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Historical School Buildings. A Multi-Criteria Approach for Urban Sustainable Projects

Maria Rosaria Guarini [1,*], Pierluigi Morano [2] and Francesco Sica [3]

[1] Department of Architecture and Design, "Sapienza" University of Rome, 00196 Rome, Italy
[2] Department of Science of Civil Engineering and Architecture, Polytechnic University of Bari, 70125 Bari, Italy; pierluigi.morano@poliba.it
[3] Doctoral School of Architecture and Construction, Department of Architecture and Design, "Sapienza" University of Rome, 00196 Rome, Italy; francesco.sica@uniroma1.it
* Correspondence: mariarosaria.guarini@uniroma1.it; Tel.: +39-347-3394586

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Abstract: It is recognized, in Europe and elsewhere, that there is a need to implement sustainable urban intervention policies based also on the recovery of existing public real estate assets. In Italy, the schools are a significant part of public property. At this time (2019), many buildings destined for teaching need to be redeveloped, both from a structural and plant engineering point of view, and with regard to the management of the spaces available for teaching and social activities. Although, there have been many attempts by the legislator to regulate the modus operandi in the school construction field, it is clear that there is a lack of a unique regulatory system in which the technical and functional-managerial aspects relating to the same school are considered together. On this basis, with this study a multi-criteria evaluation protocol to support intervention planning for the redevelopment of existing school buildings is proposed. The study defines an evaluation framework with which we can establish the design priorities to be carried out in accordance with the building features and community needs. The evaluation framework is tested on a renewal project regarding a school building located in the historic center of Rome (Italy).

Keywords: urban sustainable development; historical school buildings; multi-criteria evaluation

1. Introduction

The urban policies of many countries, both European and not, are characterized by sustainable intervention practices [1,2]. Among these, some concern specifically the preservation of ecosystems, while others concern the conservation of territorial infrastructure and existing buildings [3–7]. Since 2007, with the Leipzig Charter [8], the European Union Member States promoted development policies based on integrated planning actions, mainly for the regeneration and upgrading of both buildings and urban areas [9,10]. There are many European strategies and plans in which the aspects linked to the physical regeneration of territory and those regarding its economic, social and environmental system are considered jointly [11,12].

In Italy, the Legislative Decree 102/2014 [13], which implements the European Directive 2012/27/EU, outlines a strategic reference framework specifically aimed at promoting urban renewal projects on public real estate assets in order to improve their energy efficiency [14–17]. This also with the use of renewable resources present in nature, building systems and technological solutions capable of producing a low environmental impact [18–22].

With regard to the Italian context, the set of public buildings consists of 1,056,404 units divided into 11 homogeneous clusters [23]. The clusters with more than 10,000 buildings include offices

(48,376 units), homes (594,337), sheds and warehouses (66,657), garages and car-parks (184,532), shops (28,794), barracks (13,931), schools (46,429), hospitals (11,731), and sports facilities (15,725) [24].

Along with dwellings and car-parks clusters, school buildings are one of the largest clusters. According to data in *Anagrafe dell'Edilizia Scolastica* (AES), made available (26 September 2018) through the portal of the Education, University and Research Ministry [25], in Italy there is a school building stock of 40,151 buildings in use, and 22,000 of these were built before 1970. A little more than half of the stock buildings are equipped with measures to reduce energy consumption (57.5%) and have a static test certificate (53.2%). The 22.3% of buildings without this certificate were built before 1970. A total of 59.5% do not have a fire prevention certificate, and 53.8% lack a habitability certificate. The situation regarding the emergency plan, present in 78.6% of schools, and architectural barriers, removed in 74.5% of buildings, is better. On the basis of these data, the Italian school heritage is mainly composed of buildings built before 1975, not only with technological criteria typical of their construction time, but also conforming to educational needs different from the current ones. Only those built after 1975 are characterized by the typological specialization enshrined in the currently legislation that takes into account the new international educational-didactic guidelines. With reference to international guidelines, the school is no longer conceived only as a space for students and school staff offering services closely related to education, but also as a place to carry out activities in order to make the urban context in which the school is located more livable [26,27]. By providing the community with structures, spaces, and services, the school can be an aggregating territorial polarity (civic center), and it can improve the quality of life in the community [28–30].

Over time, there have been multiple attempts to direct the modus operandi of intervention on Italian school buildings with specific measures. Among these, those issued from 1960 onwards, and some currently in force are:

- the Circular n° 425/1967 of the Public Works (Studies and Planning Service) Ministry concerning building and urban planning standards, in particular the Appendix C of the aforementioned Circular contains indications on influence radius to be assumed for the identification of the territorial area in which the school is;
- the Ministerial Decree (MD) (Ministry of Public Works in agreement with the Ministry of Public Education) of 18/12/1975 (Updated technical standards relating to school building) [31];
- the Law n° 23/1996 (Regulations on school building) [32];
- the Legislative Decree n° 106/2009 (concerning the protection of health and safety in the workplace) [33];
- the Agreement of 18 November 2010 according to Article 9 of Legislative Decree of 27 August 1997, n° 281, between the Government, regions, autonomous provinces of Trento and Bolzano, provinces and municipalities (Guidelines for the prevention of indoor risk factors for allergies and asthma in schools) [34];
- the Ministerial Decree (Ministry of Infrastructure and Transport) of 17 January 2018 (Technical Regulations for Construction, in particular Chapter 8, which contains the anti-seismic safety parameters to be followed by existing structures) [35];
- the Law n° 107/2015 (Reform of the national education and training system and delegation for the reorganization of current legislative provisions) [36];
- the Law n° 81/2019 (art. 4-bis: Adaptation of school buildings to fire regulations) [37] (for a more specific description see Section 2).

Significant among the guidelines that directly affect the construction and redevelopment of school buildings are those relating to the:

- internal architecture of schools, by the Education, University and Research Ministry after hearing the Unified Conference (MD 11 April 2013), bearing the technical standards-framework, containing the minimum and maximum indices of urban functionality, construction, also with reference to

technologies in the field of efficiency and energy saving and production from renewable energy sources, and teaching, to ensure appropriate and homogeneous reference design guidelines on the national territory [38];

- recommendations for the energy upgrading of school buildings, produced by the Italian *Ente per le Nuove tecnologie, l'Energia e l'Ambiente* (ENEA) aimed to disseminate knowledge and operational tools at the basis of the energy upgrading of buildings for training, following an updated approach to the latest regulations and the current possibilities for economic incentives [39] for a healthy school environment in Europe.
- environmental quality in external and internal spaces of European schools, in 2015 the pilot project SINPHONIE (Indoor Pollution in Schools and Health—European Observatory) [40], funded by the European Parliament and supported by the European Commission, aimed at investigating the quality of air inside and outside school environments, and the effects that pollutants can have on the health of school users. Through the SINPHONIE pilot project, it was possible to establish methodologies and define standardized tools for characterizing school interiors and assessing health risks for students and staff, in order to maintain a healthy and livable school environment [41–43].

Each of the legislative acts take into account one of the many aspects to be considered with reference to the life cycle of the school building. This is in relation to mono-dimensional logics that consider in a disjointed manner the design and construction components of the transformation or redevelopment project preferring a solving approach to that of integrated problem based-solving type [44–46].

The many investment programs aimed at upgrading the existing school heritage and new schools, promoted at the national and/or regional level since the second half of the last century, have followed a solving approach logic. The allocations for interventions on the school building stock have been directed to finance interventions on the school buildings for their construction, renovation, safety, anti-seismic adaptation, energy efficiency and innovation [47]. However, from 2015, according to Art. 10 of Legislative Decree n° 104/2013 (now Law n° 128/2013), the three-year national planning of school building interventions was introduced. The substantial funding allocated to school building in recent years has preferred a modus operandi to solve specific problems, not often taking into account the mutual relations that there may be between multiple technical and regulatory aspects of a transformation/redevelopment intervention.

On the basis of such a complex and articulated technical-regulatory framework, due to the multiple aspects and mutual relations that characterize the reference system to be taken into account in the field of school building, the execution of actions on the same school building in different times in a non-integrated way may involve intervening in the same building in a way not perfectly congruent functionally and aesthetically with the need to interrupt or move educational activities with a consequent increase in the costs [48,49].

So, in the present work a multi-criteria evaluation protocol for the definition of integrated action strategies regarding new school buildings or existing ones is proposed. With reference to the part of the school building already in use, the implementation of the proposed methodology is aimed at identifying, on the one hand, the need and degree of a functional and structural adaptation of the school, and on the other, the re-modelling of the internal spaces and external ones to be used by the community. This takes into account both the technical and structural features of the building, and the socio-economic characteristics of the urban context. Using the proposed evaluation methodology, the types of intervention to be adopted in order to ensure the building conforms to the regulations in force and to satisfy the people's needs are defined. The validity and flexibility of the proposed method are tested by implementing the evaluation approach in the case of a redevelopment project concerning the school building located in the historic centre of Rome (Italy).

In the following sections, Section 2 describes the type of technical-regulatory material for the execution of initiatives on school buildings with particular reference to Italian case, Section 3 defines the phases of the

multi-criteria methodology, and Section 4 illustrates the case study. Finally, conclusions are reached, and the potential for application of the proposed instrument and future research prospects are defined.

2. Materials

2.1. Premise

In order to highlight the multi-dimensional character of initiatives aimed at enhancing and/or modifying the existing schools in an integrated manner, it is necessary to take into account, in the planning and design phase, multiple aspects according to a multicriteria logic [50–54].

For the recovery and/or enhancement of existing school buildings, it is advisable to verify at the planning and design stage the correct sizing of the spaces for teaching in compliance with the endowment of minimum areas per capita, the compliance with the parameters of seismic safety and fire prevention, as well as the overcoming of any architectural barriers present, and the energy efficiency of the building and the healthiness of the indoor spaces. These checks allow one to define the objectives to be pursued, and the actions to be carried out for the requalification/enhancement of the building. In addition to technical and regulatory considerations, it is also important to highlight which are the primary needs of the urban context to be answered, both through the reorganization of the existing educational offer and by allocating some areas to the exercise of extra-curricular activities. In the following, the technical and regulatory aspects of the Italian context are taken into account.

Thus, preferring a logic of integration between the design aspects related to the same intervention, the proposed multi-criteria evaluation approach includes each of them in order to establish the priorities for action in compliance with the current regulatory system and technical-structural characteristics of the building, as well as the economic and social conditions of the urban context in which the school is located. A careful survey of the state of the building allows us to establish the degree of transformability from the interventions that need to be carried out for the adaptation of the building in compliance with the technical and legislative provisions in force and the community's needs. It should be noted that the main aspects to be considered in order to upgrade the existing building in an integrated manner are listed below. We will not go into the details of each one, especially for those of technical nature, because for each aspect a specific sector study by experienced professionals (such as the one on the energy performance of the building, and/or the rehabilitation of its structure) is required. The methodology proposed supports the programming of sustainable interventions in existing school buildings, and also accessing the funds for the redevelopment and renovation of the schools, taking into account multiple aspects in an integrated way.

2.2. Regulatory Overview and In-Depth Analysis of the Main Italian Legislative Measures for School Construction

As previously specified, in Italy, since the 1970s, there have been many legislative measures in the field of school building aimed at providing planning and/or design indications for the execution of interventions on existing schools, preferring a problem-solving-based approach, and not one of integration and compensation between multiple effects deriving from the same settlement transformation intervention. The main reference standard documents currently in force (2019) for school building are the:

- Ministerial Decree (MD) of 18 December 1975, which illustrates the Technical Standards referring to school buildings, including the educational, building and urban planning functionality indices, to be observed in the design and verification of interventions on existing schools. These indices vary according to the type of study courses and the morphological-urban characteristics of the urban context in which the school building is located. The same MD also distinguishes between indoor spaces (units for teaching and special activities, sanitary facilities, indoor gyms, administrative offices, classrooms for common events) and outdoor ones (outdoor sports fields and parking areas);

- Law n° 23/1996 (School Building Regulations), aimed at the construction of a national information system on existing school buildings resulting from the collection of data on the state of maintenance, the safety level of existing school structures and the rate of usability of the same by the community in extra-educational time. With the above law, *Anagrafe dell'Edilizia Scolastica* (AES), with which the management of interventions on school building at national and regional level is carried out, is established;
- Legislative Decree n° 106/2009, which contains additional and corrective provisions to Legislative Decree n° 81/2008, on the protection of health and safety in the workplace, especially with regard to the presence of materials containing asbestos;
- Agreement of 18 November 2010 pursuant to Article 9 of Legislative Decree n° 281/1997, for the implementation of project initiatives aimed at preventing indoor risk factors for allergies and asthma in schools;
- Ministerial Decree of 14 April 2013, containing the new guidelines of reference for the construction of new schools, also with regard to technologies in the field of energy efficiency and saving and production from renewable energy sources, and teaching. The provisions contained in this MD, of a performance type, deviate from the prescriptive style of the previous illustrated in the MD of 18 December, 1975;
- Law n° 107/2015 ("Good School Law"), specifically aimed at describing the objectives to be pursued in the design and implementation of "innovative schools" from an architectural, plant engineering, technical-construction, energy, anti-seismic and fire safety point of view. This law identifies the types of extra-educational functions at the service of the community to which to allocate part of the school space;
- ENEA guide published on 19 April 2016, which also illustrates the types of intervention related to the building envelope, lighting and daylight, heating systems, renewable energy and water management to be implemented for the redevelopment of a school building;
- Ministerial Decree of 17 January 2018, containing provisions on anti-seismic safety to be taken into account when intervening in the construction, as in the case of existing schools;
- Law n° 81/2019, which illustrates certain provisions for the adaptation of existing school buildings to the requirements of the fire regulations.

These standards can be used as a reference both for existing buildings and new constructions. From each one, the technical-regulatory objectives to be pursued can be defined, and the corresponding parameters (Evaluation Criteria) can be identified with which one it is possible to express the degree of achievement of each objective.

Table 1 shows some of the main regulatory references in the field of Italian school buildings. The basic purpose is described for each of them, and the corresponding evaluation criteria is specified with which one can express the level of conformity between the actual state of the school building and the legal requirements to be complied with. With respect to the list of normative references described above, in Table 1 the normative references containing provisions for Italian school field still in force are taken into consideration.

Table 1. Main regulatory references for Italian school buildings and corresponding evaluation criteria.

Main References for School Buildings	Objective to Be Pursued	Evaluation Criteria
Ministerial Decree of 18 December 1975	Provide technical standards for school buildings	Respect of the per capita surface area allocation for each space
Law n° 23/1996	Collect information on the building to renewal	Check and acquisition of the data availability relating to the school
Legislative Decree n° 106/2009	Proposals of interventions for the safety of school spaces from pollutants and harmful factors	Control of the implementation of interventions to remove polluting materials
Agreement 18 November 2010	Establish lines of action for the prevention of indoor risk factors	Check of the implementation of measures to prevent surface condensation inside the spaces used for teaching
Ministerial Decree of 17 January 2018	Define security parameters for existing buildings	Possible inactivity of internal/external spaces to school building

Description of the Information Contained in the Data Sheet for School Buildings

Among the normative references illustrated above, the Law n° 23/1996 (Norms on school building) underlines the necessity to carry out a planning phase of interventions aimed at the conservation of the existing building considering the survey about the characteristics of the school structures in use and of the urban context. Through this law, the *Anagrafe Regionale dell'Edilizia Scolastica* (ARES) is established with the aim of systematizing the information system on the regional school property assets.

Each region and autonomous province independently manages access to ARES, and the provinces and municipalities are responsible for compiling, updating and implementing the data collection forms for each individual school building. This was done through direct surveys and inspections conducted at the school of interest.

The module for collecting data on school buildings contained the elements needed to acquire information ascertained through the completion of two questionnaires:

(i) *Questionario Edificio* (QE), aimed at collecting elements to evaluate quantitatively and qualitatively the school in use;

(ii) *Questionario istituzione scolastica*, aimed at collecting information on individual school units, i.e., whether or not there are several school units in the same building, what type and how they are organised.

The data that can be deduced from (i) on the school building are summarized in the Appendix of *Questionario Edificio* in ARES by Law 23/1996. For a more detailed specification, please refer to the Instruction Manual of QE in ARES for the compilation of the school building stock survey sheets.

In order to have a clear view of the current state of the suitability of the school building for its functions when new work is to be carried out on the building, the relevant data which are particularly interesting include the most recent work on the structure (Point 9.0—Subsequent transformations). For each intervention, it is important to establish the intervention class and the execution year. The classes of intervention referred to in the survey, aimed at determining the state of maintenance, and consequently the level of adequacy of the building to the functions for which the building is intended, both from the technological point of view and in terms of amount of space, are:

- extension and/or super-elevation: a complex of works that have the effect of enlarging an existing building, creating additional spaces or volumes. The extension can be done by "horizontal addition" (in which case it involves an increase in coverage), or "vertical addition" (i.e., elevation), or finally with actions of both expansion and elevation;
- building renovation: interventions aimed at transforming building organizations through a systematic set of works that can lead to a building organization in whole or in different parts. These interventions include the restoration or replacement of certain elements of the building, or even the elimination, modification and insertion of new elements and systems;
- integral and conservative restoration: interventions aimed at preserving the building organism and ensuring its functionality through a systematic works set that—in compliance with the typological, formal and structural elements of the building organism—allow its compatible use with them. These interventions include: the consolidation, restoration and renewal of the building's constituent elements; the insertion of ancillary elements and systems required by the use needs; the elimination of extraneous elements to the building organism;
- extraordinary maintenance: works aimed at renovating and replacing parts, including structural ones, of buildings, as well as the construction and integration of sanitary and technological services, while respecting the volumes and surfaces of the individual building units.

The state of maintenance regarding the building works and systems (Point 13.0—State of conservation) is evaluated qualitatively by attributing a score according to the following classification: 6 = does not require any intervention; 5 = requires partial maintenance; 4 = requires complete maintenance; 3 = requires replacement or partial refurbishment; 2 = requires replacement or complete refurbishment; 1 = requires ex-novo installation; X = system is not necessary;

The functional and dimensional characteristics of the rooms include the location, functional destination, size of the rooms on each floor of the building, shape (when the floor plan of a room is clearly different from a rectangular square, and it is difficult to carry out the educational activities), natural and artificial lighting, hygienic conditions (dependent not on poor cleaning but on a physical deficiency of the inner shell), and the acoustic conditions of each space.

Depending on the observations and specifications previously made, it is clear that in order to plan interventions on existing school buildings, it is necessary to comply with a number of regulatory requirements, and to obtain information on the building to be recovered. In general, the information concerning the school structure can be of various types. Each one regards a specific school aspect, both technical and organizational-functional, especially regarding the way in which the available space is used.

On the basis of the information system proposed by Law 23/1996, it can be observed, however, that the phase of reconnaissance of the state concerning the school building does not include the acquisition of data in the urban context.

With reference to the Constitutional Court (judgments 62/2013, 284/2016 and, lastly, 71/2018), within the discipline on school buildings "more subjects intersect, such as "territorial governance", "energy" and "civil protection". Thus, the proposed evaluation methodology, as specified in the following paragraph, aims to jointly consider regulatory aspects, school building features, and characteristics of the territory.

Some of the information illustrated in Table 2 is identified from the data list contained in *Questionario Edificio*. For each one, an alternative reference document to the QE is indicated, from which the data relating to the information to be quantified can be extrapolated. This is with a view to creating an information system useful for the planning and execution of projects that respect the characteristics of the building to be recovered, and that can also satisfy the citizens' needs in view of the distinctive characteristics of the local economy expressed in terms of existing services and those potentially settled in the area. In order to establish what further activities can be offered to the community by taking advantage of the internal spaces and connected externally to the school, it is necessary to identify the users' class to which the type of service provided is allocated (as specified in the following Section 3.1.2).

3. Evaluation Framework

The proposed evaluation method seeks to verify the technical, regulatory and management conditions of existing school buildings (especially with regard to the use of available space for educational activities) in order to plan transformation and/or conservation activities, not only observing the regulatory requirements in force and the physical characteristics of the building, but also the needs of the community.

The method consists of two steps: (a) knowledge phase, (b) evaluation phase. In the first phase, the reference legislation is analyzed, and technical-management information on the school is collected. In the second phase, the regulatory requirements are verified, and the main methods of intervention are defined. This is with regard to both the physical and management system of the building and the services that the school can offer to the community.

Figure 1 shows the outline of the proposed evaluation methodology and highlights the mutual relations between each of its sub-phases. The diagram in Figure 1 aims to graphically illustrate how the physical and functional characteristics of the school buildings are checked and evaluated in accordance with the reference regulations, as well as to program interventions compatible with existing community's needs. Compatibility and consistency assessments provide useful information on the types of interventions to be implemented for the renovation/recovery of the building.

Each step (knowledge phase and evaluation phase) is made of specific sub-phases analysed in the following.

3.1. Knowledge Phase

3.1.1. Collection of Data to Describe the School of Interest from a Historical, Technical (Structural, Technological, Plant Engineering) and Architectural Point of View, According to its Own Training Plan and the Active Extra-Didactic Services Offered to the Community

As already highlighted in the previous Section 2.1, it is through the ARES, established by Law no. 23/1996, that the verification and collection of information about the consistency (surface and volume) and the management system of the school space takes place, also for the purpose of planning interventions compatible with the building and the training system in force. In many cases, this database is still incomplete, inaccurate and not always updated in the information. So, it is necessary to verify the data on the school building that is the subject of the evaluation problem of intervention contained in the database through inspections and field surveys to obtain more up-to-date and complete data to be used in the implementation of the proposed methodology.

Taking into account the data contained in the QE of ARES, the main information to be considered when implementing the procedure concerns the geographical location and morphological characteristics of the building (year of construction; architectural layout, overall dimensions of the building, etc.), the type of training offered and information on the total number of students enrolled both in the last year of activity and in previous years, the superficial consistencies of the spaces (internal and external) used for teaching and not, the safety conditions (earthquake-proof, fireproof, hygienic-sanitary and environmental) of the school, and the types of services offered to students and/or people not attending school during ordinary teaching activities in teaching hours and not.

Table 2 specifies for each type of information the reference source in order to find and quantify the data of interest, even in the event that the descriptive sheet of the school in question is not present in the ARES information system. For each type of data, the usefulness (expressed in terms of objectives to be pursued) is also illustrated.

Table 2. Types of information to be collected for describing the state of the school.

Information Type	Reference Source	Usefulness Information
Geographical location and morphology of the building	Data from: ARES questionnaire; Research at the State Historical Archives and inspections carried out at the school	The reconstruction of the history of the school provides information on its possible maintenance, adaptation and renovation
Type of educational offer and total number of students enrolled	Data from ARES questionnaire	The characterization of the school in terms of education and number of students provides an indication of the type of education offered
Aggregate measurement of the consistencies of the spaces arranged on each floor of which the school is composed	Data from: ARES questionnaire; Survey campaign conducted in each space inside and/or outside the school building	Knowledge of the surface area of each environment inside and/or outside the school is necessary information to verify the per-capita budget that must be guaranteed to each student.
Types of services offered (didactic and extra)	School Self-Assessment Report (SAR)	The specification of the services offered by the school during extra-curricular hours shows how the school is used

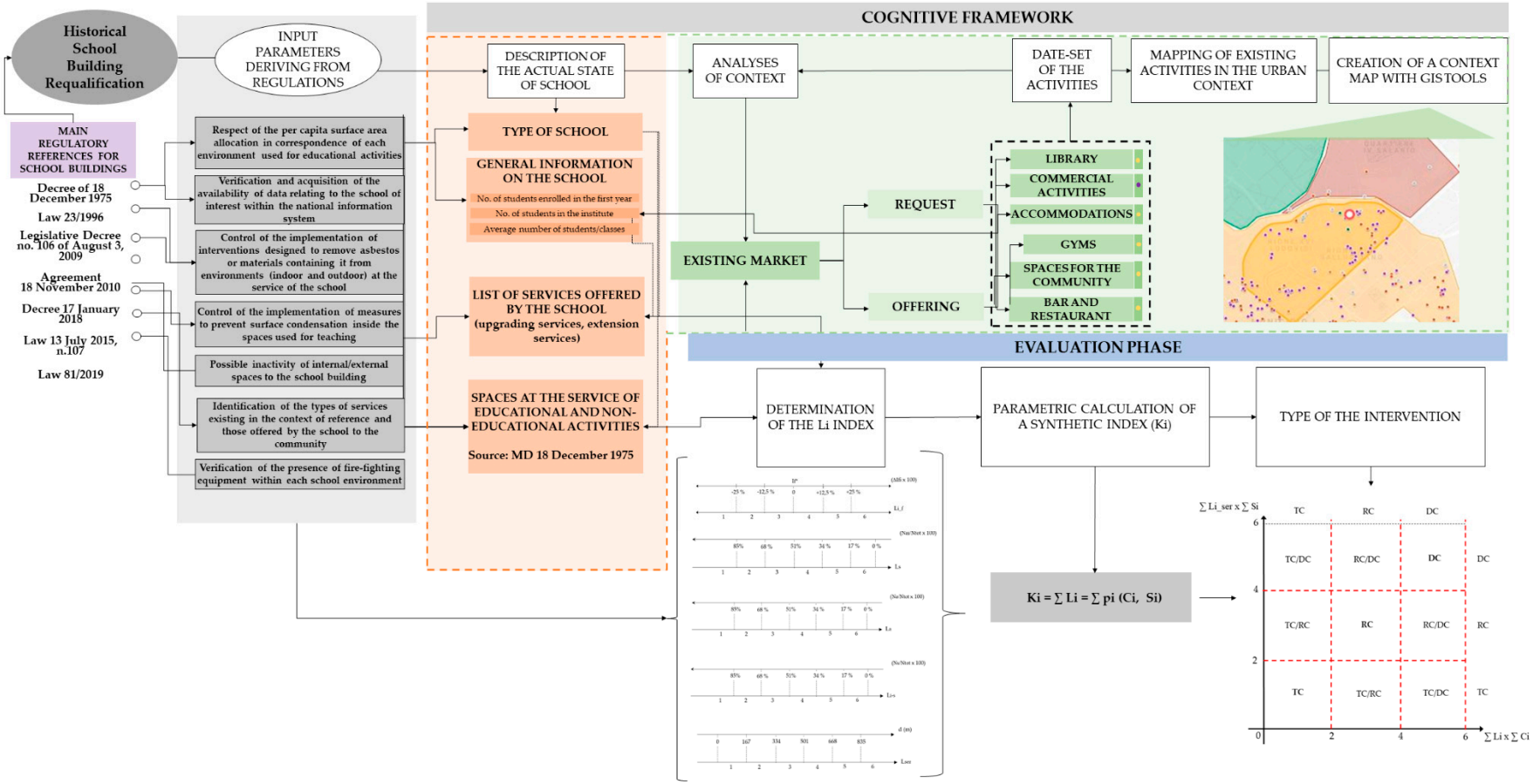


Figure 1. Diagram of the proposed evaluation methodology for the characterization of the interventions types to be carried out on existing school buildings.

3.1.2. Socio-Economic Analysis of the Urban Context

With the aim of carrying out specific interventions that can also satisfy the needs of social aggregation of the community, it is appropriate to examine the urban context of reference in terms of services for the population. This is done by analyzing the market conditions in terms of demand and services supply that characterize the territory in which the school assumes a polarizing function.

To do this, it is necessary to demarcate the territorial area of interest in which it is necessary to detect and quantify the demand and services supply characterizing the market of the urban context of reference. The criteria for identifying the analysis area can specifically concern the composition and characteristics (economic, social, etc.) of the local population, the economic-productive system of the territory, the socio-cultural apparatus of the place, or even the morphology of the urban fabric of reference of which the school is a part. On the basis of morphological aspects, the field of investigation can coincide either with the perimeter of a single district, or of a part of it, in which the school can assume a catalytic and barycentric function with respect to the evolutionary dynamics of the surrounding urban fabric, or even with larger areas in the case of schools with locations located in the city and that are distant from each other. This, in part also depends on the demographic dimension and the territorial extension of the municipality and its parts in which the school structure is located. The definition of the gravitational field can therefore be carried out on the basis of data relating to: settlement type, socio-demographic information (age, sex, nationality, educational qualification/level, social class, employment, income, etc.), geographical information (region/province/common, urban/suburban/rural area, city size, population, climate, etc.), psychographic information (lifestyle, habits, etc.), and historical, cultural and productive information.

Operationally, the quantification of these indicators and, in particular, of the number and location of services present in the urban environment, can be carried out by identifying a cluster of circular analyses with a center at the point where the school of interest is located and a certain radius. In the Circular N° 425/1967 in Appendix C, the measures of influence rays at each level of the school to be considered in order to identify the territorial area in which to include the catchment area referred to the school building considered are specified. Depending on the territorial scope of the survey thus identified and the type of supply/demand characterizing the cluster in which the school falls, the types of services offered by the school institution are compared with those present in the territory. Within the cluster analysis, the type of services considered are those illustrated in the Ministerial Decree of April 14, 2013 and include libraries, commercial activities, accommodations, gyms, bars and restaurants, and spaces for the community.

3.2. Evaluation Phase

3.2.1. Evaluations of Consistency According to the Technical and Regulatory Requirements to Be Complied with at the Design Stage and the Actual State of the School

From the identification and collection of data, both of the building to be redeveloped and of the urban context in which the school is located, it is necessary to proceed to the verification of congruence between the actual state of the school and the reference law provisions. Specifically, on the basis of the surface textures measured for each space intended for teaching (frontal and laboratory), the minimum surface area per student for each type of environment (classroom, laboratory, gym) is verified in correspondence with each floor of the building, in compliance with the minimum regulatory targets to be respected. The value of the surface area per capita to be considered during the verification phase varies with respect to the school training offer, as regulated in the Ministerial Decree of 18 December 1975; in compliance with the provisions of the law on school building, the level of compliance of the school's functional, seismic, fireproof and hygienic-sanitary system with the safety and use conditions to be guaranteed is assessed.

By means of an evaluation index (L_i), the degree of adequacy of the spatial-functional (L_f), structural (L_s), fireproof (L_a) and hygienic-sanitary ($L_{i\text{-}s}$) system of the school building to the requirements

expressed in the i-*th* reference standard is qualitatively measured, as well as the level of correlation between the services currently present in the school and those found in the territorial area of investigation (L_{ser}). For each aspect, the corresponding L_i is measured qualitatively by assigning a score (p_i) according to the scale of values from 1 to 6 used in the filling in of the questionnaire for ARES (6 = does not require any intervention; 5 = requires partial maintenance; 4 = requires complete maintenance; 3 = requires partial replacement or renovation; 2 = requires replacement or complete renovation; 1 = requires ex-novo installation). On the basis of the scale of values used to fill in the ARES questionnaire, the attribution of the score to the L_i parameter for each aspect is a function of the greater and/or lesser level of adaptation of the state (spatial, physical, functional, plant engineering, sanitation, environmental, structural) of the school to the reference regulatory requirements evaluated according to a suitable technical-regulatory criterion (C_i) (see Table 2), and the degree of correspondence between the types of services (S_i) currently present in the school and those found in the urban context in which the building to be renovated is located.

Using an algebraic-linear formulation, the L_i parameter can be expressed through the following mathematical function:

$$L_i = p_i\,(C_i, S_i) \tag{1}$$

In the following, for each L_i concerning the structural, plant engineering, sanitary, environmental, and spatial-functional aspects of the building and the services currently present in the school, the corresponding scoring system is illustrated according to the scale of values from 1 to 6. For each L_i, especially for those referring to the technical-regulatory aspects, the measurement parameters considered are such that it is possible to use a qualitative evaluation approach. For the evaluation of technical and plant engineering aspects of the sector, for which it will be necessary to take into account the act of implementing the planning of interventions to be carried out on the existing building, it is mandatory to take into account a judgment expressed through more detailed design drawings drawn up by technical professionals in the fields of seismic adjustment, energy, and plant engineering that give quantitative information. In the case of this work, aimed at providing an evaluation methodology to support the definition and planning of sustainable projects as compatible with the physical-spatial apparatus of the school building, also with a view to encouraging a more correct completion of the procedures for obtaining public funding, an evaluation methodology of a qualitative type is proposed. The use of a parameter L of reference allows us to express the level of correspondence between the state of affairs of the school building and the regulatory requirements to be complied with in the design phase. In particular, for each evaluation index:

a) the value of the parameter L_f is assigned on the basis of the increase and decrease in the surface index deriving from the direct survey of school spaces (internal and external) (If) with respect to the parameter of law If*. Figure 2 below shows the extremes of the incremental and decremental intervals (ΔIf), expressed in percentages, defined starting from the If* value and the average L_{i_f} score to be assigned to the i-*th* space according to the corresponding ΔIfi.

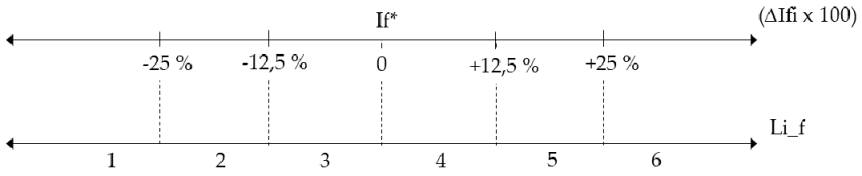


Figure 2. Scale of evaluation for the assignment of the score to the parameter L_f. If* is the value of law parameter of reference. It is the relative zero in the proposed scale of value.

b) With regard to the structural aspect, the corresponding evaluation index (L_s) is measured according to the number of rooms, used for teaching and not, distributed on each floor of the school building, which at the time of the on-site inspection are unusable and risky for the safety of

school users. Figure 3 below shows the interval extremes, expressed as a percentage, established on the basis of the number of currently unusable environments (N_{ai}) defined with respect to the total number of spaces (N_{tot}) present on each school level, and the average score to be assigned, according to the values scale [1–6], in descending order on the basis of the number of impassable spaces by the persons surveyed at the time of the inspection.

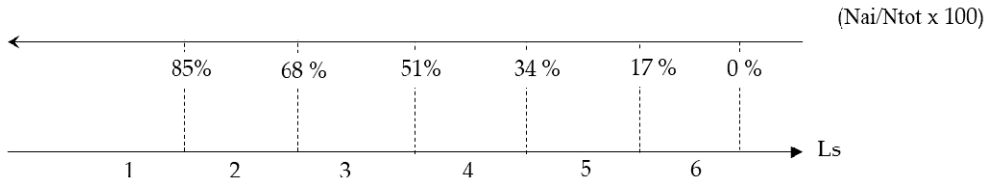


Figure 3. Evaluation scale for the assignment of the score to the parameter L_s.

c) As far as fire safety is concerned, the corresponding evaluation index (L_a) is measured taking into account the obligation deriving from the law (Law 81/2019) to provide each environment with appropriate fire protection devices (e.g., fire extinguishers, which are not exhaustive) with particular performance characteristics. In particular, the attribution of a high, or low, numerical value to the L_a index can be related to the frequency (in percentage terms) of spaces in correspondence with each floor of the school building, in which the presence, or absence, of fire extinguishers or other devices for fire risk prevention is found, compared to the total number of rooms on the same floor. Figure 4 below shows the reference diagram for the assignment of the score to the parameter (L_a) as a function of the frequency of the rooms without fire-fighting devices (N_e) compared to the total number (N_{tot}) of spaces on the i-*th* floor.

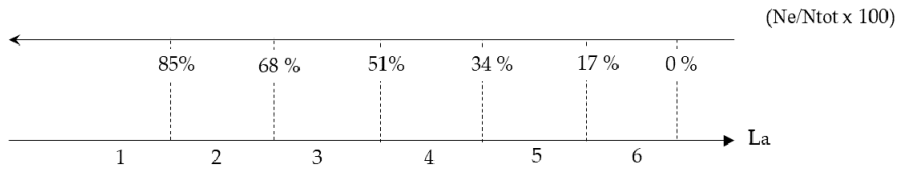


Figure 4. Scale of evaluation for the assignment of the score to the parameter La.

d) With reference, instead, to the hygienic-sanitary aspect, it is possible to refer to the possible presence of superficial condensation inside the spaces specifically destined to the carrying out of didactic activities. Similar to the previous evaluation indexes described above, the value assumed by $L_{i\text{-}s}$ is related to the number of rooms on each floor within which there are forms of surface condensation (N_s) compared to the total spaces (N_{tot}) on the i-th floor.

Figure 5 shows the scale of the scores (from 1 to 6) and the corresponding intervals of the measurement parameter considered (N_s/N_{tot}) expressed as a percentage.

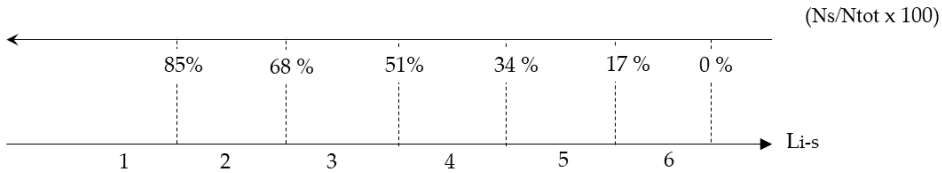


Figure 5. Evaluation scale for the assignment of the score to the parameter $L_{i\text{-}s}$.

With reference, instead, to the evaluation of the congruence level between the services currently offered through the use of the internal environments of the building with those present in the analysis buffer (with a radius of 1000 m), a qualitative score from 1 to 6 is attributed to the corresponding evaluation index (L_{ser}) according to the number of similar services found in the urban area of interest

and the relative distance (included in the analysis buffer of 1000 m) measured with respect to the point where the building is located. Figure 6 shows the scale of values from 1 to 6 according to the distance of the i-th service from the school. The maximum distance is assumed to be 1000 m, as indicated in Appendix C of Circular n° 425/1967.

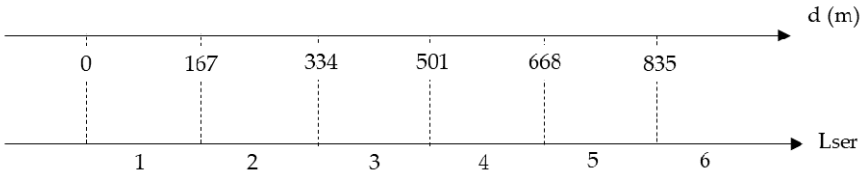


Figure 6. Scale of evaluation for the assignment of the score to the parameter Lser.

3.2.2. Identification of the Methods of Actions and Types of Interventions to Be Implemented in the Event of Non-Compliance with the Minimum Regulatory Requirements Regarding Security and Physical-Functional Management of the School Space

Following the L_i measurement operation, the intensity of the intervention to be carried out for the overall requalification of the school is identified, also taking into account the characteristics (in terms of existing services) of the urban context in which the school is located. In order to encourage requalification practices according to an integrated logic, it is necessary to jointly consider both the actions of spatial reorganization of the didactic and laboratory environments (where the value of the minimum surface endowment per students for each environment is not satisfied), and the physical interventions aimed at adapting the school to the reference regulations, both of enhancement and/or integration of the services currently offered and/or potentially to be added to the existing ones.

From this perspective, three macro-types of intervention are outlined (Total Renovation, Regulatory Compliance, Distributional Challenges), which can be implemented in order to fully upgrade existing school buildings.

Total Renovation (TR) is carried out when the school needs substantial interventions in terms of both structure, plant engineering, health and hygiene, management and use of space for teaching, and integration of new services for the community. In the case of existing school buildings, when the date of construction is prior to the year in which the first anti-seismic regulations were issued, it goes without saying that it is mandatory to carry out preliminary consolidation and adaptation work on the structure in order to ensure the safety of direct and indirect users of the school.

Regulatory Compliance (RC) occurs when it is necessary to act on the school building in order to adapt it to some legal requirements regarding seismic risk, fire prevention, energy requalification, indoor quality improvement, together with a remodeling and re-functionalization of the internal and external spaces at the service of the school building and enhancement and/or integration of additional services identified according to the characteristics (supply/demand) of the analysis scope.

The Distributional Challenge (DC) is carried out in the event that it is necessary to carry out a complete and/or partial reorganization and redefinition of the intended use of the internal and/or external school spaces, and the correspondence between the structural-implant and hygienic-sanitary state of the school with the regulatory requirements that must be considered in the planning phase of the requalification interventions is verified.

It is possible to associate the identification of the intervention methods previously described (Total Renovation, Regulatory Compliance, Distributional Challenge) with a synthetic reference index (K_i). This index allows us to express the level of intensity of the action type that needs to be implemented to upgrade the school, from the point of view of both functional and structural-implantistic-hygienic-sanitary (K_t) factors, as well as in terms of services offered to the public (K_{ser}). Both K_t and K_{ser} are obtained by algebraically aggregating the corresponding L_i values previously specified in Section 3.2.1.

The K_i parameter is obtained by means of a mathematical formulation such as:

$$K = \sum Li = \sum p_i\ (C_i, S_i) \quad (2)$$

The K_i intervals for each intervention mode are shown in Table 3.

Table 3. Range of values of the K_i parameter and corresponding switching modes.

Reference Range of Values of the Parameter $K_{i\_t,ser}$	Intervention Modalities
$\sum_{i=0}^{n} 0\ (C_i, S_i) \leq K_{i\_t,ser} \leq = \sum_{i=0}^{n} 2\ (C_i, S_i)$	Total Renovation
$\sum_{i=0}^{n} 2\ (C_i, S_i) \leq K_{i\_t,ser} \leq \sum_{i=0}^{n} 4\ (C_i, S_i)$	Regulatory Compilance
$\sum_{i=0}^{n} 4\ (C_i, S_i) \leq K_{i\_t,ser} \leq \sum_{i=0}^{n} 6\ (C_i, S_i)$	Distributional Challenge

Figure 7 below illustrates a double entry scheme according to which it is possible to identify the intervention mode (TC, RC, DC) referring to both the system of services and the technical-implantistic-hygienic-sanitary one on the basis of the corresponding score of L_i parameter. The proposed diagram shows on the abscissa and ordinate axis the intervals of values, respectively referred to K_t and K_{ser}, which identify the proposed macro-categories of intervention.

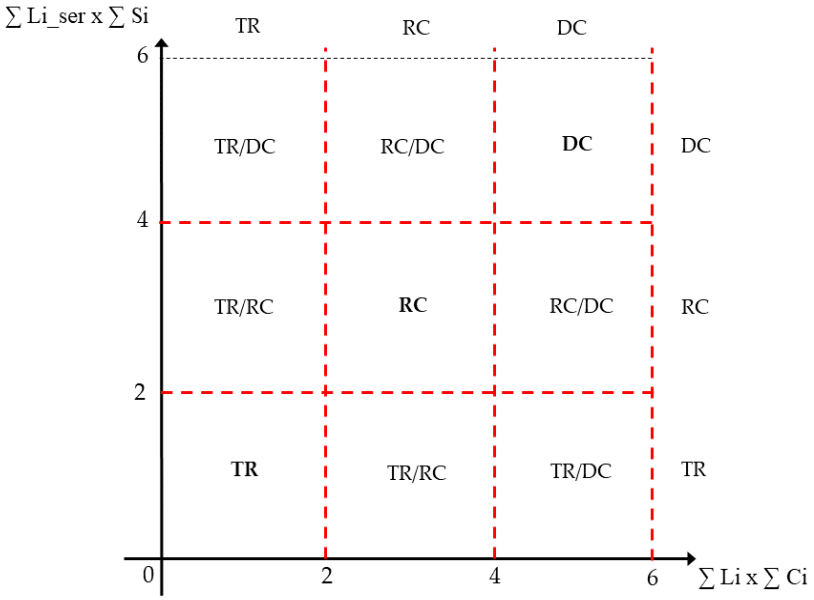


Figure 7. Double-entry diagram supporting the identification of the main intervention modalities for the integrated requalification of existing school buildings.

In Section 4, the proposed evaluation methodology is applied to the case study for the redevelopment of the *Torquato Tasso* classical high school located in the historic center of Rome (Italy).

4. Case Study

We intended to apply the proposed evaluation method considering the project of redevelopment, recovery and conservation of the school located in the historic center of Rome in Italy. The building is made of three institutes: Middle School, High School and Scientific High School. The methodology in Section 3 is tested on the part of the building relating to *Torquato Tasso* classical high school. Figure 8 shows (a) a historical picture of the building part where *Torquato Tasso* classical high school is, and (b) the façade on Sicilia Road where the principal entrance to the school is.

a. Historical picture of the school building
Source: https://www.geoitaliani.it/2017/01/liceo-tasso.html (last accessed on 12 January 2020)

b. Main entrance to school by Sicilia Road
Source: http://www.romatoday.it/formazione/scuola/migliori-licei-roma-2019.html (last accessed on 12 January 2020)

Figure 8. Pictures of *Torquato Tasso* classical high school.

It should be specified that the data on the student population in the last five years, the information on the educational offer of the institute in question, as well as the survey of the geometric dimensions of the spaces used for teaching were obtained by carrying out some investigation campaigns in the school.

4.1. Knowledge Phase

4.1.1. Description of the School from the Historical, Technical and Architectural Point of View, According to Its Own Training Plan and the Extra-Educational Services Offered to the Community

The school building is located inside the first Town Hall in the historic center of the city of Rome, specifically in the Ludovisi district. The building is strategically located with respect to both the main roads through which you can reach the city-center, and the train station of Roma Termini, as demonstrated by calculating the travel time between the school and the points of greatest infrastructural interest through Google Map.

With specific regard to the *Torquato Tasso* classical high school, the institute, founded in 1908, was proposed from the beginning as a school serving the Ludovisi district and neighboring ones. Over the years, a series of enlargements, transformations and building maintenance interventions were carried out, especially on the structure, such as the original internal and external conformation of the building is partially modified.

The school rooms are distributed over two floors as well as on the ground floor, where most of the administrative offices are located. As described in the Self-assessment Report (2019) of the institute, there are 44 classrooms for frontal teaching, three spaces for laboratories, a great hall, a Library and a Natural Sciences Museum, administrative offices and restrooms on each floor. Figure 9 shows a plan of a typical school floor plan from 1964. The plan in the figure was acquired from the school's administrative offices after an on-site inspection.

To date (2019), the school has 919 students enrolled in the first academic year (a.y.). Table 4 shows the number of students enrolled in the first year, the number of classes and sections from the academic year 2015–2016 to the academic year 2019–2020.

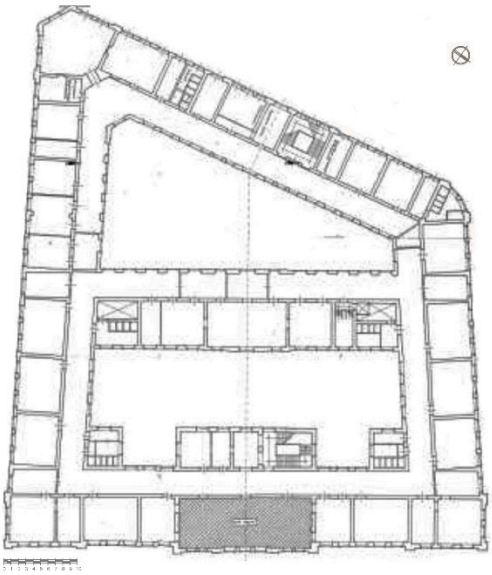


Figure 9. Typical floor plan of *Torquato Tasso* classical high school (1964).

Table 4. Time data on the students, number of classes and sections of the school.

Academic Year (a.y.)	2015–2016	2016–2017	2017–2018	2018–2019	2019–2020
N° of students enrolled in the first year	795	800	820	942	919
N° of classes	35	35	35	38	35
N° of sections	7	7	7	11	7

Source: Data obtained at the school administration offices and acquired during on-site inspections.

On the basis of the data in Table 4, a progressive increase in the student population is evident. In particular, the trend towards an increase in the number of students enrolled in the first year at each academic year has produced, over time, the gradual fragmentation of classrooms in environments characterized by different sizes. On-site inspections of three different types of large, middle and small size classrooms are revealed in Table 5, which shows the dimensions (both linear and superficial) of the three types of classroom together with those of the other rooms serving the school.

—Survey of the superficial consistencies of the internal and external spaces of the school

In order to verify the per capita surface endowment of each space inside and outside the school building, a preliminary phase of a consistency survey of the building was carried out. Table 5 shows the geometric measurements of the rooms located on a typical floor (the first and second floors on which teaching activities have the same planimetric and distributive-spatial composition). Table 6, instead, shows the data of the surfaces of the internal and external spaces in an aggregate manner.

Table 5. Planimetric dimensions of rooms of a typical floor school.

Type of Spaces	Geometric Dimensions					N° of Rooms
	Wide [m]	Long. [m]	Height [m]	Sup. [sqm]	Vol. [mc]	
SCHOOL CLASSES						N° Class-Rooms
Large	10.50	7.54	4.70	79.17	372.10	1
Middle	9.30	6.30	4.70	58.59	275.37	5
Small	6.50	5.70	4.70	37.05	174.14	7
Tot.				631.47	821.607	13

Table 5. *Cont.*

Type of Spaces	Geometric Dimensions					N° of Rooms
	Wide [m]	Long. [m]	Height [m]	Sup. [sqm]	Vol. [mc]	
SPACES FOR SPECIAL ACTIVITIES (PHYSICS, CHEMISTRY, NATURAL SCIENCES)						
Lab. ART	4.60	8.00	4.70	36.80	172.96	1
Art Class-room	6.41	5.27	4.70	33.78	33.78	1
Biology Classroom	8.13	8.00	4.70	65.04	65.04	1
Tot.				135.62	271.78	3
BATHROOMS (B)—CONNECTIVE						N° restroom
B 1	8	4.2	4.7	33.6	157.92	2
B 2	4.5	6.2	4.7	27.9	131.13	2
Connective	4.2	223.24	4.7	937.61	4406.76	
TOT.				1060.61	4695.81	4
GYMS (G)						
G 1	-	-	-	-	-	
Tot.				-	-	
SPACES FOR COLLECTIVE ACTIVITIES						
Library	13.71	12.91	4.70	177.00	831.88	1
Great Hall	9.36	24.42	6	228.57	1371.43	1
Natural Science Museum	8.00	23.22	4.7	185.76	873.07	1
Tot.				405.57	2203.31	3
SPACES FOR COMPLEMENTARY ACTIVITIES						
Atrium	-	-	-	-	-	
Administrative Offices	8.51	57.61	4.70	490.26	2304.23	1
Tot.				490.26	2304.23	1

Table 6. Surface consistencies of the school's internal and external aggregated spaces.

Types of Spaces	Surfaces	No. of Rooms Per Floor
1. INDOOR SPACES		
1.1 School Classes	1623.00 m^2	13
1.2 Spaces for special activities	135.62 m^2	3
1.3 Bathrooms—Connectives	2244.22 m^2	4
1.4 Internal gyms	457.86 m^2	0
1.5 Spaces for collective activities	716.85 m^2	3
1.6 Spaces for complementary activities	490.26 m^2	1
2. EXTERNAL SPACES		
2.1 Surfaces used for outdoor sports activities	311.25 m^2	1
2.2 Parking spaces	0.00 m^2	0

4.1.2. Socio-Economic Analysis of the Urban Context in which the School Is Located

The Ludovisi district is characterized by the significant presence of elements with a strong historical-artistic and architectural value. Not far from the school, in fact, there are the Museum Boncompagni-Ludovisi, the National Gallery of Ancient Art of Barberini Building and the Borghese

Gallery. The historical connotation of the territory contributes to define a context of strong cultural value through which the school encourage the education and training of students. The building's position in relation to some research institutes (for example, the National Research Centre) and university buildings (Sapienza University) has also made it possible to establish collaborative relationships by developing a number of joint educational initiatives in order to support the educational growth of students and also encourage the local development of the territory.

In order to analyze and characterize the territorial context of reference in which the school is placed also with regard to the types of existing services, the territorial area of analysis was included within a buffer with a radius of influence of 1000 m from the point where the school is located (Circular N° 425/1967). With the aim of identifying the prevailing services within the scope of the survey thus defined, a phase of georeferencing of the commercial, receptive, cultural and sports services was conducted.

After the georeferencing of the information, an information map (see Figure 10) was created using GIS instrumentation (Google Maps) to support the identification and analysis of services within the 1000 m buffer. Through the use of this cartography, it was possible to see that the territory is characterized by the high density of commercial activities and accommodation facilities. This is due to the presence of elements with strong tourist and infrastructural attractiveness (Roma Termini railway station) that influence the market dynamics. In the analysis buffer of 1000 meters, there are no services for the community (for example, non-exhaustive, neighborhood library, headquarters for cultural associations, spaces for social gathering).

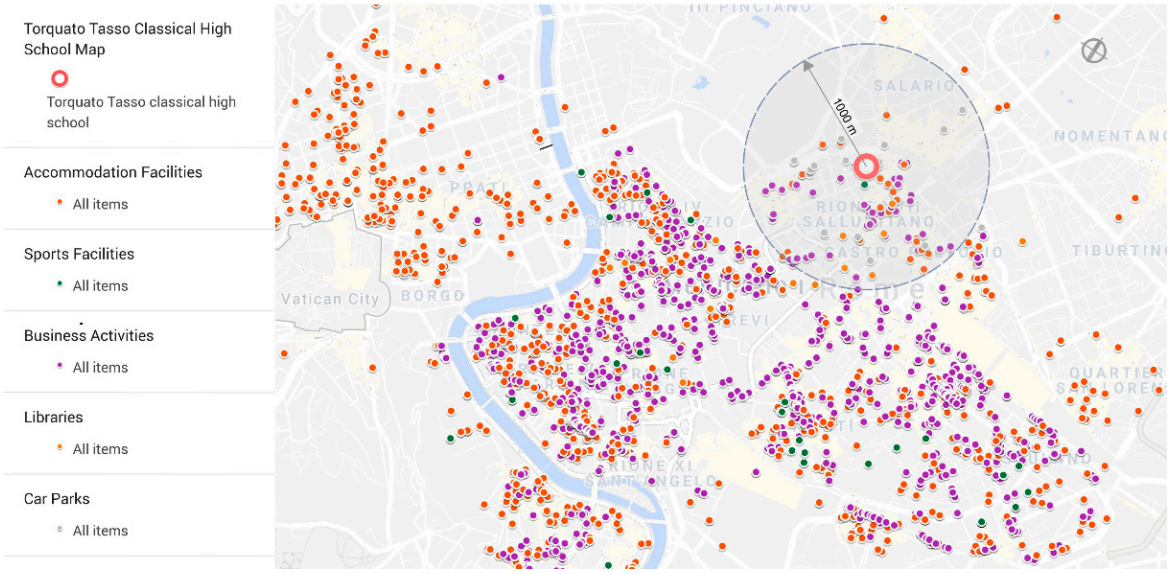


Figure 10. Map for market analysis of the study area made with GIS.

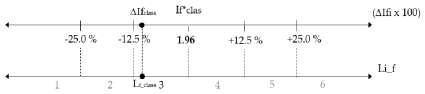
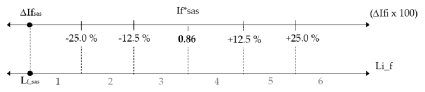
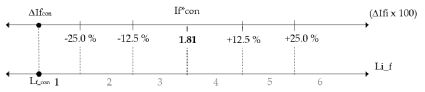
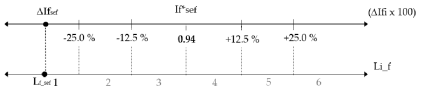
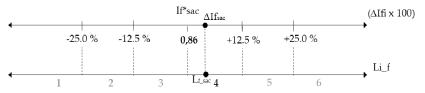
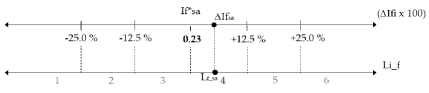
4.2. Evaluation Phase

4.2.1. Congruence Check between the Technical and Regulatory Requirements and the Actual State of the School

After the cognitive phase aimed at defining the state of the school, the congruence of the surface consistencies of the rooms surveyed (see Table 6) was verified, taking into account the regulatory requirements relating to their sizing in relation to the number of student that they host. This was done by comparing the value of the per capita equipment of each space (If), obtained by comparing the areas surveyed on site to the capacity of each space expressed in terms of number of students, with the corresponding regulatory standards (If*) contained in the Ministerial Decree of April 18 in 1975. For each type of space, the value of L_{i_fi} was defined according to the corresponding percentage ΔIfi.

Table 7 shows the surface consistencies of each type of internal and external space used by the school, the theoretical surface indices, and those deriving from on-site measurements, the corresponding ΔIfi and L_{i_f}. The score at L_{i_f} is assigned with the diagram in Figure 2. The final L_f parameter to be considered was obtained from the arithmetic mean of the L_{i_f} of each type of space. In this case, the average value of L_f was 2.3.

Table 7. Check of the surface textures of indoor/outdoor spaces of the school.

FUNCTIONAL DISTRIBUTION						
CLASSIFICATION OF SPACES	**Sup. [sqm]**	**Sup Ind. (If)**	**Sup Ind. (If*)**	**ΔIfi [%]**	**Implementation of the Methodology (b.1) for the Identification of the Score to Be Attributed to L_{i_f}**	**L_{i_f}**
Spaces for pedagogical units (Class)						
TOT.	1623	1.72	**1.96**	−12.4		3
Spaces for special activities (Sas)						
TOT.	135.62	0.17	**0.86**	−80.0		1
Connections and Toilets (Con.)						
TOT.	2244.22	0.49	**1.81**	−72.9		1
Spaces for physical education (Sef)						
TOT.	457.86	0.49	**0.94**	−0.49		1
Spaces for collective activity (Sac)						
TOT.	716.85	0.87	**0.86**	+1.15		4
Administrative spaces (Sa)						
TOT.	490.26	0.60	**0.23**	+1.63		4
$L_{f\_tot} = \sum Li\_f =$						14
$Lf = L_{f\_tot}/6 =$						**2,3**

From a structural, plant engineering, environmental, health and hygiene points of view, on the other hand, a qualitative evaluation of the school's degree of conformity with the content expressed in the reference standards was carried out.

In order to estimate the level of compliance of the school with the laws on fire prevention, safety of the structure, indoor quality, the presence of fire-fighting devices in each room inside the school was verified, as well as the possible inability of some spaces at the time of on-site inspection, as well as the formation of condensation on the walls inside the building.

With regard to the type of actions implemented within the school in order to reduce the fire risk, at the date of the inspection in March 2019, the fire-fighting system serving the building had recently been brought into conformity with the technical regulations of reference. By carrying out a series of on-site inspections, it was possible to ascertain that each room was equipped with a special fire-fighting device.

With regard, however, to the safety of the school for the prevention of seismic risk, following a campaign of on-site inspections it was possible to find that some of its internal environments were not

accessible (in particular two rooms on the first floor). The necessary interventions for their safety were being carried out in order to use them to carry out frontal and laboratory didactic activities.

Finally, again through visits to the school, it was possible to verify the presence of superficial condensation in the spaces of each floor. At the time of the inspection, some classrooms had spots of surface condensation on the internal perimeter walls (five on the first floor and two on the second).

On the basis of the ordinal scale of values used to assign a score to the parameter L_i concerning the level of compliance with the content of the technical-normative system in force, the relative verification of compliance of the state with the fire regulations was measured by assigning a score of 5. Instead, the level of congruence between the actual configuration of school building and the reference standard for the structural safety of the spaces was evaluated by assigning the corresponding parameter L_s the score of 4. From the sum of L_a, L_s, $L_{i\text{-}s}$ and L_f was obtained the $K_{t,}$ which was equal to 15.3.

With reference, however, to the estimate of the level of correspondence between the services currently present in the school and those found in the context of reference, the L_{ser} is defined for each type of service that you can see inside the building to be upgraded.

The services that are present in some rooms inside the school include a library, a space aggregative (aula magna), a museum of natural sciences, and an art laboratory. From the context analysis previously illustrated in Section 4.1.2, there are no similar services within the 1000 m analysis from the point where the school in question is located. Therefore, each L_{i_ser} is given a score of 6. The corresponding K_{ser}, deriving from the aggregation of L_{i_ser}, is equal to 24.

4.2.2. Identification of Types of Interventions to Be Implemented in Case of Non-Compliance with the Minimum Regulatory Requirements Regarding Safety and Use of School Space

After the phase of evaluation of the level of correspondence between the actual state of the school building and reference regulations, on the basis of the values obtained by K_{ser} and K_{i_t}, the methods of intervention to be followed for the planning and/or design of interventions aimed at the functional and structural-plant requalification of the school were identified.

The phase of identification of the intervention modalities was carried out using the double entry diagram of Figure 7. Reporting on the x-axis the value of K_t and on y-axis K_{ser} is defined the combination of the types of action to be implemented for the integrated requalification of the school. In this case, four types of service were considered (n° Si = 4) and four regulatory criteria were respected (n°Ci = 4). So, the extremes of the numerical intervals that identify the proposed types of intervention (TC, RC, DC) were multiplied respectively by the total number of services and technical-regulatory criteria considered.

Figure 11 shows the analysis scheme of Figure 7 for the part of the school building related to the *Torquato Tasso* classical high school.

In the light of the diagram in Figure 10, specifically concerning the school being studied, on the basis of the K_{ser} and K_t values obtained from the evaluation procedure described in Section 3.2.1, it is possible to observe that it would be appropriate to encourage interventions aimed, in particular, at making better use of the spaces dedicated to teaching and sports activities (*Distributional Challenges*), as well as actions for the safety of environments useful for carrying out training activities for students (*Regulatory Compliance*). From the analysis carried out on the types of service existing and falling within the territorial buffer of 1000 m (see Section 4.1.2), the need to enhance some environments inside and/or outside the institution to open up the cultural and social services to the community emerges. These include, for example, the opening to the public of the library inside the building, or even the use of some spaces (classrooms and/or corridors) for the exhibition of art and sculpture objects made by students in art education courses included in the educational training plan.

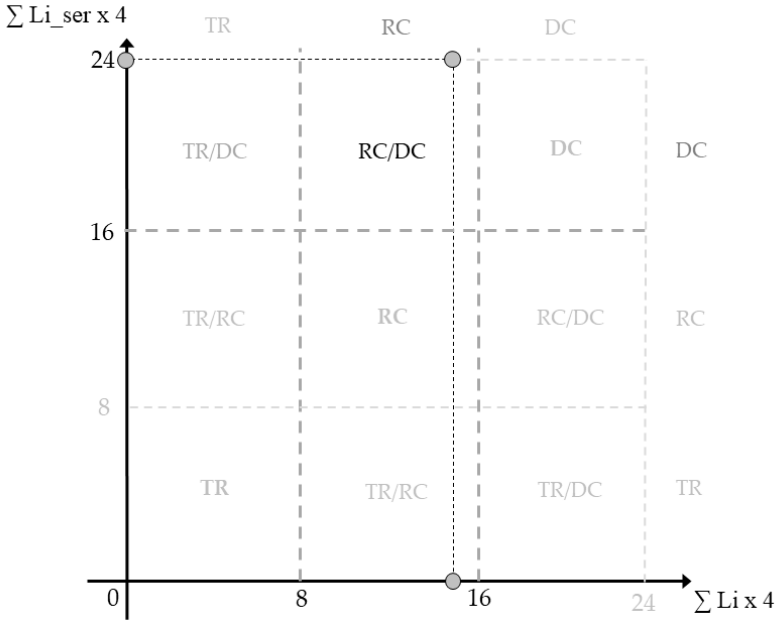


Figure 11. Double entry diagram for the definition of the intervention modalities to be implemented for the integrated requalification of *Torquato Tasso* classical high school.

5. Conclusions

In the context of the settlement transformation processes aimed at the redevelopment, recovery and enhancement of the existing building, the need to take into account, from the planning phase, multiple aspects of various kinds in an integrated manner considering the existing mutual relations among them is recognized. The complexity of jointly considering multiple characteristics of the same project, both technical and spatial-functional types, has encouraged the use of intervention practices often based on a problem-solving-based approaches and not on multidimensional ones.

This can be observed especially in the field of Italian school buildings (2019), where there is a lack of a single legislative framework in which to jointly include technical and functional evaluations with those that specifically concern the services that characterize the market of the urban context.

For supporting the planning, design and execution of interventions by preferring an integrated approach, especially with regard to the redevelopment of existing school buildings, the proposed methodology attempts to include within a single multi-criteria evaluation logic aspects of various kinds: structural, plant engineering, sanitation, spatial-functional, strengthening of existing services and integration of others on the basis of the market characterizing the city within the buffer of 1000 meters from the school is located. Appropriate criteria and qualitative measurement systems are used for each one.

The application of the evaluation methodology to the case of redevelopment of the school located in the historic center of the city of Rome (Italy) attests to the practicality of the proposed evaluation framework.

The in-depth analysis and study on a careful choice of the criterion with which to express the level of adaptation of the technical-structural features and the planimetric distribution of the schools places to the regulatory requirements and the possibility to express the use of spaces for additional services for the community outline future research prospects. Specifically, it would be interesting to implement participatory procedures for the identification of needs by the student community, for example through the administration of questionnaires, or even to return the proposed methodology in the form of mathematical expressions as the basis of the implementation of optimization linear systems of the operational research.

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