

# Urban water management in Italy: an innovative model for the selection of water service infrastructures

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*Abstract:* - Climate change affects the water cycle, in particular drought and flood risks are increasing, so there are intensifying impacts on water security and freshwater availability. According to the assessment of global risks provided by the World Economic Forum in 2015, water crises are at the top of the ranking due to their potential in causing negative impacts on the economy and welfare across countries. It is widely acknowledged that efficient water resource management plays a key role in reducing the vulnerabilities of communities and economies and the provision of drinking water and its preservation are keystone worldwide in the implementation of adaptation strategies. Mismanagement of water resources and competition for their use have worsened the consequences of water scarcity in countries which traditionally suffered from water scarcity and indeed started to cause water shortage in those countries in which traditionally water resources availability was consistent. In this respect the drought that occurred in Italy in summer 2017, proved the vulnerability of the Country and challenged water service providers in supplying high quality water and matching water demand with resource availability. This issue is particularly crucial in Italy, where there is a lack of investments in infrastructures and water facilities and an efficient management of water services is still far from being implemented. In recent years, the reports by the National Authority (ARERA) highlighted the urgent need for investments in new infrastructures and in maintenance of the existing ones and pushed towards the optimization of service operation. Due to ever stringent budget constraints and lack of financial resources, it is of primary importance to identify top priorities in ranking investments which accounts for service cost minimization, service quality maximization and environmental cost minimization. In this paper we propose an innovative theoretical valuation framework and implement a multi-criteria approach to support investment decisions in the water service sector. In detail we provide an AHP model to rank investments and select optimal investments in water infrastructures.

*Key-Words:* - Water service sector, Urban water management, Decision Support Systems, AHP, Water regulation, Water service, Economic evaluation of projects, Multi-criteria analysis

## 1 Introduction

Having assumed water as an invariant of the economic and social system as well as an

independent variable to be considered in all forms of planning, the Water Framework Directive promulgated by the European Commission

(2000/60/ EC) characterizes the problem in social (health standards), economic (access of the population and entrepreneurs to the resource) and environmental (protection and conservation of water) terms. The Directive introduces the principle of *full cost recovery*, so that the tariffs applied to users must cover the industrial costs of the management and capital as well as any environmental costs.

The specificity and delicacy of the matter place the water service out of the Directive on concessions (2014/23/EU), leaving to this day the typical management situation of each Member state.

Starting from this framework, individual countries have developed their own management models for the Water Service.

In Italy, the water service sector is characterized by a rather complex regulatory framework, the result of a consistent regulatory stratification, which has not been accompanied by a substantial intervention of coordination and legislative settlement [1].

Moreover, Italian Water Service has lots of criticalities, both technical issues and management issues. High level of real losses, lack of data about the water networks, a big number of Utilities (Societies or Municipalities) who manage the water service, lack of economies of scale to reduce costs, numerous stakeholders who are involved into the decision processes are some examples of these criticalities.

So, there is the need to improve the integrated water service in Italy through the selection of investments able to satisfy the (often conflictual) needs derived from different stakeholders.

## 2 Water Service in Italy

The fundamental step was the issuing of Law n. 36/94 (the Galli Law) which initiated a long and complex reform process, aimed at redefining the organizational and regulatory structure of the sector, introducing an industrial logic. In particular, Law n. 36/94 defined the object of the Water Service as the whole of the public services of collection, supplying and distribution of water for civil uses, sewerage and waste water purification (including the industrial uses of the waters managed within the same service), later redefined by art. 141 par. 2 of the Legislative Decree 152/2006 (Consolidated Environmental Text - TUA). The inspiring ratio of the Galli Law was that of considering the different services in a unitary vision as well as concentrating the management in order to favour the emergence of economies of scale, reducing the utility tariff gaps between neighbouring territories and starting an

entrepreneurial organization of the sector with respect to which the application of the principle of financial autonomy of the service was possible, above all with regard to investments in infrastructures. To this end, the Law identified a new territorial, supra-municipal, reference dimension, with the aim of overcoming fragmentation and achieving adequate management dimensions: the Optimal Territorial Area (ATO).

The ATO (also the former Galli Law) were defined by the regional administrations with appropriate regional laws, with the District Authorities (originally named AATO, that is Optimal Territorial Area Authority; today they are EGA, that is Area Government Authorities) acting upon them, structures with a legal status and the aim of organizing, entrusting and controlling the management of the integrated service.

The strategic planning of the water service, tariff determination and performance monitoring were delegated to the EGAs.

The Management, an autonomous entity (public or private) to whom the service was to be assigned, was assigned the operational tasks to be performed in compliance with an agreement signed with the EGA. This agreement established the obligations and rights, while also defining the methods for providing the service. In the years following the enactment of Law n. 36/94, the legislator has intervened several times about local public services and with specific interest on water, integrating and modifying the provisions on the institutional and organizational structure of the sector. Among these interventions Legislative Decree 3 April 2006, n. 152, whose Part III, Section III, regulates the water sector in an organic way, incorporating Law n. 36/1994 and dictating more precise indications on the tasks and activities that belong to the various institutional actors involved.

### 2.1 The centrality of the Galli Law: a technical and industrial innovation

The promulgation of Law n. 36 of 5 January 1994, also known as the Galli Law, marked the end of the historic phase of municipalism, which characterized the whole of the twentieth century in Italy, and represented a turning point in the reorganization of the water sector in Italy. Law n. 36/94 established a complete vertical integration of the aqueduct, sewerage and purification activities as well as a functional integration of the pre-existing services. Thus, the legislator wanted to set up a large-scale industrial management of the entire production, distribution and purification chain of drinking water,

with the dual purpose of encouraging investments in the supply of drinking water, while also creating a management capable of self-financing, through tariff revenues such as to cover at the same time the costs induced by the increased needs and the existing backlog in the sewerage and treatment sectors [2,3]. The Galli Law also established a clear separation between the planning and control functions assigned by the legislator to the public operator (EGA), and the production and management functions intended in a narrower sense, entrusted to new subjects operating according to a business logic and selected through a tender. The latter should have brought about a more efficient business organization to the production of the water service. Even if the objective of ensuring access to the resource not subject to ability to pay remained one of the cardinal principles of the welfare state, which favoured intervention policies on the supply side [4], at the beginning of the 1990s, following the widespread recognition of the ineffectiveness of these policies and the increase in the social opportunity costs of investments for the development of services, the Government tried to encourage the involvement, in the production of water service, of private individuals operating according to a business logic with the precise intent of attracting private capital [3]. The participation of private actors, catalyzing the introduction of new financial resources, should have boosted the development of services, through investments in infrastructure and human capital, while reducing the structural inefficiencies of public production deriving, on the one hand, from the existence of bureaucratic constraints and the lack of incentives aimed at improving performance and, secondly, by the overlap between planning responsibility and productive function [4]. The "privatization" process imposed a new configuration aimed at seeking efficiency in the production and provision of services, in a sector characterized by a high degree of natural monopoly as well as significant economies of scale in the high phase of the production cycle (collection, supplying and distribution) and economies of scope linked to a greater exploitation of the necessary but not completely saturable production factors, due to the presence of integrated structures typical of network systems [5,6]. In this sector, contrary to what happened in other public utilities (for example, telecommunications and transport), no process or product innovations have taken place to eliminate or attenuate some natural monopoly characteristics, with the spaces, therefore, being restricted for the competitive organization of the market, also by

virtue of monopoly rents linked to the spatial distribution of utilities (local monopoly).

The reform was therefore aimed at introducing forms of competition in the water service sector in order to ensure greater economic efficiency in the production and management of water resources as well as to exploit the economies of scale and scope typical of network services. The development of services requires huge financial resources that should be found through the application of tariffs that highlight both the social opportunity cost of the various uses of the water resource and the opportunity cost of investments for the development of services. A further element of novelty introduced by Law n. 36/1994 was the new concept of tariff, which was aimed at overcoming those management situations characterized by subsidies (in which it was difficult to cover operating costs) as well as ensure both the recovery of costs incurred by the operator, according to the principle of full cost recovery, and an "adequate" return on invested capital (Article 13).

The framework of tariff instruments envisaged by the regulation implementing Law no. 36/94, the so-called Normalized Tariff Method (NTM)<sup>1</sup> is similar, from the point of view of technical and production efficiency, a hybrid between a pure price-cap mechanism and a mechanism inspired by a principle of full cost recovery, in application of the CIP (Interministerial Committee for Programming) resolution no. 34 of 18/12/91 [7]. The NTM therefore introduced a mechanism that guaranteed the coverage of the investment and operating costs of the integrated water service, inspired by a cost of service criterion, and simultaneously imposed a tariff growth constraint according to a price cap methodology, which assumed a growth constraint in tariff revenues (Article 5 of the NTM), expressed following the lines indicated by a revenue cap mechanism. Basically, the pricing must ensure the ex-post recovery of the costs incurred by the management and an adequate remuneration of the invested capital, closely related to the dynamics prevailing in the financial markets, able to adapt in each period to the changed market conditions [8, 9]. The presence of monopoly conditions that characterized the water service sector required regulating the behaviour of the monopolist and price regulation that had to encourage the management to improve production efficiency without causing it to over-investment.

<sup>1</sup> Decree of the Ministry for the Environment and Territory Protection 1.8.1996, also called "Normalized Method to define the cost components and determine the reference tariff".

The NTM provided an incentive to improve efficiency, calculated as a percentage of operating costs (Article 6 Decree of the Ministry 1.8.1996), which led to a reduction in operating costs, favouring investments and the achievement of targets set by the planning office of the EGA. This coefficient was imposed solely on the component of operating costs and its application should have led the management to making new investments rather than to carrying out maintenance operations. Moreover, the remuneration of capital was recognized on the assets created by the management, thus encouraging it to make new investments. Following possible distortions introduced by a cost-of-service regulatory mechanism, which correlated the company's revenues with the costs incurred, on the one hand, there was a discouragement of the company to reduce operating costs and, consequently, revenues and, secondly, the tendency to overcapitalize, giving rise to a problem of over-investment à la Averch-Johnson [10, 11], to the detriment of efficient management and planning of maintenance interventions.

Given the impossibility of achieving a competitive condition in the market due to the high degree of specificity of the infrastructures that characterize the sector and the amount of irrecoverable fixed costs that constitute a barrier to entry determined by the existence of technological constraints (for example, there is no parallel pipeline system for distributing water or removing wastewater operating in conditions of competition), the reform of the water service, in order to encourage internal allocative efficiency and internal production efficiency, introduced the concept of "contestability" of the natural monopoly, through the public tendering of the companies interested in acquiring the right to manage the water service exclusively for a given period ("competition for the market"). Similar to the competition for the market, the yardstick competition, introduced by Law n.36/94 for the purposes of calculating modelled costs and the reference tariff, represented a form of second-best competition [12, 13]. The yardstick competition consisted of activating forms of indirect competition between the regulated production companies. The basis of a yardstick competition system is the idea of encouraging improvements in the work of companies that act in similar structural and institutional conditions, by comparing the results obtained by each one of them. This form of competition is generated through a mechanism according to which the constraints introduced by the regulator, for each regulated company, are defined

starting from the performances declared by the other competitors. The main purpose of the method is to incentivize the comparison between the actions of the managements to allow for the downsizing of the information advantage and of the information return they can benefit from<sup>2</sup>. The yardstick competition mechanism and the practice of management benchmarking are recognized in current literature as tools to promote best management practices that consequently favour the introduction of forms of competition between different managements. The interventions aimed at regulating the service aim to combine the advantages of competition for the market with the benefits deriving from public control over the variables that significantly affect the well-being of the community in terms of quantity and quality of services, tariffs, and environmental compatibility, in order to minimize the loss of collective well-being generated by monopoly conditions. While regulating the collective interest, environmental sustainability and technological efficiency of water service at the same time, the regulator must have a complex system of information not necessarily known to parties outside the management. The control activity is therefore the procedure that allows to complete the path that begins with the introduction of the rules in an area in which there is a significant natural monopoly.

The reform, the essential aspects of which were referred to above, should have been implemented in a short time. However, its contents, which can be considered to be fully innovative (in particular for the reference to the need to consider the problem of the efficient allocation of water resources in a unitary way), still seem to be perceived with difficulty by subjects in various capacities. involved in the distribution, collection and purification of water for drinking.

Legislative developments following the NTM have seen the transition of responsibilities for the regulation and control of water service to a national regulatory authority (Decree of Prime Minister of 20 July 2012). The ARERA (Regulatory Authority for Energy, Networks and the Environment) immediately started the reorganization of the WS, modifying the regulatory mechanisms several times and introducing different tariff methods in order to overcome the limits of the NTM as well as give greater dynamism to the regulatory instrument.

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<sup>2</sup> The regulatory experience of water services by the OFWAT (Office for Water Services - England and Wales regulators for water services) is one of the most structured examples of yardstick competition.

Given the complexity and articulation of the objectives to be pursued, the newly established national Authority first initiated a process of acquisition of information to assess the status of the plants and the opportunity cost that the end customer was willing to accept in order to improve the service. Second, it provided for a transitional period (years 2012-2013) during which such information would be acquired and analyzed in order to define a new tariff method.

During this transition, the ARERA, given the need to adapt the tariff method applied also took into account the results of the 2011 popular referendum<sup>3</sup> and issued a series of resolutions with which it defined (in relation to the 2012-2013 tariffs) the Transitional Tariff Method (TTM)<sup>4</sup>. The main innovations established by the transitional regulations included:

- the introduction of a regulatory period, i.e. a two-year time horizon during which the financial references and the criteria for updating costs remained constant;
- the expansion of the basis for calculating the capital cost including investments made by the management, including those made through non-repayable public loans, in order to increase investment activity.

The temporary situation was completed in December 2013 with the ARERA's Resolution 643/2013/R/ldr on the Approval of the water tariff method (MTI) and of the completion provisions for the determination of tariffs for the years 2014-2015. Following the study of the sector and the first indications collected in the two-year period 2012-2013, the national Authority found a serious infrastructure inadequacy combined with extremely fragmented and differentiated management of the sector, which gave rise to considerable complexity in the governance of the sector, thus requiring specific regulatory measures.

The ARERA deemed it necessary to adopt an innovative and asymmetric regulation that, due to the overall investment expense and its diverse impact on the territory, managed to pursue the need to stabilize the regulatory framework.

In detail, the MTI (water tariff method) considered:

<sup>3</sup> As a result of the popular referendum held on 12-13 June 2011, with the decree of the President of the Republic July 18, 2011 n. 116 art. 154, paragraph 1, of the legislative decree n. 152/06, therefore, the adequate remuneration of the invested capital must no longer be included among the criteria for determining the rates.

<sup>4</sup> ARERA Resolution 585/2012/R/ldr "Regulation of water services: approval of the transitional tariff method (TTM) for the determination of tariffs in the years 2012 and 2013".

- the extension of the reference time horizon (the national Authority introduced the Program of Interventions "PoI" for four years, while the preparation of tariffs remained two years);
- the introduction of a matrix of regulatory options, alternative to each other (regulatory schemes)<sup>5</sup>, which would give greater flexibility to the regulatory instrument; these options were declined based on the relationship between the existing situation and specific objectives.

The asymmetric and innovative regulation introduced with the MTI for the 2014-2015 tariffs made it possible to apply a uniform regulatory framework for the entire country; however, as early as 2013, ARERA issued a series of resolutions aimed at penalizing those managements who submitted deficient tariff proposals, or to exclude from the tariff update those who fell into certain cases (failure to adopt the Service Charter, permanence of invoices of a minimum committed consumption), highlighting a far more serious criticality: the inability or impossibility to apply the new regulation to certain contexts<sup>6</sup>.

Therefore, the national Authority, with the aim of allowing for the realization of the investments considered as priorities and, at the same time, to face the urgent critical issues of difficult management, issued a new MTI-2 tariff method<sup>7</sup> that extended both the duration of the regulatory framework period (the 2016-2019 tariff preparation became four-years) and the regulatory framework matrix introducing the per capita value of the operating costs component.

The innovation in the dependence of the maximum eligible annual increase of the tariff from the entity of the per-capita expenditure for the operating costs implied an incentive both to the sustainability of the tariffs to the users (the higher the expense attributable to the individual inhabitant, the lower the percentage increase admissible), as well as to the aggregation of the management (the higher the

<sup>5</sup> The ARERA adopted as a main methodological reference, A Theory of Incentives in Procurement and Regulation, Laffont Tirole, 1993, MIT Press specifying how "the application of incentive regulatory schemes is rather widespread in the international experience, in the context of which, in particular, with reference to the water sector, the one used by OFWAT, especially since 2009" (Document for consultation ARERA 356/2013/R/ldr "Public consultation in tariff regulation of water services").

<sup>6</sup> Document for consultation ARERA 406/2015/R/ldr "Water tariff method for the second regulatory period MTI - 2. General Framing and Intervention lines"

<sup>7</sup> ARERA Resolution 664/2015/R/ Idr Approval of the water tariff method for the second regulatory period MTI - 2.

number of inhabitants served, the more contained the indicator of operating costs per capita).

Finally, in the same Resolution 664/2015/R/Idr, the national Authority provided for the biennial update of the tariff arrangements (by March 31, 2018) for the years 2018-2019.

It is precisely the biennial update of the tariffs that is the last chapter of the tariff evolution that, to date, the ARERA has promulgated, regulating it through the resolution 918/2017/R/Idr and the relative application resolution 1/2018/R/Idr of 29 March 2018.

In particular, the resolution regulates the criteria to be followed for updating the cost components admitted to the tariff recognition for the years 2018 and 2019 and introduces:

- an additional component of the operating costs, aimed at covering the costs of adaptation to certain technical quality standards<sup>8</sup>;
- the prevalent destination of the second equalization component (named UI2) to the promotion of the same technical quality;
- the third equalization component (named UI3) aimed at fueling an equalizing mechanism operating nationwide for the distribution of the social water bonus to the WS users in conditions of economic and social hardship;
- a cost component intended to cover the improvement facilities provided for by the EGA (additional water bonus).

Finally, the ARERA's Resolution about the water tariff method for the third regulatory period (MTI-3) is expected by the end of this year.

## 2.2 The current regulation of the water service in Italy

As previously mentioned, in the absence of a clear liberalization strategy by the European Union, national water services have evolved according to different models. In the intentions of the Italian legislator, the norm should have been inspired by the reform model of that had been adopted years before in England and Wales, characterized by a reorganization both from an industrial and institutional point of view.

The regulatory project emerging from the Galli reform has, however, taken on a different physiognomy from the Anglo-Saxon model in which the broad and incisive regulatory powers

were assigned to a single independent authority: the Water Services Regulation Authority (OFWAT).

The Italian legislator, on the one hand, had a clear desire to favour the industrialization of the water service, while on the other, he had not fully realized that to protect the public interests, it was necessary to ensure effective regulation, based on the competence and independence of the Authority.

The Italian model established with the Galli reform, presented itself on the European scene as a hybrid model. The regulation was entrusted to a plurality of normative (EU, State, Regions), planning (Hydrographic District Authority, Region), contractual (EGA, Region for the standard Agreement), and jurisdiction (administrative magistracy) sources. The functions of discretionary regulation were relatively non-existent, if not for some soft-regulation activities that the law attributed to the competence of the Supervisory Commission on Water Resources (COVIRI).

In brief, the reform aimed at a model in which the Local Authorities were, through the EGAs, to carry out the main regulatory activities locally (as in Germany). The EGA was reserved the preparation of the Area Plan, the choice of the form of management, the assignment of the service, the control of the work of the manager and the periodic adjustment of the tariff.

In this regulatory context, the relations between the EGA and the Management, regardless of the choice of the form of management of the service, were of a negotiating nature with a contract at the base: the management agreement.

It can therefore be stated that the WS is characterized by a contract adjustment, combined with independent adjustment factors that can be found in a national tariff system (Normalized Method) and in the functions of the Local Regulatory Body (EGA).

Subsequent amendments to the TUA of 2006 resulted in the repeal of the Galli Law, while with the Decree of Prime Minister of 20 July 2012 art. 1, it was assigned the functions relating to water service due to the Ministry for the Environment and Protection of the Territory and the Sea (MATTEM) along with art. 3 being attributed the regulatory and control functions transferred to the former AEEGSI (Authority for Electricity, Gas and the Water System), today ARERA (Regulatory Authority for Energy Networks and the Environment), which immediately started the reorganization of the service.

## 2.3 The Area Plan

<sup>8</sup> ARERA Resolution 917/2017/R/Idr Setting the technical quality of the integrated water service or each of the individual services that compose it (RQTI).

Originally the AATOs, today the Area Government Authorities (EGA), had the task of entrusting the service, in the territory of competence, to a single entity through a management agreement lasting thirty years<sup>9</sup>. The planning role assigned by the law to the EGA is of equal importance, with it imposing (article 149 of Legislative Decree 152/2006) the drafting of the Area Plan (PDA). This is the main instrument of the WS infrastructure planning. First, this tool operates the recognition of the functional criticalities afflicting the territory under the jurisdiction of the EGA. Consequently, it identifies both the necessary investments on the networks as well as their repercussions on the tariff applied to users on the basis of the service applied.

Therefore, the Area Plan is the main technical, economic and financial planning tool available to the EGA, with it defining the status of the service on an area level, establishing the objectives to be pursued, as well as the technical and organizational standards. It also identifies any investments to be made, the available resources to realize what is planned as well as the tariff impact and the organizational and management model required by the sole management of the WS [14, 15].

The Area Plan pursuant to art. 149 of Legislative Decree 152/2006 consists of the following parts:

- survey of the infrastructures;
- program of interventions;
- management and organizational model;
- financial economic plan.

### **3 Aims of the ARERA Planning in the EU context: Intervention Program and comparison of investment alternatives**

In the new regulatory scenario, the ARERA operates under resolution 585/2012/R/Idr (which incorporates the indications of Article 154 paragraph 4 of Legislative Decree 152/2006), with the local regulator (EGA) preparing the tariff proposal that will be applied to the Management. This proposal must contain the Program of Interventions (PoI), where the investments that the Management will have to carry out within the

<sup>9</sup> In some Italian regions, the Area Government Agencies have been identified by a specific regional law and assume different names depending on the regional areas in which they operate; this, for example, is the case of Campania, where the Ente Idrico Campano (EIC) has been established pursuant to the Regional Law. n. 15 of 2 December 2015, or of Abruzzo, where the Regional Body for Integrated Water Service (ERSI) was established with L.R. No. 9 of April 9, 2011.

regulatory framework are identified by ARERA in detail<sup>10</sup>.

This is an instrument that reconciles the priority objectives of the public matrix (social, economic and environmental of the community concerned), all expressed and represented in the PDA, with those of the Management (however relevant for the financial sustainability of the management model). Even if the law is the responsibility of the tariff proposal, the necessarily concerted scope of the tariff construction process is evident, in a close confrontation between the public and private sectors.

Especially since, to date, the information system (stocks of assets, technological features of the infrastructures, investment and maintenance costs, types of utilities, user requirements, etc.), necessary to consciously develop the tariff project, is almost exclusively a prerogative of the private operators (WS Utilities), with evident cognitive asymmetry in the negotiation process.

The ARERA, in setting the regulatory directives, in the matter of planning investment projects, refers to the framework of the European Community, which can be summarized as follows:

- Directive 2000/60/EC, in Article 9, requires Member States to take into account “the principle of recovery of costs of water service, including environmental and resource costs, taking into consideration the economic analysis carried out based on Annex III and, in particular, according to the polluter pays principle”;
- Communication COM (2000) 477, in which the European Commission acknowledges the fundamental role of charging policies in promoting sustainable water management, arguing that they “must be based on the evaluation of the costs and benefits of the use of resources water and take into account both the financial cost of providing the service, and the related environmental and resource costs”. In the provision, the Commission underlines that water pricing systems must “strongly encourage a more sustainable use of water resources and ensure

<sup>10</sup> The program of interventions is introduced for the first time among the documents to be drawn up for the tariff preparation with Resolution 643/2013/R/Idr, referring to the 2014-2015 regulatory period. This program of interventions involved a three-year period and the years 2014-2017. Subsequently, with the resolutions 664/2015/R/Idr and 918/2017/R/Idr (respectively, tariff preparation for the 2016-2019 regulatory period and two-year updating of the same), the reference period of the interventions program becomes coincident with the regulatory period, therefore four years at first and then biennial, for the tariff update.

that environmental objectives are achieved in a more cost-effective way". In this context, it is noted that adequate comparative analyzes of the quality, costs and prices of water service allow "to compare and improve definitions and calculation methods for the evaluation of certain variables, such as prices and costs, in situations of monopoly that do not allow for the transition from one water service provider to another, the comparative analysis of supplier performance can be a spur to adopt more efficient behaviours and to improve the quality of services offered, with the consequent reduction of costs and prices";

- the Altmark ruling of 24 July 2003 (Case C-280/00), in which the Court of Justice ruled that the compensation of public service obligations is a correct cost coverage and does not constitute State aid where it is respected, among others, the condition for which the compensation does not exceed the standard calculated according to efficiency criteria;
- Communication COM (2012) 672, in which the Commission notes that "the implementation of the provisions of the Water Framework Directive on the recovery of costs and price incentives has been limited", also highlighting that "the efficiency under the cost profile and cost-benefit analysis was rarely used by Member States to give priority to investments";
- Communication COM (2012) 673, containing the Blueprint Plan, in which the Commission indicates, among the specific objectives of the Plan, the determination of "prices of water that promote efficiency", proposing among the specific actions for the relative achievement "enforcing water pricing/cost recovery obligations under the Water Framework Directive, case, consumption measurement";
- the 30 points of the Seventh Environment Action Program up to 2020 – annexed to Decision 1386/2013/EU – highlight how "in all economic sectors, it is necessary to focus on innovation to improve resource efficiency and improve competitiveness in a context characterized by an increase in the price of resources, by the shortage of resources, by restrictions on the supply front of raw materials (...)";
- the most recent Communication COM (2015) 120 final, in which the Commission once again highlighted the need for the renewal of water infrastructures at a European level and, in particular, noted that "... failure to recover costs, including environmental costs, of resources and infrastructures, does nothing but make the bill

even higher for future generations in those sectors that will have to face an extreme water shortage and the decline of water infrastructures".

All the references mentioned are substantiated in precise regulatory directives of the ARERA such as the 643/2013/R/ldr, 549 and 664/2015/R/ldr, 917/2017/R/ldr (Regulation of Technical Quality – RQTI). The ARERA incorporates the EU guidelines within the tariff regulations, requesting, for the analysis of the intervention programs, the explicit definition and evaluation of investment alternatives in the resolution of the critical points identified in the territory of competence. The possible alternatives must always be compared at least with the option zero or that of do-nothing.

### 3.1 The structure of the Intervention Program

In the PoI, the local Authority highlights the investments that the Management must make in the four-year programming period to respond to emerging needs in the area of competence.

In general terms, the needs of the entire ATO are listed in the PDA within a set  $\{C_A\}$  (critical) and described therein with respect to their relevance and the impact they determine.

With the Resolution 3/2014-DSID, the ARERA identified 40 critical issues, classified in 7 thematic areas, to which each EGA had to return the problems encountered in its territory of competence. Subsequently, with 2/2016-DSID, the classification of the critical issues became more detailed by presenting 8 Areas, 57 Sub-areas and 137 critical issues. On the other hand, the EGA remained free to measure them according to its performance indicators. Today, the national Authority, with deliberation 1/2018-DSID, has again changed the classification of the critical issues with many to many correlations that make it not immediately transposed from the previous [16]. The current overall classification structure is shown in Fig. 1 (next page).

Some Areas relate to management problems (for example: Area EFF - general management problems), others refer to technical problems (for example: Area DIS - Criticality in distribution). Each Area is broken down into numerous Sub-Areas. For example, the Area DIS presents the following Sub-Areas: DIS1 – Inadequacy of distribution infrastructures, DIS2 – Pressure problems, DIS3 – Absence and/or obsolescence of process and user meters.

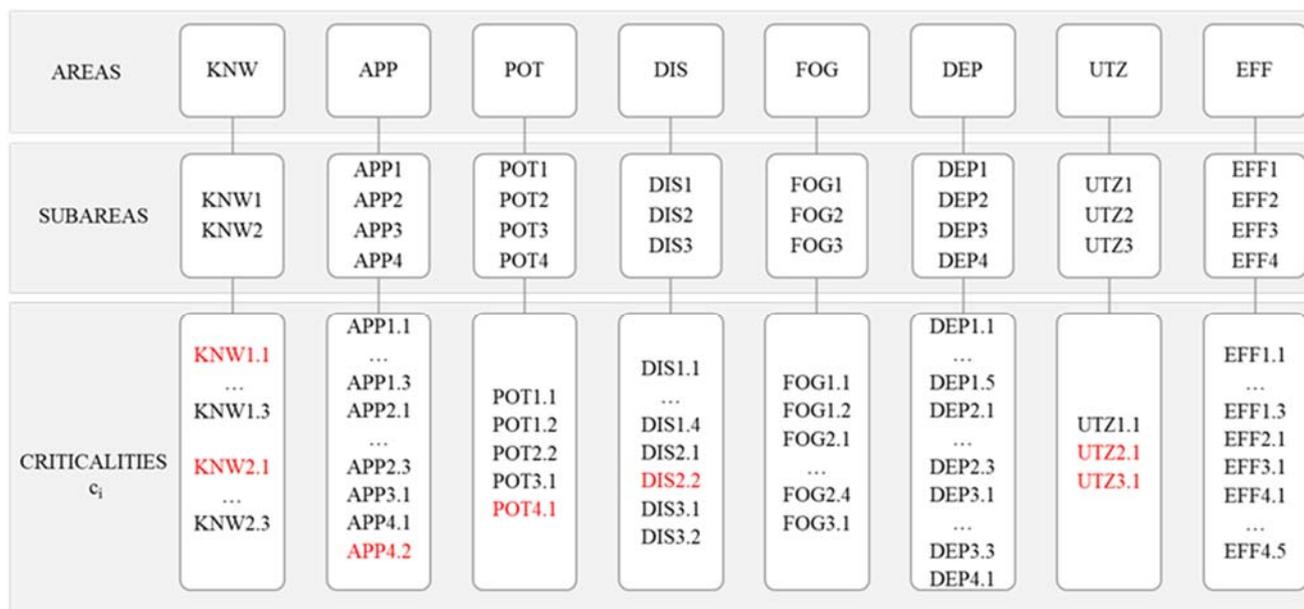


Fig. 1: Total ramifications of the critical issues  $\{C\}$  imposed by the national Authority. An example of a subset is highlighted in red  $\{C_T\}$

Finally, each of the Sub-Areas includes critical issues. For example, the DIS1 Sub-Area has the following criticalities: DIS1.1 – Partial or total absence of the distribution networks, DIS1.2 – Inadequate physical conditions of the networks and distribution systems, DIS1.3 – Hydraulic capacity of the infrastructures not responding to demand levels, DIS1.4 – Inadequate capacity for tank compensation and reserve.

In summary, there is a general classification of the critical issues  $\{C\}$  carried out by the ARERA that is specified for each optimal territorial area in a subset  $\{C_A\} \in \{C\}$ .

Initially, the models implemented for the definition of the critical issues  $c_i$  in PDAs often provided their descriptive characterization, without any indication of the parameters that could measure them. This discretion often provokes the lack of a clear, evident and shared correspondence between the critical issues and related indicators, therefore the ARERA, with Resolution 89/2017/R/Idr starts a process of development and sharing of a set of  $Pc_i$  quantitative indicators (suggested, but not imposed) for the quantification of the infrastructural and operational criticalities of the water service. Finally, with the resolution 1/2018-DSID, the ARERA associates with most of the identified problems an indicator or more impacted technical quality indicators. Now, the EGA is not obliged to the use these indicators, but it is preferable. However, the use of the RQTI macro-indicators for the measurement of the technical quality standards is obligatory.

When the ATO is not managed by a single operator but rather by multiple Managements, who are entrusted with different portions of the territory,  $T$ , the subset  $\{C_A\}$  will have to compare with the specificities of each of these, resulting in a subset of criticalities  $\{C_T\} \in \{C_A\}$  with respect to which coherent and congruous investments must be planned.

For every criticality of the subset of territorial criticalities ( $\forall c_i \in \{C_T\}$ ), the EGA and the Management will have to agree (even if the standard formally attributes this responsibility only to the EGA) to identify, with respect to a multiplicity of possible project solutions  $a_i$ , the project  $a_j$  (action) to be included in the PoI in order to reduce the impact of the criticality  $c_i$ .

In the drafting of the PoI, the selection process – among other investment proposals – of the best project solution  $a_{Mi}$  must therefore be explicit and verifiable.

The ARERA thus tries to change the principles of Legislative Decree n. 228/2011<sup>11</sup>. This provides for the integration of intervention projects of pre-eminent national interest (for the purpose of their inclusion in the Pluriennial Planning Document that the Regions, the Autonomous Provinces, the Metropolitan Cities and other competent bodies transmit to the Ministry of Infrastructures and Transport to compete for possible financing) with

<sup>11</sup> Implementation of Article 30, paragraph 9, letters a), b), c) and d) of the Law of 31 December 2009, n. 196, regarding the evaluation of investments related to public works.

feasibility and ex-ante evaluation studies adapted to the methods and criteria defined in the prescribed guidelines.

The Legislative Decree 228/11 responds to a systemic weakness in the life cycle of public works projects accumulated by Italy, which is confirmed both in the conclusions reached by a Comparative Study on international methods of the preventive assessment of public works carried out some years ago by the Ministry of Infrastructures and Transport, as well as in the annual report compiled by UVER (Unit for Verification of Public Investments) on the timing of the implementation and expenditure of public works.

### 4 The proposed model

The protocol proposed in this study responds to the selection needs of the project alternatives imposed by the ARERA and is based on the use of the AHP methodology as a tool for comparing alternatives. The method is among those recommended by ARERA (see page 3 of Annex 1 of Resolution 2/2016-DSID).

The choice is justified based on the information profile to be elaborated which, as mentioned, has qualitative-quantitative characteristics, with it requiring a multi-criteria tool [17].

However, it innovates the regulatory approach for three reasons.

First, the model outlines an original modality of selection of the best project alternatives  $a_{Mi}$  aimed at solving the critical issues of the Service. Second, the model allows to elicit project alternatives that may

be relevant to more than one critical issue, thus rewarding multi-objective technical solutions. Furthermore, it introduces three new criteria – compared to those proposed by the ARERA – capable of explaining the economic and financial scope of the project solutions. Third, the model configures a route of final hierarchization of the selected interventions  $a_{Mi}$ , compared to the needs expressed by the EGA in the PDA, able to direct the contract negotiations between the EGA and the WS Utilities torn between the interests of the community and business objectives. Among the  $a_{Mi}$  defined to respond to the different criticalities, some are more oriented towards the public sector, while others are in favour of the private sector. It is obvious that WS Utility tends to favour investments in those segments (for example, water with respect to the sewerage) or in those activities (for example, the reduction of losses in densely populated areas compared to the construction of a new branch of the network useful for a small urban fraction) that are more immediate financial profitability [18].

Fig. 2 presents the logic relating to the first and second objectives of the hypothesised model.

Fig. 3 (next page) shows the logic of the third objective of the theorised model.

The third objective of the model is obviously absorbed in the implementation of the first two objectives. It seemed useful to represent it autonomously, since in current legislation there is no reference to similar temporal hierarchy of the interventions to be implemented in the PoI. Therefore, this passage is entirely original with respect to the indications of the law.

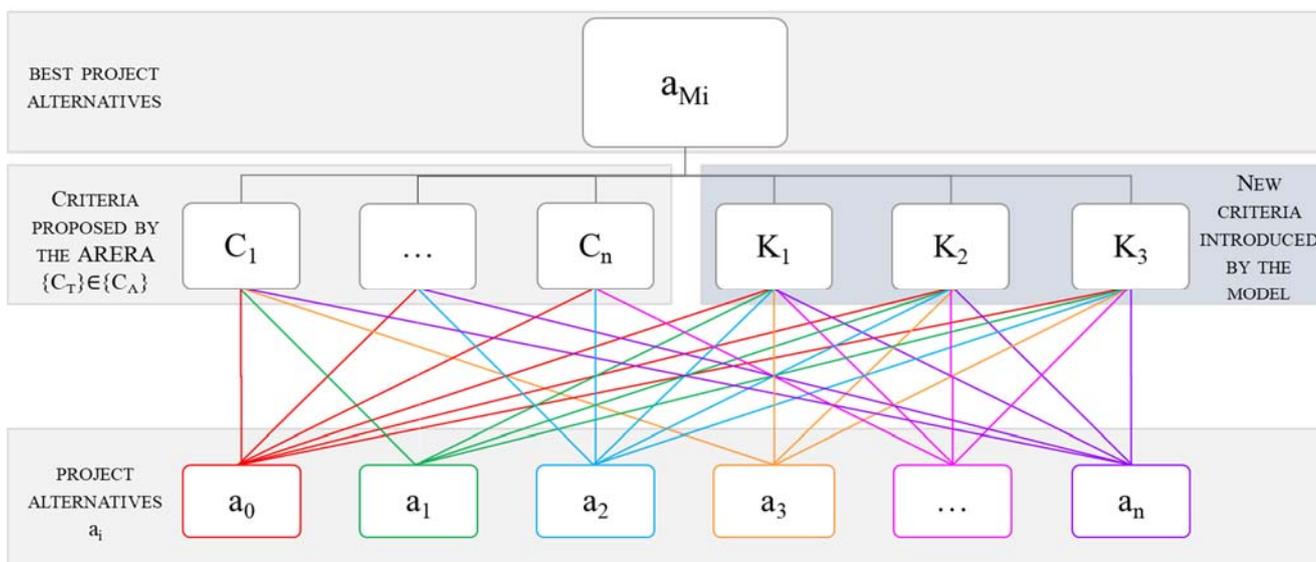


Fig. 2: Proposed model, rationalization of the alternative project choices  $a_{Mi}$

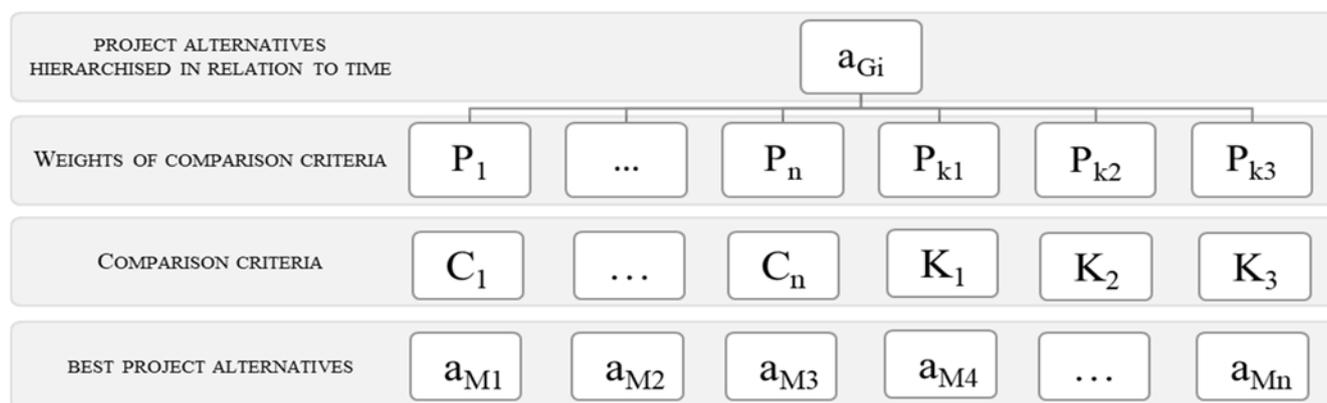


Fig. 3: Proposed model, hierarchy of the project alternatives  $a_{Mi}$  in relation to time

## 5 The structure of the model

The model has three phases.

There are two steps in the first phase  $F1$  - *Selection and measurement of the critical issues*:  $F1_1$  e  $F1_2$ .

In step  $F1_1$  - *Selection of the critical issues*, the EGA and Management must define the critical issues  $c_i$  of the subset  $\{C_T\}$ , deducing them from those already exposed by the EGA in the subset  $\{C_A\}$  as described in the set  $\{C\}$  defined by the ARERA.

In step  $F1_2$  - *Measurement of the critical issues*, on the basis of the list provided by ARERA or its own professional experience, the EGA and the WS Utility must identify the technical parameter  $P_{c_i}$  capable of allowing to measure the impact level of the critical issues  $c_i$ . This step is essential to circumscribe the problems which the investments must meet as well as to provide a quantitative survey.

This step presents the problem of the reliability of the parameter assumed (see page 2 of annex 1 of Resolution 2/2016-DSID), i.e. the degree of truthfulness of the measurement taken. The scarcity of information systems available in this country also induces Management to provide a tendential or approximate measurement of  $P_{c_i}$ . This decreases the reliability of this phase (F1) and, above all, significantly affects the results of the second phase (F2). Thus, ARERA (resolution 664/2015/R/Idr) introduced important indications so that higher standards of reliability of the measurements are adopted in the process of defining the rates. This process is part of a much larger chapter of operational innovation introduced by the national Authority with the Regulation of Technical Quality (resolution 917/2017/R/Idr).

The second phase  $F2$  - *Project alternatives*, in the model is subdivided into three steps:  $F2_1$ ,  $F2_2$  and

$F2_3$ . Step  $F2_1$  - *Identification of alternatives*, involves the construction of design alternatives  $a_j$  useful to reduce or cancel the impact of any critical issues  $c_i$ .

Step  $F2_2$  - *Effects of the alternatives*, provides for the quantification of the progress measured for each critical issue in relation to the potential realization of each project alternative, this measurement is done by using the variation of the value of the chosen  $P_{c_i}$  indicators to quantify the effects.

Step  $F2_3$  - *Selection of the preferable alternative*, using the AHP, allows to select the best alternative to  $a_{Mi}$  for every critical issue  $c_i$ . The substantial novelty introduced by the model consists of integrating the critical issues of ARERA (Fig. 1) with three other criteria ( $K_i$  in Fig. 2) that take into account the impact of the project solutions in terms of the population concerned; investment cost required by the project solutions; cost of maintenance associated with the project solutions.

The third and last phase of the model,  $F3$  - *Hierarchization of investments*, allows to draw up, through a multi-criteria application with AHP, a hierarchy that implements the prevailing alternatives. The ranking allows the local authority, EGA, to direct the Management's investments according to time priorities that favour the strategic objectives of greatest importance in the PDA. Appropriately calibrated, this phase also supports a correct reconciliation of the managerial objectives of the WS Utility.

Further description of the steps is presented below.

### 5.1 $F1_2$ : measurement of the critical issues

For each critical issue to be addressed in the regulatory period (currently 2016-2019), an indicator of the  $P_{c_i}$  performance is identified to quantify the status quo of the problem. Obviously,

the passage from the variable to the representative parameter of this can occur on various scales (descriptive, ordinal, cardinal).

To date, reliable values of the indicators are held by the WS Utility, through the knowledge acquired from managing the activity over the years; they must be adequately verified by the EGA, with all the difficulties related to the inadequacy of the SITs (Territorial Information Systems) available in Italy. Even in this sector, as previously mentioned, the ARERA has acted with resolution 917/2017/R/Idr. The choice of the parameter is determined by the following factors, according to the recommendation of the *International Water Association* [19], implemented in Annex A of Resolution ARERA 89/2017/R/Idr:

- ability to provide a synthetic, comprehensible and immediately usable information;
- possibility of objective quantification, based on information already available;
- reliability and ability to detect variations and make comparisons;
- absence of ambiguity.

The reliability of the indicators represented is based on the evaluation system identified by ARERA, which can be summarized in the table 1.

For example, for the critical issue DIS1.2 - Inadequate physical conditions of the networks and distribution systems, and, in particular, in the case of High level of water losses along the distribution networks (critical issue B4.1 ex Resolution 2/2016-DSID), one of the performance indicators identified by the ARERA with the Technical Quality Regulation is described below (1).

The parameter M1a - Linear water losses defined as the ratio between the volume of total water losses and the total length of the aqueduct network in the year (a) is considered as a performance indicator:

$$M1a^a = \frac{WL_{TOT}^a}{365 * L_p^a} [m^3/km/gg] \quad (1)$$

Where:

- $WL_{TOT}^a = \sum W_{IN}^a - \sum W_{OUT}^a$  represents the total volume lost during the year  $a$  in the phases of the aqueduct service managed, defined as the difference between the sum of the volumes entering the aqueduct system (from the environment or imported from other systems) and the sum of the volumes leaving the same system (authorized consumption, invoiced or not invoiced, and exports to other systems); among

the outgoing volumes, it is also possible to account for treatment losses, provided that the flow in and out of the drinking water treatment plants is measured (and not estimated); it is specified that the lost volume includes the c.d. apparent losses ( $m^3$ );

Table 1: Evaluation system for the reliability of data and performance indicators

Degree of Reliability	Description
1	Performance indicators determined based on measured or detected data, and/or quantities calculated on the basis of measured or detected data
2	Performance indicators determined on the basis of data and parameters partly taken from current technical and scientific literature or estimated and partly detected, and/or quantities calculated on the basis of parameters partly taken from current technical and scientific literature or estimated and partly detected
3	Performance indicators determined on the basis of data and parameters drawn exclusively from current technical and scientific literature or estimated, and/or quantities calculated on the basis of data and parameters taken exclusively from current technical and scientific literature or estimated

- $Lpa$  is the total linear development of the supply and distribution pipelines, excluding the derivations of users (or connection ducts), managed on December 31st of the year at (km).

Obviously, the reliability of this indicator derives from the possibility of knowing the various terms of the equation. However, cases in which the WS Utility does not have detailed information is not uncommon, in some circumstances they do not even know precisely the volumes entering the network, although this, to date, is a prerequisite for the exclusion from incentive mechanisms and the allocation of the tariff with the *teta* tariff multiplier (9) equal to 0.9 (Resolutions 917/2017/R/Idr and 918/2018/R/Idr). This coefficient *teta* requires the WS Utility to reduce the water tariff by 10% compared to current values.

## 5.2 F2<sub>1</sub>: identification of alternatives

This moment is of a predominantly project nature and involves the related expertise (engineering, management, legal, socio-economic, etc.). Constructing the ways to contain, improve or cancel any critical issues is a complex and multidisciplinary matter.

Evidently for some critical issues, solutions are circumscribed (for example, to reach unserved utilities, it is possible to build a new network or verify the conditions for direct drainage from groundwater), for other problems a greater planning articulation is required (for example, to reduce network losses, it is possible to reduce pressures, repair networks, build new networks, etc.).

It is also worth considering that, with reference to the zero alternative (i.e. not to intervene, maintaining the status quo), the  $Pc_i$  parameter discloses the current state of the critical issue without providing for improvements.

## 5.3 F2<sub>2</sub>: effects of the alternatives

The measurement of the effects determined by the project alternatives includes the forecast of the improvement of the critical conditions determined by the hypothesised investment initiatives. It is well-known that ex-ante evaluations are all the more reliable when the cases are historicized and analytically documented, from which to obtain information on the final balance. The ex-post information, correctly catalogued and summarized, provide consistent and reliable forecast indicators. This historical framework does not exist in the water infrastructure sector in Italy. This lack determines situations of informative asymmetry. For the WS Utilities, it is easier to identify the costs and benefits of investments, deducing them from their datasets. For the Regulators (both local and national), it is more complicated to verify the forecast data provided by the WS Utilities that lack correctly structured information collections in order to define the so-called standard costs. In this regard, the authors are verifying expeditious models to estimate these costs [20].

## 5.4 F2<sub>3</sub>: selection of the preferable alternative

Defined in step F2<sub>1</sub>, the set of solutions  $a_j$  related to the critical issues, the model provides for the application of the AHP methodology [21, 22] to identify the best one.

The first step in the use of the AHP is the definition of the comparative hierarchy:

- level 1: (general objective of the evaluation) identification of the best project solutions ( $a_{Mj}$ );
- level 2: evaluation criteria with respect to which selection should be made;
- level 3: alternatives to be compared.

The criteria are not assigned a weight, with the all being considered equivalent.

All the project alternatives are compared in pairs in relation to all the critical issues. If the project alternative has an impact on criticalities, it will improve the corresponding performance indicator, which will remain unchanged in the other cases. It is worth recalling that project solutions can often result in improvements compared to more than one critical issue (for example, the replacement of an old and/or malfunctioning lifting system affects the critical issues *DIS1.2 – Inadequate physical conditions of the systems and networks distribution*, but also the critical issue *EFF3.1 – Critical issue on the safety of working conditions* and on *EFF4.1 – High consumption of electricity in the aqueduct*).

As previously mentioned, the model introduces three innovative criteria  $K_{ir}$ :

- $K_{i1}$  – Population. It refers to the number of users affected by the critical issue  $c_i$ . For example, if it is a loss of a distribution network, the variable indicates the number of users who benefit from the improvements induced on the infrastructure by the proposed project intervention. Obviously, the improvement in the value of the predictor has a positive impact on the resolution of the critical issue  $c_i$  addressed;
- $K_{i2}$  – Investment costs. It refers to the capital cost of the project  $a_j$  to be carried out to resolve the critical issue  $c_i$ . A negative impact for the growth of value of the predictor is assumed, hypothesising that between two completely similar alternatives, the one that costs less is preferable. The variable considers the expenses to be incurred in the four-year regulatory period, even when they are distributed over several functional lots according to which the project can be implemented;
- $K_{i3}$  – Maintenance costs. It refers to the maintenance costs that the project  $a_j$  requires. It generates a negative impact on the selection function as its own value increases. In order to adequately consider the containment effects of the expenditure deriving from the construction of new infrastructures compared to the simple conservation of existing assets (alternative to  $a_0$ ),

the estimate of the predictor is extended over eight years, i.e. two regulatory periods. It is clear that this criterion works in symbiosis with the previous one, rationalizing the effects on the defined selection procedure.

Once the set of excellent solutions  $a_{Mj}$ , has been selected, for every critical issue  $c_i$ , the optimal solution  $a_{Mi}$  is internal to this set and will be configured as the one among the solutions conferring with  $c_i$ , which will have obtained the highest score from the application of the AHP.

### 5.5 F3 phase: hierarchy of investments

The last step of the proposed protocol, having defined the optimal project alternatives  $a_{Mi}$  that contribute to the resolution of the criticalities found in  $\{C_T\}$ , organizes them in a ranking that indicates the historical priorities to be respected in the investments to be carried out.

As previously mentioned, the timing of the investment expenses is a sensitive subject of public-private contract negotiation, given the different and conflicting objectives. On the one hand, the public aims included in the Area Plan, where the EGA has extensively identified the shortcomings and objectives to be pursued in the territorial area to be governed. While, on the other, the managerial purposes of the WS Utilities, which tends to invest in the segments that ensure greater and more immediate profitability.

The model provides for a new application of the AHP, where the goal is the temporal hierarchization of the optimal project proposals  $a_{Mi}$ .

The criteria remain unchanged compared to step F2 discussed in paragraph 4.

However, the vector of the criteria weights (hitherto assumed constant and equal) is modified, in accordance with the priorities that the PDA attributes to every critical issue.

A scale of priorities that is not always clear or explicit in the PDA is sometimes expressed in verbal and discursive terms, rarely through performance indicators.

In the application of the model, the weight vector is compiled by submitting the judgment on the temporal urgency of the different criticalities to the EGA, by means of a comparison procedure in pairs. In the future, it will be necessary to redesign the PDAs using quantitative parameters representative of the priority that the public attributes to the solution of the different critical issues.

The judgment on the weight carrier must also be requested from the WS Utilities, so as to ensure the consideration of its interests. An appropriate sensitivity analysis on the results of the hierarchization obtained with respect to the different points of view will conclude the implementation of the model.

This last function of the proposed model is schematized in Figure 3.

## 6 Conclusion

The aim of this work was to construct and illustrate a model useful for integrating the regulatory provisions concerning tariff regulation for the Water Service in Italy. It proposes an architecture capable of rationalizing the project choices for investments in water infrastructures specific to the Intervention Program as regulated by Resolution ARERA 664/2015/R/Idr and 918/2017/R/Idr.

The model allows, through the AHP application, to compare the project alternatives with respect to the criteria indicated by ARERA and innovative criteria that include both the economic relevance objectives (population involved in the investment) as well as the financial relevance (investment and maintenance costs). It also allows to reward those project solutions that solve more critical issues at the same time, thus reducing intervention times while respecting the principle of maximum cost-effectiveness of the intervention. Finally, the model helps the public-private partnership, rationalizing the decisive negotiation phase for the time span of the investments to be made with the Management's funds.

In a publication under completion, the model will be implemented on the case of an Italian ATO and a private management entrusted with a part of the Area, highlighting the positive effects and any application weaknesses of the protocol.

To date, there are no examples of models with similar functions or objectives in the specialized bibliography.

The proposed protocol will soon be used in a software capable of supporting the action of the EGA as well as rationalizing the collaboration process with the WS Utilities.

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