Water resources management and territorial development: Technological changes in Apulia during the post-unification period

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Abstract

The history of water management in Apulia is the result of a complex interplay between gradual evolution of traditional technologies and rapid and profound technological changes after the unification of Italy. This led to the accomplishment of an enormous effort for the domestication of water, which led, amongst other things, to the creation of the largest aqueduct in Europe.

This article will analyse the conditions, strategies and consequences of the course of radical technological change that was undertaken in 20th century Apulia.

Challenging the idea, perhaps once considered reassuring, of progress as a linear path of growth and continuous overcoming of limits, this article will discuss the limitations of a heroic vision of technical progress by proposing a more human conception of technology and a renewed role for it within the environmental context.

Keywords

Technological change, Water management, Sustainable territorial development, Apulia.

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From diligence to fatalism: The many traditional technologies for water resource management in Apulia

The evolution of the traditional water harvesting, storage and distribution technologies in Apulia may be seen as the result of an ongoing dialectic between a sort of fatalistic sense of resignation to a state of total lack and deprivation, that is the result of an inherent scarcity of surface water and a semi-arid climate of the region, and endeavours to develop ingenious ways to obtain water in such an unforgiving territory.

In the writings of the ancients, Apulia as a thirsting land is already to be found as early as the 1st century BC when Horace spoke of "*Apulia siticulosa*" (thirsting Apulia) and with some surprise describes sales of water in the Capitanata area. This scarcity of resources, coupled with a general inattention to water issues that typified, albeit differently, the Lombards of Benevento and the Byzantines who were settled in different parts of the region in the 7th century AD, even brought about the suggestion that the name *Apulia* itself was derived from the Greek ἀπώλεια (apoleia), meaning "destruction" or "ruin" (Sirago, 1993). *Paulus Diaconus* (Paul the Deacon) wrote in his *Historia Longobarda* of *"Apulia a preditione",* and discussed how the herbs and plants in the region dried up much sooner due to the heat of the sun[1].

Faced with such scarcity of resources, considerable efforts were made in order to come up with a number of ingenious methods to obtain water. Consider, for example, the civic water works and cisterns that were already present during the Roman period, a period when the towns in Apulia were being repopulated after the long periods of poverty and population decline that had marked the previous epoch[2]. Both individual and communal cisterns soon became one of the main systems of water supply in Apulia. Cisterns of various types were built throughout the region in order to provide drinking water and water for livestock. These cisterns were found in urban areas, next to dwellings, and also in the countryside. They were mostly bell-shaped, with walls that were typically coated with tufa and covered with a mixture of impermeable tufa, lime and crushed pottery shards. In addition, they had a vaulted roof with an opening from which water was drawn. Water itself was channelled through a series of small canals made of terracotta or carved out of the rocks. Now mostly in fallen into disuse, these systems are sometimes still used today as reserve cisterns and filled with groundwater distributed by specially equipped trucks. This in turn enables avoiding a whole series of previously necessary practical maintenance tasks on the channels in order to avert contamination from soil accumulating in the cisterns.

Rural cisterns are also interesting, rectangular in shape and very popular in the area of Murgia. In this case, water was collected by means of sub-soil micro-filtration and the natural condensation resulting from temperature differences (Laureano, 2001); on the roof there was a well, from which water was collected and used mainly for livestock. In several rural areas it is also interesting to note the presence of so-called *neviere*, i.e., buildings with a square or rectangular base, dug to a depth of 5-6 metres in the ground, roofed with a barrel vault and with access to one of the two sides at ground level. These structures collected the snow that accumulated over winter months so as to augment water resources during the summer with the melted snow water.

Among cisterns, bell-shaped ones are particularly interesting, which are carved out at the bottom of karst depressions. These had side walls consisting of filtering stones and a base covered for the most part with impermeable clay. They collected water through lateral surface filtration, thus exploiting seasonal increases in water and reducing loss from evaporation in the summer. This type of construction is exemplified by the bell-shaped wells built on the lake beds of Conversano[3]; formerly they were mostly owned privately, subsequently they became of communal property, as at the beginning of the 19th century the municipality took them over for collective use. Another form similar to these cisterns were the *pozzelle* in Salento. These were from 3-6 metres deep and had their opening closed off with a stone with a hole in the centre. They were also dug out at the bottom of karst depressions and constructed where the aquifer was very deep (De Giorgi[4], quoted in Costantini, 1988). These were to be found mostly in the vicinity of towns such as Martignano, Zollino, Castrignano, Corigliano, Soleto and Martano. They were even to be found, albeit less conspicuously, in the open countryside where once villages and hamlets had stood, which disappeared in the Middle Ages[5]. Although most of them had vanished, some did indeed remain in use until the early decades of the 20th century.

Another example of ingenious water supply technology is that of the *foggare* (underground conduit/*qanat*), which are typically found in northern Africa, providing a harvesting system for underground microflows. Some of them are to be found in Gravina di Puglia and in some areas of Gallipoli, where they were known as *formali* (De Giorgi, 1919), as well as in the vicinity of Taranto[6].

Diligent attempts to develop and use local water supply technologies also marked the era of Arab domination. The Arabs, settling in Bari in the 9th century AD, started a period of growth and prosperity for the coastal populations. This period saw intensive crop cultivation, such as vegetable gardens and orchards, rather than the hitherto cultivated grain crops. In addition to this, there was the construction of a series of wells, equipped, in some areas such as in Mola di Bari, with ingenious mechanical extraction systems known as *norias*[7], designed to harvest water from the aquifer. The *noria* system was based on the principle of 'cutting' the surface fresh water that floats on the saline sea water that infiltrates tufa, with lower rates of drainage than groundwater recharge. However at the end of the 1950s, the replacement of this system with motorised and/or electric pumps, that were spreading rapidly due to the prohibition on the use of workhorses, led to a rapid increase in drainage flow and the progressive infiltration of brackish water into coastal areas, thus signalling a decline in agriculture in vast coastal areas of Apulia.

A massive operation of restoration and renewed construction of public and private cisterns began in 1800 in order to cope with increasing population, as well as the increase in available arable land resulting from remorseless deforestation (see also Denitto, this edition). At that time cisterns were considered to be the easiest means of water supply, albeit not enough to guarantee drinking water throughout the whole year.

What has been discussed so far, along with other developments, characterised the Apulian people's endeavours to gain new and greater water resources in order to meet their needs. Nevertheless, the people did not always demonstrate any ability to maintain these systems, so that water supply in Apulia was the subject of many worrying reports between the end of the 18th and the beginning of the 19th century. These reports, while giving due credit to a population that had been so ingenious in harvesting water in conditions of absolute natural scarcity, nevertheless lamented the inability to develop appropriate sanitation practices for their correct use. "Our betters, the ancients, did not spare any expense in order to have good drinking water. Where they could not obtain it from wells, they procured it at distance with walled aqueducts built with great skill and magnificence. In the absence of these, they constructed beautiful and practical cisterns to store rainwater, water which is the most healthful when it is understood how properly to collect and store it. Since these regulations are not respected in Apulia, there is generally a lack of good drinking water, which, where it is not brackish, is filthy in all seasons. It is not always the fault of the air that we need to grieve, but it is mostly that of behaviour" (Galanti[8] , quoted in Viterbo, 2010, p.11). The "little respect for specific health regulations", especially in times of famine, was the main reason for the poor state of health in the province of Bari in 1791 according to Giuseppe Maria Galati.

Soon before the unification of Italy the most basic hygiene rules were disregarded. Water piped into the cisterns did not undergo any filtration, nor was there any particular care to the cleaning of roofs and downpipes before the harvesting of water. In the case of public cisterns, the situation was even more worrying since these were collecting water from the streets and open public places where, in the absence of sewers and tanks for the collection of sewage, slurry and waste of various kinds were amassed or dispersed so that when rain fell "that otherwise Spartan swill, without being filtered, was deposited into the communal cisterns built at huge cost. Only a process of natural sedimentation of heavier materials could even partially clarify those liquids" (Filonardi[9], quoted in Viterbo, pp. 52-53). The cisterns, often referred to as "pools" in rural areas, collected water from farmlands and local roads, as well as water that sometimes ran off barnyard and farmyards covered in cattle manure. In times of drought, this water, which was normally used to irrigate gardens and for livestock, was also used for drinking by the local peasants. Wells were often located in the vicinity of cesspits or livestock, which in turn led to the faecal contamination

of the water they stored. Finally, the water contained in tanks and wells was even so scarce that the use of sea water for cooking and drinking was widespread.
In his 1881 report, the engineer Filonardi, who between 1878 and 1879 had travelled all around the Bari area, condemned these terrible sanitation practices. Not only did he note the scarcity of water but also the terrible quality of water normally used for drinking, so that he admitted it was almost an unbelievable luck to have "a glass of water that does not contain[ed] a myriad of insects, which do not even require a lens or microscope to be seen swimming around". On the other hand, the scarcity of water meant that in times of drought it even became necessary to transport it on special trains from Ofanto at huge cost to the population. In Filonardi's view therefore, the need for water in Apulia reached the proportions of a "real and great social question" (Filonardi, quoted in Viterbo, p. 52).
Even in 1902, when the construction works for the *Acquedotto Pugliese* (Apulian Aqueduct) were about to start, Apulia was being described as a wasteland. In his report to the *Camera dei Deputati* (Chamber of Deputies) on the proposed Apulian Aqueduct Bill, De Cesare stated, "Crossing the plain of the Tavoliere or the wastelands of the high plateau in the summer months, through arid grasslands and parched stubble reflecting a blinding light, beaten by a sun that raises the temperature above forty degrees and suffocated by the foehn wind, kilometre after kilometre without finding a stream from which to drink, only on the occasional *masserie* (farm houses), at the bottom of some barrel or bucket of warm and unhealthful water drawn from wells or polluted ponds, will the traveller find something to drink. The *masserie* of Apulia, bare of trees, and yet so picturesque in early June, offer an image of desolation in the summer ... One drinks polluted water almost everywhere, with detritus floating in it, which are

visible to the eye. The water itself has a yellowish colour, but a warm temperature, and a flavour that only the need, even more so than any habit, makes tolerable. It is the water from shallow cisterns and wells: wells and cisterns without supervision and proper management, being them private or municipal ..." (De Cesare[10], quoted in Viterbo, p.20). Apulia was indeed repeatedly afflicted by epidemics of typhus and cholera, which claimed many victims from amongst the general population.

This state of affairs contributed to root a kind of disbelief amongst local people with regard to any real hope of solving the serious problem of water by themselves. In this respect, the case which occurred in 1864 is significant. The citizens of Grumo Appula suddenly decided to close their communal well, a well that had been constructed that very same year, at the urgent request of the drought afflicted authorities, by the French engineer Bossu, the construction manager of the Bari-Taranto railway line. Indeed, this well had flowed so copiously that it ended up flooding the area, leaving the people in the grip of the fear of not being able to control it. In the end, the people were unable to find any other solution than to close the well and have another public cistern constructed (Sirago, 1993).

Nevertheless, in Lecce in 1885, at the second International Contest for water extraction devices and wind power mechanisms, an attempt was made to deepen the well near the station in order to assess the possibility of reaching deeper and more abundant aquifers. However, despite the encouraging predictions of scholars such as De Giorgi, drilling could not penetrate right though the local limestone strata. The exploration of deep aquifers in Lecce was only carried out later by Count Cozza and Guardati enterprise (1896-1899), who drilled a new well to bring water into the new urban aqueduct, which began operating in 1906[11]. Even in this case, the excellent results achieved by the

experiment were not enough to surmount the scepticism and concerns of the municipality of Lecce; in fact this left the acquisition and operation of the aqueduct to a private company, that ran operations until 1929. In 1929 the system was then connected to the Apulian Aqueduct and its waters were streamed into the *Grande Sifone Leccese* (Great Siphon in Lecce), in addition with and also integrating the waters of the river Sele. This happened until the end of the 1950s, when contamination of the aquifers made it impossible to use these waters for drinking water purposes (Delle Rose, 2005).
Amongst others, these episodes demonstrate the profound dialectic that came so fiercely to the fore after the unification of Italy, that is to say between the fervour to create innovative solutions from the bottom-up and an attitude of resignation that expected top-down solutions.

A mammoth challenge: technological change in post-unification Italy

The idea that unification should also inspire a national solution to unresolved local problems certainly helped strengthen the idea that Apulia alone could not win its battle for water and that there was a need for outside intervention, for one of those "grand solutions", invoked by Viterbo (2010, p. 312), as the only possible strategy to resolve the problem of water supply in the region. Opinions, such De Giorgi's, based on the autonomous exploitation of local resources, soon became minority views and the idea of a grand design emerged in which the water works were supposed somehow, as if by magic, to resolve every local problem.
The all pervasive dissemination of this idea of powerful technology coming from above saw the demand for

drinkable water solutions, supported by the rhetoric of thirst, converge with the urgent need to meet irrigation requirements. This went hand in hand with the image that spread of a thirsting region, which was at the same time "unable to match the pace of the civil and economic development of the country [...] forced into decline and backwardness by the absence of any possibility of irrigating the countryside and by the forced choice for the prevailing and extensive cultivation of grain ..."[12] (Masella, 1995, pp. 21-22).

In the aftermath of unification, the *Consiglio Provinciale di Bari* (Provincial Council of Bari) called unsuccessfully on the government to support studies with the dual purpose of supplying water for drinking and irrigation. So while in 1865 the provincial administration in Bari launched a design contest about how to supply the city with drinking water, between 1867-1868 the *Consiglio Provinciale di Foggia* (Provincial Council of Foggia) alongside the national government financed studies for an irrigation project in the Capitanata, and the city of Foggia itself commissioned a number of studies in order to find a solution to the city's drinking water problem. It was thanks to the visionary ideas of Rosalba in 1968 that a link could be seen between the plans for those two areas of Apulia, as he was proposing the construction of a mammoth system conveying water from the springs of the river Sele in Caposele, Irpinia, at the same time solving the irrigation and drinking water problems in Capitanata and in *Terra di Bari* respectively. Up until then, hypothetical construction ideas regarding water supply from other regions had been limited to the use of the nearest potential sources in Lucania or to the Ofanto river, hence to the construction of a system limited to the province of Bari. Instead, the project made by engineer Rosalba foresaw the construction of a huge tunnel in the Apennines that would be able to convey water from the

springs in Caposele to the provinces of Bari and Foggia, an idea which only the most advanced construction technologies of the time could made possible.
The ideas on which Rosalba's design was based were elaborated further in the projects presented at the end of the 1880s by the engineers De Vincentiis and Zampari; these ideas then formed the basis for subsequent research conducted by a royal commission appointed in 1896 to study the issues related to drinking water and, in particular, the Apulian Aqueduct. The system supplied by the springs of the river Sele would bring drinking water to the entire region and not just to the provinces of Bari and Foggia.
The approval shown by early governments, to which many illustrious meridionalists such as Imbriani belonged, and also the political role played by the new intellectual class of the early 20th century (Masella, 1995), led to the governmental decision to co-finance operations. In 1902, a consortium for the *Acquedotto Pugliese* became part of the organisation between the state and the three provinces of Bari, Lecce and Foggia that were to fund construction and retain ownership. In 1919 the state then assumed full responsibility for the completion of works through the establishment of the *Ente Autonomo per l'Acquedotto Pugliese* (E.A.A.P.: Autonomous Apulian Waterworks Authority) that completed the construction works after the expulsion of the Genoese company, Ercole Antico.
Meanwhile, water was flowing into Bari and the other various towns in Apulia. In 1915 the first public fountain in Bari was inaugurated; in 1918 water flowed into Brindisi; into Foggia in 1924 and Lecce in 1927. People greeted these events with overwhelming joy and great hope and had no hesitation in abandoning the wide range of water supply systems that had been used in the past. With the construction of this spectacular feat of engineering and the possibility of obtaining from it drinking water supply, the

old systems soon lost their maintenance. Despite calls to keep the remaining wells and cisterns in operation, so as to prevent the region being brought to its knees in the event of a failure of the new water works (Viterbo, 2010), the ancient water supply systems were nevertheless soon to be abandoned and condemned to destruction.

The construction of the aqueduct did not stop with the arrival of water in the main towns and cities of Apulia. Subsequent decrees entrusted the construction and the management of municipal sewerage to the E.A.A.P. and extended its catchment area to the municipalities of Lucania, where it started running the newly completed water works in Agri, Basento and Caramola as well as other minor municipal systems. A further impetus for the development of the system took place soon after the Second World War, owing to funding from the *Cassa per il Mezzogiorno* (Southern Development Fund), which aimed at expanding and improving supply and distribution systems. Indeed, the second half of the 20th century was to see the construction of a tunnel system designed to convey water from the springs of the river Calore at Cassano Irpino and, subsequently the creation of a sophisticated interconnected system encompassing the main water works system and a number of others that were being built at Pertusillo-Sinni[13]**;** Fortore[14]; Ofanto[15] and Locone[16]. The master plan of water works in Italy, 1963, reserved the right of Apulia to use, at least in part, water from the reservoirs of Monte Cotugno on the river Sinni, of Pertusillo on the river Agri, of Occhito on the river Fortore, of Conza on the river Ofanto and of Locone on the river of the same name, as well as the unexploited waters from the streams Temete and Atella. Today, water from these dams contributes to 60% of the Apulian Aqueduct supply, as opposed to a mere 22% harvested from springs. These are supplemented by yield from the underground aquifer that contributes to over 18%

(AATO Puglia, 2009)[17]. The need to use for drinking purposes not only pure spring waters but also reservoir water, once only used for irrigation and industrial purposes, brought up the new question of the treatment and purification of water. Up until then these processes had been studied only on small scale and not for such a large scale distribution system

Despite a reduction in average flow in the main channel because of the damages caused by the 1980 earthquake, which could not be completely repaired by various restoration works (AATO Puglia, 2009), the Apulian Aqueduct is today the largest water works in Europe and the third largest in the world. With its 20,752 km network and 323 tanks it distributes more than 18,500 l/sec of water to a population of over 4,000,000 people in Apulia, Basilicata, Campania and Calabria for a total of 366 municipalities (Scagliarini, 2010).

However, the problems of managing this enormous water system are also significant. Despite the technologies employed to check leakages, to date the system loses approximately 55% of the 563,000,000 m^3 of water channelled into the water network from various sources (AATO Puglia, 2009). The reduction in the capacity of the Sele-Calore springs, in the quantity of water supplied by reservoirs in periods of low rainfall and in the availability of ground water from the aquifer have prompted the Apulian Aqueduct to note the inadequacy of water supply in relation to demand and therefore to seek new medium- to long-term solutions for supplying drinking water to Apulia.

In the preface of the new edition of Viterbo's work, Scagliarini states "Today Apulia no longer suffers from thirst, but it is still looking for the security that its territory, poor in natural sources, cannot provide; it is enough just to think of the alarm caused by the decrease in water levels of

reservoirs, which today guarantee more than 60% of drinking water for Apulia" (Scagliarini, 2010).
However the Apulian Aqueduct project was only one part of the whole effort for the domestication of water performed in the 20th century (Rienzo, 2012), which constituted the basis for a radical transformation in the environmental, social and industrial structures within Apulia. This undertaking was not only concerned with the issue of drinking water supply but also with other uses of water, primarily irrigation, considered by many to be an integral factor in the issue of the "slowed" development of our region (Cafagna, 1989).
Apart from the aforesaid construction of large dams for multiple uses, the 1900s saw the construction of a capillary network of irrigation systems by the newly created *Consorzi di Bonifica* (*Land Reclamation Consortia)*. These were taking water from surface reservoirs or from a system of wells, which constituted, especially in particular areas of Apulia such as Salento, the main, if not the only, available water source. Particularly illustrative of the effort of domestication of water is the case of the activities of the Land Reclamation Consortium of Capitanata, which was created in 1933, , with the daunting task of streamlining and organising the management of water resources in the area. On the one hand, that consortium initiated the construction of a series of dams on major rivers that crossed the Tavoliere (Fortore, Candelaro and its tributaries, Cervaro, Carapelle and Ofanto); on the other hand, it made the design of complex water systems and reclamation schemes. The discussion upon the feasibility of these systems had started prior to the unification of Italy, when Carlo Afan De Rivera, in his capacity as director of the *Corpo di Ponti e Strade, Acque, Foreste e Caccia del Regno delle Due Sicilie* (Corps of Bridges and Roads, Water, Forestry and Hunting of the Kingdom of the Two Sicilies), had

drafted the first irrigation plans for the Tavoliere in Apulia (Di Biasio, 1993). With the establishment of the Land Reclamation Consortium, three plans dealt with the restructuring of the Tavoliere, starting with Roberto Curato's plan of 1933 (Bevilacqua, 1988), the Carrante-Medici Perdisa plan of 1938 and the plan of the agrarian economist Mazzocchi Alemanni of 1946, which challenged the extensive farming of that period. The final result was an impressive plan of action that led to a radical change in the Tavoliere, not only infrastructural but also productive, social and environmental (Rienzi, 2012).

Parallel to these consortia operations, the 20th century also saw the widespread dissemination of decentralised systems for groundwater extraction. These were often seen as a back-up solution for irrigation by those who, in the short term, were not able to obtain water through the large centralised schemes already mentioned. The idea that an increase in the water supply was an irrefutable right, especially for a population that had long suffered from the lack of water, and the underestimation of the impact that the spread of modern water extraction technologies would have on hydrological cycles and groundwater dependent aquatic ecosystems *de facto* led to rather weak checks on such practices. This in turn led to the result that today, compared to 873,000,000 m^3 per year of estimated consumption for irrigation (INEA, 2009), only little more than 200,000,000 m^3 is provided by the Land Reclamation Consortia, with the rest coming from private wells which are for the most part illegal. Irrigation in Apulia is, indeed, supplied at more than 75% from private wells (Distretto Idrografico dell'Appennino Meridionale, 2010), which makes planning and management of this sector an extremely complicated task.

Prometheus' dream: Premises, strategies and consequences of technology

Much has been written on the interpretation of the historical and political processes behind the construction of large hydraulic projects in Apulia. The Apulian Aqueduct, in particular, has often been described as a symbol of a process of induced modernisation within a southern Italian context marked by a past of "culpable feudal backwardness" (Masella, 1995). This was a result of the prominence of the new intellectual class of the early 20th century, which was working towards building up a strong alliance between the most productive and upwardly mobile sections of society with a new idea of the state as "political entrepreneur" (Masella, 1995).

Nevertheless, it is not so much the historical and political interpretation of this effort that I would like to discuss here, as much as the technological dimension and the profound changes that were brought about in terms of our understanding of technology and its role in progress. I will look into, in other terms, the premises, strategies and outcomes of this process of radical technological change that materialised in the post-unification period and that nourished the hope in Apulia of "freeing itself definitively from insufficiency and from its age-old thirst" (Viterbo, 2010).

The premise is to be found in the way the faculties of engineering at the time responded to the question of technological expertise and formed a new class of engineers working in Italy on the eve of unification. These include, primarily, the *Scuola di Applicazione di Ponti e Strade* (School for the Construction of Bridges and Roads) at the University of Naples, the first school of engineering in Italy, that was established in 1811 by the decree of Gioccchino Murat and modelled on the Napoleonic *École*

d'Application des Ponts et Chaussées. It aimed to train engineers who were then to be recruited into the *Corpo degli Ingegneri di Ponti e Strade* (Corps of Engineers of Bridges and Roads) in charge of the design and execution of public works in the Kingdom of Naples. People such as Giuliano de Fazio, Carlo Afan de Rivera and Luigi Giura spirited this important period. That dauntless forerunner of the Apulian Aqueduct, Camillo Rosalba, also attended this school in which students, owing to frequent trips abroad and the excellent school library, were trained on the most important scientific discoveries and technological innovations that had been introduced in the main European countries. So it was that the Neapolitan engineers achieved authentic primacies during the 19th centuries, from the first steamboat (1818) to the iron bridges over the Garigliano and the Calore applying catenary principles (1832-35), the steam engine and the Naples-Portici-Castellammare railway line (1839) (Russo, 2010).
In this school's view, technology was seen as a means to break through the boundaries of what was possible, to achieve what had never been accomplished before and to challenge preconceived limitations in order to demonstrate the power of the intellect. It is this conception of "Promethean" technologies that inspired the studies of a technical and intellectual class who were behind the conception and achievement of such a mammoth enterprise as the Apulian Aqueduct. It was the dream of Prometheus, to steal fire from the gods and give it to humanity, thus enabling man to break free from his bondage of ignorance in order to pursue and build his own ideas and no longer be fettered by the constraints imposed by a transcendent deity (Aeschylus,1995). The ancient myth of Prometheus, who, contrary to the will of Zeus, gifted humans the use of fire has since ancient times been indeed

the metaphor of man's power over nature and explains what is understood in popular imagination as the parable of our path towards mastery of the world.
It is in this process of progressive challenge to natural constraints that the relationship between man and nature is transformed, even in relation to the power of technology and its tools. If at first the gift of Prometheus did not allow man to break the rules that govern nature, it is because, as the Titan himself admits, "technical progress is by far weaker than necessity" (Aeschylus,1995). Nonetheless, man's continuous attempts to alter the structure of nature to suit himself has also led "man so far from his origins as to make obsolete the legacy of the customs in which he grew up and in which he had thought when Nature was his limit, and in this limit man discerned the structure of his certainties... The seal with which even Prometheus limited the possibilities of technology is now broken. [...] This transformation not only affected things, but the relationship that humanity has always acknowledged as impotence in its designs with respect to the insurmountability of the limits." (Galimberti,1999, p. 52).
In Apulia this conception of technology as an instrument of power and domination over nature led to challenging those limits, that had been set by the hydro-geological situation, and to attempt the hitherto unattempted, that is to carry up to 6,500 l/sec of water through a tunnel 55 km beneath the Apennines with yet another one 16 km below the Murgia, taking a course of about 250 km, from Caposele to Villa Castelli, in a pipeline which distributes water under natural load. This is the challenge which at the time seemed "'verging on madness, a challenge to nature" (Viterbo, 2010, p. 317) even to worthy men of science. However, for others it symbolised a victory of intellect over the tyranny of nature. In the dialectic between sceptics and ardent proponents of the enterprise, as is known, the latter

overcame the former and by the late 1920s the nation had a water works system that did not shy from comparison to the other major systems in the world[18]. On the contrary, it was well worth encouraging all visitors to become "admirers convinced by this superb Italian feat of engineering and the will of the nation" (Postiglione, 1926, p.28), thus becoming in the popular imagination that "work of enduring civilisation without equal that has opened up before Apulia a phase of progress exceeding all expectations" (Viterbo, 2010, p.312).

The complex multi-sectoral water network, of which the Apulian Aqueduct represents one of the main pillars, has indeed contributed decisively to bringing about dramatic changes in standards of living and patterns of development within the region. The rapid improvement of sanitary conditions and the great increase in agricultural productivity that commenced in the 20th century would surely not have been possible had these operations not made vast amounts of water available (Masella, 1995; Del Monte *et al.*, 1978) and in turn allowed for a partial replacement of traditional extensive crops with irrigated crops, which were more profitable, alongside the adoption of irrigation practices for crops that had traditionally been dry farmed (INEA, 2013). On the other hand, in the industrial sector the development of the large industrial centres of the Second World War such as the chemical plant in Manfredonia, the petrochemical industrial area of Brindisi and the mixed (steel, petrochemical and concrete/cement) industrial settlement of Taranto would not have even been thinkable had it not been in conjunction with the complex system of water management that was taking place (Masella, 1995) and is now able to provide an industrial water volume to the order of 145,000,000 m^3 (AdBP, 2012). In the recent past, ILVA Taranto alone has had freshwater concessions exceeding

100,000,000 m³ per year, although its actual consumption has dropped to considerably lower levels in recent years[19].

With regard to these profound changes in agriculture and industry if, on the one hand, they were part of an overall development aimed at freeing areas of the Mezzogiorno from the backwardness to which their past seemed to have bound them, on the other hand they generated new and significant demand for resources which heavily affected the evolution of main water infrastructures (Masella,1995). So it was that the search for additional water sources and the need to develop additional supply systems became constant concerns after the Second World War; coinciding with the launch of that complex project of agrarian reform and industrialisation by the *Cassa per il Mezzogiorno* that was to cause substantial changes in patterns of regional development. Nevertheless, the fact that the placement of new activities was not restricted to the location of pre-existing and already available water resources but relied rather on the power of modern technology to bring water where it was needed, led in some cases to an underestimation of the impact of such activities on water resources and potential conflicts arising over their utilisation.

In the industrial sector, the location in Taranto of the 4th national iron and steel hub, later to become home to the largest steelworks in Europe, was the outcome of a long and controversial debate in which economic issues were intertwined with the great national political debate on the industrialisation of the Mezzogiorno in the spirit of the Vanoni Plan (Pizzigallo, 1989). In this debate, the fact that in Taranto there was already a chronic shortage in the drinking water supply was not seen as any obstacle to the creation of large industrial complexes given that they were to be in the vicinity of exploitable resources such as the Pertusillo dam (Masella, 1995); this regardless of the impact and potential conflicts that might have been generated by the use of such resources[20]. In fact, the presence of sources of fresh water near to hand, although at that time not yet available for industrial use, was one of the location factors highlighted in the technical reports that the *Camera di Commercio* (Chamber of Commerce) and the Municipality of Taranto used to support the candidature of the city for the allocation of the industrial plant[21] (Dattomo, 2011).

In the agricultural sector, the conversion of traditional dry farmed crops to irrigated crops has led to Apulia's having a much greater irrigated surface area and likewise higher level of irrigation-dependent crop production today than neighbouring regions even though these other regions are far richer in water resources[22]. In the same way, within the confines of Apulia, this transformation has also affected zones, such as the Salento area, with a dearth of water resources[23] (Distretto Idrografico dell'Appennino Meridionale, 2010).

Nonetheless, today, some decades after the period in which these complex transformations of the economic and industrial structures in the region were initiated, some studies are beginning to question the sustainability of the choices that were made, due to the increasing environmental awareness and the increasing awareness of the perils of compromising the quality and quantity of water resources in Apulia (Regione Puglia, 2009). For example in agriculture, a study by the *Istituto Nazionale Economia Agraria* (INEA, National Agrarian Economic Institute), examined the sustainability of crop choices in the southern regions by comparing the types of crops planted, the irrigation technologies used and the pedoclimatic and hydrological characteristics of the respective regions. The INEA study showed, even in the case of Apulia, widespread unsustainable irrigation practices on a territorial basis (INEA, 2009). Moreover, the recent reform of the

EU Common Agricultural Policy also tackles the tough problem of the relationship between productivity and sustainability, requiring greater integration between the agricultural and the environmental component and more forceful protection of natural resources and the environment[24] (European Commission, 2010).

Concluding remarks

The profound changes in water supply technologies in Apulia during the post-unification period have gone hand in hand with a process of radical change in understanding the relationship between man and his environment and the very meaning of the word progress. Progress has become synonymous with breaking with the past and attempting to break free from the constraints of the environment and from age-old deprivation. By adopting this course of action, all that pertained to tradition was deliberately jettisoned, even those traditional methods of rainwater harvesting and the use of alternative sources that today, in many ways, are beginning to become the focus of renewed attention[25] (EC, 2007; Ward *et al.*, 2012; Palla *et al.*, 2012). At the same time, the heroic idea of technical progress taking up the challenge to supply water to the region is all pervasive, and whereas, on the one hand, it does indeed enable fulfilling the important objectives of productivity and growth, on the other it has serious effects on the development models of our territory.

In this sense, the crisis in the availability of resources in our region, the constant lack of resources, which prevented water supply to meet demand, the constant search for additional resources, and, on the other hand, the increasingly compromised quality and quantity of water sources are not just technical problems. The crisis that characterises today's water resource issues in Apulia along with its supply and distribution systems is, first and foremost, a crisis in the very concept of technology, where technology is seen as a means to transcend the constraints of nature, thereby daring to get things never thought of before. It is the crisis of a Promethean vision of technical progress and a symbol of Nietzsche's "will to power" as a means to provide man with a never-ending ability to achieve his aims (Severino, 1988). As a powerful shielding mechanism in the fundamental relationship between man and nature (Bevilacqua,1996), the Promethean conception of technology typical of the post-unification period has beguiled us into thinking we are able to overcome the constraints set by the environment. The weaknesses of the system of which we are part leave us thus in constant pursuit of repeatedly unsuccessful aim.

Now abruptly awakened from the positivist dream of risk-free unlimited progress, contemporary man is today bearing evermore witness to the potentially catastrophic scale of the reckless misuse of his technologies. As in the imaginary dialogue between Prometheus and the Eagle that Bevilacqua describes in his recent book, more and more these technologies show, in unpitying contrast, the illusory side of human progress, dilemmas that envelop those persons and organisations who have subdued nature and built a fragile and artificial building upon it (Bevilacqua, 2005). Facing the "Prometheus unbound" of today's technological society and faced with the realisation that the promises made by modern technology have become dangers, contemporary man is called upon to be conscious of the meaning and scope of technological development and to develop a new concept of technology. This need to be based on a renewed "ethic of responsibility" (Jonas, 1979) and to surpass the heroic vision of technology and

innovation that has been a characteristic of the post-unification period.
That ancient pact between man and nature, severely stricken by modernity and the ideas about technology, which supported it, requires a re-establishment of a relationship based on a renewed sense of awareness with regard to the irreversibility of natural processes and man's responsibility in deciding the fate of the world in which he lives. As the Nobel Laureate Ilya Prigogine states, "it is high time that we accept the risk of human adventure. … Scientific knowledge, drawn from dreams of a revealed, that is to say supernatural, revelation, can be discovered today at the same time as a poetic ear lent to nature and a natural process in nature, an open process of production and invention, in an open world, productive and inventive. (Prigogine and Stengers, 1979[1986], p. 393)

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1 For how Apulia is viewed in German culture, see Lorenzo Lozzi Gallo (2012), which analyses the image of Apulia from the medieval Germanic texts and testimonies from the world of the Lombards.

2 In Canosa, for instance, in the 1st century A.D. a city aqueduct was built with funds from the Athenian magnate, Herodes Atticus, who had married a woman from Canosa; cisterns were built in Ruvo and

Egnatia; a source by the sea, near the port of Brindisi, was exploited for the supply of water to travellers; an aqueduct was built in Taranto in the 4th century AD to convey water to the spa complex at Pentascinensi (Sirago, 1993).

3 In 1820, 103 cisterns were counted in Conversano in addition to the large cistern of Terrarossa, even though more than half of these were in a poor state of repair (L'Abbate, 1990).

4 De Giorgi C.: Manoscritto n. 132, Biblioteca Provinciale di Lecce. (Manuscript. 132 Provincial Library of Lecce).

5 There are some historical *pozzelle* in few abandoned old villages in Salento, like Apiliano and Masseria Gloria between Zollino and Martano. One of them was also present at Ortelle and perhaps a number of *pozzelle* were present in Melendugno and in the vicinity of Acaja. In the *Pozzelle* area in Martano there seems once to have been "One hundred cisterns arranged in order, each with the name of the family who owned and used it" (Costantini, 1988); these are now remembered in local toponomy; in Martignano a *pozzelle* park was recently opened, which includes some of the 68 wells of San Pantaleo.

6 The conduit in Gravina was particularly impressive: at 3 km in length, it harvested microflows of sub-soil water from the hill at Botromagno and conveyed it to the edge of the ravine in a cave, converted into a church in medieval times. From 1700, it supplied water to the town of Gravina, owing to the construction of a stone arched aqueduct (Laureano, 2001).

7 A *noria* was a device widespread in Apulia in and around Mola di Bari. It was used to raise water that was then conveyed into an irrigation canal. At the opening of a well there were two fixed toothed wheels, one was powered by a blinkered donkey or mule that drove a bar in rotation and thus moved a large conveyor fixed with buckets that drew water from the well which then tipped the contents into a water tank.

8 G.M. Galanti, relazione al Governo di Ferdinando IV sulle condizioni della Puglia, 1791. (Report to the Government of King Ferdinand IV on the conditions of Apulia, 1791).

9 A. Filonardi, relazione al progetto di massima per condurre acque in provincia di Bari, Roma, 1881. (Report to draft guidelines for conveyance of water in the province of Bari, Rome, 1881).

10 R. de Cesare, Relazione alla Camera dei Deputati sul progetto di legge dell'Acquedotto Pugliese, Roma, 1902. (Report to the Chamber of Deputies on the Draft of the Apulian Aqueduct Bill, Rome, 1902.

11 This was supplied by a lifting device, similar to a *noria*, invented by Guardati, the capacity of which was approximately 31 l/sec; this was not only sufficient to the needs of the population of Lecce, but also to provide drinking water to the populations of Bari during the drought of 1911-1913, as well as to supply the naval ships anchored in the port of Brindisi during the First World War (De Giorgi, 1922).

12 Indeed, the Neapolitan Member of Parliament Netti wrote on this matter to the *S*ocietà Economica Reale (Royal Economic Society). "A spring too short and not very wet is with us; too long and warm is our thirst. Man-made irrigated meadows are almost free from the whims of the seasons: as they give regular products, man can more or less adapt them to meet his needs. But how does one obtain irrigated meadows in a region that lacks rivers and is wanting in any continual sources of fresh water?".(Proceedings of the Reale Società Economica di Terra di Bari, quoted in Viterbo, 2010, p.14).

13 This is the main part of the Ionian-Sinni water works system, now including several reservoirs and three separate water systems and ensuring multiple water supply to a vast area comprising the Ionian arch of Basilicata and Apulia, Salento and part of north-eastern Calabria (the area of Castrovillari). It handles more than 1,000,000,000 m^3 of water per year, of which approximately 250,000,000 m^3 is intended for domestic use, 720,000,000m^3 for irrigation and 30,000,000 m^3 for industrial purposes. Of particular importance in terms of the volume of water conveyed by the Apulian Aqueduct is the Monte Cotugno dam on the river Sinni and the dam at Pertusillo on the river Agri. The Pertusillo dam, built between 1957 and 1962, has a height of 95 m and an exploitable capacity of approximately 145,000,000 m^3. The reservoir at Monte Cotugno, built later between 1970 and 1982, in the vast countryside area of Senise, with its 430,000,000 m^3 of usable storage is the largest earth dam in Europe. The Sinni pipeline (the so-called *Canna del Sinni*), starting downline from this dam, with its 3 m in diameter and its 190 km in length reaches Nardò in Salento and supplies water to the area of Metaponto and southern Apulia. The pipeline conveys variable flows (design flow rates reached a maximum of 20,000-22,000 l/sec, the current maximum level being approximately 16,000l/sec).

14 The Fortore water works system was built between 1968 and 1973 for the partial use of water from the Occhito dam on the river Fortore, originally built for irrigation purposes but now supplying 55,000,000 m^3 of its 250,000,000 m^3 per year for drinking water (Scagliarini, 2010). Designed in the early decades of the 20^{th} century by

the *Commissione Reale per le Irrigazioni* (Royal Commission for Irrigation) and superintended by the Member of Parliament Girolamo Giusso from Foggia, it required complex works of adduction conveyance, adjustment, and embankment along the river and its tributaries. Today, with a flow rate of 2,400 l/sec, the Fortore system supplies drinking water to most of the province of Foggia, with the exception of a few municipalities on the border of the province that are supplied by the Molisano-Destro system. A further enhancement of its supply is expected with its connection to other secondary reservoirs.

15 The construction of the Ofanto water works system began during a period of water crisis at the beginning of the 1980s and was made in two stages, in 1982 and 1986 respectively. It was designed as an alternative carrier to the main water channel in the Apennine tract from Padula, in the Calitri (AV) countryside, to Venosa, as well as a means to convey drinking water to central Apulia from the potabilization plant at Conza, currently nearing completion. The first stage of bypass works allowed the restoration of those parts of the main channel that had been affected by landslides during the 1980 Irpinia earthquake. It was constructed with a 2m diameter, 63km long pipeline with a maximum flow rate of 6,500 l/sec, equal to the maximum yield allowed in Caposele and Cassano Irpino. Following on from the first, the second stage of works is 45 km long in total and has a diameter of 2.4 m. It was built to complete the conveyance system of the Conza potabilization plant. It starts at the Venosa hub and terminates at the Monte Carafa forebay, in the countryside around Canosa di Puglia, where also the Casamassima-Canosa channel (Pertusillo-Sinni water works system) is connected, thus completing the interconnection between the various water works systems.

16 The Locone water works system began to operate in 2009; it connects the Locone dam to the Barletta network through a steel pipeline with a diameter of 1.6 m and a maximum flow rate of 1,500 l/sec.

17 At the time of data collection (2008) the Conza dam was not yet operational. The reservoirs considered are only those of Pertusillo, Monte Cotugno, Occhito and Locone.

18 In a lecture given in Foggia to engineers from the University of Padua, the engineer Postiglione proudly compared in terms of capacity and linear development the Apulian Aqueduct "serving six provinces, more than 2,500,000 inhabitants over approximately 20,000 km^2 of territory, and when completed 2,670 km long" to the largest water systems of that time, amongst which the Colgardie system in

Australia (564 km long but with a flow rate of only 300 l/sec) and the grand system of Catskil, New York (with a considerable flow rate of 26,000 l/sec however less than a tenth the length of the Apulian Aqueduct) (Postiglione, 1926, p.3).

19 According to data provided by the plant operator at the time of the request of the *Autorizzazione Integrata Ambientale* (AIA/Integrated Environmental Authorisation) to the Italian Ministry of the Environment – which are confirmed by the annual reports on Environment and Security by ILVA (ILVA , 2010), ILVA had concessions to harvest water from Sinni and Tara, from private wells in the area of the plant, and from the Fiumetto canal. To this may be added the supply of drinking water for domestic use from the Apulian Aqueduct. Owing to a gradual reduction in production in recent years, ILVA has consumed a lower volume of water than allocated, with a total consumption to the order of 50,000,000 m^3 per year in 2007, subsequently reduced to about 40,000,000 m^3 per year in 2010 (ILVA, 2010). A further reduction in the consumption of fresh water is anticipated by virtue of a recent decision of the *Giunta Regionale* (Regional Executive Committee) of the Apulia Region (DGR July 4th, 2011), implemented in accordance with the AIA requirements of July 2011 and confirmed by the judgement of the Regional Administrative Court (TAR Lecce, 11th July 2012), obliging ILVA to establish, within 24 months, a system of internal water distribution that, as a priority, would allow the treated waters from the urban effluent treatment facility in Taranto Gennarini/Bellavista for use in its manufacturing plants. In addition ILVA was obliged, within six months of the AIA publication, to have a feasibility study in place aiming at a reduction in primary consumption of water by 20% within 3 years and 50% by the time of expiry of the AIA through the reuse of fresh water used in the production cycle and through the reuse of waste water from the domestic water treatment plants in the area.

20 Any assessment of the environmental impact of the consumption of water resources in connection to ILVA industrial production is highly complex since the aforesaid volumes of water represent only a small percentage in comparison to the total volume consumed by the plant. This also includes large volumes of salt water, approximately 1,500,000,000 m^3 per year, pumped out of the Mar Piccolo. This latter activity is rapidly altering the fragile biological and ecological balance in the area, causing an increase in salinity in Mar Piccolo as water from the Mar Grande is richer in salts. Given the

complexity of the evaluations, it has been deemed better to defer such assessments elsewhere.

21 These factors include the availability of flat land, with good geotechnical characteristics; the proximity to port facilities where loading and unloading of raw materials and finished products can be performed; good access to the road and railway network and the proximity to fresh water sources and limestone quarries (Dattomo, 2011).

22 As part of the *Distretto Idrografico dell'Appennino Meridionale* (Southern Apennines Hydrographical District), which includes an area of approximately 68,200 km^2 and includes the entire regions of Apulia, Campania, Basilicata and Calabria, and in part, Molise (97%), Lazio (21%) and Abruzzo (15%), it can be seen that Apulia has a total Utilized Agricultural Area (UAA), representing approximately 36% of the total UAA in the district, yet that includes approximately 48% of the irrigated area of the entire district (INEA, 2013). In addition, considering the more or less homogeneous distribution of water-dependent crops within the district, half of total water-dependent crop production in the district is to be found in Apulia.

23 The frequency of water-dependent crops in comparison to all crops cultivated is greater in the provinces of Taranto, Brindisi and Foggia, where cultivation of irrigated crops and vegetables in general is widespread. However, they are present also in the province of Lecce, where there is no internally available water source to be exploited other than already over-exploited groundwater resources (Distretto Idrografico dell'Appennino Meridionale, 2010).

24 Albeit agriculture still plays a central role in the generation of income and employment in large areas of the country and in Europe, the enormous and unsustainable pressure that it is exerting upon water resources in relation to the increasingly evident effects of climate change, amongst other things, has led the European Commission (within the framework of the new Common Agricultural Policy/CAP) to demand that water management be planned along strategic as well as efficient lines, in an endeavour to encourage a sustainable use of water resources. In particular, CAP reform underlies the importance of information on reducing water use in agriculture, including crop choice, on improving soil humus to increase water retention and on reducing the need to irrigate (see Regulation (EU) No 1306/2013 of the European Parliament and of the Council of 17 December 2013 on the financing, management and monitoring of the Common Agricultural Policy).

25 Indeed, research has shown in some cases how precisely that continuity of knowledge and traditional methods has constituted the starting point for interesting technological developments; developments which have led to new solutions emerging that are able to function even under differing socio-environmental conditions compared to the past (Agarawal, 1997; Barbanente *et al.*, 2012; Grassini, 2013).