1*
Emilia Romagna	0.0	0.0	0.0	6.3	56.3	37.5
Lazio	0.0	0.0	93.8	6.3	0.0	0.0
Marche	0.0	0.0	0.0	16.7	83.3	0.0
Tuscany	0.0	9.5	28.6	19.0	38.1	4.8
Northern Apennines	*0.0*	*2.7*	*28.0*	*10.7*	*41.3*	*17.3*
Tuscany	0.0	0.0	0.0	33.3	33.3	33.3
Serchio River basin	0.0	0.0	0.0	33.3	33.3	33.3
Abruzzo	17.4	0.0	23.9	10.9	41.3	6.5
Lazio	5.8	0.0	63.5	0.0	30.8	0.0
Marche	0.0	0.0	0.0	12.5	87.5	0.0
Tuscany	0.0	28.6	0.0	28.6	42.9	0.0
Umbria	0.0	0.0	6.7	66.7	13.3	13.3
Central Apennines	*8.1*	*1.5*	*33.1*	*14.0*	*39.7*	*3.7*
Abruzzo	0.0	0.0	88.0	0.0	8.0	4.0
Basilicata	0.0	28.0	20.0	10.0	40.0	2.0
Calabria	11.7	11.7	15.6	3.9	51.9	5.2
Campania	23.9	12.5	36.4	2.3	23.9	1.1
Lazio	0.0	38.1	0.0	4.8	57.1	0.0
Molise	0.0	0.0	0.0	60.0	40.0	0.0
Puglia	0.0	2.9	94.4	1.3	0.4	1.0
Southern Apennines	*3.8*	*7.3*	*72.1*	*2.7*	*12.6*	*1.5*
Sicily	*0.0*	*14.7*	*19.1*	*39.7*	*19.1*	*7.4*
Sardinia	*3.7*	*0.0*	*0.0*	*66.7*	*29.6*	*0.0*
ITALY	10.0	8.7	34.3	2.8	37.0	7.1

Source: Data Elaboration provided by INEA, SIGRIAN Data 2010

Table 8 - Characteristics of the of the primary and secondary irrigation network in Regions and in River Basin Districts (RBD)

River Basin Districts	Type of use			Types of network (km)						Total length (km)
	Irrigation	Multiple	Not specified	Open channels	Closed channels / gravity	Tunnels	Pipes	Section of water course (Reg. 41/00)	Not specified	
Emilia - Romagna	224	805	-	762	45	8	25	189	0	1,029
Emilia - Romagna - Lombardy	150	295	-	434	1	-	10	-	0	445
Lombardy	1,357	1,996	-	3,078	83	18	173	-	2	3,353
Lombardy - Piedmont	-	1,894	-	1,889	-	4	1	-	-	1,894
Piedmont	3,001	588	-	2,663	258	19	234	-	415	3,589
Trentino - Alto Adige	55	-	-	3	5	0	46	-	-	55
Valle d'Aosta	939	28	-	359	305	4	295	-	4	967
Po River basin	*5,727*	*5,605*	-	*9,188*	*697*	*53*	*784*	*189*	*421*	*11,332*
Friuli Venezia Giulia	525	214	-	525	5	0	208	-	1	739
Trentino-Alto Adige	631	-	-	29	20	1	581	-	-	631
Veneto	1,240	521	-	1,488	59	0	161	-	54	1,762
Eastern Alps	2,397	735	-	2,042	84	1	950	-	55	3,132
Lombardy	143	149	-	292	0	-	0	-	-	292
Trentino-Alto Adige	2	-	-	-	-	-	2	-	-	2
Veneto	87	-	-	55	17	-	9	-	7	87
Eastern Alps - Po River basin	*232*	*149*	-	*347*	*17*	-	*11*	-	*7*	*381*
Emilia - Romagna	163	423	-	416	70	-	25	75	-	586
Liguria	24	-	-	23	-	2	-	-	-	24
Marche	29	-	-	-	-	-	29	-	-	29
Tuscany	84	3	-	11	6	25	46	-	-	87
Northern Apennines	*301*	*427*	-	*449*	*76*	*26*	*101*	*75*	-	*728*
Emilia - Romagna	44	94	-	125	13	-	1	0	-	138
Northern Apennines - Po River basin	*44*	*94*	-	*125*	*13*	-	*1*	*0*	-	*138*
Tuscany	28	-	-	28	-	1	-	-	-	28
Northern Apennines - Serchio River basin	*28*	-	-	*28*	-	*1*	-	-	-	*28*
Lazio	69	-	-	-	-	-	69	-	-	69
Lazio - Tuscany	16	-	-	-	-	-	16	-	-	16
Tuscany	18	-	-	-	-	-	18	-	-	18
Tuscany - Umbria	8	-	-	-	-	-	8	-	-	8
Umbria	73	-	-	-	-	-	73	-	-	73
Central Apennines - Northern Apennines	*183*	-	-	-	-	-	*183*	-	-	*183*
Abruzzo	402	-	-	14	4	18	366	-	-	402
Lazio	120	19	-	36	19	-	84	-	-	139
Lazio - Umbria	29	5	-	19	-	-	15	-	-	34
Marche	231	-	-	126	66	-	38	-	-	231
Umbria	41	-	-	-	-	-	41	-	-	41
Central Apennines	*823*	*23*	-	*195*	*89*	*18*	*545*	-	-	*846*
Abruzzo	162	-	-	8	13	-	141	-	-	162
Central Apennines - Southern Apennines	*162*	-	-	*8*	*13*	-	*141*	-	-	*162*
Basilicata	399	-	23	41	-	-	381	-	-	423
Basilicata - Campania	14	-	-	0	-	-	14	-	-	14
Basilicata - Apulie	355	-	-	53	-	-	302	-	-	355
Calabria	988	-	285	151	42	8	1,073	-	-	1,273
Campania	894	-	40	338	11	8	577	-	-	934
Campania - Lazio	64	-	-	20	-	-	44	-	-	64
Lazio	64	-	-	5	2	-	57	-	-	64
Molise	231	-	-	-	-	4	120	-	106	231
Apulie	622	-	57	13	26	20	621	-	-	679
Southern Apennines	3,631	-	405	621	80	40	3,189	-	106	4,036
Sicily	1,007	-	61	300	39	17	712	-	-	1,068
Sardinia	1,208	-	0	286	14	59	849	-	-	1,208
ITALY	15,744	7,034	466	13,589	1,121	215	7,467	265	589	23,244

Source: Data Elaboration provided by INEA, SIGRIAN Data 2010

Table 9 - Water Charges in Regions and in River Basin Districts (RBD)

River Basin Districts (RBDs)	Regions	Fixed rate of double charge	Single charge / Variable rate of double charge
Po River basin	Emilia Romagna	Other	€/ha irrigated
		Other	€/ha per crop type
		€/ha irrigated	€/m^3
			€/ha irrigated
			€/ha per crop type
	Emilia Romagna- Lombardy	Other	€/m^3
			€/ha irrigated
	Lombardy	Other	€/ha irrigated
		€/ha irrigated	€/m^3
			€/ha irrigated
			€/ha per irrigation system
	Lombardy - Piedmont	€/ha irrigated	€/ha per crop type
			€/ha irrigated
			€/ha per crop type
	Piedmont	Other	€/ha irrigated
		€/ha irrigated	€/ha irrigated
		€/ha irrigated	€/ha per crop type
			Other
			€/ha irrigated
	Trentino-Alto Adige		€/ha irrigated
			€/ha per crop type
			€/ha per irrigation system
	Valle d'Aosta		€/ha irrigated
			€/ha per crop type
			€/ha per irrigation system
Eastern Alps	Friuli Venezia Giulia		€/ha irrigated
			€/ha per irrigation system
	Trentino-Alto Adige		€/ha irrigated
			€/ha per crop type
			€/ha per irrigation system
	Veneto		€/ha irrigated
			Other
Eastern Alps – Po River basin	Trentino-Alto Adige		€/ha irrigated
	Veneto		Other
			€/ha irrigated
Northern Apennines	Emilia-Romagna	Other	€/ha irrigated
		Other	€/m^3
		€/ha irrigated	€/m^3
			€/ha irrigated
	Liguria		€/ha irrigated
	Marche	€/ha irrigated	€/m^3
			€/ha irrigated
	Tuscany	other	€/ha per crop type
		€/ha irrigated	€/m^3
		€/m^3	€/m^3
			€/ha irrigated
Central Apennines – Northern Apennines	Lazio	€/ha irrigated	€/m^3
	Lazio - Tuscany		€/ha irrigated
	Tuscany		€/m^3
	Tuscany - Umbria		€/m^3
	Umbria		€/m^3
Central Apennines	Abruzzo		€/ha irrigated
	Lazio	€/ha irrigated	€/m^3
			€/ha irrigated
	Marche	€/ha irrigated	€/m^3
			€/ha irrigated
	Umbria	€/ha equipped	€/ha irrigated

segue >>>

segue >>>

River Basin Districts (RBDs)	Regions	Fixed rate of double charge	Single charge / Variable rate of double charge
Central Apennines – Southern Apennines	Abruzzo		€/ha per crop type
			€/ha per irrigation system
Southern Apennines	Basilicata		€/ha irrigated
			€/m^3
	Calabria		Other
			€/ha irrigated
			€/m^3
			€/ha per crop type
	Campania	€/ha equipped	€/m^3
			€/ha irrigated
			€/m^3
	Campania – Lazio		€/ha irrigated
	Lazio	€/ha irrigated	€/ha irrigated
		€/ha irrigated	€/m^3
			€/ha irrigated
	Molise	Other	€/m^3
		€/m^3	€/m^3
			Other
			€/ha irrigated
	Puglia	Other	€/m^3
		€/ha irrigated	€/m^3
			Other
			€/ha irrigated
			€/m^3
			€/ha per crop type
Sicily	Sicily		Other
			€/ha irrigated
			€/m^3
			€/ha per crop type
Sardinia	Sardinia	Other	Other
		Other	€/ha irrigated
			Other
			€/ha irrigated
			€/m^3
			€/ha per crop type

Source: Data Elaboration provided by INEA, SIGRIAN Data 2010

Technical Annex

Technical Annex

Methodology and the SIGRIAN Data

Forward

The Italian Irrigation Atlas aims to provide a geographical representation of the Italian irrigation system resorting to information collected in the SIGRIAN Database (the National Information System for Water Management in Agriculture).

The SIGRIAN is a *Geographic Information System* (GIS) and it was obtained from merging different databases of the SIGRIA (the *Information System for Water management in Agriculture*). The databases were developed by INEA in the Southern Regions and the Island Regions, — within the MOP, the *Multiregional Operative Programme* of Water Resources for the years 1994-1999 — and by INEA in the Central and the Northern Regions — within the project, funded by *MiPAAF*, named '*Monitoring Irrigation Systems in the Central and the Northern Regions*'—. The standardization and modernization of different databases aiming to establish a national (database) system are provided for by the National Rural Network project (see INEA project RGR 3b).

Technical Characteristics

Information collected in the SIGRIAN mainly concerns the areas implementing collective irrigation, irrigation management, economic and management characteristics of Irrigation agencies, irrigation infrastructures (water supply structures, irrigation networks). The contents included thereof, are:

- Administrative constrains of Irrigation Bodies;
- Limits of areas and river basin districts;
- Resources for irrigation purposes;
- Nodes and sections of the network;
- Wastewater treatment plants located in areas of operation of Irrigation agencies.

The mapping is on a scale of 1:10000. In general, the basic mapping used may include: Regional Technical Map (*Ctr - Carta Tecnica Regionale*), Military Geographic Institute (IGM) on a scale of 1:25.000, maps of cadastral parcel sheets (1:2.000 scale), territory digital orthophotos in black and white or in colour or in some cases paper-printed. The system of reference currently used is WGS 84 Lat/Lon (EPSG: 4326).

Thematic queries tackled in this Atlas

Technical characteristics concerning exclusively thematic queries and data used to develop the National irrigation Atlas are shortly described hereafter.

Irrigation agencies

Irrigation agency means the basic legal entity which manages irrigation at a territorial level in terms of management and maintenance of irrigation networks, organization of water resources distribution for irrigation purposes. Given the different situation of the regions as to the legal status of the Irrigation agencies, it was decided, together with the Regions on a case-by-case basis, which consortia were to be considered Irrigation agencies.

Water Charges

The system of water pricing, typical of Irrigation and Reclamation Consortia refers to the so-call water charges associated with the benefits consumer draw from irrigation services provided. There are 2 types of water charges: the so-called '*contributo monomio*' — a 'Single charge' — and '*contributo binomio*' — a 'Double charge. The first water charge is all-inclusive. It is a single charge, which does not require any specific volume for operating irrigation. The second, instead, differentiates between fixed rate the users pay and general/overhead costs (e.g.: routine maintenance of equipment), plus a variable rate for irrigation.

Irrigation Scheme

'Irrigation Scheme' means the large irrigation works implemented by irrigation. In general, they constitute separate and stand-alone schemes compared to other schemes implemented in the use of water (resources) for other purposes. However, in other situations, they may share important intersecting nodes, at a spring level, but also at a primary and secondary network level. The Irrigation Scheme, that normally supplies and defines river basin districts, includes:

- One or several water supply;
- One main network comprising the primary and a secondary network originated from the first partition of the primary network;
- A distribution network, supplying river basin dis-

tricts which is not geographically represented in the current document.

The water supply structures

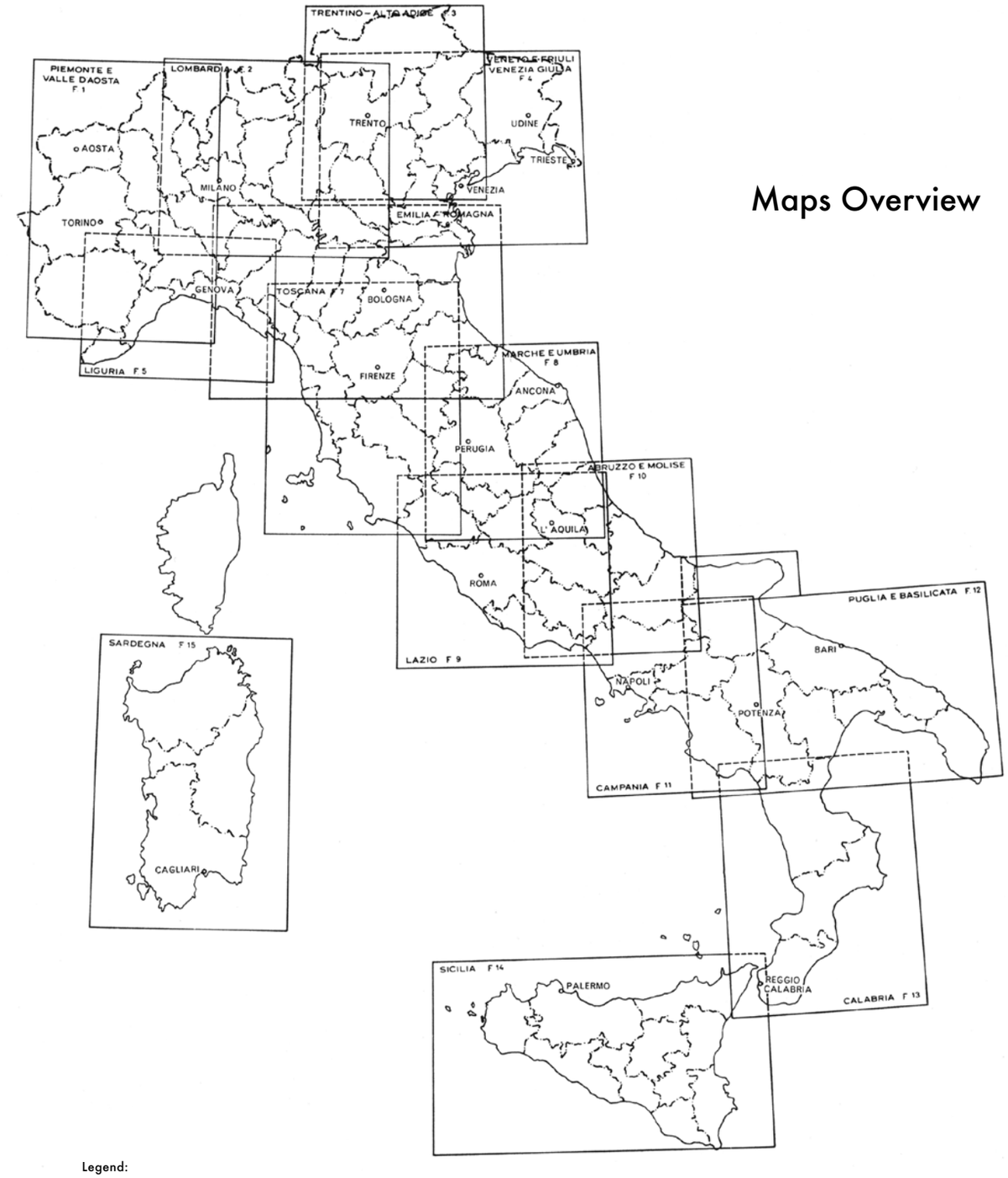
Supplying system means the structures located in natural or artificial water bodies from which the irrigation scheme is originated. The source may be an water supply structure replenished by a spring, natural or artificial lake, water bodies and well field, etc. It may also include a wastewater treatment plant or a water connector from an intersecting facility that supplies water constantly and delivers water for different user types (water for household, agriculture and industrial use).

Irrigation Network System

It is the totality of sections (channels and conducts) intersected with the so-called nodes, that are not geographically represented in this study. Commonly they are structural works (lifting facilities, etc.) or account for changes in technical characteristics (diameters, sections, materials, etc.).

Annex - Historical Maps

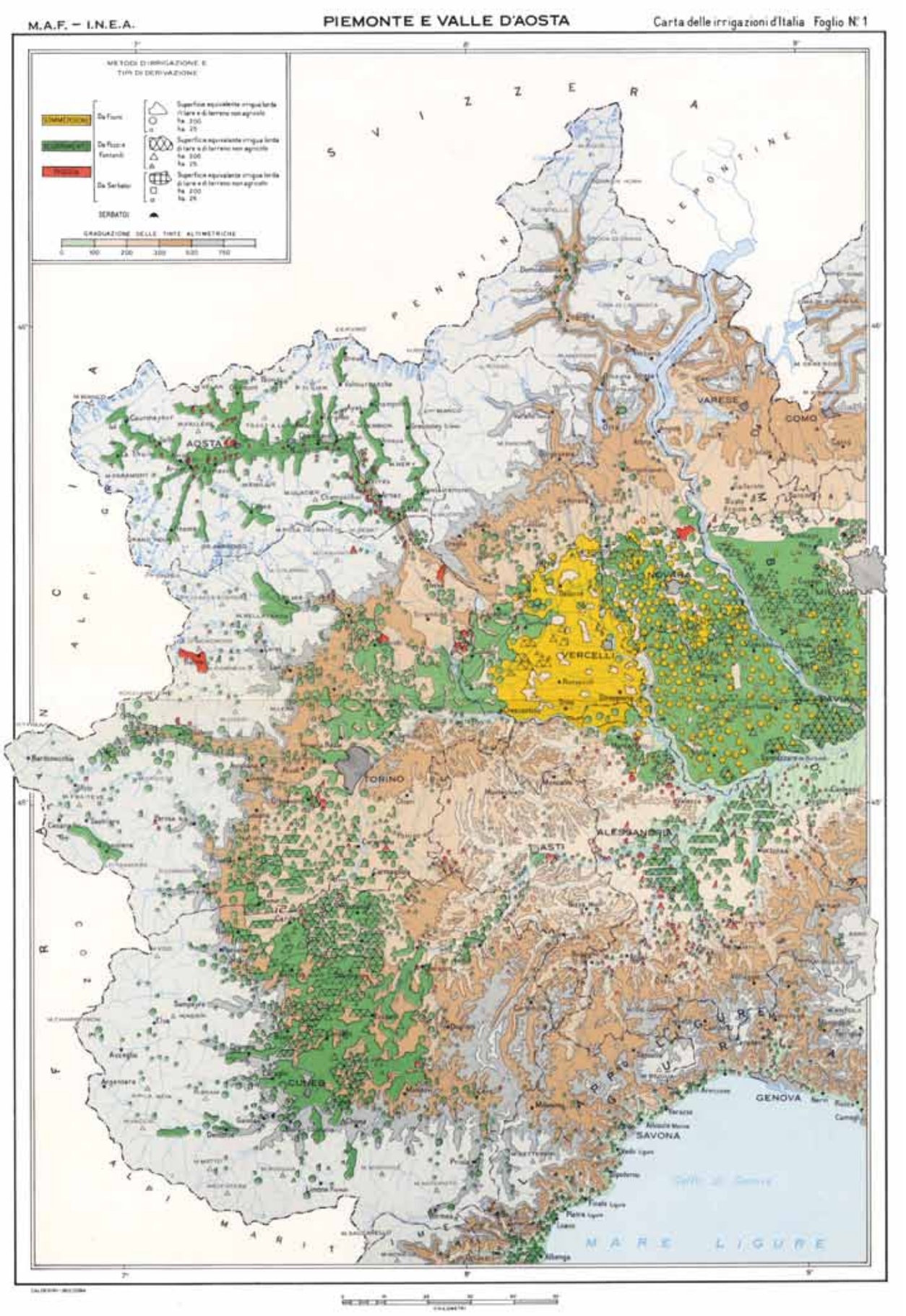
CARTA
DELLE IRRIGAZIONI D'ITALIA



Legend:

- Borders of the State
- Borders of the Regions
- Borders of the Provinces

Maps Overview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PIEMONTE E VALLE D'AOSTA
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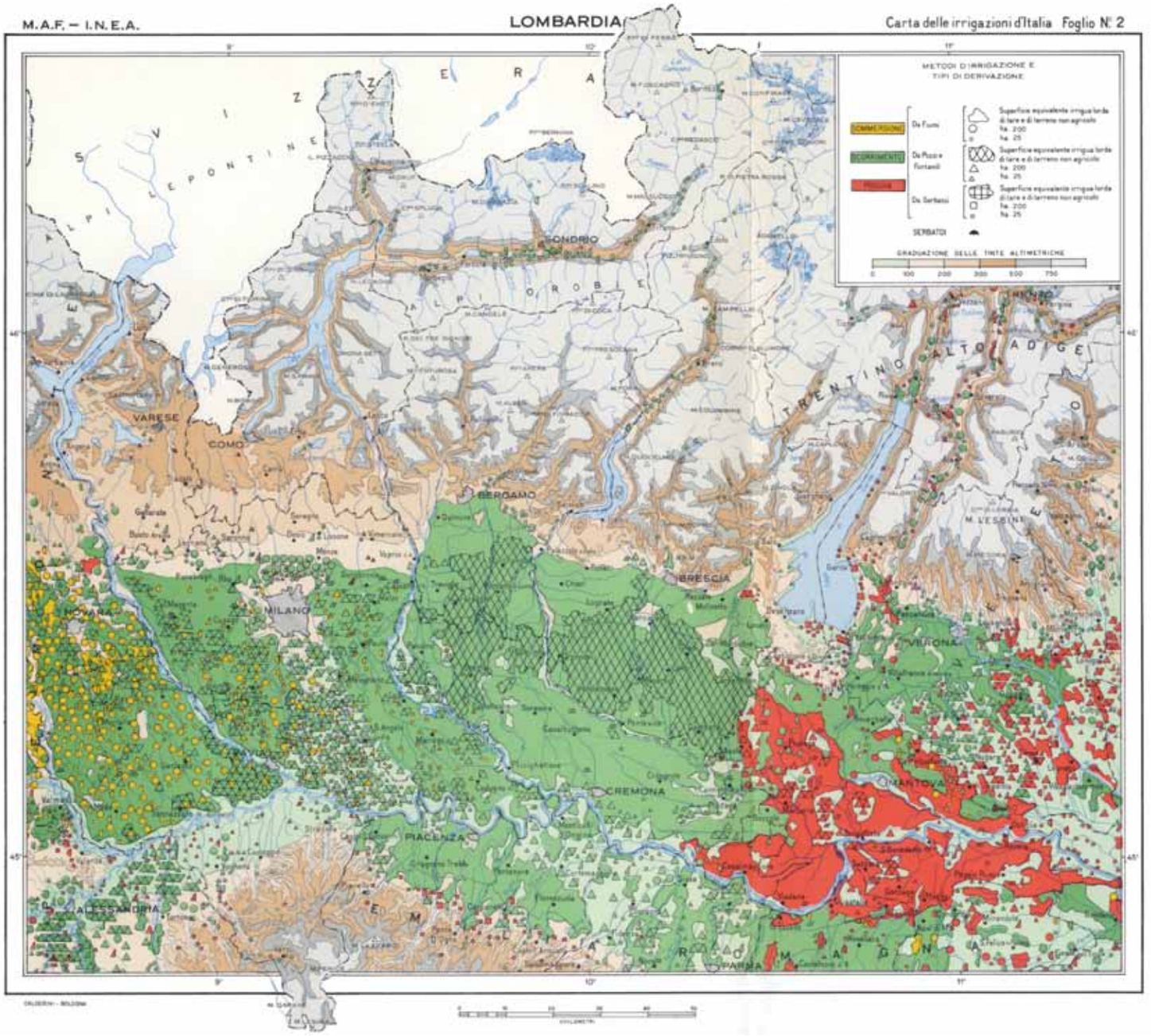
METODI D'IRRIGAZIONE E TIPI DI DERIVAZIONE
SERBATOI
GRADUAZIONE DELLE TINTE ALTIMETRICHE
SVIZZERA
AOSTA
VARESE
COMO
NOVARA
VERCELLI
PAVIA
TORINO
ALESSANDRIA
ASTI
CUNEO
GENOVA
SAVONA
MARE LIGURE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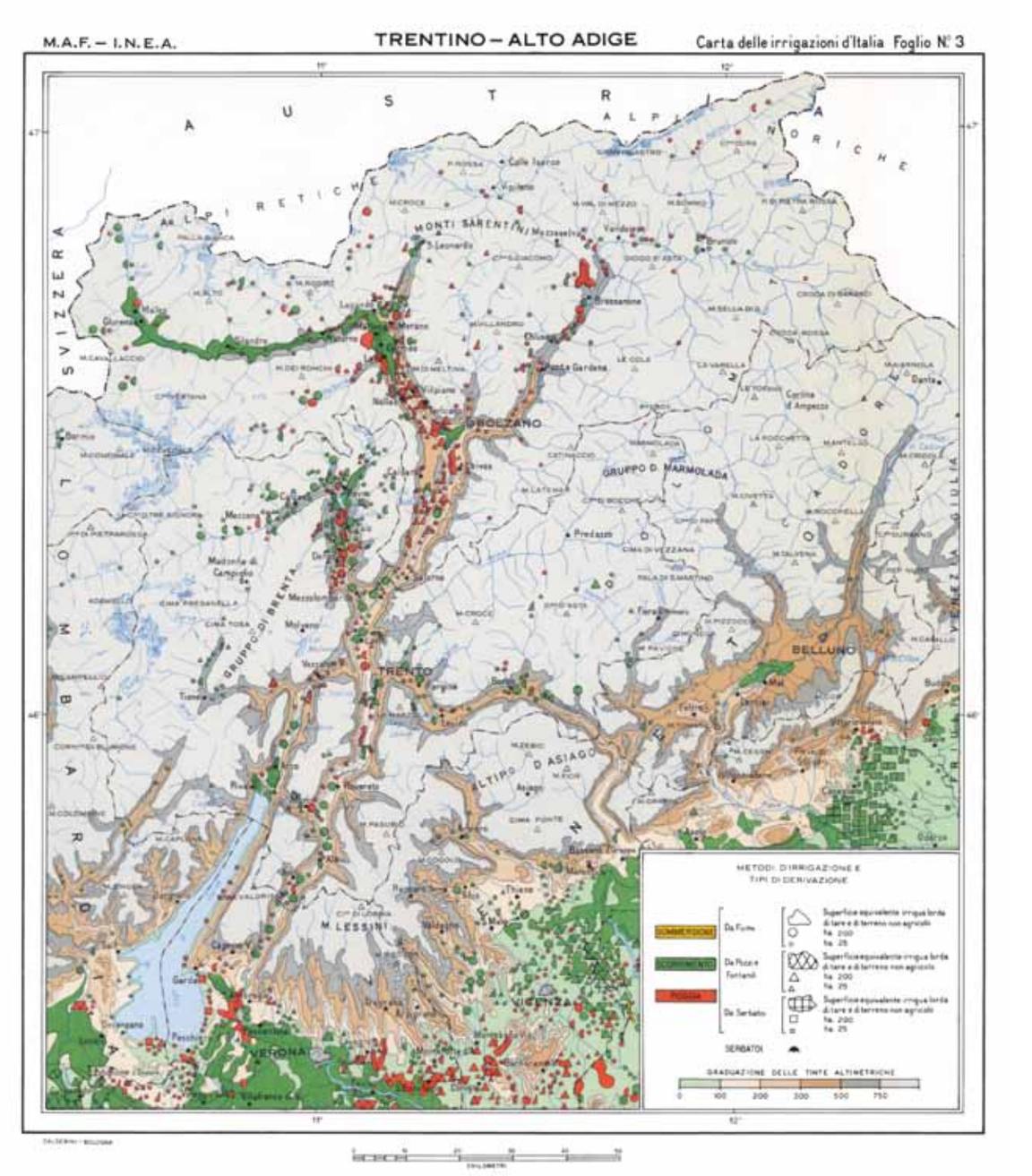
LOMBARDIA
Carta delle irrigazioni d'Italia Foglio N. 2
METODI D'IRRIGAZIONE E TIPI DI DERIVAZIONE
SOMMERSIONE
SCORRIMENTO
PIOGGIA
Da Fiume
Da Pozzi e Fontanili
Da Serbatoi
SERBATOI
GRADUAZIONE DELLE TINTE ALTIMETRICHE
0 100 200 300 500 750
SONDRIO
VARESE
COMO
BERGAMO
BRESCIA
MILANO
VERONA
CREMONA
MANTOVA
PIACENZA
ALESSANDRIA
PARMA
TRENTINO ALTO ADIGE
ALPI RETICHE
ALPI LEPONTINE
APPENNINO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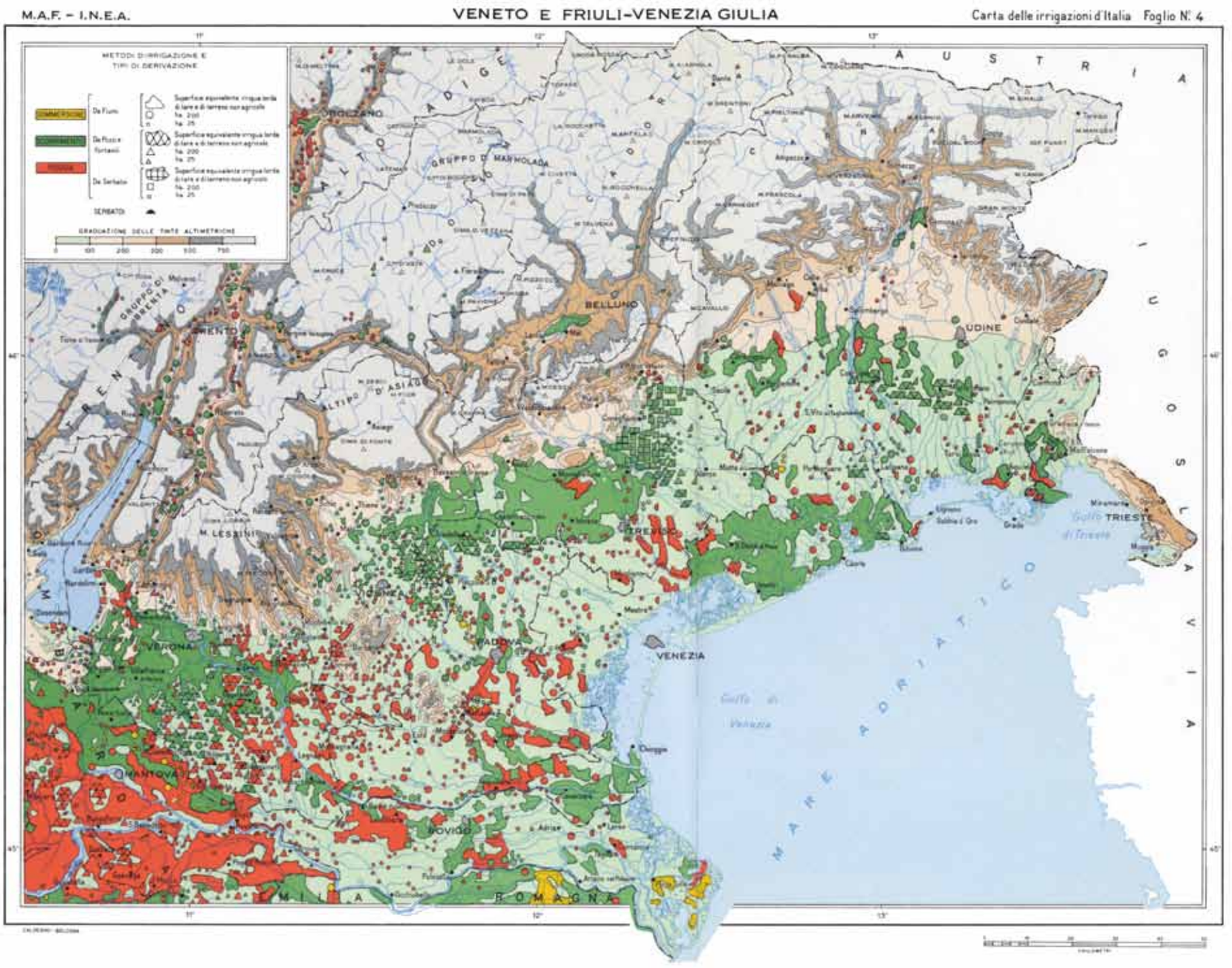
TRENTINO – ALTO ADIGE
Carta delle irrigazioni d'Italia Foglio N° 3
AUSTRIA
SVIZZERA
ALPI RETICHE
ALPI NORICHE
MONTI SARENTINI
GRUPPO DI BRENTA
GRUPPO DI MARMOLADA
ALTIPIANO DI ASIAGO
M. LESSINI
BOLZANO
TRENTO
BELLUNO
VICENZA
VERONA
METODI D'IRRIGAZIONE E TIPI DI DERIVAZIONE
SCOLO NATURALE
SOLLEVAMENTO
PRESSIONE
Da Fonte
Da Pozzi e Fontanili
Da Serbatoi
SERBATOI
GRADUAZIONE DELLE TINTE ALTIMETRICHE
0
100
200
300
500
750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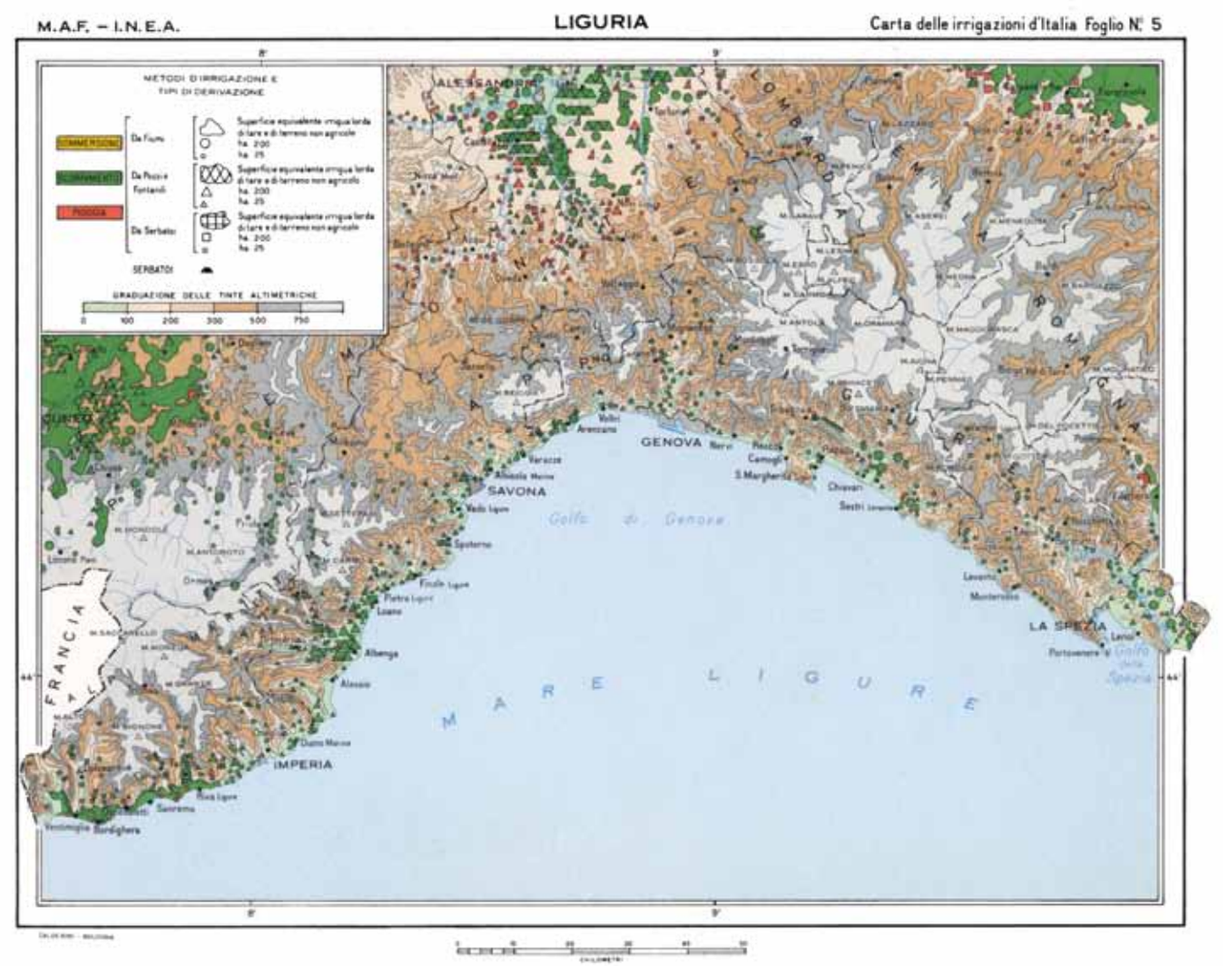
VENETO E FRIULI-VENEZIA GIULIA
Carta delle irrigazioni d'Italia Foglio N. 4
METODI DI IRRIGAZIONE E TIPI DI DERIVAZIONE
GRADUAZIONE DELLE TINTE ALTIMETRICHE
ALTO ADIGE
BOLZANO
GRUPPO DI MARMOLADA
BELLUNO
UDINE
TRENTO
GRUPPO DI BRENTA
ALTIPIANO D'ASIAGO
M. LESSINI
VERONA
PADOVA
TREVISO
VENEZIA
TRIESTE
MANTOVA
ROVIGO
AUSTRIA
JUGOSLAVIA
MARE ADRIATICO
EMILIA ROMAGNA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Carta delle irrigazioni d'Italia Foglio N. 5
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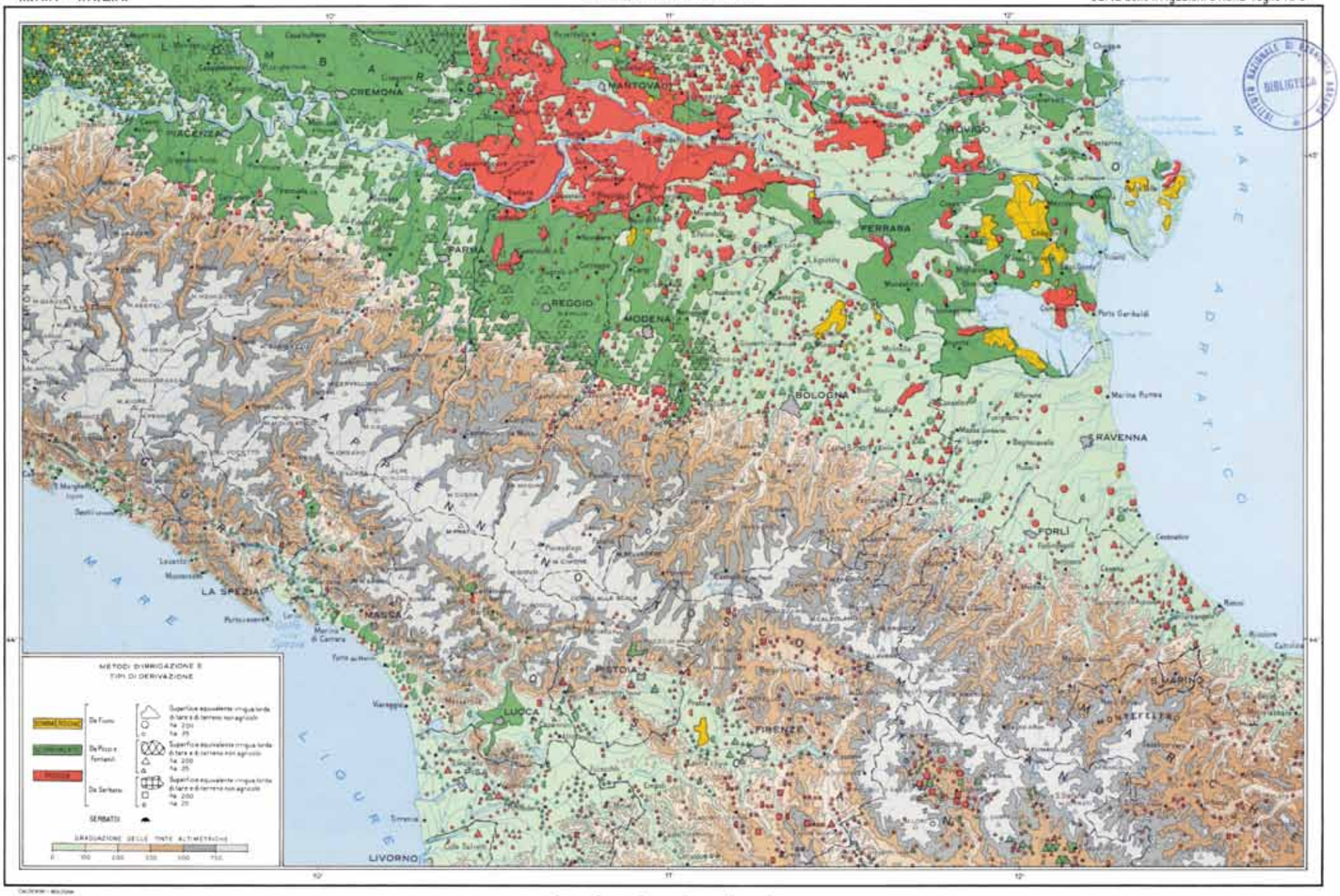
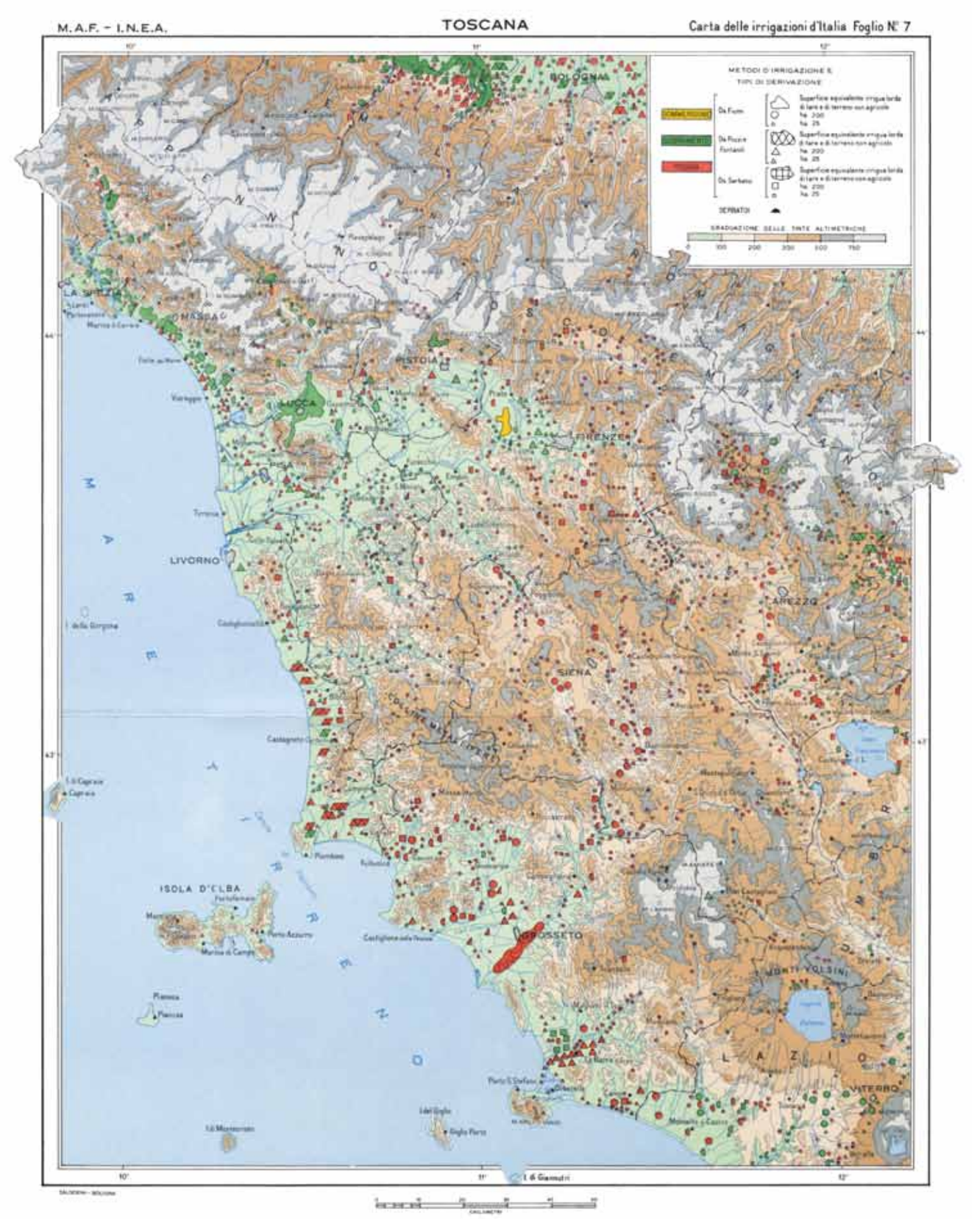
SERBATOI
GRADUAZIONE DELLE TINTE ALTIMETRICHE
0 100 200 300 500 750
ALESSANDRIA
GENOVA
SAVONA
IMPERIA
LA SPEZIA
Golfo di Genova
MARE LIGURE
FRANCIA

M.A.F. – I.N.E.A.

EMILIA – ROMAGNA

Carta delle irrigazioni d'Italia Foglio N. 6

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TOSCANA
Carta delle irrigazioni d'Italia Foglio N° 7
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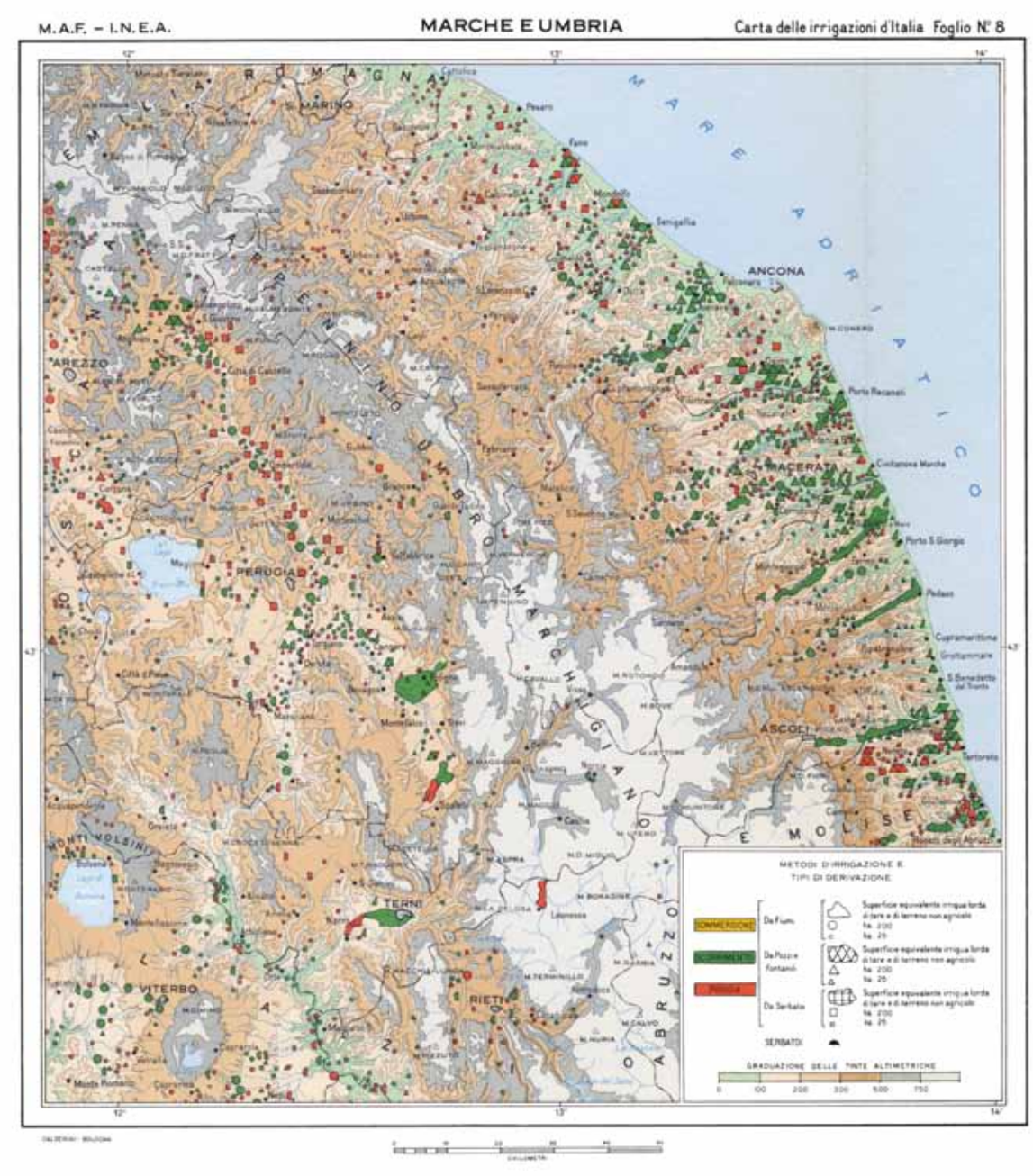
SERBATOI
GRADUAZIONE DELLE TINTE ALTIMETRICHE
BOLOGNA
PISTOIA
LUCCA
FIRENZE
LIVORNO
AREZZO
SIENA
GROSSETO
ISOLA D'ELBA
MONTI VOLSINI
VITERBO
L A Z I O
M A R T I R R E N O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MARCHE E UMBRIA
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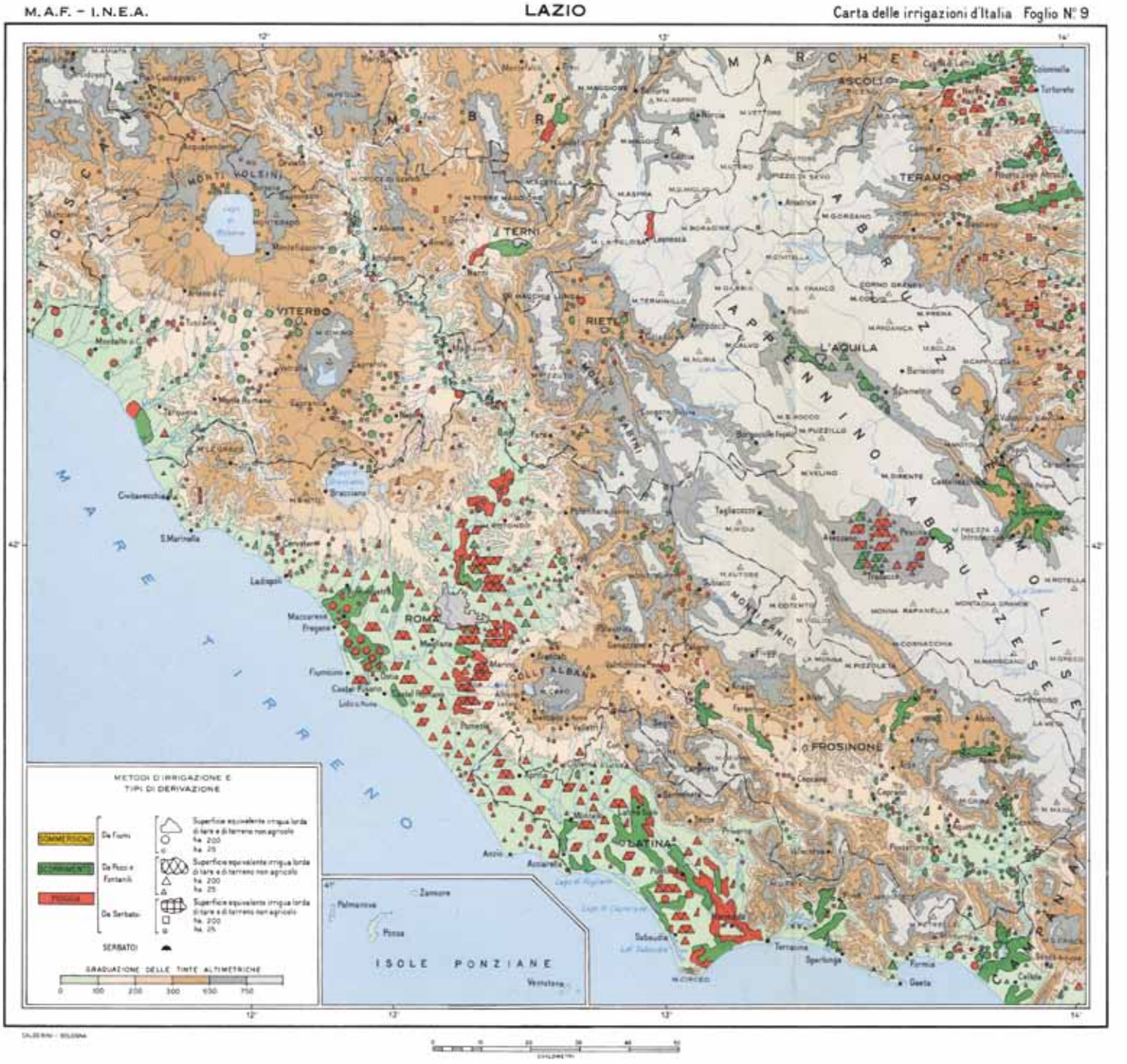
TOSCANA
UMBRIA
MARCHE
ABRUZZO E MOLISE
MARE ADRIATICO
ANCONA
AREZZO
PERUGIA
MACERATA
ASCOLI
TERNI
RIETI
VITERBO
MONTI VOLSINI
METODI D'IRRIGAZIONE E TIPI DI DERIVAZIONE
Da Fiumi
Da Pozzi e Fontanili
Da Serbatoi
SERBATOI
GRADUAZIONE DELLE TINTE ALTIMETRICHE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LAZIO
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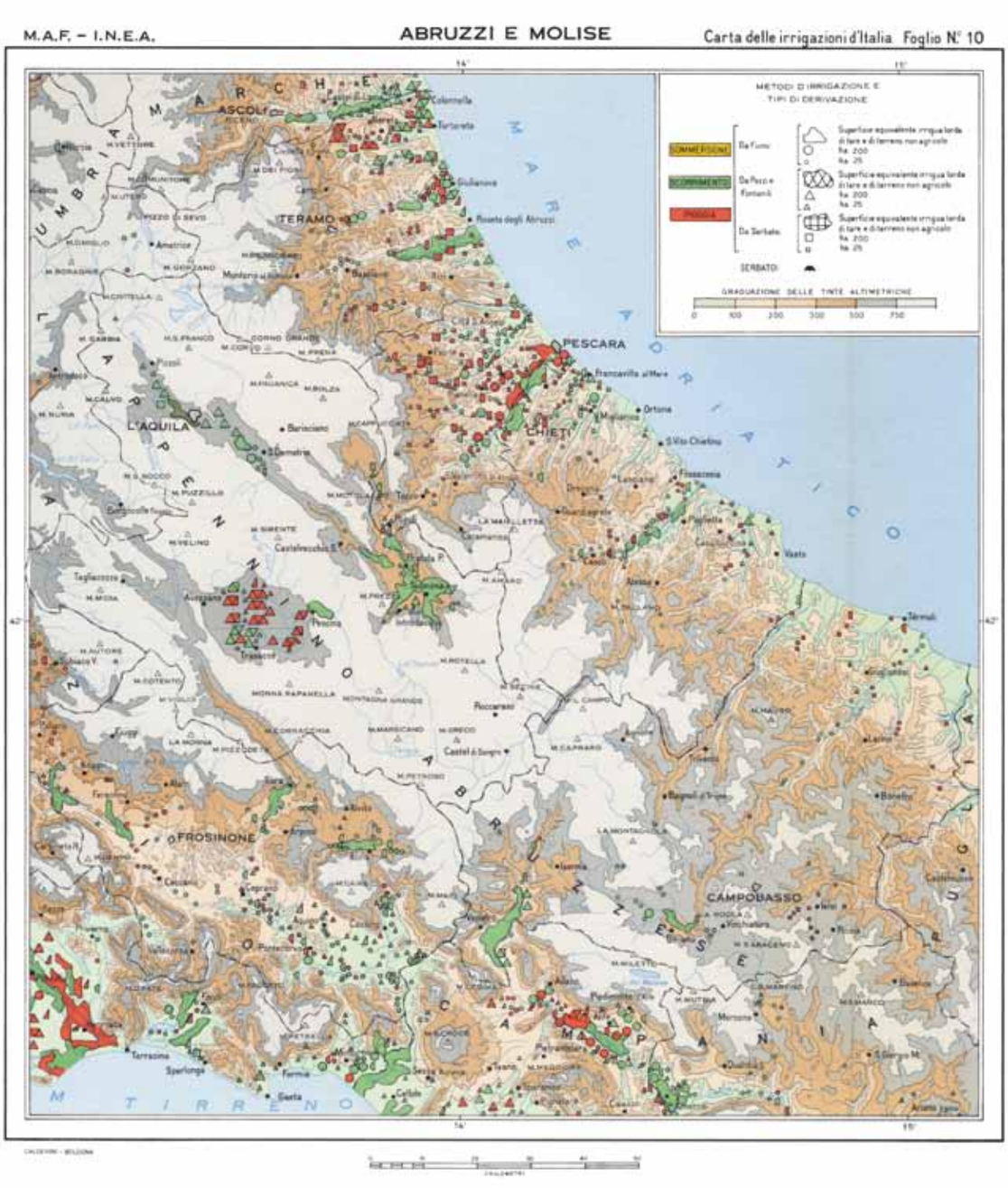
ABRUZZI
TERAMO
ASCOLI
L'AQUILA
TERNI
VITERBO
RIETI
ROMA
FROSINONE
LATINA
ISOLE PONZIANE
METODI DI IRRIGAZIONE E TIPI DI DERIVAZIONE
SOMMERSIONE
SCORRIMENTO
PER ASPERSIONE
Da Fiumi
Da Pozzi e Fontanili
Da Serbatoi
SERBATOI
GRADUAZIONE DELLE TINTE ALTIMETRICHE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Carta delle irrigazioni d'Italia Foglio N° 10
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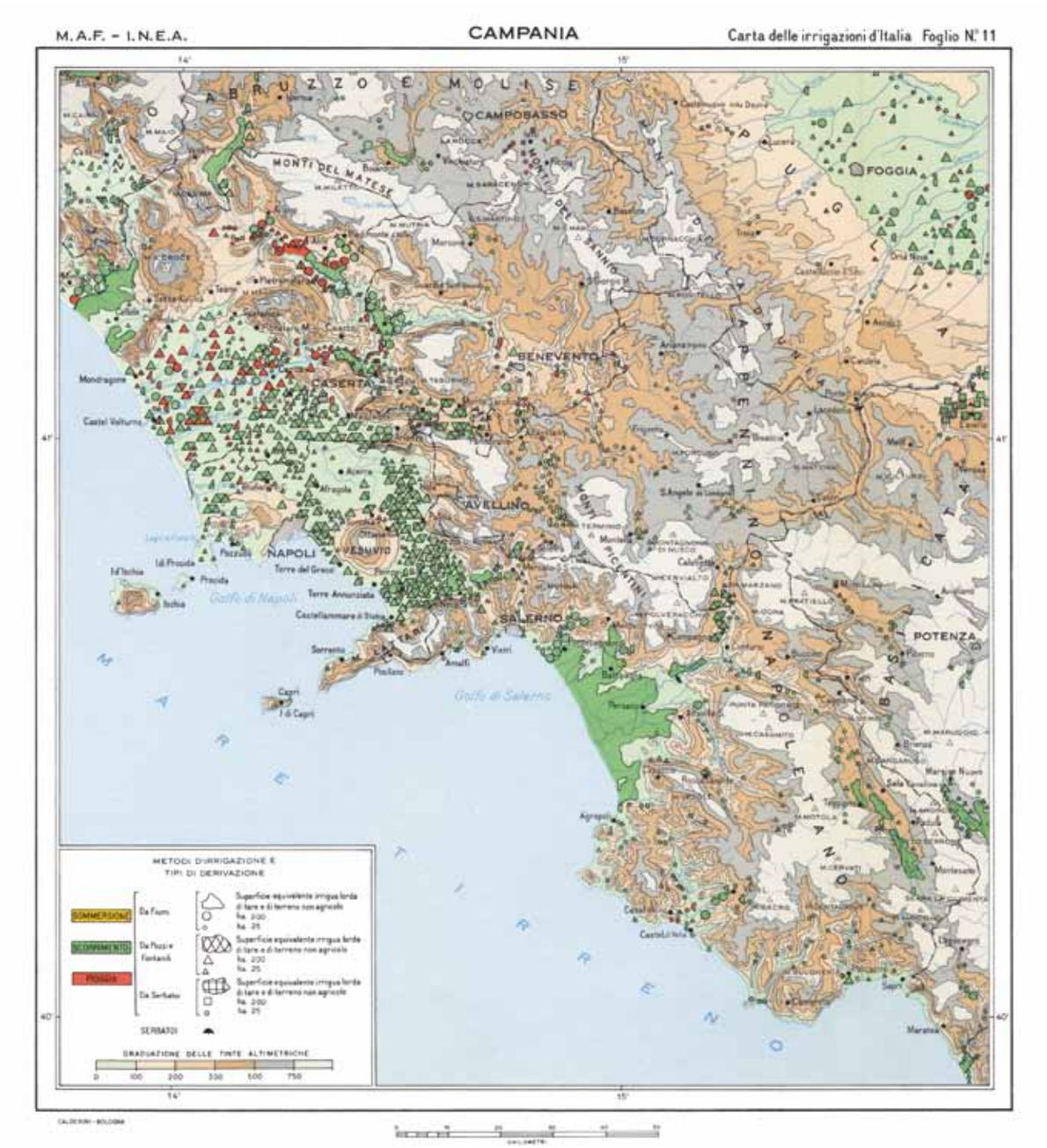
SOMMERSIONE
SCORRIMENTO
PIOGGIA
SERBATOI
GRADUAZIONE DELLE TINTE ALTIMETRICHE
PESCARA
L'AQUILA
CHIETI
TERAMO
FROSINONE
CAMPOBASSO
M. TIRRENO
M. ADRIATICO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CAMPANIA
Carta delle irrigazioni d'Italia Foglio N.° 11
ABRUZZO E MOLISE
CAMPOBASSO
FOGGIA
BENEVENTO
CASERTA
AVELLINO
NAPOLI
VESUVIO
SALERNO
POTENZA
MONTI DEL MATESE
MONTI DEL SANNIO
MONTI PICENTINI
Mondragone
Castel Volturno
Ischia
Procida
Capri
Sorrento
Amalfi
Vietri
Golfo di Napoli
Golfo di Salerno
METODI D'IRRIGAZIONE E TIPI DI DERIVAZIONE
SOMMERSIONE
SCORRIMENTO
PIOGGIA
Da Fiumi
Da Pozzi e Fontanili
Da Serbatoi
SERBATOI
GRADUAZIONE DELLE TINTE ALTIMETRICHE
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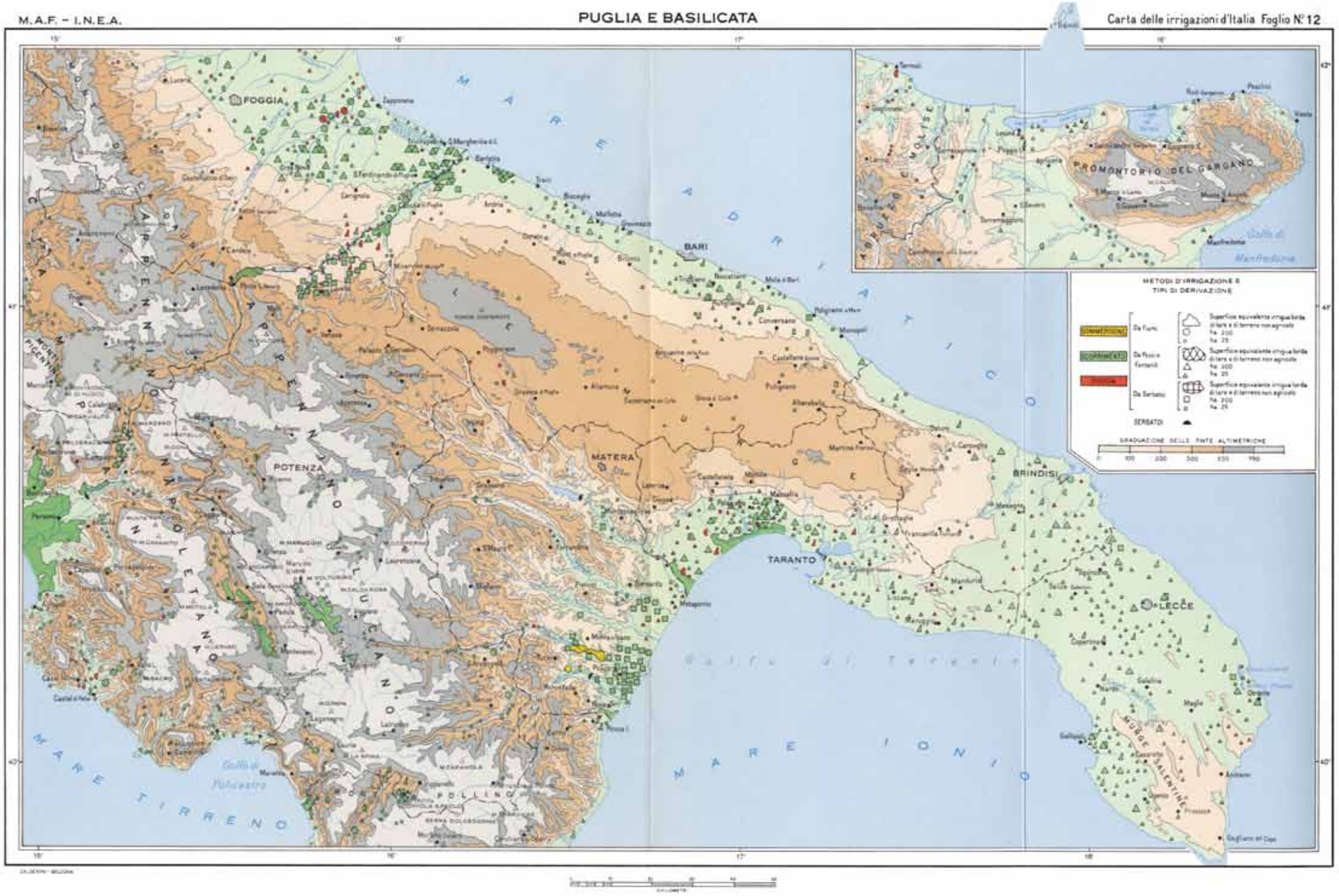
M.A.F. – I.N.E.A.
PUGLIA E BASILICATA
Carta delle irrigazioni d'Italia Foglio N° 12
FOGGIA
BARI
MATERA
POTENZA
TARANTO
BRINDISI
LECCE
PROMONTORIO DEL GARGANO
METODI D'IRRIGAZIONE E TIPI DI DERIVAZIONE
SOMMERSIONE
SCORRIMENTO
INFILTRAZIONE
Da Fiumi
Da Pozzi e Fontanili
Da Serbatoi
SERBATOI
GRADUAZIONE DELLE TINTE ALTIMETRICHE
MARE ADRIATICO
MARE TIRRENO
MARE IONIO


M.A.F. – I.N.E.A.
CALABRIA
Carta delle irrigazioni d'Italia Foglio N. 13
CAMPANIA
BASILICATA
Golfo di Policastro
Golfo di Taranto
MAR TIRRENO
MAR IONIO
SILA GRECA
SILA GRANDE
SILA PICCOLA
COSENZA
CATANZARO
MESSINA
REGGIO DI CALABRIA
PROMONTE
Golfo di Squillace
Golfo di Sant'Eufemia
Stretto di Messina
SERBATOI
GRADUAZIONE DELLE TINTE ALTIMETRICHE
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100
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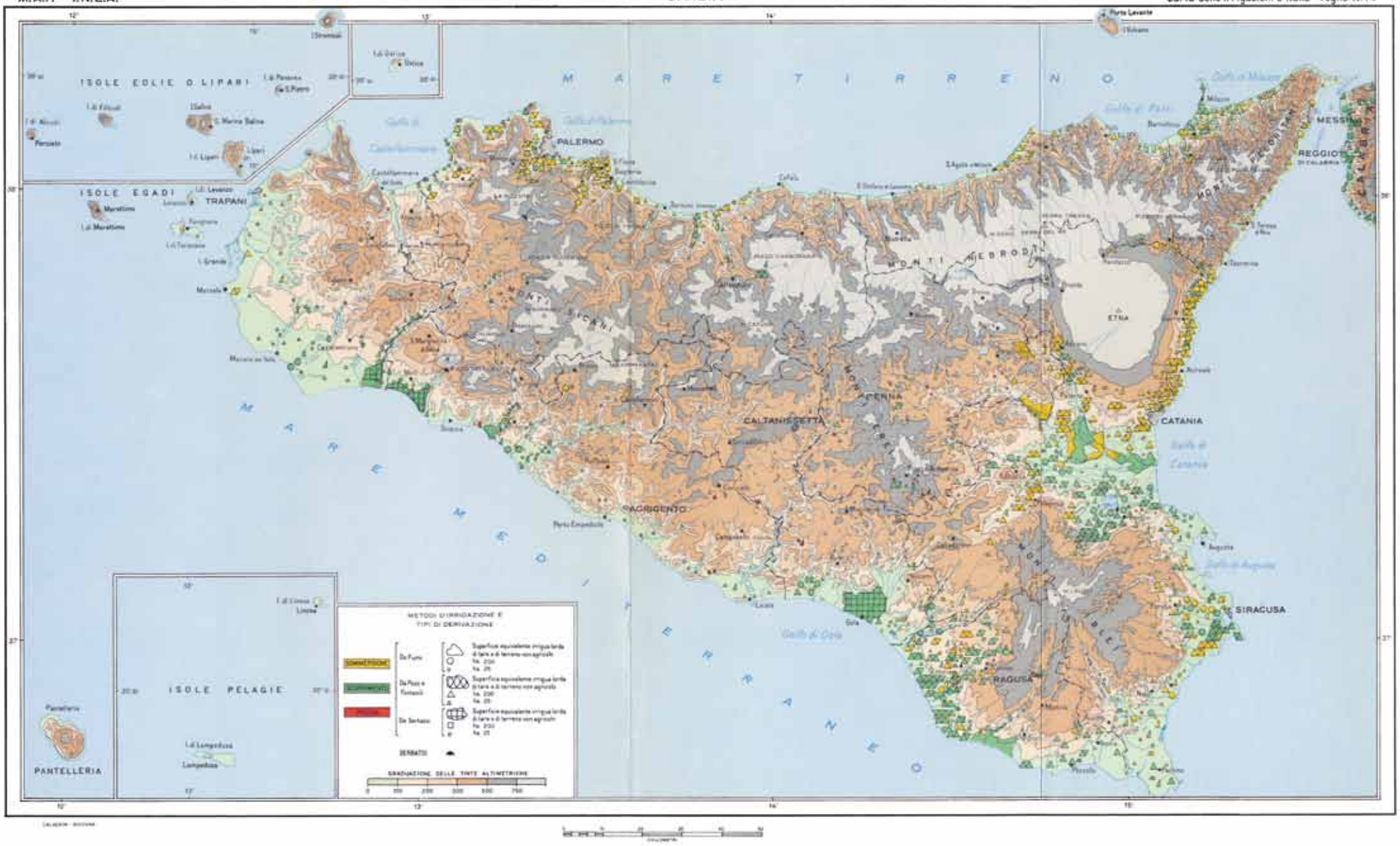
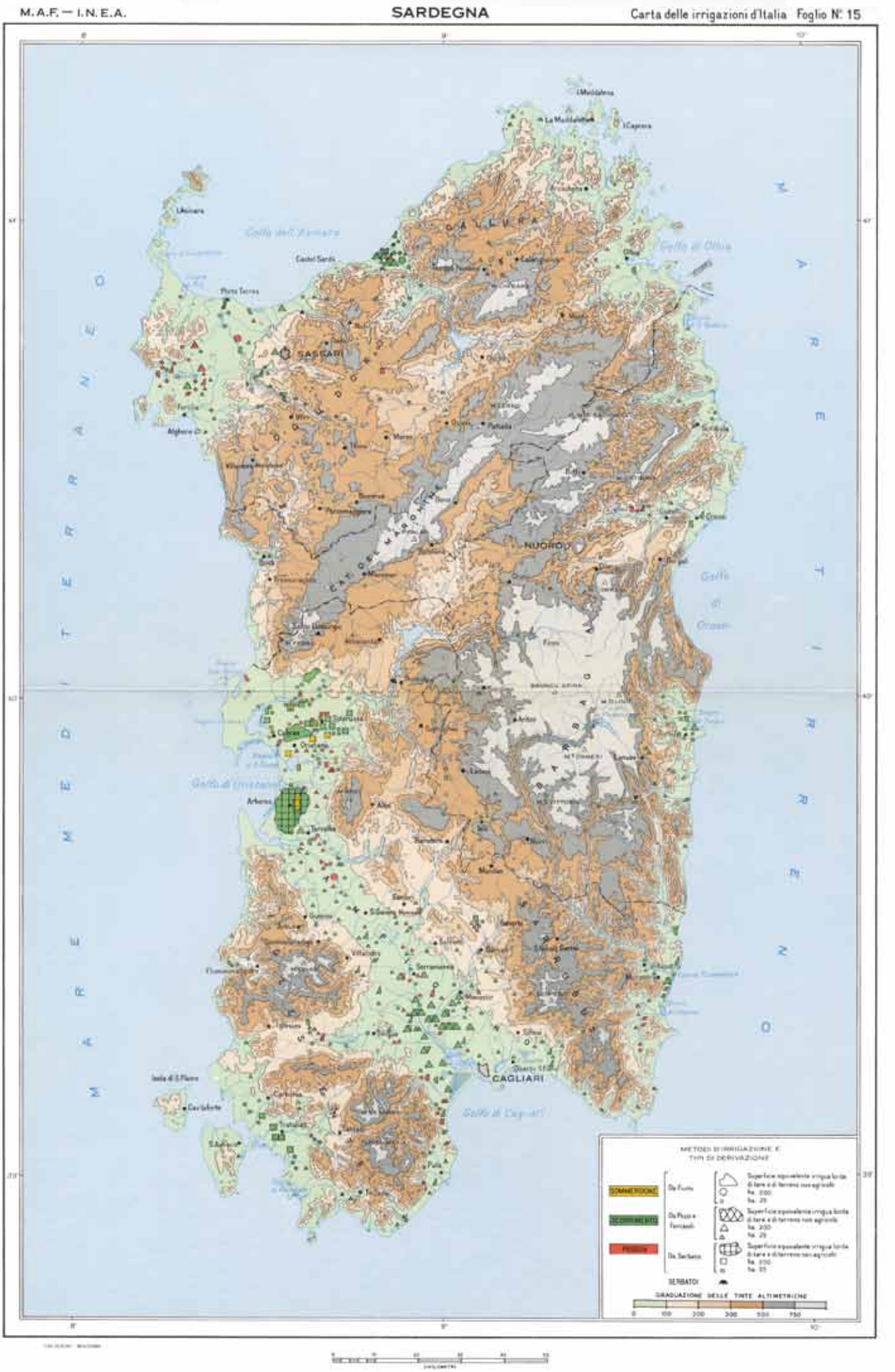
753

M.A.F. – I.N.E.A.

SICILIA

Carta delle irrigazioni d'Italia Foglio N°14

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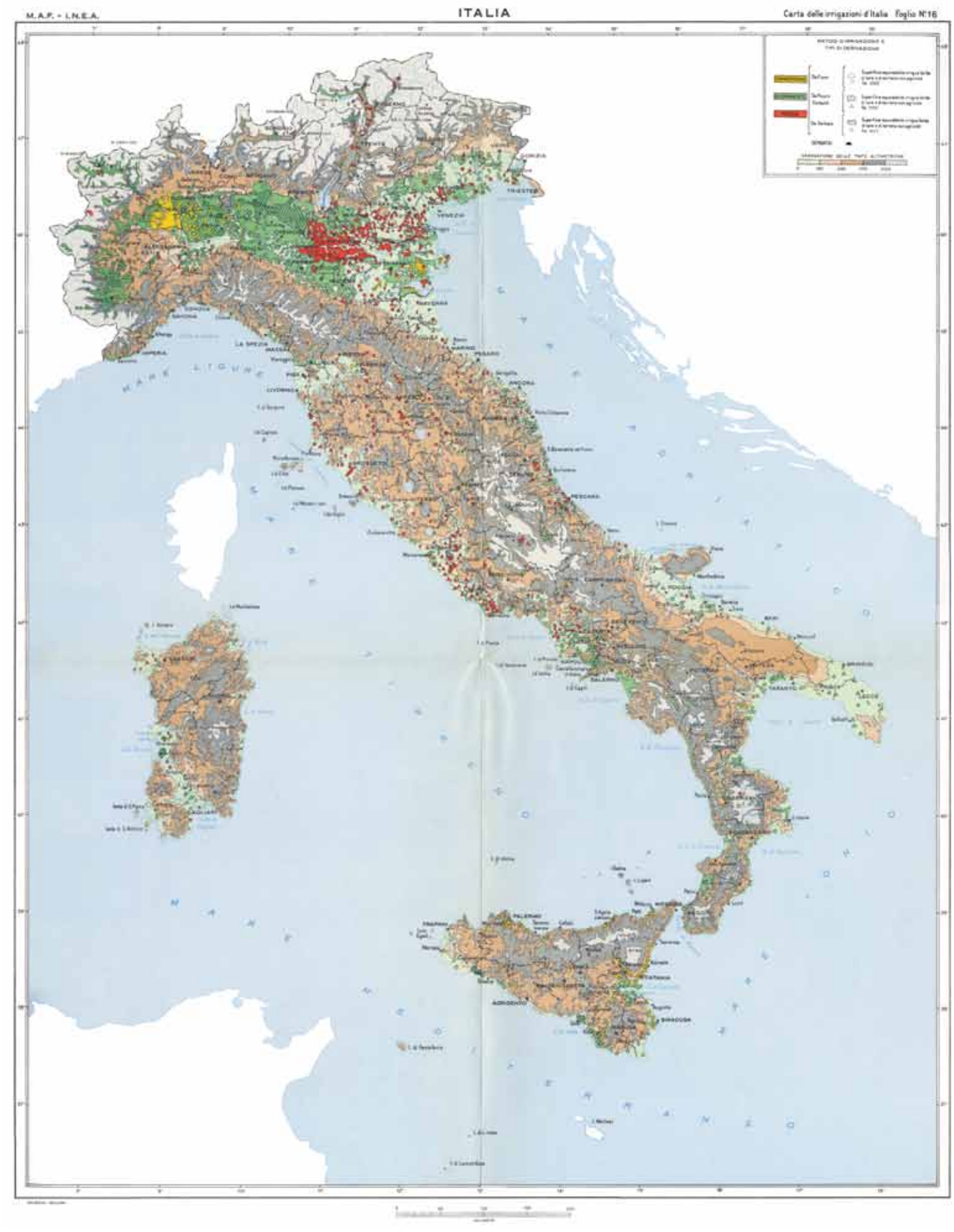
SARDEGNA
Carta delle irrigazioni d'Italia Foglio N. 15
SASSARI
NUORO
CAGLIARI
Golfo dell'Asinara
Golfo di Orosei
Golfo di Cagliari
Golfo di Oristano
Isola di S. Pietro
METODI DI IRRIGAZIONE E TIPI DI DERIVAZIONE
SOMMERSIONE
SCORRIMENTO
PERDITA
Da Fiume
Da Pozzo e Fontanili
Da Serbatoio
SERBATOI
GRADUAZIONE DELLE TINTE ALTIMETRICHE
0
100
200
300
500
750


M.A.P. - I.N.E.A.
ITALIA
Carta delle irrigazioni d'Italia Foglio N°16

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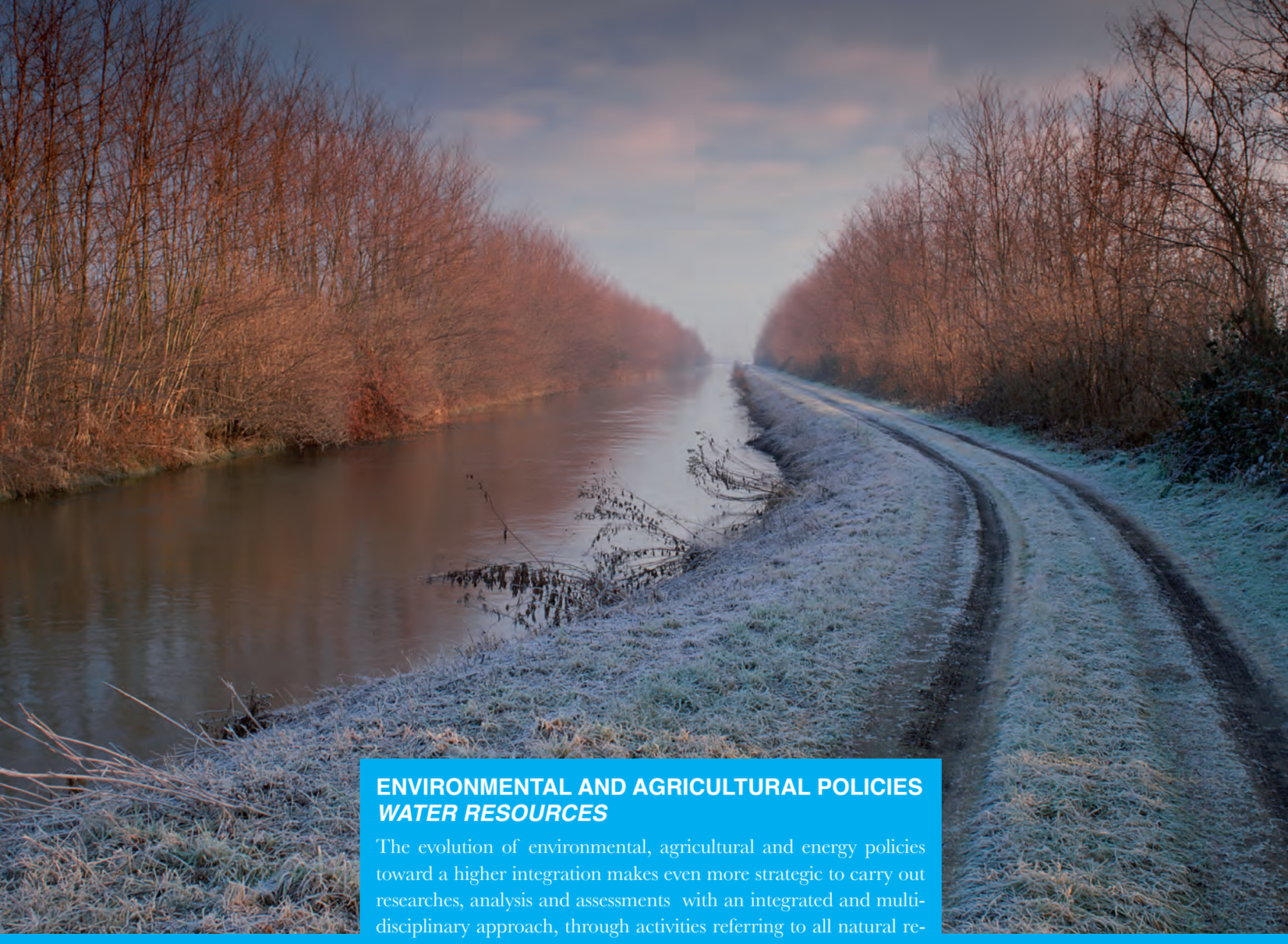

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