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[8];
- 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 (MATTM) 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

[8] 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[9]. 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 regulatory framework are identified by ARERA in detail[10].

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

[9] 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.

[10] 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/idr, 549 and 664/2015/R/Idr, 917/2017/R/Idr (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.

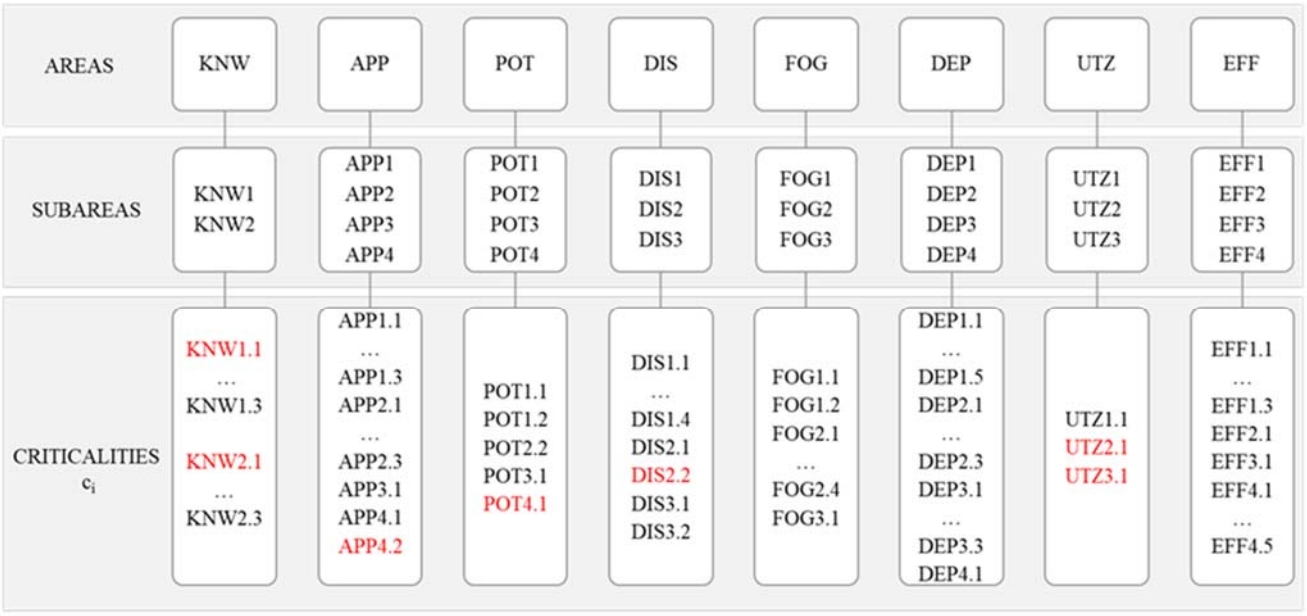

Fig. 1: Total ramifications of the critical issues {C} imposed by the national Authority. An example of a subset is highlighted in red $\{C_T\}$

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[11]. 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

[11] 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.

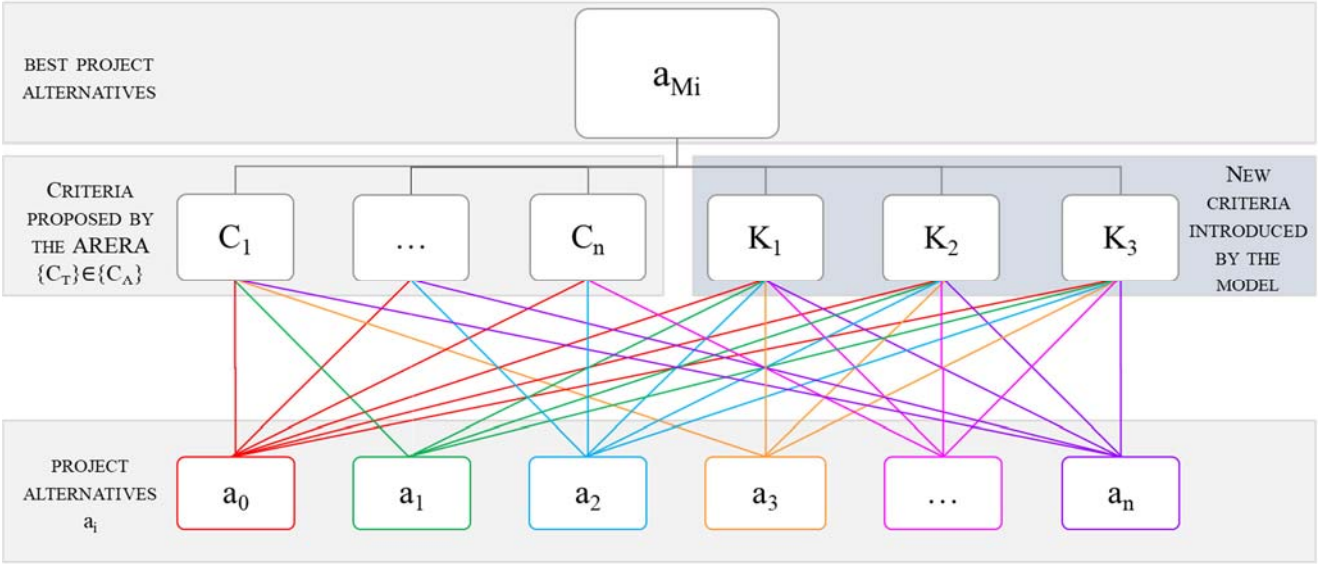

Fig. 2: Proposed model, rationalization of the alternative project choices a_{Mi}

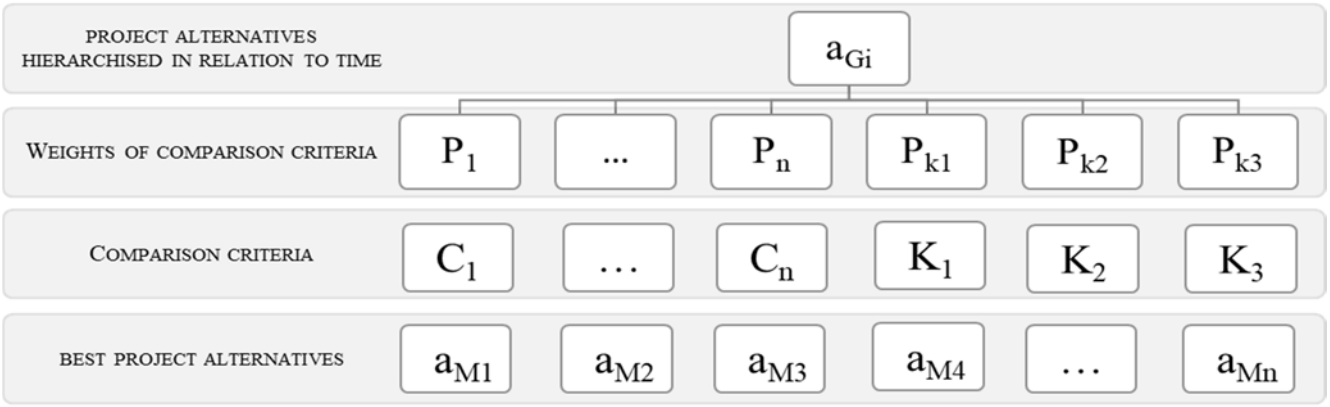

Fig. 3: Proposed model, hierarchy of the project alternatives a_{Mi} in relation to time

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 Pc_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 Pc_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 Pc_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 Pc_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:

$$M1a^a = \frac{WL^a_{TOT}}{365 * L^a_p} \; [m^3/km/gg] \; (1)$$

Where:

- $WL^a_{TOT} = \sum W^a_{IN} - \sum W^a_{OUT}$ 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 Reliabilty	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 literarture 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 (ϑ) 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 $F2_1$: 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 $F2_2$: 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 $F2_3$: selection of the preferable alternative

Defined in step $F2_1$, 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 $a_{M}i$ 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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