The Real Estate Risk Assessment: An Innovative Methodology for Supporting Public and Private Subjects Involved into Sustainable Urban Interventions

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Abstract. Projects carried out under Public-Private Partnership (PPP) forms are increasingly being used for construction, new infrastructure implementation, urban redevelopment operations and more general land interventions. PPP projects, due to their complexity, are characterized by risks that undermine their success, for this reason risk assessment models for PPP projects are essential to their successful implementation. In this context, the research proposes an innovative real estate risk assessment methodology for supporting the Public Administration and the Private Entrepreneur involved into PPP projects. The research proposes an *ex-ante* real estate risk assessment methodology, based on the multicriteria Analytic Hierarchy Process (AHP) technique that can be used at different territorial scales and by both public and private parties involved in urban transformations projects. The construction of the risk index is obtained through the logical-operative framework that consists into a protocol of 7 ordered and sequential phases. The methodology turns out to be flexible and reproducible and allows for parallel analysis of qualitative and quantitative aspects that in terms of risk undermine the success of projects.

Keywords: real estate risk assessment · PPP · risk index · assessment methodology · composite indicator · flexible evaluation

1 Introduction

In recent decades, the attention paid to environmental, economic and social sustainability together with the containment of land consumption has been at the center of public debates related to urban development processes. Urban regeneration is one of the main strategies to be conducted to achieve resilient urban paradigms and innovative housing models. In particular, the aim of current governments is to promote urban transformation interventions aimed at both the redevelopment of disused or abandoned buildings and the redevelopment of degraded areas. In order to achieve an adequate match between

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the functions to be settled and the actual changing needs of local communities, the recent development programs aim to define safer and greener cities, consistent with the international purposes of the 17 Sustainable Development Goals set out in the 2030 Agenda [1] and the recent strategies financed within the EU Next Generation and the European Green Deal programs, received in the National Plan of Recovery and Resilience (PNRR) [2].

For these reasons, there is an increasingly important need to develop tools that implement effective urban regeneration strategies for which land use governance policies must give priority to the rehabilitation of existing built and underused urban spaces. In this way, therefore, the traditional physical transformations of the land should be replaced by the general improvement of the community's quality of life, in terms of social wellbeing, environmental value and economic inclusive cities.

However, the complexity that characterizes the overall urban regeneration interventions, and more generally the land transformations, requires the use of appropriate methodologies that are able to efficiently support the management of the entire process, guarantee the stakeholder's interests and the achievement of the projects' established goals. Given these needs and the scarcity of public financial resources that can cover the entire costs of the transformations, urban regeneration practices have largely been carried out through partnerships between the public and the private sectors [3]. The Public-Private Partnership (PPP) form is often adopted for its advantages of sharing, in the most suitable way, not only the benefits related to the projects, but in particularly, the several risks that can occur in all the phases of the procedure. In fact, according to Grimsey et. Al, 2004 [4], there is evidence of numerous European projects implemented with the adoption of the PPP for different sectors, such as wastewater treatment and management, public highways and railways or subways, power plants and telecommunications infrastructure, school buildings, airport facilities, public offices, prisons, light rail systems, parking stations, harbors, pipelines, cultural properties like museum, health services. Due to its flexibility, it is possible to identify numerous adoptions of the PPP, whose broad-spectrum analysis allows to identify its main advantages and, at the same time, to highlight the most critical issues related to its implementation. Among the advantages, there are: i) the compensation of the government's shortage of financial resources; ii) the possibility to ensure the success of the project through the specific entrepreneurial skills of the private subject involved; iii) the ability to provide the community's facilities by reducing the pressure of the economic development on the public sector; iv) the creation of a cooperation that can ensure the private sector development with the use of innovative technological profiles for the works; v) the distribution of the risks associated with the execution of the works [5–7].

Despite the many advantages, the PPP may be difficult in the phase of correct allocation of risks to the appropriate subject who, involved in the procedure, is able to manage it better. Several types of risks can occur during the phases of the project, from its programming to its possible dismissal, passing through the phases of planning, realization and eventual management [8]. The risk is defined in economics as "the probability that a damage or loss may occur at some instant" and therefore requires appropriate assessment methodologies to quantify, manage and reduce it. With special attention to urban interventions, property risk assessment assumes considerable importance in order

to safeguard the economic interests of the private sector that is often the main driving force of the interventions. Estimating the likelihood that damage or loss will occur at a certain instant of time depends on a number of factors attributable to the magnitude of the intervention, the legal status of the sites, the entrepreneurial capacity and individual risk aversion to which the risks are attributed. It is also essential to know the economic, physical and social conditions of the context in which the operation takes place.

In these terms, the complexity of the assessment of all risks appears evident, but the accurate identification of all the risks of the operation and then the allocation of the different types of risk among the parties involved in the real estate initiative, placed in the hands of the party(ies) with the greatest capacity, are the fundamental operations to ensure the success of projects.

2 Aim of the Work

The work is part of the outlined framework. In particular, the research is aimed at developing an innovative real estate risk assessment methodology intended for supporting the Public Administration and the Private Entrepreneur involved into PPP urban transformation intervention through the determination of a composite indicator, namely the Real Estate Risk Index (I_{RER}). The proposed methodology consists of a protocol of sequential and ordered phases that, based on an adequate socio-economic and real estate spatial data, is able to assess the level of the real estate risk that pertains to a specific territorial scale chosen for the analysis, according to the goals, the requirements, the data or the point of view (if public or private). Due to the capacity of the Analytic Hierarchy Process (AHP) multi-criteria technique for processing and aggregating both qualitative and quantitative risk indicators and the spatial distribution visualization offered by the Geographic Information Systems for the obtained risk levels, a conceptual framework and operative procedure for the ex-ante risk assessment is proposed. In this way, it is performed a rigorous decomposition of the real estate risk factors into hierarchical and clear levels that, at the same time, is simply reproducible because it doesn't require specific or high calculating and knowledge skills, with the exception of the knowledge of the socio-economic characteristics of the urban fabric under analysis and those of the real estate market.

The composite indicator determinable through the seven sequential and ordered phases allows to analyze the local real estate market features known at the moment of the evaluation, and that could affect the feasibility of a urban PPP development project.

The paper is structured as follows: in Sect. 3 an overview of the main real estate risk factors affecting PPP initiatives is carried out. In Sect. 4 the structure and the phases that characterize the proposed composite indicator methodology is explained. In Sect. 5 the advantages and limits, nor the practical implications of the proposed risk assessment methodology with the future insights of the research are discussed.

3 Background

The PPP projects are widely debated internationally. Many researchers have conducted studies aimed at understanding recurring risk factors in projects execution due to the evidence that identifying risks and assigning their responsibility represents the winning strategy for successful and effective projects.

Yelin et al. [9] analyze 9 projects related to the construction of water facilities in China to identify risks that undermine the success of projects implemented in PPP. The authors conduct a review of literature and then they proceed by studying 9 projects with the aim of conducting a data collection on the main risk factors, principally related to political, legal profiles, government conditions and local/global market dynamics. The analysis identified 11 critical risks that undermine the success of water projects in China. Poor ability to manage these risks causes consequences such as: poor project quality, delivery delays, un-respected budgets and contract disputes. The authors show that proper risk allocation strategies turn out to be essential for the success of projects.

Similarly Chan et al. [10], following the literature review, identify 34 recurrent risk factors in construction projects in China, that often cause schedule delay or/and cost overrun. The risks identified can be associated with two main categories: systematic/country risks and specific projects risks. The authors develop a questionnaire to understand industrialists' and academics' perceptions of these risks and to understand the responsibility for these risks among the parties, in PPP projects in China. The research findings showed that a key problem in China is the lack of a model for risk assessment and equitable sharing of the risks associated with the project.

Hwang et al. [11] identify 42 risk factors in PPP projects from a literary review, in the context of the implementation of road projects and public facilities. They develop a questionnaire that is submitted to contractors in Singapore. The authors obtain 48 valid questionnaires that they process using the Mean Score technique, through which they obtained a criticality ranking of risk factors in the execution of PPP projects in Singapore, in particular the risks considered most critical were found to be: lack of government support, inexperience in the execution of PPP projects, and construction delays.

Rybnicek et al. [12] develop a review analyzing the recurring risks factors in international PPP projects, without reference to a specific project or project area. The authors develop a model that consists of three steps: risk identification, risk assessment and risk mitigation. They analyze these aspects for the 8 risks most cited in the literature including: contractual issues, resources, and objectives pursued by the parties.

Carbonara et al. [13] affirms that one of the critical aspects of a successful project is risk management. This is possible by identifying the different risks associated with the project, which will differ from sector to sector. Based on a Delphi survey, they propose a list of significant risks in PPP highway projects and define the allocation of each risk. In this way the involved parties can establish effective resolution strategies.

Zou et al. [14] analyze three PPP infrastructure projects, two from Australia and one from China. They analyze financial risks, public acceptance/rejection risks, political risks, corruption risks and construction risks of each projects. The authors, from their study of the 3 projects, show how the identification of risks in the early stages and the subsequent allocation of risks to the parties that demonstrate the greatest capacity to

manage it, is a key operation. In order to preserve the interests of both the public and the private sector, while preserving the project's value for money, risk management must be defined over the entire project life cycle.

Fischer et al. [15] develop interviews, questionnaires and a literature review from which they deduce a standardization of risk types in PPP infrastructure projects such as site risk, contractual risk, financial risk. They develop a risk management process model: an Integrated Risk Management System (IRMS). Risk management processes are structured as an IRMS on four levels. The system developed serves all parties involved in projects by enabling a range of benefits including the identification of appropriate risk management strategies during all phases of the project life cycle.

Jin X.-H. et al. [16] propose an Artificial Neural Network model (ANN) to support risk allocation decision making in construction PPP projects, developed on the basis of transaction cost economics. The research shows how ANN is a satisfactory model to be used to support decision-making processes and how it is appropriate to utilize transaction cost economics and resource-based view of organizational capability to interpret risk allocation decision-making process.

Identification processes of recurring risks in the execution of PPP projects is a preliminary operation to risk assessment. The implementation of PPP projects requires the use of substantial capital resources; however, incorrect risk assessment leads to increased project costs. The use of correct risk assessment techniques allows the most critical issues of projects to be managed and allocated in the correct manner, ensuring their success.

Kumar et al. [17] analyze the investment risk of projects related to highway construction in India. The authors apply a standard risk analysis model, that is Net Present Value (NPV)-at-risk tool supported by Monte Carlo Simulation to 30 highway projects (built and under construction) in India. The analysis shows that the factors that most influence NPV in the projects considered are the discount rate and construction cost. The authors propose NPV-at-risk tool to support private investors and public entities, because the analysis of different settings permits more informed investment choices.

Valipour et al. [18] use different types of Multi-Attribute Decision-Making (MADM) methods to examine the performance of methods applied to the same case. The authors identified the top 10 recurring risks in the implementation of highway projects in Iran, such as problems in project design, limited capital, delays in resolving contractual disputes, and environmental issues. From this, a decision-making group defined 5 risk assessment criteria: impact of risk, consequence, risk predictability, risk uncertainty and detectability. The study inferred that the Step-Wise Weight Assessment Ratio Analysis (SWARA), Complex Proportional Assessment (COPRAS) and Evaluation based on Distance from Average Solution (EDAS), show the highest potential for risk assessment in PPP projects.

4 Methodology

The research proposes a methodology aimed at defining a real estate risk index able to assess - in the *ex-ante* situation – the level of the real estate risk that could derive from the dynamics of the local real estate markets. It is obtained through the logical-operative framework that consists into a protocol of 7 ordered and sequential phases. In Fig. 1 all the sequential phases of the methodology are shown.

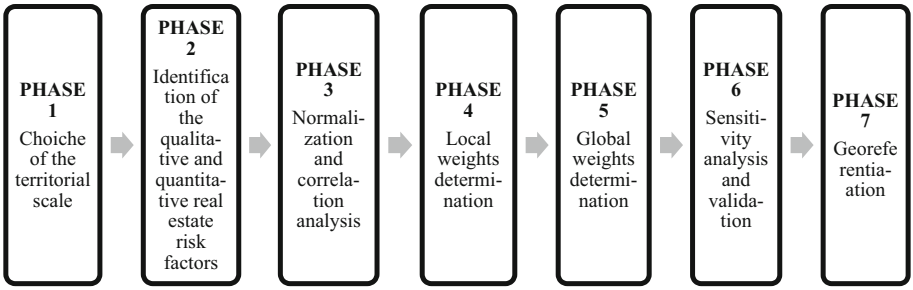

Fig. 1. Phases of the proposed assessment methodology

The high flexibility that characterizes the proposed methodology gives the opportunity to use it for constructing a real estate risk index for both public and private specific requirements, for several territorial scale (e.g. national, regional, municipal, sub-urban etc.) and for different purposes regarding the risk assessment (e.g. ranking the areas, compare the risk levels etc.). For these reasons, the description of each phase is done also by referring to some possible applications of the methodology, in order to better specify its operative usefulness.

4.1 Phase 1. Choice of the Territorial Scale According to the Final Utilization

The first step of the methodology is the definition of the uses for which the real estate risk index is intended and, therefore, the choice of the territorial scale of analysis that will influence the subsequent phases of collecting data and the real estate risk typologies to consider in the final synthetic value of the index. In other words, the different uses that the index could have directly affect the choice of the territorial scale to which the index should refers. In fact, the territorial scale must be carefully chosen in order to be adequate for the purposes of the assessment. This link between the risk index, the territorial scale and the final utilizations is better explained in Table 1.

As can be seen in Table 1, due to the high flexibility of the proposed methodology, there are 5 different territorial scales to which the protocol could allow to obtain a real estate risk index, according to the different goals. However, it is important to highlight that the present research is intended to take account also the spatial component related to the real estate data georeferentiation. This does not imply that the methodology for creating the index cannot ignore this question and directly be aimed at taking into account the point of view of the public or the private sector or changing the period of the evaluation passing from an *ex-ante* assessment to an *itinere* or *ex-post* ones and so on.

Table 1. Synthesis of the different territorial scales and possible goals related to the risk index use

N.	POSSIBLE TERRITORIAL SCALE	POSSIBLE GOALS/USES OF THE RISK INDEX
1	*Building*	It refers to the individual building and could be implemented for giving a synthetic preliminary and general view of the real estate risk based on the intrinsic and positional features or the transformation to be considered
2	*Sub-urban*	It can be used for providing an ex-ante risk assessment based on the local real estate risk factors that characterize a neighborhood
3	*Urban area*	It can be used for providing an ex-ante risk assessment based on the local real estate risk factors that characterize a neighborhood
4	*Municipal*	It involves the entire city and could be useful for comparing the ranking of the different cities and provide a more comprehensive vision
5	*Extra-urban*	It includes all the urban communities within a region or a nation and it can be chosen for carrying out an analysis for the global market

4.2 Identification of the Risk Typology to Assess

After the selection of the territorial scale to which the risk index will belong according to the specific purposes, the Phase 2) requires the identification of the specific real estate risk typology to consider. This phase, in fact, generally refers to the well-known subdivision of the real estate risk components into "systematic" and "specific". The first one is caused by global market's factors and affects all the different type of investments, therefore is extremely susceptible to the fluctuations of the general financial market: it is uncontrollable for the real estate redevelopment process, because it cannot be avoided through the diversification. The second one includes all the critical factors that characterizes a precise investment decision and it largely affects the feasibility of the projects. It appears to be more controllable than the "systematic" one and numerous typologies can be retrieved, such as property, insurance, administrative, construction, technical testing, tenant, geopolitical, location etc. Into this phase of the methodology, therefore, it is important to clearly identify the type of real estate risk that can be assessed according to the territorial scale chosen for the construction of the index. In particular, the "specific" type will guide the choice and, for example, for the building scale the risk will refers to the intrinsic and extrinsic variables, for the sub-urban scale the main risk drivers of the local demand and supply, as also for the urban area. A different behavior can be recognized for the major territorial scale, or the regional and national ones, where the geo-political issues and other main relevant global market dynamics may be considered in the real estate risk index for their influences.

4.3 Phase 3. Identification of the Qualitative and Quantitative Indicators Related to the Considered Risk Factors

The real estate risk index represents the synthesis of a sample of data and information useful for the analysis of the real estate risk typologies related to the chosen territorial scale. It derives from the aggregation of a set of *n* qualitative and quantitative indicators that are adequality able to represent each type of the real estate risk associated to the territorial scale. In this phase, the analysis of the real estate dynamics is essential for understanding what are the most suitable indicators that are able to represent each of the risk types considered. It could be assumed as a contextualization phase, where the indicators retrieved by the reference literature and professional practices, or *grey* documents, are fitted with the features of the urban tissue and the typology of available data on the real estate assets. For example, if the sub-urban scale is chosen according to the final utilization of the risk index, the market, context and tenant risk factors define the level of risk of each considered sub-urban area within the municipal territory therefore the qualitative and quantitative indicators should be identified in order to explain each of them. It is important to collect indicators due to their readability, availability, scientific background and coherence with the process and the territorial scale's peculiarities.

4.4 Phase 4. Normalization and Correlation Analysis of the Indicators Set

The sample of *n* qualitative and quantitative real estate risk indicators could be characterized by different units of measurement that don't allow to immediately compare the data and aggregate them into the synthetic risk value. If this happens, the normalization is necessary to bring all the collected data into a single and unambiguous measurement scale for comparing and aggregating purposes. The normalization techniques that could be applied is differently identified due to the several effects that the technique can induce on the final risk index's values.

The obtained normalized sample of *n* indicators should avoid the appearance of redundancy in the aggregation subsequent phase, therefore the determination of the correlation levels among all the considered indicators is important. The correlation analysis is required for eliminating the indicators with high overlapping of data in order to obtain a more robust and efficient real estate risk index and acquire a final sample of the indicators that contains only the ones that will determine the synthetic risk index. The Spearman and Pearsons methods are generally the most used for determining the correlation levels. In this phase the AHP can be utilized for structuring all the indicator's data into tree hierarchical levels as follows: the first one relates to the goal, or the creation of the real estate risk index, the second one contains the typologies of real estate risk considered after having carried out the Phase 2 of the proposed methodology and then the third and the fourth ones, respectively involve the *n* qualitative and quantitative final sample of indicators related to each of the risk types and the so-called "intensity ranges" that are defined according to the indicators values sensibility among the territorial units under analysis.

4.5 Phase 5. Local Weights Determination

Each of real estate risk factors represented by the set of the indicators differently affects and influences the final real estate risk level of the territorial unit because each of them has its importance, mathematically translated into a local weight. For all the elements of the AHP structure realized into the previous Phase 4), comparison matrices must be constructed for determining the importance, in terms of local weight, of intensity ranges, indicators and risk typology. Consultation with a panel of experts composed of several subjects, both form public and private sphere, that have a professional profile or level of knowledge adequate for the analysis and the territorial scale dynamics, can be identified for this phase for formulating the preference judgments for each comparison matrix, transformed into values through the adoption of the Saaty scale, as follows (Fig. 2).

Rating Scale	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
2	Weak	Between equal and moderate
3	Moderate importance	Experience and judgment slightly favor one element over another
4	Moderate plus	Between moderate and strong
5	Strong importance	Experience and judgment strongly favor one element over another
6	Strong plus	Between strong and very strong
7	Very strong or demonstrated importance	An element is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	Between very strong and extreme
9	Extreme importance	The evidence favoring one element over another is one of the highest possible order or affirmation

Fig. 2. Saaty scale used for the rating of the verbal judgments

It is important to note that if the indicator has a direct proportionality with the real estate risk index, the classes with the highest value of the intensity ranges will have a greater weight than those with the lowest one. For the elementary indicators for which their increasing values generates a reduction in the real estate risk level, the lower value ranges will have greater weight than the higher value ranges. The consistency of the panel of experts' judgments is verified through the calculation of the Consistency Index (CI), a control parameter proposed by Saaty that is based on the maximum eigenvalue of the matrix λ_{max} and the order n of the same, as Eq. (1) follows:

$$CI = [(\lambda_{max} - n)/(n - 1)]/\text{RandomIndex} \quad (1)$$

The Random index is a predefined table value depending on the order n of the comparison matrix. In order for the judgments expressed by the panel of experts to be used for the determination of the weights, the CI of each comparison matrix is less than 0.1.

4.6 Phase 6. Global Weights Determination

All the samples of real estate data considered in the set of final indicators are used to determine the real estate risk index by aggregating them through the implementation of a Weighted Sum Model. In particular, the proposed methodology provides for the

adoption of the following formula (Eq. 2) for the determination of the real estate risk level pertaining to the territorial units under analysis.

$$I_{RER} = p_1(\Sigma_n^n v_{n,1} * w_{n,1}) + p_2(\Sigma_n^n v_{n,2} * w_{n,2}) + p_3(\Sigma_n^n v_{n,3} * w_{n,3}) + ..p_i(\Sigma_n^n v_{n,i} * w_{n,i}) \quad (2)$$

where:

- p_1, p_2 and p_3 are the local weights of the risk types (systematic or specific according to the territorial scale of analysis);
- v_{n1}, $v_{n,2}$ and $v_{n,3}$ are the local weights determined through the pairwise comparison matrices for the *n-th* indicators of the final sample associated to each type of risk;
- $w_{n,1,}$ $w_{n,2}$ $w_{n,3}$ are the weights of the defined *m-th* intensity range associated to the *n-th* indicator.

The obtained index value, normalized within the range 0 (minimum) and 1 (maximum) in order to be easily comparable, refers to the *i-th* territorial unit considered in analysis. The higher the index value the greater is the real estate risk associated with it on the basis of the considered indicators. This operation must be carried out for each of the examined territorial units within the chosen scale of analysis.

4.7 Phase 7. Sensitivity Analysis, Validation and Georeferentiation

A combination of uncertainty and sensitivity analysis can help to gauge the robustness of the proposed risk index, to increase its transparency and to help framing a debate around it. In particular, the analysis is focused on the possible sources of uncertainty, which can arise from the:

i) selection of sub-indicators,
ii) data quality,
iii) data normalization technique,
iv) weighting scheme,
v) aggregation formulas.

There are several operations to be taken, such as the inclusion/exclusion of some indicators; the modelling of data error; the alternative intensity ranges schemes; the alternative data normalization schemes; the several weighting schemes, i.e. two methods in the participatory family (budget allocation and AHP), and one based on endogenous weighting (Data Envelopment Analysis). In particular, the disposable data with the territorial scale of analysis could guide this final phase that is aimed at testing the robustness of the obtained results of the index and also its consistency with the effective expected results derived from the real values of the indicator's set. The validation may be carried out by comparing the real estate risk levels with the ones of other studies or analysis conducted by other robust research or studies. Moreover, in order to immediately identify the distribution of the real estate risk levels among the territorial scales considered, the geographic information systems - such as for example "My Maps" (provider: Google), can help the final users to arise the knowledge on the matter and support the negotiation phase, or the sustainable planning choices.

5 Conclusions

The PPP projects turn out to be an effective strategy in approaching the complexity that characterizes urban regeneration interventions, the implementation of services and infrastructure, but more generally, any type of intervention on the territory [19–26]. The form of PPP is adopted for the implementation of many interventions on an international scale, since its advantage lies in sharing both the benefits but also the many risks associated with projects between the public and the private subjects. However, the main delicate points associated with the implementation of PPP forms relate to the identification and subsequent assessment of risks. The management of risks and their allocation among the parties involved in real estate initiatives, is the key step to ensure the success of PPP projects.

In this framework, the research aims to develop an innovative method of real estate risk assessment through the determination of a composite indicator, namely the Real Estate Risk Index (I_{RER}), in order to support the decision-making processes of Public Administration and private entrepreneurs regarding possible investments for real estate initiatives. The critical contribution of the paper consists in the development and definition of a real estate risk assessment methodology. The method developed is easily reproducible because it does not require complex computational analysis and is flexible because it can be applied at different territorial scales, (e.g. national, regional, municipal, sub-urban etc.) depending on the goals to be pursued. The proposed methodology consists of a protocol of 7 sequential and ordered phases that is able to assess the level of the real estate risk, enabling an *ex-ante* evaluation procedure for real estate interventions.

The developed operational risk assessment procedure takes advantage of the capability of the multi-criteria technique AHP, which processes and aggregates qualitative and quantitative risk indicators, and the visualization of the spatial distribution offered by Geographic Information Systems for the risk levels obtained.

The developed method allows to weigh the investment decisions in the bidding phase through an overall risk assessment. The real estate valuation risk index can thus be used by both entrepreneurs and the public administration, who can identify high-risk projects from before implementation and monitor critical factors. Research developments involve the application of the methodology to real project cases, at different territorial scales, in order to verify the efficiency of the developed risk index.

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