Seminar on

Multi-Criteria Decision Making Application in Urban and Regional Sustainability

BOOK OF ABSTRACTS

September 11-13, 2023

Politecnico di Milano

Via Giuseppe Colombo, 40, Milano, Italy

The seminar is organized within the context of the UR-DATA – Twinning for Excellence in Smart and Resilient Urban Development: Advanced Data Analytics Approach – project, and its main focus is the Multi-Criteria Decision Making (MCDM) application in urban sustainability assessment. Some of the topics covered are: (i) measuring sustainability in urban and regional contexts, (ii) Decision Support Systems in urban and regional sustainability problems, (iii) urban and regional sustainability assessment, (iv) Multi-Criteria Analysis in natural risk management, (v) Multi-Criteria Analysis in inclusive/participative decision making.

The aim of the seminar is both to share results and to connect with other experts in order to plan further research and publications.

Organizing Committee

Marta GALLIANI (Poliedra-Politecnico di Milano, Italy)

Alessandro LUÈ (Poliedra-Politecnico di Milano, Italy)

Simona MURATORI (Poliedra-Politecnico di Milano, Italy)

Scientific Committee

Marta BOTTERO (Politecnico di Torino, Italy)

Alberto COLORNI (Poliedra-Politecnico di Milano, Italy)

Peter NIJKAMP (Open University, Heerlen, Netherlands)

Alessandra OPPIO (Politecnico di Milano, Italy)

John ÖSTH (OsloMet, Oslo, Norway)

Jason PAPATHANASIOU (University of Macedonia, Thessaloniki, Greece)

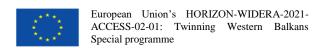Pavle PETROVIĆ (Serbian Academy of Science and Arts, Serbia)

Aura REGGIANI (University of Bologna, Italy)

Carlo SESSA (ISINNOVA, Rome, Italy)

Jelena J. STANKOVIĆ (University of Niš, Serbia)

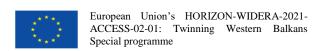Alexis TSOUKIAS (Paris Sciences & Letters University, France)

Seminar Program

Methodological frontiers of MCDM

Python based implementations of Multiple Criteria Decision Aid methods: a comprehensive approach

Jason Papathanasiou

University of Macedonia, Thessaloniki, Greece
Email: jasonp@uom.edu.gr

Multiple Criteria Decision Aid (MCDA) is an applied branch of the OR discipline that continues to grow today with an increasing number of publications every year. Such methods have been successfully applied to all possible domains and many variations of these methods there have been developed during the course of the last decades. There are many software packages available for MCDA, however most of them are proprietary software that do not fall in the free and open software category and as such are not fully available to many researchers. Python on the other hand is a robust computer language that is widely used and well known for it relatively easy learning curve that suits the academic perspective. In addition, Python is free; it has a wide variety of libraries on all topics of scientific interest; the code is clean and easily read by the non fully familiar programmer and is expected to continue developing for many years to come. Implementing an MCDA method in a language like Python offers many advantages; it helps researchers understand each step of the various methodologies with their quirks and perks; choose the data input wisely; create a proper conceptual model and at the very end check the results and interpret them correctly.

Key words: *Multiple Criteria Decision Aid, MCDA, Python*

Mobility issues

Multi-Criteria Life-Cycle Assessment of Local Public Transport fleets renewal

Pierluigi Coppola[1], Marco Bocciolone[1], Emanuela Colombo[2], Francesco De Fabiis[1]

[1] Department of Mechanical Engineering, Politecnico di Milano, Italy
Email: pierluigi.coppola@polimi.it, marco.bocciolone@polimi.it, francesco.defabiis@polimi.it
[2] Department of Energy, Politecnico di Milano, Italy
Email: emanuela.colombo@polimi.it

Among the strategies to achieve the goal of transport decarbonization, national and local government have been funding the renewal of local public transport (LPT) fleet through either the acquisition of new clean vehicles or the introduction of advanced clean (bio-)fuels. In order to optimize the investment over time and avoid undesirable indirect counter-effects, such policies need to be assessed ex ante and duly planned.

In this paper, a methodology based on a life-cycle assessment of (investment, maintenance and operating) costs and (global and local) environmental impacts is proposed to identify suitable pathways for renewal of the existing bus fleet, in the medium and long term. Using a multicriteria decision matrix, different a-priori scenarios are compared, seeking for non-dominated ones with respect to financial and environmental sustainability criteria.

The methodology has been applied to the case of the Como, Lecco, and Varese provinces (with about 860 operating buses, almost all equipped with diesel engines and operating in both the urban and the ex-urban context). In the urban context, the study has shown that the "full-battery-electric" scenario has the lowest environmental impact since there are zero tailpipe emissions and greenhouse gases are lower than all the other transition scenarios. For the ex-urban service (characterized by medium- and long-distance routes), a "full-battery-electric" scenario is not yet feasible, considering that long-range electric buses having sufficient battery autonomy to guarantee efficient operations in these contexts are not yet widely available. Liquefied natural gas-powered and hybrid electric vehicles would be other options for decarbonising ex-urban LPT, but their life-cycle impacts should be considered with care.

Implementing New Bike-Sharing Stations in Urban Areas: a Multi-Criteria Approach

Michele Rabasco, Caterina Malandri, Roberto Patuelli, Aura Reggiani, Rebecca Rossetti

Department of Economics, University of Bologna, Italy
E*mail: michele.rabasco2@unibo.it, caterina.malandri2@unibo.it, roberto.patuelli@unibo.it, aura.reggiani@unibo.it, rebecca.rossetti2@unibo.it*

Bike-sharing systems are attracting considerable interest in the literature for their potential key role in encouraging the transition from car-based private transportation to more sustainable mobility.

This paper aims to guide decision-makers in solving the problem of choosing the most suitable places – in urban areas – to implement new bike-sharing stations. Since that is an optimization problem, we use multi-criteria analysis (MCA) to provide a ranking of possible alternative locations.

The set of alternatives considered is a subset of public transportation stations where bike-sharing is not provided. The hypothesis behind this choice is that, given the complementarity between public and shared transportation, implementing new bike-sharing stations near public transportation stations would promote the use of bike-sharing.

The criteria considered are derived from the literature (Bahadori et al. 2021). Among them, there is the structure of the bicycle network (number of stations, network capacity, etc.) and the city structure (city size, points of interest, active population, etc.).

The contribution of this paper is including in the analysis a feature that has been less studied in the bike-sharing literature, i.e., its ability to promote urban transportation robustness.

The potential of bike-sharing in promoting the robustness of a transportation network is relevant in the case of disruptive events. We focus on the robustness of urban public transport networks, in structural terms (network properties and travel times) and in terms of passenger use (Zhang et al., 2019).

The scenarios were identified by a group of experts on the topic of sustainable mobility as part of the SmartHubs project.

To illustrate our approach, we apply MCA to some suburban districts in the cities of Vienna, Austria, in which there is a lack of bike-sharing stations.

This case study represents a prototype for further applications to different cities in the European Union.

Key words: Bike-sharing, Robustness, Network, Multi-criteria, Public Transport

Accessibility Indices as a Decision Support Tool in Land-use Planning
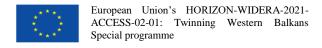
Eirik Melå Skjelsvik

Department of Architecture and Planning, Faculty of Architecture and Design, Norwegian University of Science and Technology, Trondheim

A central idea in the literature on urban form and travel behavior is that urban land-use characteristics, such as the distribution, density and distance between housing and urban opportunities, influences peoples travel behavior. By extension, residential areas with different accessibility profiles will have varying potential for sustainable travel behavior. The concept of accessibility provides a unifying concept for analyzing and communicating the interlinkages between land-use characteristics and transport. At the same time as the concept has gained widespread interest among academics, it is still a significant gap in applying accessibility as a tool that can guide policymakers in land-use planning practice.

The goal of this paper is to develop an accessibility-based decision-support method that can be used in spatial planning to prioritize areas for residential development that has a high potential for environmentally friendly-travel behavior. By utilizing highly detailed population data and a geocoded version of the Norwegian Business Entity registry at the address level, the paper develops and tests the accessibility-based decision support method in two Norwegian urban regions with different urban structures. The two regions are the monocentric Trondheim region and the polycentric region of Stavanger-Sandnes.

The method developed in the paper builds on repeated cumulative accessibility measurements with walking, bicycling and public transport to the most important destinations in the Norwegian Travel Habit Survey with a cut-off value of 10, 20 and 30 minutes for walking, bicycling and public transport respectively. Based on the proportion of trips to the different destinations and depending on the characteristics of the activities, notably if it is the number of activities that matters from a travel behavior perspective or if it is the distance to the closest service that matters, the paper develops a system for weighting accessibility to different types of destinations into integrated mode-specific maps for walking, bicycling and public transport accessibility. Next, the paper combines the weighted mode-specific maps in two composite indices, one for local accessibility to activities and one for regional accessibility to activities. The two indices are finally combined into a final normative decision-support map for residential developments for the two urban regions that can be used by policymakers to guide new residential developments to highly accessibility areas with a potential for environmentally friendly travel behavior.

Quality of life and smartness

Quantifying Smartness and Urban Development in European Cities

Ivana Marjanović, Žarko Popović

University of Niš, Faculty of Economics, Niš, Serbia
Email: ivana.veselinovic@eknfak.ni.ac.rs, zarko.popovic@eknfak.ni.ac.rs

In contemporary contexts, urban areas have emerged as primary drivers of economic expansion and affluence. The rapid and extensive proliferation of urban centers over recent decades has given rise to a critical concern regarding their durability, coupled with escalating issues concerning infrastructural, ecological, and societal dimensions. In response, the concept of smart cities has emerged as a prospective solution, aiming to bolster the competitive edge of local communities and urban zones. This is achieved through the strategic implementation of pioneering technological innovations, orchestrated to enhance the quality of life for citizens by optimizing public services and cultivating a more salubrious environment.

The principal objective of the present study entails a comprehensive evaluation and classification of European cities, contingent upon indicators that gauge their adeptness in both the smart city paradigm and urban advancement. To achieve this, an analytical framework is devised, drawing upon data procured from four successive iterations of Eurostat's Urban Audit Perception Survey, spanning the temporal expanse from 2009 to 2019. The dataset encompasses perceived urban performance metrics, as assessed by residents domiciled within these urban agglomerations. This evaluative schema encompasses multifaceted dimensions of urban sustainability and development, encompassing economic, social, environmental, and governance facets.

Notably, citizens' perceptions of the quality of life within their respective urban environs are deemed invaluable informational substrates. This primary data source serves as the bedrock upon which targeted enhancements in urban performance are predicated, particularly in domains perceived as deficient by inhabitants.

To underpin the scrutiny of diverse attributes germane to urban performance, a composite model embracing multiple criteria is engendered. The construction of this model integrates entropy analysis to ascertain the relative weights of these criteria. This amalgamation is complemented by the application of VIKOR (VIšeKriterijumska Optimizacija I Kompromisno Rešenje), a multi-criteria optimization and compromise solution methodology, to facilitate the ranking of cities. Respondents' subjective inclinations are captured through a quantified interpretation of their responses, marked on a 4-point Likert scale. This quantification of qualitative data substantiates the analytical processes.

The instantiated multi-criteria model in this scholarly discourse encompasses a diversified assemblage of 28 discrete criteria, each bearing approximate commensurate significance. These criteria are methodically organized into six overarching categories. The study encompasses a dynamic sample set, with the number of European cities under observation spanning from 73 to 111, contingent upon the sample sizes inherent to each research iteration.

The culminating outcomes of the ranking exercise are presented visually, providing insights into the geographical locales within Europe where residents perceive the highest echelons of smartness and sustainable urban evolution. A pivotal observation emerging from this research is the preponderance of Western European cities, predominantly concentrated within the United Kingdom, amid the upper echelons of the ranking. It is pertinent to acknowledge that, apart from a select few such as Vienna, Luxembourg, Copenhagen, and Stockholm, the remaining scrutinized capitals do not consistently feature within the top decile across the observed years.

Key words: MCDM, urban perceptions, entropy, VIKOR, sustainable urban development

A multidimensional profile assessment of stellar cities by means of DEA modeling

Peter Nijkamp[1], Karima Kourtit[1], Soushi Suzuki[2]

[1]Open University, Heerlen, The Netherlands
[2]Hokkai-Gakuen University, Sapporo, Japan
E*mail: pnijkamp@hotmail.com, Ek_kourtit@hotmail.com, soushi-s@lst.hokkai-s-u.ac.jp*

Asia hosts several mega-cities with great economic power, which are often in a mutual competitive relationship. Despite smart specialisation and heterogeneity on national and global markets, they are often in pursuit of the highest possible socio-economic outcome so as to outperform their peers in this dynamic region. The present study seeks to present an operational comparative framework for judging the complex performance of several (12) large urban agglomerations in Asia. In the framework of this paper, these cities are called '*stellar cities*'. Two particular research challenges are addressed: (i) the development and application of a new Data Envelopment Analysis (DEA) approach, culminating—after a cascade of sequential analytical steps—in an Autoconfiguration Target Model which serves as a quantitative statistical tool for evaluating the (relative) multidimensional goal-oriented performance of the cities concerned; and (ii) a new functional interpretation of the DEA slack space for the possible improvement of inefficiently operating cities on the basis of Amartya Sen's capability theory. In the paper, we use an extensive database on 12 Asian stellar cities, extracted from the annual Global Power City Index (GPCI) system which contains more than 60 urban performance indicators, which has been constructed by the Institute of Urban Strategies (Tokyo). We find that the performance ranking of these Asian mega-cities shows the 'winners', but also a high variability, with several positive and negative outliers. We conclude that there is clearly scope ('capability') for further improvement of the efficiency of most Asian cities in various specific policy domains, as shown by the DEA results.

Key words: Stellar cities, Data Envelopment Analysis (DEA), Super-Efficiency, Distance Friction Minimization, Target-Oriented DEA, Fixed Factor Model, Autoconfiguration Target Model, multidimensional goal-oriented performance

Data exchange

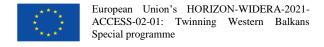# E015 Data Space enabling Multi-Stakeholders Data Exchange to improve Sustainability

Emiliano Sergio Verga, Michele Bonardi, Marco Rocco

Cefriel – Politecnico di Milano, Italy
Email: emiliano.verga@cefriel.com, michele.bonardi@cefriel.com, marco.rocco@cefriel.com

Sustainability improvement needs the adoption of various digital solutions, both to promote behavioural change of citizens, and to support institutions in making decisions. All these digital solutions should be realized by public and private players, and need to be fed by real-time data, coming from other players: it is important to promote and manage many-to-many data exchange, preserving every single player data sovereignty. E015 is a multi-years institutional Data Space of Lombardy Region Government, that, according to a common legal and organizational framework, enables the publication and request for use of data flows by public and private players. E015 has enabled more than 560 data exchange relationships, and it is successfully adopted to monitor and improve sustainability; for example, environmental data exchange enabled by E015 improves dams' safety or mitigates pollution related to agriculture activities. E015 is widely adopted in mitigating natural risk: civil protection alerts data are integrated on the websites of municipalities to inform citizens, or the same data are used by institutions to monitor glaciers. Electric mobility strategic planning by Lombardy Region Government is performed with a data-driven approach, based on E015: Charge Point Operators (CPO) give access to data related to the charging infrastructure they manage, to support the Public Administration in evaluating sustainability indicators and identifying where new infrastructures need to be financed. CPOs are engaged as data providers and the clauses requesting the publishing of data within the E015 Data Space are directly added to public tenders, with no additional costs for the Public Administration in leveraging data from companies. E015 successful model has been adopted also on other scale levels: for example, it is implemented to make Malpensa Cargo supply chain more efficient, or within the DXM – Data eXchange Marketplace – of the MIND Milano Innovation District, to foster innovation and coopetition between tenants.

Key words: *Data Space, Data Sovereignty, Civil Protection, Electric Mobility, Smart Sustainable District*

Sustainability

Flood damage assessment and mapping: the MOVIDA project

Alberto Colorni[1], Daniela Molinari[2], Simona Muratori[1], Paola Tresca[1]

[1]*Poliedra-Politecnico di Milano, Italy*
Email: alberto.colorni@polimi.it, simona.muratori@polimi.it, paola.tresca@polimi.it
[2]*Department of Civil and Environmental Engineering (DICA), Politecnico di Milano, Italy*
Email: daniela.molinari@polimi.it

MOVIDA is the Italian acronym for *Modello per la Valutazione Integrata del Danno Alluvionale*, i.e. model for the integrated assessment of flood damage. The objective of the MOVIDA project was to provide−in accordance with The European Floods Directive (2007/60/EC)−an Information System able to perform an analytical evaluation and mapping of the expected damage in the Po River District, overcoming the limitations of previous maps, where the evaluation of risk remained highly qualitative and subjective. Proper damage assessment tools were identified for the five macro-categories of exposed elements included in the Floods Directive: population, infrastructures (roads and railways, strategic buildings), environment and cultural heritage, economic activities, hazardous installations.

In this work, we present the Multi Criteria Analysis methodology we used to compute and visualize on a map through a GIS the expected damage in the considered areas, according to color classes representing different levels of expected damage. The damage assessment was synthesized into four main attributes: Monetary damage, Exposed people, Damage to cultural heritage, Damage to transport network. Subsequently, the Electre Tri rating methodology was employed to assign each territorial unit (census geographic unit) to a class of expected damage. To determine the weights of the different attributes, that reflect the value system of the decision maker, 16 experts were interviewed through a questionnaire. An analysis was conducted to investigate the sensitivity of the results to variations in the weights, showing that in most Territorial Units the classification is quite robust.

Key words: *flood damage, multi criteria analysis, Electre Tri, sensitivity analysis*

Multiobjective analysis of the impact of agro farming on air quality and GHG emissions in the Po Valley

Michele Francesco Arrighini[1], Apu Basak[2], Claudio Carnevale[2], Giorgio Guariso[3], Andrea Tonola[2], Laura Zecchi[1], Marialuisa Volta[2]

[1]*Dipartimento di Ingegneria dell'Informazione, Università degli Studi di Brescia, Italy. Email: m.arrighini007, laura.zecchi@unibs.it*

[2] *Dipartimento di Ingegneria Meccanica e Industriale, Università degli Studi di Brescia, Italy. Email: a.basak, claudio.carnevale, andrea.tonola, marialuisa.volta@unibs.it*

[3]*Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano, Italy. Email: giorgio.guariso@polimi.it*

The Po basin area is well-known for its high levels of air pollution, mainly fine particulate matter (PM2.5), which comprises secondary fractions produced by precursor gases. A relevant portion of such precursors are emitted by intensive livestock farming and industrial agriculture which also produce climate-altering gases like methane (CH_4) and nitrous oxide (N_2O).

A multiobjective problem is defined to identify efficient policies to improve air quality at the lowest possible emission reduction cost. The air quality is encapsulated into a single index representing the annual average of PM2.5 over the entire domain of Northern Italy, strictly related to human health damages.

The solution of such a multiobjective problem is made possible by using a surrogate model to estimate the variation of PM2.5 concentration for different emission reduction decisions. This study uses neural networks to represent such a link in a computationally efficient way. The neural networks were trained using a set of emission scenarios simulated with the CAMx deterministic chemical-transport model.

The multiobjective problem is solved under different settings. We first assume that emission reduction measures pertain only to the agricultural sector, and then that they can be coupled with energy and technical measures in all sectors. Additionally, PM2.5 concentrations can be transformed into health damage to the resident population and summed to the value of reduced GHG emissions to provide a full estimation of external costs.

The results of the study highlight the significant impact of the agricultural and livestock sectors in the Po Valley and the importance of including the related policies in developing local air quality and carbon emission reduction plans.

Key words: Air quality, Agriculture, Particulate matter, Integrated modelling, Surrogate models

A spatial composite index for landscape strategic assessment

Sebastiano Barbieri, Caterina Caprioli, Marta Bottero

Interuniversity Department of Regional and Urban Studies and Planning, Politecnico di Torino, Italy
Email: sebastiano.barbieri@polito.it, caterina.caprioli@polito.it, marta.bottero@polito.it

Landscape is a multifaceted issue that involves not only ecological but also environmental, social and economic values, and the presence of different actors (public government representatives, planners, citizens, developers and owners). In this context integrated approaches are required for supporting landscape planning, design and management. Moreover, when dealing with landscape systems, the analysis of the geographical patterns of the elements under investigation plays a fundamental role.

The paper proposes an innovative approach for supporting landscape strategic assessment based on the integration of Geographic Information Systems (GIS) and a specific Multicriteria Analysis technique, named Analytic Hierarchy Process (AHP). Starting from a real case related to the Landscape Plan of Piedmont Region, the present paper considers the construction of a composite spatial index based on the combination of several indicators, such as soil consumption, hydrogeological risk, naturalness, to name a few. The contribution illustrates the development of the evaluation procedure and the final results in terms of synthetic maps able to visualize the outcomes of the analysis and to monitor landscape transformation over time; furthermore, the synthetic maps can be helpful for easing the communication with the different stakeholders involved in the decision-making process related to the definition and assessment of future development strategies for landscape development and management.

MCDM to assess municipalities' inclination to heritage-based development processes in inner areas

Marco Rossitti[1], Francesca Torrieri[2]

[1]*Department of Architecture and Urban Studies (DAStU) – Politecnico di Milano, Italy. Email: marco.rossitti@polimi.it*
[2]*Department of Architecture, Built Environment and Construction Engineering (DABC) – Politecnico di Milano, Italy. Email: francesca.torrieri@polimi.it*

The Covid-19 pandemic has forced reflection on the leading urbanization model's limits and placed greater attention on marginal areas' role. In Italy, the related scientific and media debate has focused on the territorial dimension of inner areas. Since 2014, these territorial realities have represented the target of an innovative national cohesion policy to tackle depopulation and the ongoing shrinking dynamics: the National Strategy for Inner Areas (SNAI). Indeed, Italian inner areas are endowed with extraordinary natural capital and are based on settlement models far from urban density. Thus, they seem to respond perfectly to the newly raised living needs.

However, leaving aside the optimistic rhetoric, strong political and administrative choices are necessary to trigger a 'return process' based on this wider attention towards inner areas, thus countering humankind's natural tendency to concentrate in urban realities.

In this light, the contribution proposes a tool, based on MCDM, to support decision-makers in the SNAI domain in understanding municipalities' inclination to undergo heritage-based development processes as a precondition to effectively promote the conservation and enhancement of inner areas' under-used built heritage. After a critical reading of the new challenges for planning posed by the pandemic and SNAI's role within them, the contribution moves to frame the decision support tool, focusing on inner areas' specificities. Finally, the tool's application to a case study, an inner area in Campania Region, allows to outline and discuss its possible benefits to SNAI implementation and its limits, as well as its integration possibilities with other methodologies from an inclusive and participative perspective toward decision-making.

Key words: MCDM, Decision support tool, Local development, Inner areas, Built heritage

A methodological framework to assess Nature-Based Solution (NBS) through Multicriteria Analysis (MCA)

Giulia Datola, Alessandra Oppio

Department of Architecture and Urban Studies (DAStU), Politecnico di Milano, Italy.
E-mail: giulia.datola@polimi.it, alessandra.oppio@polimi.it

Urban and territorial systems are exposed to multifaceted and multidimensional shocks and stresses, both natural and man-made. Various policies and actions have been undertaken at different levels from international to national (National Recovery and Resilience Plan) to find tangible solutions to make cities, territorial systems, and communities able to respond and resist such pressures. Nature-Based Solutions (NBS) have gained great relevance and interest, among different actions.

NBS are currently implemented in urban and territorial systems to address and solve multifaceted issues concerning social, environmental, and economic dimensions. Therefore, NBS design and implementation are both a challenge and an opportunity to overcome multidimensional aspects. According to this interest, an important task has to be fixed, or rather, the necessity of the appropriate assessment tool able to evaluate NBS according to their complexity and multidimensional challenges of implementation, to properly support the decision process. In the literature, Multicriteria Analysis (MCA) are widely explored and applied to address complex and multidimensional decision process. However, the application of MCA for NBS strategies assessment is quite limited.

This research aims at proposing a methodological framework to assess NBS strategies through MCA. Firstly, this contribution provides a set of multidimensional criteria, concerning society, environment, and economic dimensions. Secondly, the research proposes the application of the Simple Multi-Attribute Rating Technique Extended to Ranking (SMARTER) method to rank different criteria. This application aims at addressing and testing SMARTER effectiveness and suitability to assess the importance of multidimensional criteria, in order to support and facilitate a participatory and multidimensional evaluation process for NBS implementation strategies.

Key words: *Nature-Based Solutions (NBS), Multicriteria Analysis, SMARTER, Indicators, National Recovery and Resilience Plan*

A multidimensional evaluation framework to assess the Ecosystem Services provided by green roofs

Alessandra Oppio[1], Caterina Caprioli[2], Marta Dell'Ovo[1], Marta Bottero[2]

[1] *Department of Architecture and Urban Studies (DAStU), Politecnico di Milano, Italy.*
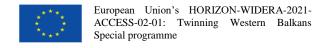*Email: alessandra.oppio@polimi.it, marta.dellovo@polimi.it*
[2] *Interuniversity Department of Regional and Urban Studies and Planning, Politecnico di Torino, Italy.*
Email: caterina.caprioli@polito.it, marta.bottero@polito.it

Ecosystem Services (ES) have been defined as the benefits that humans derive from nature (Millennium Ecosystem Assessment - MEA, 2005), including food, fibre and fuel provision, climate regulation, air and water purification, flood protection, soil formation, nutrient cycling, recreation benefits, to name a few. The notion "ecosystem services" has pointed out its role in reinforcing the societal value of nature's and landscape's functions and nowadays are at the centre of green cities' policies and strategies tackling the challenges of sustainability. In Europe, in fact, more than 70% of the population is already living in urban areas, and this number is still rising. Within this context challenges for sustainable development will be more concentrated in cities and urban green spaces since considered as having an essential role in contributing to policy objectives for sustainable urban development, such as improving public health, preserving biodiversity, reinforcing social cohesion, supporting the economy, providing opportunities for recreation and helping cities adapt to a changing climate. Landscaping rooftops and courtyards are some of the strategies for creating new natural spaces and increasing the presence of green infrastructures in the cities. The present contribution aims at evaluating green roofs according to an ecosystem perspective, by considering the evidence of their benefits on inhabitants' wellbeing, their ability to mitigate climate change and to preserve biodiversity. An integrated evaluation model is proposed to take into account the different dimensions of value in the study of Ecosystem Services (ESs) and to support decision makers (DMs) in the definition of actions able to increase the quality of life in cities. The proposed methodology evaluates the biophysical and economic values provided by ESs, by integrating cost-based (initial, maintenance and operating costs) and value-based approaches (socio-cultural values through Multicriteria Decision Analysis). The integrated framework is applied for the analysis of the overall values produced by a project of a green roof in the city of Turin (Italy).

Key words: Ecosystem Services, Green roofs, Integrated evaluation model, Cost-based, Value-based

Mapping and Bundling Ecosystem Services for Spatial planning with the AHP technique. A Case-Study in Tuscany (Italy)

Massimo Rovai[1], Tommaso Trinchetti[2], Francesco Monacci[2]

[1] Department of Civil and Industrial Engineering (DICI), University of Pisa, Italy.
Email: massimo.rovai@unipi.it
[2] Department of Agricultural, Food and Agro-Environmental Sciences (DAFE), University of Pisa, Italy

Agricultural and forest ecosystems provide multiple ecosystem services (ESs) fundamental to the well-being and quality of life of citizens. However, in the European context, these ecosystems are often threatened by processes of urban development, around cities, or abandonment, in mountainous or remote areas. Faced with the need for solutions oriented towards greater sustainability and resilience of socio-ecological systems, planning should contribute to rebuilding more integrated and mutually beneficial relationships between urban and rural areas, ensuring the effective production of multiple ESs. The regulation and management of ESs are complex and require scientifically sound and widely understandable policies and governance models, based on detailed assessment methods. The availability of spatially explicit information is particularly important in the design and implementation of plans and policies for ES management. Many approaches and methods for mapping ESs have been developed, ranging from the simple use of land use and land cover (LULC) maps to dynamic process-based models. We propose a method for mapping the supply of five ESs produced in agricultural and forest areas, based on the processing of open-source territorial data through the analytic hierarchy process (AHP), and tailored for the Tuscany region (Italy). The method integrates the LULC map with other data to obtain a comprehensive ESs assessment, and then uses cluster analysis to identify bundles of ESs. The AHP allows to develop a method for ES mapping that, from a methodological point of view, is not as resource intensive as many models but, at the same time, can be more comprehensive and specific than only using LULC maps. We present the results of the application of the method to the territory of the Municipality of Lucca. Based on the first trials, the method seems to show high potentialities as a Decision Support System to promote innovative governance models for ES management.

Key words: *Ecosystem Services mapping and bundling; AHP for planning; Rural areas planning;*

Multi-criteria analysis for identifying suitable sites for multi-purpose artificial reservoirs

Matteo Masi, Chiara Arrighi, Fabio Castelli

Department of Civil and Environmental Engineering, University of Florence, Italy. Email: matteo.masi@unifi.it, chiara.arrighi@unifi.it, fabio.castelli@unifi.it

Due to water scarcity, climate change, and a growing population, there is a pressing need for improved water resources management practices. In particular, increasing water storage with the construction of new artificial reservoirs is crucial in addressing these challenges, to meet the community's requirements for drinking water, energy, irrigation, and flood risk mitigation.

While the geographical locations of the reservoirs can be evaluated on a merely topographic basis, there are other essential aspects, usually in conflict with each other, that need to be taken into account in order to identify the candidate sites, such as bio-physical, socio-economic, regulatory, and environmental factors.

In this work, we present a methodology, based on multi-criteria decision making (MCDM), for identifying the optimal locations for new reservoirs while simultaneously considering all the aspects above. The developed framework is subdivided into two steps. In a first step, an algorithm automatically analyses a large number of sites based on a Digital Elevation Model (DEM). For each site it optimizes the location and orientation of the dam and calculate the geometrical characteristics, such as the dam length, dam volume and the water storage volume.

In a second step, a MCDM analysis is performed to rank all the potential sites. The selection criteria are defined quantitatively, based on a territorial analysis combined with hydrological modelling. The criteria include: geometric and morphological aspects (reservoir volume, etc.), hydrological indicators (water balance, potential flood mitigation), anthropization (population, infrastructures, etc.), landscape, archaeological heritage, ecology, environmental components and natural hazards. A web-based survey platform was developed to involve all the stakeholders in the decision-making process, by collecting their opinions on the relative importance of each individual criterion.

We present the application of the developed methodology to a case study in the Arno river basin, Italy.

Key words: *Multi-criteria evaluation, water storage, dam site suitability, water scarcity, GIS*

Advancing Sustainability Assessment in Port Regions: Utilizing an MCDM Approach for Composite Index Development

Jelena J. Stanković[1], Saša Drezgić[2]

[1] *Faculty of Economics, Niš, Serbia. Email: jelena.stankovic@eknfak.ni.ac.rs*
[2]*University of Rijeka, Faculty of Economics and Business, Rijeka, Croatia.*
Email: sasa.drezgic@efri.hr

Maritime transportation and ports constitute pivotal conduits within the intricate web of global economies, facilitating the exchange of more than 90% of commodities in international trade. The profound economic significance of maritime transport casts a substantial influence on the societal fabric and environmental equilibrium of port regions. The present study endeavors to forge composite indices, which stand as salient, empirically-grounded instruments employed to juxtapose and oversee diverse facets of sustainability across 37 maritime port regions spanning seven countries along the European periphery of the Mediterranean. This comprehensive analysis envelops a quinquennial span from 2014 to 2018. The devised model enshrines a corpus of data gleaned from Eurostat and OECD repositories, encompassing annual data at the NUTS2 territorial level. This expansive dataset encapsulates the triad of economic, social, and environmental dimensions that collectively form the bedrock of sustainability considerations. Notably, within the cohort of economic indicators, pivotal emphasis is laid on two pivotal markers of maritime activity: the transport of goods and the conveyance of passengers across maritime domains.

In the creation of these composite indices, an intricate framework underpinning multicriteria decision-making (MCDM) was harnessed. This approach seamlessly interweaves the entropy methodology within the weightage schema, harmonizing it with the Preference Ranking Organization METHod for Enrichment of Evaluations (PROMETHEE) as the quintessential mode of aggregation. The culmination of this analytical framework culminates in a nuanced panorama that illuminates the intricate tapestry of sustainability across these maritime port regions.

The findings bring into stark relief two salient indicators, namely GDP per capita and population density, as the preeminent barometers of relative importance in the realm of port region sustainability. The discerned ranking outcomes furnish a fascinating tableau, wherein Attica emerges as the apical region in terms of holistic sustainability assessment. Notwithstanding this, it is intriguing to observe that the preponderance of top-tiered port regions are concentrated within the geographical confines of Italy, Spain, and France.

Key words: *Maritime Sustainability, Sea Port Regions, Composite Indices, MCDM*

A Multi-Criteria Tool for Urban Renewable Energy Community Projects

Sibilla Ferroni, Francesco Causone

Department of Energy - Politecnico di Milano, Italy
Email: sibilla.ferroni@polimi.it, francesco.causone@polimi.it

Renewable energy community (REC) models play a vital role in the energy transition, aiming to decarbonise the built environment by promoting energy retrofit interventions and accelerating the deployment of on-site renewable energy sources. However, designing these communities present multifaceted challenges, especially in urban areas with high density of population and limited space for renewables. Here, effective decision-making is essential but hindered by the lack of a reference design framework and evaluation criteria.
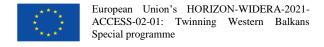
In Europe, local authorities (LAs) are pivotal in implementing REC models, particularly in the initiation phase. At this stage of the design, LAs seek to evaluate the feasibility of REC implementation in their territory, considering environmental, economic, and performance objectives simultaneously. To address this challenge, the presented work discusses the development of a tool to support LAs in the early design stages of REC in urban contexts.

The proposed tool aims to provide LAs with a quantitative approach capable of addressing multiple and conflicting objectives. Therefore, the tool will be based on the complementary relationship between multi-objective optimisation (MOO) models and multi-criteria decision-making (MCDM) methods. The MOO model focuses on finding a diverse set of efficient solutions, highlighting the trade-offs between conflicting objectives, while MCDM is adopted to provide a framework to evaluate and compare these solutions based on the stakeholder's preferences.

By integrating MOO and MCDM, the tool will enable LAs to explore a range of viable solutions for REC design while considering various criteria simultaneously. This approach allows decision-makers to make informed choices aligned with their priorities and objectives.

Continuity, transformation, sustainability: a framework to design and evaluate emergency scenarios for the city of Kharkiv (Ukraine)

Vanessa Assumma[1], Francesco Pittau[2], Lidia Bernasconi[3], Alice Ghezzi[3], Elisabetta Valsecchi[3]

1 Department of Architecture, University of Bologna, Italy. Email: vanessa.assumma@unibo.it
2 Department of Architecture, Built Environmental and Construction Engineering (DABC), Politecnico di Milano, Italy. Email: francesco.pittau@polimi.it
3 School of Architecture Urban Planning and Construction Engineering (AUIC), Politecnico di Milano, Italy.
Email: lidia.bernasconi@mail.polimi.it, alice1.ghezzi@mail.polimi.it, elisabetta.valsecchi@mail.polimi.it

The present contribution illustrates an academic and educational experience focused on addressing sustainability and resilience in emergency scenarios, that are threatened by socio-political conflicts. The aim of this work is to develop a multi-level assessment framework able to address continuity, transformation, and sustainability in conflicting contexts and to deliver an emergency response project. The problem under investigation is tackled by considering a real case study, that is the city of Kharkiv (Ukraine). Two Multicriteria Decision Analysis techniques (MCDA) are identified to support rational and shared choices along the evaluation process and design phases. An Analytic Hierarchy Process (AHP), which allows for a rational breakdown structure of the problem, is adopted within a localisation study. A set of criteria are identified through an investigation of emergency facilities conceived as best practices. These are then compared with respect to the facilities to select the one closest to the project. Parallelly, a Simple Multi-attribute Rating Extended to Ranking (SMARTER) ranks the relevance of a set of criteria representing the characteristics of emergency response structures. Finally, the evaluation process is carried out, involving both local stakeholders and specialists, with expertise in emergency, spatial planning, building construction and neuroscience.

The twofold evaluation approach would overcome the issue of a limited amount of information due to conflict emergency conditions and substantiate the most suitable solution.

The MCDAs have brought concrete results from the point of view of the choice of the project area and of the characteristics of the structure, thus providing a reliable decision support for the project design.

The contribution also reflects on the role of decision support systems to tackle complexity and uncertainty, according to a multi-level and spatio-temporal approach, while opening to future transdisciplinary research directions.

Key words: *Conflict resilience, Emergency management, Sustainable construction system, MCDA, Decision-making process*

Evaluation of the most economically advantageous tender in public procurement procedures: the main evidences provided by the multi-criteria decision-making approaches

Debora Anelli[1], Pierluigi Morano[1], Francesco Tajani[2], Tiziana Acquafredda[1]

[1] Department of Civil, Environmental, Land, Building Engineering and Chemistry, Polytechnic University of Bari, Italy
Email: debora.anelli@poliba.it, pierluigi.morano@poliba.it, tizianaacqua@yahoo.com
2 Department of Architecture and Design, Sapienza University of Rome, Italy. Email: francesco.tajani@uniroma1.it

The European Commission within the "Europe 2020" strategy has considered the public procurement as one of the vital market-based policy approaches for the achievement of a smart and sustainable development of the European economy. However, the management of the public procurement procedures is often difficult: choosing the most suitable criteria for achieving the aims of the urban intervention by evaluating the suppliers, being coherent with the European regulatory framework for the sustainable development, carrying out a transparent and clear assessment procedure are only some of the most critical issues related to the public procurement system of the urban development. Due to the multidimensional nature of the projects' selection, several multi-criteria decision-making approaches have been developed for giving an ordered methodological structure, rather than a supporting guideline to the operators involved in the public procurement process. The aim of the work is to provide a systematization of the existing scientific literature on the applications of the multicriteria decision making approaches in order to identify: i) the most used multi-criteria technique for each of the public procurement step, ii) the most considered type of criteria for the tenders evaluation, iii) the main advantages and disadvantages of each multi-criteria technique, iv) the main future insights of the research field in order to highlight the cogent needs for improving the public procurement system with the help of the multi-criteria decision-making approaches. The achieved results suggest interesting and useful issues, especially for the weighting of the criteria, the construction of the final ranking of the suppliers and the integration of multi-criteria techniques, by giving the possibility to improve the existent knowledge on the public procurement field.

Key words: *multi-criteria decision-making, public procurement, systematic analysis, project selection*