Process Integration and Optimization for Sustainability (2023) 7:473–474
https://doi.org/10.1007/s41660-023-00317-y

EDITORIAL NOTE

Addressing Uncertainties in Planning Sustainable Systems Through Multi-criteria Decision Analysis (MCDA)

John Frederick D. Tapia[1] · Michael Angelo B. Promentilla[1] · Florentin Smarandache[2]

Accepted: 30 January 2023 / Published online: 9 February 2023

Sustainable development involves the creation of systems and technologies that not only improve human lives but also enable natural resources to be consumed responsibly. These systems include integration of technologies for efficient resource consumption, better production, and lower negative impacts on the environment. Over the years, humanity has developed these technologies and commercialized through a series of advancements: from prototype creation to commercialization. Even with the promise of sustainable development, these technologies took a long time before being deployed on a large scale. Decisions are needed to be made to create policies, regulations, and implementation strategies for these technologies. These decisions will be based on different economic, environmental, social, and technical factors, among others. In doing these decisions, one of the major factors needed to be addressed is uncertainty.

Statistical techniques can be used to manage uncertainties that involve randomness. For instance, the prediction of the leaching behavior of complex copper-cobalt-bearing ores is performed using an artificial neural network with a back-forward algorithm (Mbuya and Mulaba-Bafubiandi 2023). However, the existence of uncertainties in new and emerging technologies is due to the lack of information about how technologies can be deployed for use by the society. Policymakers rely on expert judgment to be able to determine which technologies can be scaled up for testing, or which technologies are better than the others. Expert judgments are based on available information where most of the uncertainties arise. Incomplete and vague information about different systems leads to inconclusive insights. Inconsistency with different expert judgments also hinders the deployment of emerging technologies. Ambiguity also adds to the challenge of uncertainty, as information can be excessive and is based on different assumptions. Several decision-making tools adopt these kinds of uncertainties into their framework. In addition, these tools make explicit the preferences and values of the stakeholders in the decision-making process. Such decision-making tools and their application, which are studied and developed in the field of *multi-criteria decision analysis* (MCDA), are as follows.

Attaining a large share of renewable energy in the energy mix is one of the major goals of sustainable development. The development of a Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)–based linear programming (LP) approach enables planning of integrating renewable energy sources into the energy mix considering technical, environmental, and social factors (Oluklu and İç 2022). An MCDA tool for evaluating the transportation sustainability of different countries was also developed based on different versions of data envelopment analysis (DEA; Babaei et al. 2022). Analytic Hierarchy Process (AHP), a well-known MCDA tool, is also applied for assessing the surface irrigation potential of the Ethiopian River Basin (Gemechu 2022). The decision framework developed in these papers makes use of the available data in a deterministic or uncertain form.

Some of the widely used representations of uncertainties are fuzzy sets (Zadeh 1965), Pythagorean fuzzy sets (Yager 2014), and neutrosophic sets (Smarandache 2006) where an element's belongingness to a set is characterized in different ways. Recent work on addressing uncertainty using fuzzy set is determining the effects of green supply chain (GSC) practices on sustainable performance indicators (Panpatil et al.

✉ John Frederick D. Tapia
john.frederick.tapia@dlsu.edu.ph

[1] Department of Chemical Engineering, De La Salle University, 2401 Taft Avenue, 0922 Malate , Manila, Philippines

[2] University of New Mexico, 705 Gurley Ave., Gallup, NM 87301, USA

2022b) and the development of a novel decision tool for identifying factors affecting climate change and the impact of urbanization on hydropower plants (Shil et al. 2023). In this work, the subjective perspective of human judgment has been considered in developing the decision tool. A similar study where GSC enablers are now involved is done by Panpatil et al. (2022a) where the uncertainty is modelled as a Pythagorean fuzzy set. In this work, the complexity in terms of the multi-facet and multi-dimensional nature of the decision problem is considered. Neutrosophic set–based tools are also developed for the diagnosis of COVID-19 and other lung diseases (Karataş and Ozturk 2022) and for optimal resource allocation for achieving sustainable development goals in Egypt (Badr et al. 2022). Quadripartitioned single-valued neutrosophic properties are also introduced and applied to assess the influential factors affecting energy prices (Granados 2022). These works proposed decision aids that consider the degrees of membership, non-membership, and indeterminacy in which a different set of these elements provides a representation of inconsistent, vague, ambiguous, incomplete, and uncertain data.

The recent developments on addressing uncertainties in planning sustainable systems have led to different decision-making tools to enable the deployment of technologies associated with it. These tools incorporate mathematical concepts of fuzzy sets and their extension to address uncertainty in sustainable systems. The research gap that needs to be addressed for now is on how these extensions represent uncertainty specific to different systems. In the case of neutrosophic sets, the degrees of non-membership and indeterminacy should be defined in the context of the decision problem, i.e., answering the question "What do non-membership and indeterminacy mean in the system?" Such mathematical concept will be a powerful tool for improving MCDA tools for easier decision-making and policymaking. This special issue in *Process Integration and Optimization for Sustainability* provides different ways to address uncertainty with the aim of giving the readers ideas about the capabilities of different mathematical techniques.

References

Babaei A, Khedmati M, Jokar MRA (2022) A new model for evaluation of the passenger and freight transportation planning based on the sustainability and safety dimensions: a case study. Process Integr Optim Sustain 6:1201–1229

Badr E, Seidy EE, Elrayes A, Rabie A (2022) Analyzing the application of the sustainable development goals for Egypt using a neutrosophic goal programming approach. Process Integr Optim Sustain. https://doi.org/10.1007/s41660-022-00265-z. (in press)

Gemechu MF (2022) GIS-based multi-criteria approach surface irrigation potential assessment for Ethiopian river basin: in Case of Upper Awash River Basin. Process Integr Optim Sustain. https://doi.org/10.1007/s41660-022-00267-x. (in press)

Granados C (2022) Quadripatitioned single-valued neutrosophic properties and their application to factors affecting energy prices. Process Integr Optim Sustain. (in press)

Karataş E, Ozturk TY (2022) An application method for the use of neutrosophic soft mappings in decision-making the diagnosis of COVID-19 and other lung diseases. Process Integr Optim Sustain. https://doi.org/10.1007/s41660-022-00290-y. (in press)

Mbuya B, Mulaba-Bafubiandi AF (2023) Predicting optimized dissolution of African Copperbelt copper-cobalt bearing ores by means of neural network prediction and response surface methodology modeling. Process Integr Optim Sustain. (in press)

Oluklu D, İç YT (2022) A forecasting study for renewable energy resources investments in Turkey: TOPSIS-based linear programming model. Process Integr Optim Sustain. https://doi.org/10.1007/s41660-022-00297-5. (in press)

Panpatil SS, Prajapati H, Kant R (2022) Analysing a GSCM enabler–based model for implementation of its practices: a Pythagorean fuzzy AHP and CoCoSo Approach. Process Integr Optim Sustain. https://doi.org/10.1007/s41660-022-00289-5. (in press)

Panpatil SS, Prajapati H, Kant R (2022) Effect of green supply chain practices on sustainable performance indicators: a fuzzy MADM approach. Process Integr Optim Sustain. https://doi.org/10.1007/s41660-022-00260-40. (in press)

Shil B, Sinha P, Das S, Tripathy BC, Poojary P (2023) Grey relational analysis based MADM strategy under possibility environment and its application in the identification of most important parameter affecting climate change and the impact of urbanization on hydropower plants. Process Integr Optim Sustain. in press

Smarandache FS (2006) Neutrosophic sets: a generalization of intuitionistic fuzzy sets. IEEE International Conference on Granular Computing, 10–12 May 2006

Yager RR (2014) Pythagorean membership grades in multicriteria decision making. IEEE Trans Fuzzy Syst 22(4):958–965

Zadeh LA (1965) Fuzzy sets. Inf Control 8(3):338–353