An Analytic Network Process (ANP)-Based Approach for Investigating Alternative Planning Scenarios of Mining Activities in Piedmont Region

Vanessa Assumma(✉), Marta Bottero, Giulio Mondini, and Elisa Zanetta

Interuniversity Department of Regional and Urban Studies and Planning, Politecnico di Torino, 10125 Turin, Italy
{vanessa.assumma,marta.bottero,giulio.mondini}@polito.it, elisa.zanetta@gmail.com

Abstract. The paper aims to explore a set of future scenarios in the context of the Strategic Environmental Assessment (SEA) for the adoption of the Regional Plan for Mining Activities in Piedmont region (Italy). The study investigates the use of a Multicriteria Decision Analysis technique (MCDA), namely the Analytic Network Process (ANP), with the aim to support the definition of the best sustainable scenario. The ANP model evaluates a protocol of objectives and strategies in order to explore their complex relations and to guide the evaluation of alternative planning scenarios. The paper shows how the ANP model may be considered a suitable support to aid the decision-making process in better understanding the full range of impacts generated by mining activities on the territory, thus supporting the creation of integrated and sustainable planning policies at regional scale.

Keywords: ANP · Regional planning · Decision-making process

1 Introduction

Anthropogenic activities represent the main driving forces that generates pressures on the environment, that is ever more fragile and sensitive to changes. The pressures determine impacts on both abiotic and biotic components, and their intensity solicits the environment to respond, transform and adapt itself [1].

Despite mining activities represent an important pillar for the economic development and competitiveness of a region, these are considered as very impacting on the environment during their life cycle and after their closure: soil erosion, water pollution, noise and vibrations, acid drainage [2], loss of soil ecosystem services are some significant effects of the shrinking of scarce resources [3, 4]. Despite the crisis that affected mining industry in recent years, that caused the closure of several quarries [5], this still play a very important role into the national and regional economy.

The latest report by SNPA [6] has given an overview of the current trends and possible future scenarios for limiting the impacts on the environment, according to the

© Springer Nature Switzerland AG 2020
O. Gervasi et al. (Eds.): ICCSA 2020, LNCS 12253, pp. 355–365, 2020.
https://doi.org/10.1007/978-3-030-58814-4_25

SD Goals targets [7]. The progressive transition toward a model of Circular Economy (CE) with the European Circular Economy package [8] is transforming the relations between economy and environment [9] with positive signals also in the mining industry. Grande and colleagues [10] have introduced the term of "Circular Mining" as adaptation of the circular economy paradigm to the mining industry, with the aim at promoting a novel concept of mining industry "technical feasible, economically profitable and environmentally sustainable".

Over the last years, a domain to regulate the planning of mining industry in a more efficacy and transparent way is emerged, in terms of release of mining grants, reopening of quarries, environmental recovery, relation with landscape, protected areas and so on. In Italy, the power on mining activities has been transferred to the regions through the D.P.R. no. 616/1977, D.lgs. no. 112/1998 and D.lgs no. 83/2012 [11–13], even if most of the regions have not yet provided a regional plan in the field. There are some regions that have adopted a regional plan of new generation in subject and/or that are moving for it. Piedmont Region has recently adopted the Regional Law no. 23/2016, that introduces the Regional Plan of Mining Activities (Piano Regionale delle Attività Estrattive - PRAE) to regulate the planning and management of the existing mining activities and the potential open of new sites and extensions, according to the sustainability and circular economy principles [14].

The adoption of a regional plan requires the procedure of Strategic Evaluation Assessment (SEA), for evaluating the possible impacts generated by the regional plan on environment and its components [15, 16]. The SEA procedure must favor a wide participation of actors and stakeholders, with different visions and expertises, and in this sense the use of decision aiding tools may help them to envision future scenarios for the activation of regional policies and actions [17, 18].

In this sense, the Multicriteria Decision Analysis (MCDA) has been retained a reliable supporting tool to be considered within the SEA procedure of the regional plan. Among the different MCDA methods, the present study proposes a methodological contribution based on the adoption of the Analytic Network Process (ANP) to investigate the relations between the objectives and strategies of the Regional Plan of Mining Activities, thus guiding the definition of the best sustainable scenario. In this way, the actors and stakeholders may easily identify the priorities to be traduced in actions that will be activated in the most sustainable scenario.

2 Methodology

As already said, MCDA has been widely recognized as a useful approach for supporting decision problems in various and different fields, e.g. environmental assessments, urban and territorial planning, being able to guide the decision-making process for achieving common planning goals, by considering multidimensional aspects and different points of view. The MCDA counts many applications that carried promising outcomes for environmental and social challenges [19, 20] regeneration of downgraded industrial areas [21] strategies for net-zero energy districts [22] landscape ecology and economics [23] urban resilience [24], urban development and design processes [25].

In the present research, the Analytic Network Process (ANP) has been proposed [26] because reveals particularly suitable for this type of decision problem. More in details,

the ANP model is considered an evolution of the simpler Analytic Hierarchy Process (AHP) because represents the decision problem as a network in which the elements of the problem are linked through interdependency relationships and at different levels [27]. In this research work, the network allows the exploration of the relations between strategies belonging to different objectives, thus aiding the evaluator to identify the direct and/or indirect effect determined by a strategy and the potential synergies with the connected ones for reaching shared regional goals. For these reasons, this application may carry an added value on the current knowledge and practice.

From the methodological point of view, the ANP requires a network structure to represent the problem, as well as pairwise comparisons to establish the relationships within the structure. To develop an ANP model, it is necessary to carry out five fundamental steps that can be described as follows:

1) Structuring of the decision-making process. This step involves defining the main objective of the evaluation and identifying groups or "clusters" constituted by various elements (i.e. nodes) that influence the decision, and alternatives or options from which to choose. The network model has been then structured through the software Superdecisions (http://www.superdecisions.com/);
2) Pairwise comparisons. In this phase pairwise comparisons are developed in order to establish the relative importance of the different elements, with respect to a certain component of the network. The comparisons are based on the use of a 1–9 points scale where the value 1 indicates equal importance between two elements, whereas the value 9 indicates that one element is extremely more important than the other;
3) Supermatrices formation. The third step consists of the progressive formation of three supermatrices: the initial or unweighted supermatrix, the weighted supermatrix and, finally, the limit supermatrix. The unweighted supermatrix contains all the eigenvectors that are derived from the pairwise comparison matrixes of the model. The eigenvector obtained from the cluster level comparison, with respect to the control criterion, is applied to the initial supermatrix as a cluster weight and the result is the weighted supermatrix. The supermatrix elements allow a resolution to be made concerning of the interdependencies that exist between the elements of the network;
4) Final priorities. In this step the weighted supermatrix is raised to a limiting power to converge and to obtain a long-term stable set of weights that represents the final priority vector;
5) Sensitivity analysis. The last step consists in carrying out the sensitivity analysis on the outcome of the model in order to test its robustness and to verify the stability of the results.

The 5 steps of the method will be detailed in the next section with reference to the application on the considered case study.

3 Application

The paper illustrates an ongoing study considering the application of a ANP model for the evaluation of the Regional Plan of Mining Activities of Piedmont Region. The

present application is based on a simulation of the real decision-making process in which an experts' panel for the evaluation of the network's elements in order to explore the suitability of the ANP approach, to support the definition of intervention priorities and the assessment of alternative planning scenarios. Following the methodology, the first step of the method is finalized to structure the decision problem and it is represented by the elements described below.

- Clusters: they represent the objectives introduced by the Regional Law of Piedmont no. 23/2016 (Table 1);
- Nodes: they represent the strategies considered by each objective. Given the high number of nodes, it has been retained useful in some clusters to merge those strategies considered as redundant. In Table 1, the symbol * means that the strategies belonging to the i-th objective have been merged for facilitating the experts in the comparisons. In fact, it is reasonable to evaluate at least 2 and maximum 8 strategies, for each objective, to prevent incoherent comparisons;
- Alternatives: they represent planning scenarios that must be evaluated at level of clusters and nodes. According to the literature in the context of scenario planning, experts normally use a recognizable set of scenarios, i.e. inertial, tendential and strategic scenarios that should consider the desiderata of actors and stakeholders involved into the process [28, 29]. In our case, we adapted the scenarios that have been identified by actors and stakeholders during the SEA scoping phase (see Table 2).

Figure 1 illustrates the structuring of the ANP model elaborated through the software Superdecisions.

Once having defined the elements of the network, it is possible to identify the relationships. These can be "external" when these occur between two or more elements of the network, and "internal" (i.e. loop), when relationships exist between nodes belonging to the same cluster.

Table 1. Objectives and strategies as cluster and nodes of the ANP model. (Elaboration from Regional Law Piedmont no. 23/2016).

Clusters (i.e. Objectives)	Nodes (i.e. Strategies)
a) Definition of guidelines for a correct balance between environmental values, such as territory, environment landscape, and the mining activity and the reference market.	8*
b) Protection and safeguard of the fields under cultivation, those recognized and the relative resources, considering mineral deposits and mining as primary resources for the socio-economic development of the territory.	6*
c) Valorization of cultivated materials through their integral use and adequate to their specific features.	6*

(*continued*)

Table 1. (*continued*)

Clusters (i.e. Objectives)		Nodes (i.e. Strategies)
d) Unification of the mining activities on the entire territory of the region.		4
e) Orientation of mining activities towards a better balance between industrial production and optimization of interventions for the purpose of recovering and valorizing deteriorated and disused sites.		8*
f) Promotion, protection and qualification of the work and business.		4
g) Facilitation of the recovery of inert aggregates coming from construction and demolition, as well as the use of inert recycling materials.		5
h) Insurance of monitoring mining activities.		3
i) Facilitation of environmental and economic synergies arising from interventions by arrangement and maintenance of river auctions and hydroelectric basins.		8
j) Indications for the supply of the materials required for the realization of public works.		7
Total	10	59

Table 2. Set of alternative scenarios considered in the ANP model.

Alternative scenarios	Description
1) Inertial scenario	It envisages the maintenance of the planning in force, applying the new provisions deriving from current regulations. No Regional Plan on mining activities is provided.
2) Limiting scenario	It is very preserving versus the environment and landscape and it limits the release of new authorizations, that could determine the closure of the existing mining activities.
3) Trend scenario	It envisages all the objectives of the Regional Law, balancing the needs between territorial values, mining activities and the reference market with the promotion, protection and qualification of work and businesses.

Subsequently, the pairwise comparison method is used to investigate the importance of the various network elements. In the present simulation, a questionnaire was proposed to a panel of experts with expertise on regional and urban planning and management of mining activities, asking them to evaluate pairwise the network elements at the clusters level and then at the nodes level. Moreover, the software allowed to the experts to evaluate coherently the network elements, thanks to the Consistency Ratio index (CR)

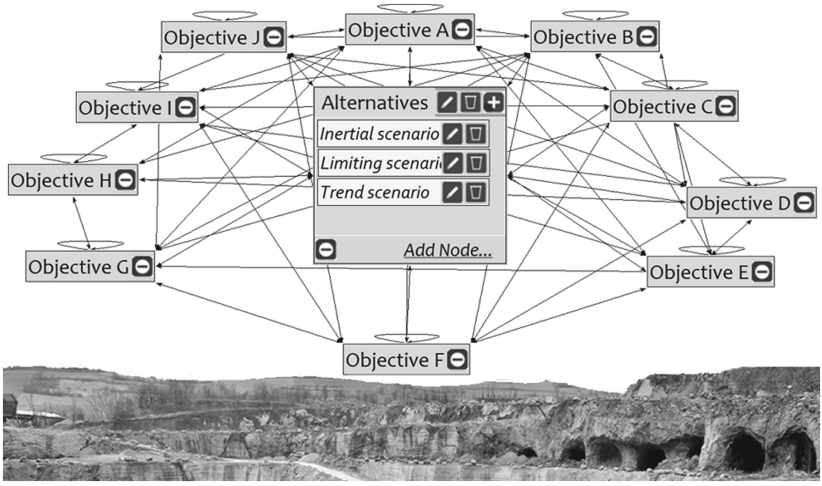


Fig. 1. Structuring of the objectives of the Regional Law 23/2016 according to the ANP model (Elaboration through Superdecisions software)

that ensures the comparisons be coherent and not contradictory. In fact, the comparisons are coherent when CR index is less or equal to 10%. As an example, Table 3 reports the comparison matrix derived from the comparisons of the strategies belonging to the objective D "Unification of mining activities on the entire territory of the region" with reference to the Trend scenario.

Table 3. Comparisons between the nodes in objective D with reference to trend scenario.

Nodes	d.1	d.2	d.3	d.4	Priorities
d.1 Give guidelines on the main opportunities for increasing the technology of the abatement techniques that may be used in the various types of mining activities in the region	1	4	1/5	1/3	0.13833
d.2 Give guidelines for the definition of actions related to the problems of stability of the excavation fronts, with reference to their conformation, in the meanwhile and at the end of the cultivation process	1/4	1	1/5	1/5	0.06075
d.3 Define the regional distribution of the mining activities of the three sectors, and in particular of the first one, whose activities are more diffused and less constrained for the mining distribution	5	5	1	2	0.49891
d.4 Verify the location of mining activities with respect to landscape components, cities and their development, natural protected areas and infrastructure systems	3	5	1/2	1	0.30201
	CR ratio:				0.07710

The experts comparisons were converted by Superdecisions as vectors and then it was possible to elaborate three supermatrices: 1) the initial supermatrix collects the vectors at node and cluster levels; 2) the weighted supermatrix aggregates both vectors of nodes and clusters; 3) the limit supermatrix multiplies these vectors for themselves until when the vectors became stable (see Fig. 2). In this way, it was possible to obtain the ranking of final priorities of the objectives and strategies considered in the planning process. Lastly, a sensitivity analysis on the ANP model was performed to test its reliability through the software function "ANP Sensitivity" on some strategies that revealed crucial for the present application [26].

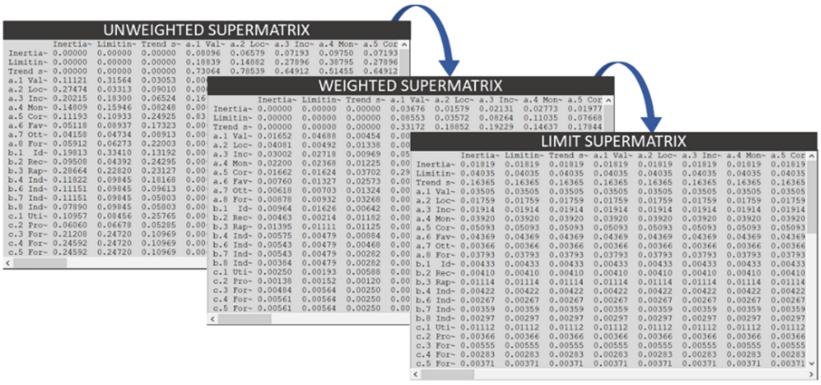


Fig. 2. Elaboration of the supermatrices to calculate the final priorities.

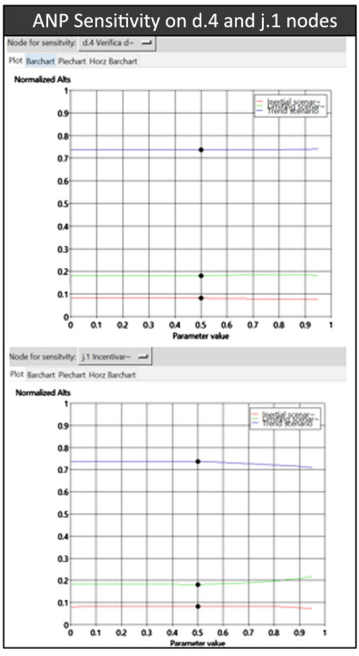
4 Discussion of Results

As shown in Fig. 3a, from the elaboration of the preliminary results coming for the methodological exploration, the ANP application is useful to identify some strategies emerged as relevant for the future policies of the region on mining activities. According to the obtained results, the valorization and safeguard of natural resources, such as the water bodies and ecosystems, play a transversal importance that must be considered by policy decisions (a.1); this may be achieved through a major sensitivity to the localization of new mining activities with respect to the environmental components (a.4.) and a more balanced regional planning between mining activities and other sectoral plans (e.g. Landscape Regional Plan or Waste Management Regional Plan) (a.5). Furthermore, it is important for mining activities to achieve the circular economy purposes (a.6.). These strategies reveal crucial in all considered scenarios. A suitable representation of those areas in that are located mining activities and the potential extension areas is the fundamental basis on which to base the cognitive analyzes of the regional territory (b.3) and it is closely related to the building of a regional infrastructure system that integrates various data sources (h.1.). The formulation of guidelines to favor an integral use of the resource in all phases of the extracting process (c.3), and to valorise and mantain the sawing sludge (c.4) may aid on one hand on the maximization of the performance of the resource and

on the other hand the reduction of processing costs. It is important to distribute mining sites at regional level and according to the three sectors (i.e. aggregates, industrial materials, ornamental stones) (d.3.), in coherence with the landscape components, cities, protected areas and infrastructures (d.4.). The creation of alternative solutions to new wells (e.3) and the progressive ecological recovery of brownfields habitats (e.4, i.4) look toward the zeroing of the land take in Piedmont region. A protocol of environmental sustainability for mining activities (f.1.) and the promotion of local materials may aid the competitiveness of the region (f.3.). The diffusion of alternative materials (g.1) and the progressive integration of certified recycled materials in the market (j.1.) may facilitate the recovery of aggregates deriving from demolitions and recycling processes; these strategies reveal very important for the Limiting scenario which may be incorporated also in the Trend scenario. The collaboration between the Departments of Regione Piemonte, with different expertises, in the development of analysis may support the estimation of treated materials in replacement of quarry materials (g.4.), thus contributing to reduce the impacts on environmental components. The evaluation of a work must consider the environmental benefits and the balance between construction costs and marketing revenues (i.7). It is important to favor the closeness to new works, in order to reduce CO_2 emissions and transport costs of materials on site (j.5); finally, the creation of synergies between public works may optimize the interchange of materials (j.6). All the mentioned strategies assume relevant importance as basis for the new plan.

Strategies	Normalized by Cluster	Limiting
a.1	0,142	0,035
a.4	0,159	0,039
a.5	0,206	0,051
a.6	0,177	0,044
a.8	0,153	0,038
b.3	0,337	0,011
c.1	0,371	0,011
c.3	0,185	0,006
d.3	0,373	0,020
d.4	0,423	0,023
e.3	0,185	0,011
e.6	0,141	0,008
f.1	0,334	0,015
f.3	0,281	0,013
g.1	0,256	0,024
g.4	0,266	0,025
h.1	0,526	0,059
i.4	0,163	0,006
i.7	0,211	0,007
j.1	0,283	0,020
j.5	0,184	0,013
j.6	0,212	0,015

a



b

Fig. 3. Relevant priorities derived from the limit supermatrix (a) and sensitivity analysis on some significative nodes (b).

Figure 3a reports the priorities of all strategies as resulting from the preliminary investigation illustrated in the present paper. The synthesis of the final priorities, will be performed in the real evaluation process. We give in Fig. 3c some plots of the sensitivity analysis that testify the stability of the results of the model.

5 Conclusions

The paper has illustrated the methodological application of the ANP model within the SEA procedure for the design of the regional plan on mining activities in Piedmont Region.

From the presented study, the ANP model has appeared as particularly effective to support the decision-making process in the assessment of future scenarios of plans and programs, thanks to its dynamic approach to define the various relations between objectives and strategies.

From a methodological point of view, the many comparisons, due also to the transversal relations of strategies, have implied an effort of the experts in this evaluation. In this sense, for the real application it could be useful to reduce further the number of strategies before the building of the ANP model, such as through a Multivariate Redundancy Analysis (MRA) [30].

The next step of this research work will be the involvement of real actors and stakeholders to validate the results obtained through the survey. Subsequently, a focus group will be organized for aiding the real actors and stakeholders to share the role and the importance of the objectives and strategies to orient the regional planning on mining activities toward the best sustainable scenario, thus enforcing the performance of the future plan.

The authors will implement the ANP model with GIS methods [31] to aid both actors and stakeholders to better visualize the final model's outputs. This integration could aid the decision makers for example to identify the suitable areas for the localization of new quarry activities as well as for the recovery of inactive mines; in this sense, the authors consider the role of geodatabases crucial as an opportunity to take this promising research path [18]. In addition, the authors will consider the Geo-Design methods [32] to facilitate actors and stakeholder to visualize the priority strategies in the region, thus envisioning shared scenarios to support the regional planning.

Acknowledgements. This work has been developed within the research project related to the Strategic Environmental Assessment of the Regional Plan for mining activities of Piedmont Region (Scientific Coordinator: Prof. Giulio Mondini, Interuniversity Department of Urban and Regional Studies and Planning, Politecnico di Torino).

References

1. Cutter, S.L.: Resilience to what? Resilience for whom? Geogr. J. **182**(2), 110–113 (2016)
2. Onwe, R., Abraham, E.: Environmental problems of surface and underground mining: a review. Int. J. Eng. Sci. (IJES) **4**(12), 12–20 (2015). ISSN 2319 – 1813
3. Millennium Ecosystem Assessment (MEA): Millennium ecosystem assessment ecosystems and human well-being: current state and trends assessment. Island Press, Washington

4. Baveye, P.C., Baveye, J., Gowdy, J.: Soil "ecosystem" services and natural capital: critical appraisal of research on uncertain ground. Front. Environ. Sci. **4**, 1–41 (2016). https://doi.org/10.3389/fenvs.2016.00041
5. Zanchini, E., Nanni, G. (eds.): Legambiente: Rapporto Cave. I numeri e gli impatti economici e ambientali delle attività estrattive nel territorio italiano. Le opportunità e le sfide nella direzione dell'economia circolare (2017) https://www.legambiente.it/sites/default/files/docs/rapporto_cave_2017.pdf. Accessed 01 Mar 20
6. Sistema Nazionale per la Protezione dell'Ambiente (SNPA). Rapporto Consumo di suolo, dinamiche territoriali e servizi ecosistemici (Report on Land take, territorial dynamics and ecosystem services) (2019). https://www.snpambiente.it/2019/09/17/consumo-di-suolo-dinamiche-territoriali-e-servizi-ecosistemici-edizione-2019/. Accessed 01 Mar 20
7. United Nations: Transforming Our World: the 2030 Agenda for the Sustainable Development (2015). https://www.unric.org/it/images/Agenda_2030_ITA.pdf. Accessed 01 Mar 20
8. European Commission: Closing the loop - An EU action plan for the Circular Economy, Com (2015) 614 communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. European Commission, Brussels (2015). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614. Accessed 01 Mar 20
9. Pearce, D.W., Turner, R.K.: Economics of Natural Resources and the Environment. Johns Hopkins Press, Baltimore (1990)
10. Grande, J.A., et al.: The paradigm of circular mining in the world: the Iberian Pyrite belt as a potential scenario of interaction. Environ. Earth Sci. **77**(10), 1–6 (2018). https://doi.org/10.1007/s12665-018-7577-1
11. D.P.R. no. 616/1977. Attuazione della delega di cui all'articolo 1 della legge 22 luglio 1975, n. 382. http://legislature.camera.it/_bicamerali/questreg/norme/dpr616.htm. Accessed 01 Mar 20
12. Parlamento Italiano: D.lgs. no. 112/1998, Conferimento di funzioni e compiti amministrativi dello Stato alle regioni ed agli enti locali, in attuazione del capo I della legge 15 marzo 1997, n. 59. Gazzetta Ufficiale n. 92 del 21 aprile 1998 - Supplemento Ordinario n. 77. http://www.parlamento.it/parlam/leggi/deleghe/98112dl.htm. Accessed 01 Mar 20
13. Parlamento Italiano: D.lgs 83/2012, Misure urgenti per la crescita del Paese
14. Regione Piemonte: Legge regionale n. 23 17 novembre 2016, Disciplina delle attività estrattive: disposizioni in materia di cave (2016). http://arianna.consiglioregionale.piemonte.it/. Accessed 01 Mar 20
15. European Commission: Directive 2001/42/EC of the European Parliament and of the Council on the Assessment of the Effects of Certain Plans and Programmes on the Environment, Brussels (2001)
16. Dlgs 152/2006 – Testo Unico Ambiente http://www.isprambiente.gov.it/it/garante_aia_ilva/normativa/normativa-ambientale/Dlgs_152_06_TestoUnicoAmbientale.pdf. Access 01 Mar 20
17. Bottero, M., Mondini, G. (eds.): Valutazione e sostenibilità. Piani, programmi, progetti, Celid, Torino (2009)
18. Bottero, M.C., Polo Pérez, I., Taddia, G., Lo Russo, S.: A geodatabase for supporting planning and management of mining activities: the case of Piedmont Region. Environ. Earth Sci. **79**(4), 1–12 (2020). https://doi.org/10.1007/s12665-020-8815-x
19. Bottero, M., Ferretti, V., Pomarico, S.: Assessing different possibilities for the reuse of an open-pit quarry using the Choquet integral. J. Decis. Anal. **21**(1–2), 25–41 (2014)
20. Mondini, G.: Integrated assessment for the management of new social challenges. Valori Valutazioni **17**, 15–17 (2016)

21. Becchio, C., Bottero, M., Corgnati, S.P., Dell'Anna, F.: A MCDA-based approach for evaluating alternative requalification strategies for a net-zero energy district (NZED). In: Zopounidis, C., Doumpos, M. (eds.) Multiple Criteria Decision Making. MCDM, pp. 189–211. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-39292-9_10
22. Bottero, M., Caprioli, C., Berta, M.: Urban problems and patterns of change: the analysis of a downgraded industrial area in Turin. In: Mondini, G., Oppio, A., Stanghellini, S., Bottero, M., Abastante, F. (eds.) Values and Functions for Future Cities. GET, pp. 385–401. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-23786-8_22
23. Assumma, V., Bottero, M., Monaco, R., Soares, A.J.: An integrated evaluation methodology to measure ecological and economic landscape states for territorial transformation scenarios: an application in Piedmont (Italy). Ecol. Indicat. **105**, 156–165 (2019). https://doi.org/10.1016/j.ecolind.2019.04.071
24. Bottero, M., Datola, G., Monaco, R.: Exploring the resilience of urban systems using fuzzy cognitive maps. In: Gervasi, O., et al. (eds.) ICCSA 2017. LNCS, vol. 10406, pp. 338–353. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-62398-6_24
25. Dell'Ovo, M., Oppio, A.: Bringing the value-focused thinking approach to urban development and design processes: the case of Foz do Tua area in Portugal. Valori Valutazioni **23**, 91–106 (2019). ISSN 20362404
26. Saaty, T.L.: Decision making—the analytic hierarchy and network processes (AHP/ANP). J. Syst. Sci. Syst. Eng. **13**, 1–35 (2004). https://doi.org/10.1007/s11518-006-0151-5
27. Bottero, M., Lami, I., Lombardi, P.: Analytic Network Process. La valutazione di scenari di trasformazione urbana e territoriale. Alinea Editrice, Firenze (2008)
28. Godet, M.: The art of scenarios and strategic planning: tools and pitfalls. Technol. Forecast. Soc. Change **65**, 3–22 (2000)
29. Amer, M., Daim, T.U., Jetter, A.: A review of scenario planning. Futures **46**, 23–40 (2013). https://doi.org/10.1016/j.futures.2012.10.003
30. Whitley, B.E., Kite, M.E. (eds.): Principles of Research in Behavioral Science. Routledge, New York (2013). ISBN 978-0-203-08521-9
31. Malczewski, J., Rinner, C. (eds.): Multicriteria Decision Analysis in Geographic Information Science. Advances in Geographic Information Science. Springer, Heidelberg (2015). https://doi.org/10.1007/978-3-540-74757-4
32. Steinitz, C.: A Framework for Geodesign: Changing Geography by Design. ESRI Press (2012)