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Editorial

Multi-Objective and Multi-Attribute Optimization for Sustainable Development Decision Aiding

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Received: 23 May 2019; Accepted: 27 May 2019; Published: 31 May 2019

Abstract: Optimization is considered as a decision-making process to get the most out of available resources for the best attainable results. Many real-world problems are multi-objective or multi-attribute problems that naturally involve several competing objectives that are required to be optimized simultaneously, while respecting some constraints or selecting among feasible discrete alternatives. In this Special Issue, 19 research papers co-authored by 88 researchers from 14 different countries explore aspects of multi-objective or multi-attribute modelling and optimization in crisp or uncertain environments by suggesting multiple-attribute decision-making (MADM) and multi-objective decision-making (MODM) approaches. The papers elaborate the approaches on the state-of-the-art case studies in selected areas of applications related to sustainable development decision aiding in engineering and management, including construction, transportation, infrastructure development, production, and organization management.

Keywords: multiple-attribute decision-making (MADM); multi-objective decision-making (MODM); optimization; engineering; management; sustainable development

1. Introduction

Sustainable decision-making has a direct impact on the economy, the environment, and society. Researchers are continuously trying to adopt it in their research domain, mainly in the field of financial modeling, supply chain, healthcare system, transport system, construction management, business intelligence, etc. However, most of the real-life problems that we encountered in these domains were not limited to single criterion decision-making problems. Therefore, many researchers are motivated to develop some new models in these areas under a multi-criteria/multi-objective decision-making framework.

Some authors (Zimmermann [1]; Chen and Hwang [2]) have divided multi-criteria decision making (MCDM) into two categories: (1) multi-attribute decision making (MADM), which concentrates on problems with discrete decision spaces; and (2) multi-objective decision making (MODM) problems, which naturally involve several competing objectives that are required to be optimized simultaneously. From a practical viewpoint, MADM is associated with problems where the number of alternatives are predetermined. The decision maker (DM) is to select/prioritize/rank a finite number of courses of action. Alternatively, MODM is associated with problems in which the alternatives have been non-predetermined.

It is often said that the only certain thing about the data involved in real world decision-making problems is uncertainty. This uncertainty is caused by many reasons, as the available data are not

always exact or precise, there is insufficient data and linguistic information, there is a lack of evidence, decision makers' judgments are subjective and vague, statistical analysis is imperfect, etc.

Over past few decades, many researchers developed a number of theories/tools/techniques to deal with real-life uncertainty problems. Fuzzy set (Zadeh [3]), Dempster Shafer theory (Shafer [4]), rough set (Pawlak [5]), intuitionistic fuzzy sets (Atanassov [6]), grey set (Deng [7]), and hybrid sets (Liu [8]) are among the most successful approaches that efficiently handle uncertainty in decision-making problems. These techniques have been successfully applied by many researchers in the context of uncertain environments addressing mathematical, theoretical, and behavioral aspects of real-life applications.

Yet, the literature is still promising in the above-mentioned domains, and many research gaps remain. Consequently, we have introduced this Special Issue to identify the underlying research themes and suggest directions for future research. Thus, the purpose of this Special Issue is to propose a research agenda for multiple-attribute decision-making (MADM) and multi-objective decision-making (MODM) approaches for sustainable engineering and management decisions in crisp or uncertain environments.

2. Contributions

The Special Issue collects 19 original research papers. The papers contribute to multi-objective and multi-attribute optimization by offering multiple-attribute decision-making (MADM) and multi-objective decision-making (MODM) approaches for sustainable engineering and management decisions in crisp or uncertain environments.

The topics of the Special Issue attracted attention of a wide scientific community: 88 scientists from 14 countries contributed to the Issue. Distribution of papers according to countries is presented in Figure 1.

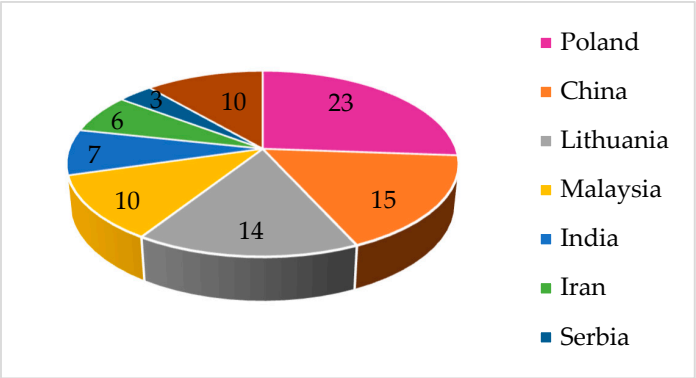

Figure 1. Number of publications from different countries.

The largest number of Authors were from Poland (23 authors). China and Lithuania contributed almost equally, with 15 and 14 authors, respectively. Next came Malaysia, with 10 authors. Seven contributors were from India, six from Iran, and three from Serbia. Authors from the following seven countries contributed from 1 to 2 papers: Vietnam, Kazakhstan, Germany, Saudi Arabia, Hungary, Bosnia and Herzegovina, and Thailand.

As international collectives prepared almost a half of papers, the distribution of papers according to authors' affiliations is presented in Table 1.

Authors and co-authors from Lithuania contributed seven papers, mostly in international collectives in collaboration with Iran, Kazakhstan, Poland, India, Serbia, Bosnia and Herzegovina, Germany, Hungary, and Saudi Arabia. Authors from Poland contributed six papers, but only to a single international publication with Lithuanian co-authors. Authors from China prepared four papers without international collaboration. Two papers involve cooperation of authors from three countries: Serbia, Bosnia and Herzegovina, and Lithuania, as well as Vietnam, Iran, and Malaysia. A single paper united researchers from five countries from Europa and Asia: Germany, Hungary, Lithuania, Iran, and Saudi Arabia.

Table 1. Publications by countries.

Countries	Number of Papers
Poland	5
China	4
Thailand	1
Lithuania	1
Iran–Lithuania	1
Kazakhstan–Lithuania	1
Poland–Lithuania	1
India–Lithuania	1
Serbia–Bosnia and Herzegovina–Lithuania	1
Germany–Hungary–Saudi Arabia–Iran–Lithuania	1
Vietnam–Iran–Malaysia	1

Distribution of papers according to research areas is presented in Figure 2.

The publications explore aspects of multi-objective or multi-attribute modelling and optimization in crisp or uncertain environments by suggesting multiple-attribute decision-making (MADM) and multi-objective decision-making (MODM) approaches, or several other optimization tools. MADM optimization area attracted slightly more attention; 10 papers contributed to the area, while MODM optimization was explored in six papers.

The papers elaborate usual or extended optimization approaches on the state-of-the-art case studies related to sustainable development decision aiding in engineering and management, including construction, transportation, infrastructure development, production, and organization management. All the mentioned application areas gained almost some attention; from two to six papers contributed to each area.

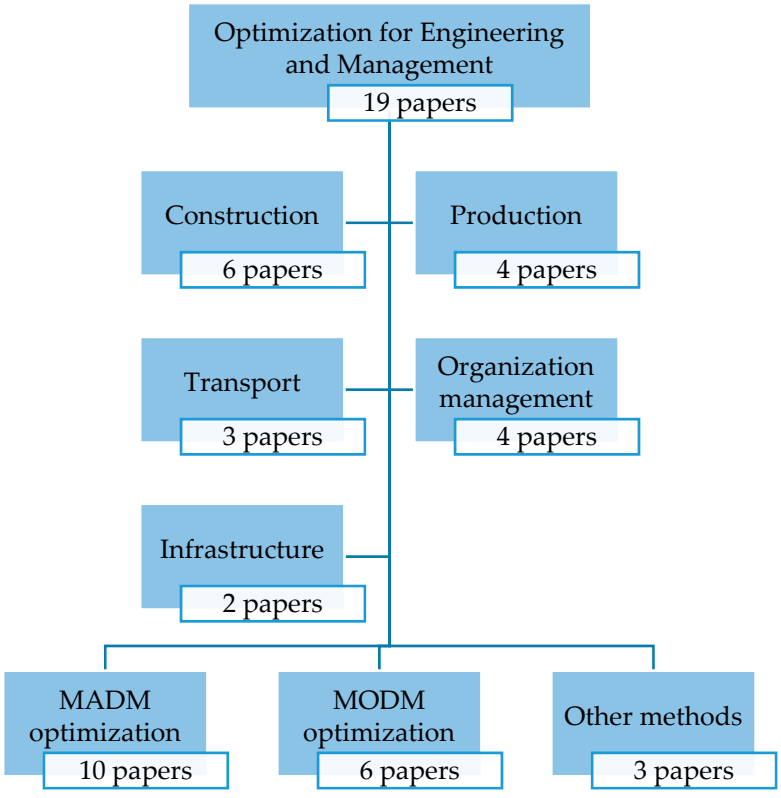

Figure 2. Research areas of publications.

The most numerous application areas can be considered construction engineering (five papers). MADM and MODM approaches to support sustainable decisions can be applied in the area.

Two papers analyze construction project management. One paper suggests sustainable construction project management model aimed at practical use; therefore, a rather well known analytic hierarchy process (AHP) method is applied. A comprehensive set of criteria is developed, and a Turkish case study is presented. The other paper is aimed at evaluating contractors risk of investment project in construction. The originality of the paper is based on a fact that a special case of MADM–verbal analysis is suggested, while usual risk valuation methods are more often applied in the literature [9,10].

Energy efficiency and comfort of use of buildings is another topical issue in the literature [11,12]. Adaption of historic regional architecture in terms of energy efficiency and comfort of use of buildings is analyzed in one paper of the current Issue. A set of assessment criteria is proposed, and the new utility functions considered. The example of historic building located in Zakopane, Poland is presented.

Ecological wall systems as a significant component of sustainable construction are analyzed. Three variants of ecological walls made from local materials are suggested, and their cost calculation is provided. You can find similar topics in other publications, related to design of sustainable facades [13], roofs [14], or floors [15].

Construction delay problems considering sustainable environment requirements are analyzed. The authors develop a new model that combines several different MCDM methods under uncertainty: a Step-wise Weight Assessment Ratio Analysis (SWARA), the Technique for Order Preference by Similarity to Ideal Solution with Grey numbers in Minkowski Space (TOPSIS-GM), Additive Ratio ASsessment with Grey numbers (ARAS-G) techniques, and Geometric Mean. A case study of the housing industry is a market of Mashad, Iran.

A topical problem of location selection in construction is solved in [16,17]. The authors of one paper prepare a hierarchical programming model and design a bi-level multi-objective particle swarm optimization (BLMOPSO) algorithm to deal with the healthcare facility location decisions. The suggested approach can be applied for various facilities location decisions. The next paper related to location selection analyzes traffic infrastructure and an optimal roundabout location. MADM problem is solved in an uncertain environment; therefore, application of rough set theory is suggested. Rough Best–Worst Method (Rough BWM) and Rough-Weighted Aggregated Sum Product Assessment (Rough WASPAS) methods are applied. The input to methodological novelty of the approach lays in developing a Rough Hamy aggregator.

The other paper related to transportation suggests applying MADM methods for assessing transport policy in terms of innovation. The authors of the paper demonstrate the application of a simple additive weighting (SAW) method to evaluate policy measures in surface transportation.

Public transport problems and development of sustainable public transport are discussed. Development of the city increases transport problems related to emission of pollutant, travel time, etc. The paper analysis actions and measures taken for development of sustainable transportation in Rzeszow, Poland.

Several papers analyze infrastructure problems as water or energy supply. A hybrid MODM method for water resource management is presented. The researchers implement hybrid novel meta-heuristic algorithms: the bat algorithm (BA) and particle swarm optimization (PSO). They are applied for power production and irrigation supply problems.

In another paper, renewable energy technology selection is solved by applying hybrid optimization: Step-Wise Weight Assessment Ratio Analysis approach with a hierarchical arrangement (H-SWARA) and Multi-Objective Optimization on the basis of Ratio Analysis plus the full MULTIplicative form (MULTIMOORA). An Iranian case study is presented.

A hybrid MADM approach is also applied for assessing cleaner production in gold mine. At first, crisp numbers and probabilistic linguistic term sets (PLTSs) are simultaneously applied to evaluate quantitative and qualitative information, and expert method based on PLTSs is used to calculate criteria

relative significance. Next, an extended Tomada de Decisão Interativa Multicritério (TODIM) method with hybrid values is suggested to rank the alternatives.

A hybrid MODM model is developed for optimization of the traffic path in port scheduling. The model is built and solved by an improved non-dominated sorting genetic algorithm II (NSGA-II). A case study of scheduling of berths and quay cranes is presented.

Multi-objective evolutionary optimization for the passive vibration suppression of a single-cylindrical engine is presented. A hybrid of multi-objective population-based incremental learning, and differential evolution (RPBIL-DE) is adapted.

Multi-objective optimization of processes of apple cubes drying and rehydration are analyzed. To simulate and optimize parameters of drying and rehydration processes, hybrid methods of artificial neural network (ANN) and multi-objective genetic algorithm (MOGA) are developed.

One more hybrid approach for scheduling optimization in projects is developed. Two algorithms are suggested: the first one is based on the non-dominated sorting genetic algorithm II (NSGA-II) with a special critical path-based crossover operator, and the second algorithm is a steepest descent heuristic that solves the discrete time/cost trade-off problem with different deadlines.

Sustainable organizations are analyzed [18–21]. Total interpretive structural modeling (TISM) has been applied for identifying the links among the sustainability factors in organizations. The paper, submitted to the Special Issue, presents the fourth dimension of sustainability involving stakeholders besides three usual dimensions of economy, natural environment, and social environment.

Hospital evaluation problem is analyzed. As decision-makers are faced with qualitative criteria, a linguistic hesitant fuzzy set (LHFS) is adopted. A new aggregation operator—simple linguistic hesitant fuzzy weighted geometry (SLHFWG)—is proposed under the LHFS context. Criteria relative significances are estimated using a newly proposed linguistic hesitant fuzzy statistical variance (LHFSV) method, and alternatives are ranked using the new linguistic hesitant fuzzy VIKOR (visekriterijumska optimizacijai kompromisno resenje) under the LHFS context (LHFVIKOR) method.

A topical question of critical information infrastructures of European Union sustainable development is discussed. Integrated MADM techniques under uncertainty involving fuzzy Weighted Aggregated Sum Product ASsessment (WASPAS-F) and analytic hierarchy process (AHP) methods are suggested to be applied.

3. Conclusions

The scope of the Special Issue raised the interest of numerous researchers; papers involving 88 researchers from 14 countries were published.

Papers contribute to sustainable development by offering crisp or uncertain multiple-attribute decision-making (MADM) and multi-objective decision-making (MODM) approaches.

The main topics of papers published in the Special Issue mainly cover five research areas in engineering and management, including construction, transportation, infrastructure development, production, and organization management.

Author Contributions: All authors contributed equally to this work.

Acknowledgments: Authors express their gratitude to the journal *Sustainability* for offering an academic platform for researchers to contribute and exchange their recent findings in sustainable construction.

Conflicts of Interest: The authors declare no conflict of interest.

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