A Model to Mitigate the Peripheralization Risk at Urban Scale

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Abstract. The uncontrolled expansion of built-up areas and of multiple forms of poverty, on a global level, determines a new geography of degradation, extended both to suburbs and to central zones, thus exposing cities, in their entirety, at risk of peripheralization. In this framework, counteracting actions at the urban scale, such as regeneration programmes, need to be targeted primarily at areas of significant risk, occurring with a combination of vulnerability factors, in three dimensions: social, building and urban. Furthermore, in order to be effective, such programmes must be geared to maximizing risk mitigation. This is possible when the planning of interventions takes into account the evaluation results of the better design alternative in order to reduce pre-existing vulnerability. Such an approach constitutes the novelty of the study. So, the aim of the work is to provide an innovative model for the mitigation of peripheralization risk at urban scale. For this purpose, the contribution defines a set of mitigation indicators and a protocol for evaluating the most effective design alternative based on the Analytic Hierarchy Process (AHP).

Keywords: Peripheralization risk · Urban regeneration · Mitigation indicators · Analytic Hierarchy Process (AHP)

1 Introduction

Due to global urbanization trends, at different observation scales, complex peripheralization processes have produced new and diversified peripherality conditions. On an urban scale, in particular, such conditions are no longer recognizable in peripheries, i.e. neighborhoods born on the edge of historic cities since the post-war period [1–5].

Rather, peripheral condition is understood both in spatial sense, with reference to suburban areas, where the identified risk is mainly related to the phenomenon of sprawl and land consumption, both in aspatial sense. In this case, reference is made to degraded areas, while the identified risk is connected to poor quality of buildings, lack

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of services and reduced quality of life for the population. More generally, it refers to the multidimensional concept of urban poverty [6–10], or to the European one of deprivation [11, 12].

Issues such as reducing land consumption and urban poverty through the regeneration of deprived areas are central to the recent recommendations of the European Union [13, 14] and to the New Urban Agenda, in which urban planning is recognised as playing a key role in the definition of enforcement actions [15].

Since the 1990 s in developed countries, including Italy, tools to combat the degradation of urban areas have been tried. Such instruments, supported by public funding, are known as complex programmes. On an urban scale, they refer to planning tools implementing the general development plan, with the aim of lowering physical and functional degradation of neighborhoods, also including social animation initiatives. To this end, 'complex' programmes provide a plurality of project actions and involve multiple subjects [16].

Over the years, the European Commission has financed several actions to reduce degradation, from complex programs to more recent urban regeneration projects[1].

Urban areas targeted for funding have often been peripheries, which in Europe and in Italy are traditionally associated with degraded neighbourhoods [17–20].

In Italy, where there is still no national legislation for urban regeneration, scientific criteria are generally not used for the identification of degraded areas subject to intervention, but their recognition is usually delegated to the municipal authorities on the occasion of sporadic calls for funding. As a result, urban regeneration interventions translate into operations often independent of urban planning, mainly driven by economic convenience in real estate transformations.

In contrast to this, some scholars propose multi-criteria evaluations of project proposals, in order to maximize public benefits. Among the different techniques, the use of the Analytical Hierarchy Process (AHP) is frequent. Compared to other models, the AHP allows to consider a greater number of criteria, an important feature for the technical-economic evaluation of complex urban programmes [24–29].

However, the continued expansion of cities, which is accompanied by the increasing spread of degradation and multiple forms of poverty even in traditionally central areas [30–34], requires a change of approach, especially in the light of the multiplication of natural and man-made hazards [35], which end up accentuating peripheralization processes.

Thus, in the light of the new urban and socio-economic geography, regeneration interventions must be directed primarily to areas with a significant co-presence of potential degradation factors. Consequently, the choice by decision makers of the best design alternative must be informed by the knowledge of vulnerability levels that characterize areas subject to intervention, and oriented towards the solution that maximizes their reduction.

[1] In chronological order (with date of first appearance): Urban Pilot Projects (1989–1993); Community Initiatives POVERTY III (1989–1993); URBAN I (1994–1999); URBAN II (2000–2006); URBACT II (2007–2013); URBACT III (2014–2020).

To this end, it is necessary to integrate the phase of interventions planning in highly vulnerable areas with that of the multi-criteria evaluation of the most effective project. This integration constitutes novelty element of this work.

The contribution is part of a wider research project, which proposes a methodology for the localization of the areas subject to urban regeneration with reference to the general theory of territorial risk. According to this approach, priority areas are those in which the greatest risk of peripheralization occurs, determined by high levels of aggregated vulnerability. The latter, in turn, is given by the combination of social, building and urban vulnerability, and it is measured with reference to quantitative indicators, describing the potential degradation factors of the goods exposed in the social, building and urban domains of the city. With regard to these dimensions, the elements at risk are, respectively, population, buildings and urban fabric [36–39].

The objective of this paper is to characterize a model for the mitigation of peripheralization risk at urban scale. Specifically, the proposed methodology aims to provide a decision support system useful for assessing the effectiveness of urban regeneration programmes in high-risk areas, therefore priority of intervention. Following a brief description of the approach and of AHP technique on which the model is based (Sect. 2), the contribution proposes a set of indicators for the mitigation of the social, building and urban vulnerability of priority areas (Sect. 3). The hierarchical structure that conforms the study protocol, as well as the calculation algorithms that govern the system, are in Sect. 4. Section 5 reports the conclusions of the research, notes the effectiveness of the model for selecting the investment best able to pursue the objectives, and finally outlines research perspectives.

2 Methodological Approach

The proposed methodology requires the previous identification of urban areas most at risk, where regeneration interventions should be prioritized. Given that a high risk level depends on a significant aggregated vulnerability, the method for estimating that vulnerability is crucial. This is especially true because in the international scientific community there is no agreement on both the most appropriate set of vulnerability indicators and how to combine them. In the broader research project to which the work belongs, a set of indicators has already been designed with reference to the social, building and urban domains. In addition, a method of combining vulnerability indicators based on fuzzy logic was proposed, allowing to manage the uncertainty related to their aggregation [36].

Following the above-mentioned work, the method here proposed identifies a set of mitigation indicators, which allow to estimate the effects of project initiatives on social, building and urban domains, with the aim of reducing vulnerability and, therefore, risk.

Subsequently the procedure is articulated in the own phases of the Analytic Hierarchy Process (AHP). Specifically, the AHP provides for three basic steps: structuring the problem hierarchically; comparing judgments; synthesizing priorities [40, 41]. The first phase consists in defining the hierarchy, explaining: the objective of the evaluation; the criteria, which coincide to the domains examined; the sub-criteria, to which the mitigation indicators correspond. The second phase allows the relative

importance of the criteria and sub-criteria to be measured in respect to the general objective. This phase is divided into further sub-phases:

- pairwise comparison of the design alternatives with respect to each sub-criterion;
- pairwise comparison of sub-criteria;
- pairwise comparison of the criteria.

The last step allows the choice of the best design alternative on the basis of the assessments carried out (Fig. 1).

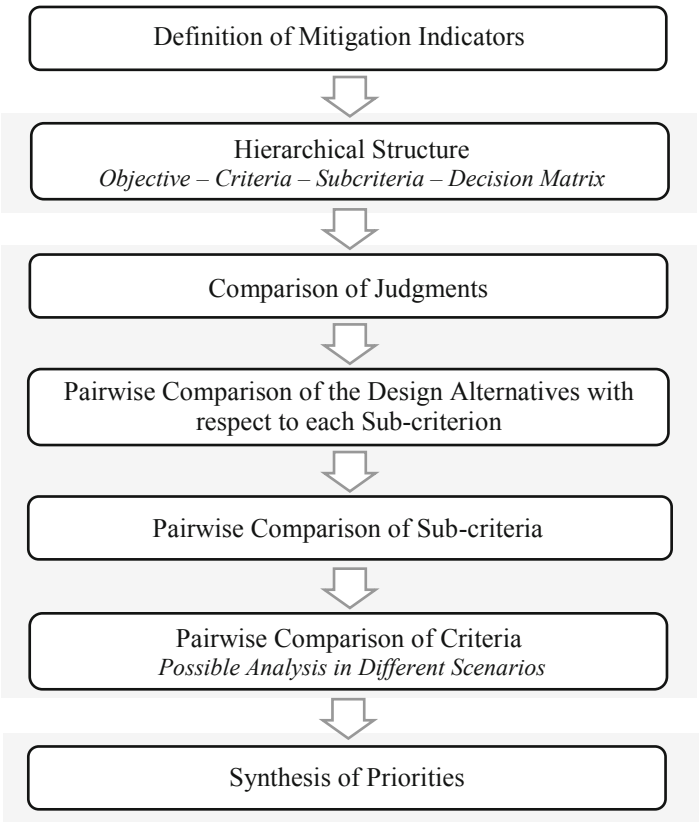


Fig. 1. Workflow of the proposed methodology.

3 Definition of Mitigation Indicators

This phase is carried out with specific reference to vulnerability indicators used for the localization of priority urban areas of intervention.

The indicators of social vulnerability are: unemployment rate; failure to reach minimum levels of education; incidence of the elderly.

Building vulnerability indicators, on the other hand, refer to the quality of building-housing stock. In particular, they measure the state of conservation and technological obsolescence of buildings.

Finally, the indicators for urban domain measure the fragmentation of urban fabric and the composition of the latter, with reference to non-permeable areas.

Other indicators of urban vulnerability are the lack of services and the presence of urban criticalities, such as disused or abandoned areas and solid waste accumulation zones [36].

So, mitigation indicators proposed in this contribution (Table 1) are able to measure the impact of urban transformation interventions on the vulnerability factors described above. With reference to the social domain, they measure actions aimed at improving employment, education and demographic structure, in terms of number of new employees, graduates in secondary school, ability of the city physical-functional structure to attract young families. The latter action can be measured by qualitative judgment, which is associated with a scalar value from 1 to 7. It is the only qualitative indicator out of the total of those proposed.

With regard to the building domain, mitigation indicators measure interventions that lead to improvements in the state of building-housing stock, in terms of number of buildings recovered and/or adequate from a hygienic-sanitary point of view.

For the urban domain, indicators estimate actions aimed at increasing supply of services and permeable green spaces, recovery of abandoned and/or degraded areas, as well as reducing the fragmentation of urban fabric.

4 An Innovative Hierarchical Analysis Model

The definition of the hierarchy is fundamental for the modeling of the complex problem [42]. The proposed dominance hierarchy consists of three levels, as in Fig. 2. At the highest level there is the objective (goal), which consists in evaluating the best design alternative in terms of peripheralization risk mitigation in the social, building and urban domains. At the second level there are the criteria (C_i), which, in this case, correspond to the vulnerability domains analyzed: the social criterion (C_s); the building criterion (C_b); the urban criterion (C_u). At the third level there are the subcriteria (C_{ij}), to which mitigation indicators correspond (I_{Mij}). Those indicators are: three (I_{Ms1}, I_{Ms2}, I_{Ms3}) for the subcriteria of the social domain (C_{s1}, C_{s2}, C_{s3}); three more (I_{Mb1}, I_{Mb2}, I_{Mb3}) for the subcriteria of the building domain (C_{b1}, C_{b2}, C_{b3}); four (I_{Mu1}, I_{Mu2}, I_{Mu3}, I_{Mu4}) for the subcriteria of the urban domain (C_{u1}, C_{u2}, C_{u3}, C_{u4}).

All ten sub-criteria are measurable for each of the k design alternatives among which the decision maker is called to choose. This is in order to mitigate the vulnerability components of the risk for the area under consideration.

For each design alternative, the values of mitigation indicators constitute the lines of the decision matrix, while the columns relate to the values of the specific sub-criterion for all the project proposals. The decision matrix, therefore, is of the type in Table 2.

Starting from the decision matrix, we proceed to the pairwise comparison of the design alternatives P_k with respect to each sub-criterion. Thus, for the ten defined

Table 1. Mitigations indicators, unit of measurement and definition.

Mitigation indicator		U.M.	Definition
Social Domain			
I_{Ms1}	New employees	n.	Number of new employees in the age group corresponding to the workforce
I_{Ms2}	New graduates at secondary school cycle (middle school)	n.	Population of 15 years and over who will obtain a middle school diploma per year
I_{Ms3}	Ability to attract young families	value	Ability to attract young families of city physical-functional structure: 1. very shoddy; 2. shoddy; 3. very low; 4. low; 5. medium; 6. medium-high; 7. high
Building Domain			
I_{Mb1}	Recovered buildings of historical, architectural or artistic value	n.	Number of buildings with historical, architectural or artistic value subject to restoration
I_{Mb2}	Recovered residential buildings in bad and mediocre conservation state	n.	Number of residential buildings subject to extraordinary maintenance or renovation
I_{Mb3}	Improper housing recovered	n.	Number of improper housing subject to health and hygiene improvements
Urban Domain			
I_{Mu1}	Edge density	m/ha	Ratio between total sum of perimeters of the polygons of built areas and the total surface of investigated area
I_{Mu2}	Increment of permeable areas	m^2	Surface for additional permeable areas
I_{Mu3}	Increase in urban planning standards	m^2	Surface provided for additional urban planning standards
I_{Mu4}	Urban critical areas retrieved	m^2	Surface of enclosed recovered spaces: abandoned production areas; areas with newly built artifacts that have not been used; undeveloped areas devoid of specific use or abandoned; areas with waste accumulation

sub-criteria, there are ten comparison matrices, in which the elements a_{ij} represent the dominance coefficients, obtained using the Saaty semantic scale (Table 3).

By placing on this scale the values from time to time to be compared, if they fall into the same band, the dominance coefficient a_{ij} of each value with respect to the other is 1; if a band separates them, the coefficient a_{ij} is 3 for the highest value and the reciprocal 1/3 for the lowest value; if there are two bands between them, a_{ij} is 5 for the highest value and it is 1/5 for the lowest one, and so on. Intermediate coefficients may also be used.

The subsequent pairwise comparison between sub-criteria, belonging to the same domain, aims to establish their reciprocal importance.

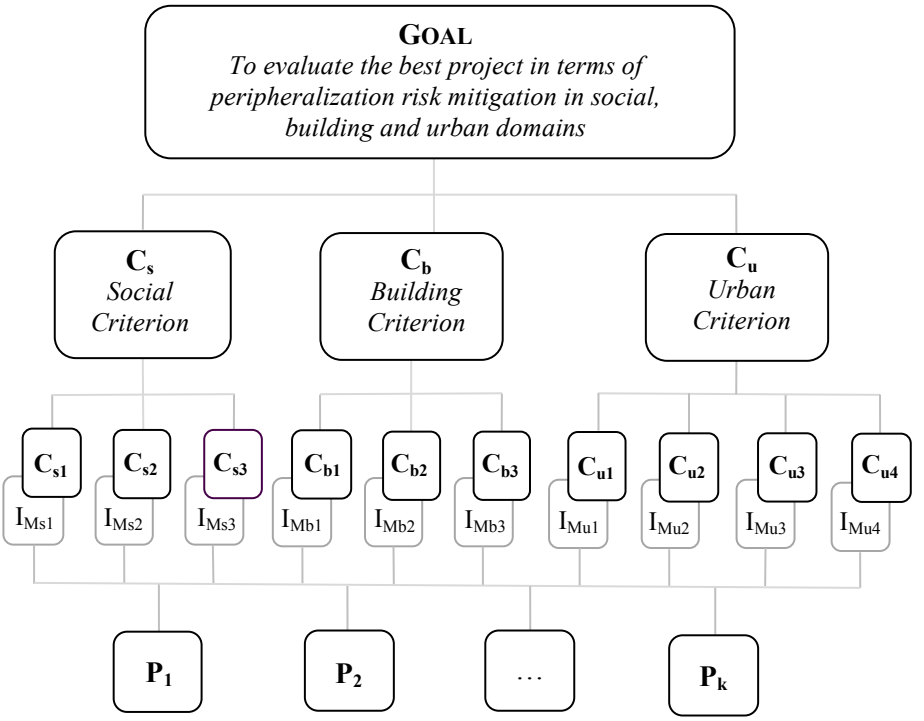


Fig. 2. Hierarchical structure of the proposed model.

Table 2. Decision matrix scheme.

	C_{s1} [n.]	C_{s2} [n.]	C_{s3} [value]	C_{b1} [n.]	C_{b2} [n.]	C_{b3} [n.]	C_{u1} [m/ha]	C_{u2} [m^2]	C_{u3} [m^2]	C_{u4} [m^2]
P_1										
P_2										
…										
P_k										

Table 3. Semantic scale of Saaty.

Intensity	1	3	5	7	9	2-4-6-8
Judgement of Importance	*Equal*	*Moderate*	*High*	*Very high*	*Extreme*	*Intermediate levels*

Finally, the comparison in pairs between criteria aims to establish the importance of one domain with respect to the other. In this regard, in relation to different possible objectives of Economic Policy, the analysis can be developed with reference to several scenarios. For example, the study may consider the following two scenarios:

- *scenario 0*, whereby all criteria have the same importance;
- *scenario 1*, where the weight of the criteria depends on the vulnerability levels obtained from the peripheralization risk analysis.

In scenario 1, the more vulnerable a domain is, the more important are the actions aimed at that specific dimension. For each domain, vulnerability mapping returns different vulnerability classes: *low; medium; high; very high*. The linguistic values *low, medium, high and very high*, can be converted into proportional scalars. In particular, the low value will correspond to the scalar 1, the medium value 2, the high value 3, while the very high value 4.

At this point we proceed with the pairwise comparison, in order to establish the relative importance of the elements according to the scale in Fig. 3. This figure allows to divide the four ranges 1(low) - 2(medium) - 3(high) - 4(very high) into the 5 typical Saaty value ranges 0–0, 8–1, 6–2, 4–3, 2–4, 0 returned in the lower part of Fig. 3. Thus, the matrix of Table 4 is derived.

In order to evaluate the priority of one project proposal over the other, we refer to the principle of hierarchical composition, determining the importance of each element of the hierarchy in relation to the objective. More precisely, in the calculation of the orders, each proposal has a priority equal to:

$$PP_k : \sum \boldsymbol{wP}_{kij}\, \boldsymbol{wC}_{ij}\, \boldsymbol{WC}_i$$

Where:
PP_k = priority of the k-th project proposal;
$\boldsymbol{wP}_{kij}$ = normalized vector of subcriteria for each project proposal;
$\boldsymbol{wC}_{ij}$ = normalized vector of subcriteria for each domain;
$\boldsymbol{WC}_i$ = normalized vector of criteria;
with $k = 1, \ldots, n$; i = s, b, u; $j = 1, \ldots, 4$.

Ultimately, with reference to each of the proposed scenarios, a summary matrix is obtained. Such matrices allow to identify the priorities of the different design alternatives in order to guide the decision maker's choice.

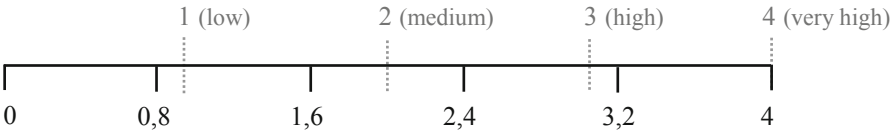


Fig. 3. Positioning on the graduated scale of values corresponding to vulnerability levels.

Table 4. Matrix for assigning weights to the criteria.

	Low	Medium	High	Very high
Low	1,000	0,333	0,167	0,111
Medium	3,000	1,000	0,333	0,167
High	6,000	3,000	1,000	0,333
Very high	9,000	6,000	3,000	1,000

5 Conclusions

The uncontrolled growth of urban areas and of multiple forms of poverty, accentuated by natural and man-made hazards which must be faced with increasing urgency, determines a new geography of degradation. This decay extends to both suburbs and central areas, exposing cities, in their entirety, to a peripheralization risk.

In order to optimize the use of scarce resources available, planning tools to combat urban scale degradation – among others, mention can be made of regeneration programmes – must be directed primarily to areas most at risk and aimed at maximizing its mitigation.

In this context, our research highlights the need to integrate the planning of urban regeneration interventions with the technical-economic evaluation of the most effective design alternative in terms of vulnerability mitigation, in the various dimensions examined: social, building and urban. For this purpose, an innovative multi-criteria model is proposed that can take into account the different factors and levels of vulnerability in the domains investigated. The algorithms of the analysis model are based on the logical schemes that characterize the Analytical Hierarchy Process (AHP).

For the model implementation, a set of mitigation indicators is defined, with reference to the vulnerability factors considered to locate priority areas of intervention. Mitigation indicators are defined so as to analytically estimate the benefits brought by project actions, such as to determine the reduction of vulnerability indicators values.

It should be noted that the selection of mitigation indicators is carried out in order to build a complete, non-redundant and coherent set, generalized for urban-scale interventions. In addition, as well as for the AHP model implementation, the same indicators can also be used for temporal monitoring of the improvement effects produced by the projects on the specific vulnerability components.

Once the values of the proposed mitigation indicators have been clarified, the model allows to select the design solution that maximizes the reduction of pre-existing vulnerability levels.

The structure of the model, the indicators on which it is based and the aims that the model tends to pursue, constitute novelty of the work.

Research prospects concern the application of the proposed model to case studies, which is, moreover, already in progress with fully satisfactory indications.

References

1. Copus, A.K.: From core-periphery to polycentric development. Concepts of spatial and aspatial peripherality. Eur. Plann. Stud. **9**(4), 539–552 (2001). https://doi.org/10.1080/713666491
2. Taylor, P.J., Lang, R.E.: The shock of the new: 100 concepts describing recent urban change. Environ. Plann. **36**, 951–958 (2004). https://doi.org/10.1068/a375
3. Kühn, M., Bernt, M.: Peripheralization and power – theoretical debates. In: Fischer-Tahir, A., Naumann, M. (eds.) Peripheralization. Springer, Wiesbaden (2013). https://doi.org/10.1007/978-3-531-19018-1_15
4. Kühn, M.: Peripheralization. Theoretical concepts explaining socio-spatial inequalities. Eur. Plann. Stud. **23**(2), 367–378 (2015). https://doi.org/10.1080/09654313.2013.862518
5. United Nations Human Settlements Programme: The fundamentals of urbanization. Evidence base for policy making, UN-Habitat (2016). ISBN 978-92-1-132730-4. https://unhabitat.org/the-fundamentals-of-urbanization-evidence-base-for-policy-making. Accessed 30 Apr 2020
6. Conway, M., Konvitz, J.: Meeting the challenge of distressed urban areas. Urban Stud. **37** (4), 749–774 (2000)
7. Baharaoglu, D., Kessides, C.: Urban poverty. In: A Sourcebook for Poverty Reduction Strategies, Chapter 16. World Bank, Washington D.C. (2002)
8. Bernt, M., Colini, L.: Exclusion, marginalization and peripheralization. Conceptual concerns in the study of urban inequalities, Working Paper. Leibniz Institute for Regional Development and Structural Planning, Erkner, Germany (2013)
9. Geneletti, D., La Rosa, D., Spyra, M., Cortinovis, C.: A review of approaches and challenges for sustainable planning in urban peripheries. Landscape Urban Plann. **165**, 231–243 (2017). https://doi.org/10.1016/j.landurbplan.2017.01.013
10. Gerundo, R., Marra, A.: Il rischio nei fenomeni di periferizzazione delle aree urbane e metropolitane. Urbanistica Informazioni **278 s.i.**, 338–342 (2018)
11. Townsend, P.: Deprivation. J. Soc. Policy **16**(2), 125–146 (1987). 10.1017/S0047279400020341
12. Ministry of Housing, Communities and Local Government: The English Indices of Deprivation 2019, Statistical Release. (2019). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/835115/IoD2019_Statistical_Release.pdf. Accessed 30 Apr 2020
13. European Commission-EU: Guidelines on best practice to limit, mitigate or compensate soil sealing, Luxembourg (2012)
14. European Commission-EU: Integrated regeneration of deprived areas and the new cohesion policy approach, Luxembourg (2015)
15. United Nations-UN: New Urban Agenda. A/RES/71/256 (2017)
16. Gerundo, R.: I programmi urbani complessi. Graffiti, Napoli (2000)
17. Guiducci, R.: Periferie tra degrado e riqualificazione, Laterza, Bari (1993)
18. Oliva, F.: Il sistema insediativo. In: Selicato, F., Rotondo, F.: Progettazione Urbanistica. Teorie e Tecniche. McGrawHill, Milano (2010)
19. Decree of the Italian Prime Minister n. 249, October 15th 2015. Interventi per la riqualificazione sociale e culturale delle aree urbane degradate. http://www.mit.gov.it/sites/default/files/media/notizia/201601/dpcm_15_ottobre_2015.pdf. Accessed 30 Apr 2020

20. Decree of the Italian Prime Minister, May 25th 2016. Bando per la presentazione di progetti per la predisposizione del Programma straordinario di intervento per la riqualificazione urbana e la sicurezza delle periferie delle città metropolitane e dei comuni capoluogo di provincia. http://www.governo.it/sites/governo.it/files/Bando_periferie_urbane.pdf. Accessed 30 Apr 2020
21. Nijkamp, P., Rietveld, P., Voogd, H.: Multicriteria Evaluation in Physical Planning. North Holland Publications, Amsterdam (1990)
22. Vincke, P.: Multicriteria Decision-Aid. Wiley, New York (1992)
23. Tzeng, G.H., Huang, J.J.: Multiple Attribute Decision Making Methods and Applications. CRC Press, Taylor & Francis Group, Boca Raton (2011)
24. Stanghellini, S., Mambelli, T.: La valutazione dei programmi di riqualificazione urbana proposti dai soggetti privati. Scienze Regionali **2**(1) (2003)
25. De Mare, G., Nesticò, A., Tajani, F.: Building investments for the revitalization of the territory: a multisectoral model of economic analysis. In: Murgante, B., et al. (eds.) ICCSA 2013. LNCS, vol. 7973, pp. 493–508. Springer, Heidelberg (2013). https://doi.org/10.1007/978-3-642-39646-5_36
26. Nesticò, N., Sica, F.: The sustainability of urban renewal projects: a model for economic multi-criteria analysis. J. Prop. Invest. Finance **35**(4), 397–409 (2017). https://doi.org/10.1108/JPIF-01-2017-0003
27. Nesticò, N., Somma, P.: Comparative analysis of multi-criteria methods for the enhancement of historical buildings. Sustainability **11**(17), 4526 (2019). https://doi.org/10.3390/su11174526
28. Guarini, M.R., Nesticò, A., Morano, P., Sica, F.: A multicriteria economic analysis model for urban forestry projects. In: Calabrò, F., Della Spina, L., Bevilacqua, C. (eds.) ISHT 2018. SIST, vol. 100, pp. 564–571. Springer, Cham (2019). https://doi.org/10.1007/978-3-319-92099-3_63
29. Nesticò, A., Maselli, G.: Sustainability indicators for the economic evaluation of tourism investments on islands. J. Cleaner Prod. **248**, Article no. 119217 (2020). https://doi.org/10.1016/j.jclepro.2019.119217
30. Gerundo, R., Fasolino, I., Grimaldi, M.: ISUT model. a composite index to measure the sustainability of the urban transformation. In: Papa, R., Fistola, R. (eds.) Smart Energy in the Smart City. GET, pp. 117–130. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-31157-9_7
31. Sebillo, M., Vitiello, G., Grimaldi, M., Buono, D.D.: SAFE (safety for families in emergency). In: Misra, S., et al. (eds.) ICCSA 2019. LNCS, vol. 11620, pp. 424–437. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-24296-1_34
32. Fasolino, I., Naddeo, V., Grimaldi, M., Zarra, T.: Odour control strategies for a sustainable nuisances action plan. Glob. Nest J. **4**, 734–741 (2016). https://doi.org/10.30955/gnj.002109
33. Naddeo, V., Fasolino, I., Grimaldi, M., Zarra, T.: Implementation of integrated nuisances action plan. Chem. Eng. Trans. **54**, 19–24 (2016). https://doi.org/10.3303/cet1654004
34. Grimaldi, M., Sebillo, M., Vitiello, G., Pellecchia, V.: An ontology based approach for data model construction supporting the management and planning of the integrated water service. In: Misra, S., et al. (eds.) ICCSA 2019. LNCS, vol. 11624, pp. 243–252. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-24311-1_17
35. Sebillo, M., Vitiello, G., Grimaldi, M., De Piano, A.: A citizen-centric approach for the improvement of territorial services management. ISPRS Int. J. Geo-Inf. **9**(4), 223 (2020). https://doi.org/10.3390/ijgi9040223
36. Gerundo, R., Marra, A., De Salvatore, V.: Construction of a composite vulnerability index to map peripheralization risk in urban and metropolitan areas. Sustainability **12**(11), 4641 (2020). https://doi.org/10.3390/su12114641

37. Gerundo, R., Grimaldi, M., Marra, A.: A methodology hazard-based for the mitigation of the radon risk in the urban planning. UPLanD J. Urban Plann. Landscape Environ. Des. **1**(1), 27–38 (2016). https://doi.org/10.6092/2531-9906/5031
38. Gerundo, R., Fasolino, I: Sicurezza territoriale ed efficienza urbanistica. Edizioni Scientifiche Italiane, Napoli (2010)
39. Office of the United Nations Disaster Relief Coordinator: Natural disasters and vulnerability analysis. Report of Expert Group Meeting, 9–12 July 1979. United Nations, Geneva, Switzerland (1980). https://digitallibrary.un.org/record/95986. Accessed 30 Apr 2020
40. Saaty, T.L.: A scaling method for priorities in hierarchy structures. J. Math. Psychol. **15**(3), 234–281 (1977)
41. Saaty, T.L.: The Analytic Hierarchy Process. McGraw-Hill, New York (1980). Reprinted by RWS Publications, 4922 Ellsworth Avenue, Pittsburgh, PA, 15213 (2000)
42. Saaty, T.L.: Decision Making for Leaders: The Analytic Hierarchy Process for Decision in a Complex Word. RWS Publications, Pittsburg (1999)