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Editorial. Featured papers on Environmental Decisions (Special Issue).

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Editorial Featured Papers on

Environmental Decisions (2019)

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Editorial

Abstract

Our society is facing serious environmental challenges related to climate change, pollution, diminishing resources, and biodiversity loss. Such problems are often ill-defined and are characterized by high uncertainty. Environmental decisions have strong impacts on society and demand clear and transparent trade-offs across values and priorities of stakeholder groups. This Feature Issue on Environmental Decisions includes papers focused on important environmental applications approached through various disciplinary backgrounds. The papers highlight advanced–often interdisciplinary–methodological approaches and include the perspectives of different stakeholders in the *process* of environmental decision-making. A wide range of methods are explored, ranging from a comprehensive review (for sustainable transport by Marleau Donais et al.) to an opinion paper proposing the use of Records of Engagement and Decision-making (RoED; by Cockerill et al.). Stakeholder engagement and preference elicitation required the development of new aggregation models for Multi-Criteria Decision Analysis (MCDA; by Reichert et al.). The integration of Cost-Benefit Analysis (CBA) with MCDA was found to be necessary in practice (by Liu et al.; Marleau Donais et al.). MCDA was extended to include the spatial dimension by integrating Geographic Information Systems (GIS; by Guay et al.; Schito et al.). The importance of considering the resilience of systems to better respond to and recover from unpredictable risks was emphasized (by Leyerer et al.; Mustajoki and Marttunen). These papers demonstrate the richness of approaches to environmental decision-making. Environmental issues offer ample exciting research opportunities to a broader scientific community. We encourage the readers of this Feature Issue—and of EJDP—to engage in environmental decision-making projects to support emerging societal needs.

Main text

Our society is facing serious environmental challenges on global, regional, and local scales. We need to tackle the immense challenge of climate change, reduce land degradation, air and water pollution, and lower the speed of biodiversity loss, just to name a few. What we decide today can have strong immediate impacts on the environment and society. Our decisions may have long-term and, in some cases, irreversible consequences. Society is asking for urgent solutions for the sustainable use of diminishing resources.

Environmental problems are often ill-defined with unclear system boundaries and complex interconnections among environmental media, animals, plants, and humans. Impacts of environmental decisions may be difficult to quantify and can be present at different spatial and temporal scales. Capturing this complexity and predicting the outcome of any management action is usually a complex endeavor, characterized by high uncertainty. Not surprisingly, environmental policy decisions to address these challenges are usually very complex and difficult to make. They typically concern a range of stakeholders with different values, interests, and roles. Since such decisions may have long-term impacts, they can affect future generations that do not have a voice today, resulting in many environmental justice and ethics considerations. Our actions may also affect people without power or the means to participate in decision-making processes, e.g., those in the Global South. Some decisions may result in significant societal burdens, others in significant environmental impacts, demanding clear and transparent trade-offs across different stakeholder groups and policy makers with different systems of values.

Fortunately, the fields of decision analysis, risk assessment, and related disciplines actively address these needs through developing integrated methods and tools to aid individual decision-makers as well as federal, state, and local authorities, and other stakeholder groups. These fields are diverse and include decision analysis, risk assessment, policy analysis, operational research, economics, psychology, and the natural and engineering sciences. Recent reviews clearly show the proliferation of these tools in the literature (e.g. Cegan et al., 2017; Marttunen et al., 2018), and an increase in their use by federal agencies (Kurth et al., 2017). These and other papers clearly show that a single disciplinary perspective is insufficient to address management and policy needs, and thus interdisciplinary approaches and multiple tiers of analyses are required.

In this Feature Issue on Environmental Decisions of the EURO Journal on Decision Processes, we include papers that come from different disciplinary backgrounds and application fields. These papers showcase advanced methodological approaches and the inclusion of the perspectives of different stakeholders in the *process* of environmental decision-making in real case studies. Many papers also go across disciplinary boundaries, addressing many of the above-mentioned challenges, including the exploration of trade-offs between costs and benefits in environmental decision-making. These important issues are explored in different types of analyses ranging from a comprehensive review (for sustainable transport by Marleau Donais et al., this issue) to an opinion paper on stakeholder engagement processes (by Cockerill et al., this issue). Several papers document case studies with stakeholder engagement (those by Cockerill et al.; Liu et al.; Mustajoki and Marttunen; Reichert et al.; and Shito et al.; this issue). Methodological developments including new testing strategies and decision-making frameworks are discussed (by Liu et al.; and Mustajoki and Marttunen; this issue). Decision Support Systems (DSS) are presented (by Guay et al.; Leyerer et al.; and Schito et al.; this issue), and aggregation models for Multi-Criteria Decision Analysis (MCDA) to represent stakeholder preferences are developed (by Reichert et al., this issue).

A wide range of individual MCDA and other methods are explored, including the MCDA methods MAVT/ MAUT, PROMETHEE, and GAIA, and e.g. specifically the parametrization of aggregation models in MAVT/ MAUT. Further explored are Cost-Benefit Analysis (CBA), the Structured Decision Making framework (SDM), a proposal for Records of Engagement and Decision-making (RoED), application of Geographic Information Systems (GIS), the resilience matrix, optimization (Mixed Integer Linear Problem, MILP), and development of Decision Support Systems (DSS), including visualizations with 3D. The application fields cover important urban sectors, namely sustainable urban transport (Marleau Donais et al., this issue), designing the electric grid (Schito et al., this issue), and eco-friendly, resilient urban parcel delivery (Leyerer et al., this issue). Other papers address environmental problems in agriculture, specifically biosecurity management (Liu et al., this issue), and more generally spatial regional planning (Guay et al., this issue). Environmental issues in the water sector are addressed, namely reservoir or lake regulation (Mustajoki and Marttunen, this issue) and lake shore management (Reichert et al., this issue). Moreover, the conservation of threatened species is addressed, as well as competition for resources, cultural identities, and environmental health governance (Cockerill et al., this issue).

Below, we give a short summary of each of the individual papers in this Feature Issue.

The review paper of Marleau Donais et al. (this issue) focuses on the comparison and integration of Cost-Benefit Analysis (CBA), a popular method from economics, with Multi-Criteria Decision Analysis (MCDA), typically used in decision-making under uncertainty and disparate stakeholder concerns; here in the context of sustainable transportation. This is a major issue in regulatory acceptability of MCDA – the majority of the current regulations are focused on implementing CBA, despite its limitations. MCDA is often not used because of lack of regulatory requirement and multiple misconceptions in the field about the practical applicability of MCDA. The paper by Marleau Donais et al. (this issue) is important because it addresses this very issue–i.e. the actual and perceived limitations of each method. It is based on a comprehensive literature review and expert judgment. The authors conclude that integration of these methods is very important to address a variety of challenges in the transportation domain.

Liu et al. (this issue) also study the integration of CBA with MCDA. They motivate their work by explaining that environmental decision-makers are often confronted with the problem of having to incorporate stakeholder participation into environmental decision-making processes. This may impose some difficulty not just because of tensions, but also because stakeholder engagement options have associated costs, and, in fact, can be very expensive and time consuming. Decision-makers may need guidance to choose the most cost-effective engagement process, an aspect that has been neglected in the literature. Liu et al. (this issue) develop a framework based on Structured Decision-Making (SDM; Gregory et al., 2012), Cost-Benefit Analysis (CBA), and Multi-Attribute Value Theory (MAVT/ MCDA) to support decision-makers in making this choice. The framework was applied to a potential biosecurity threat for a banana growing region in Australia, where an outbreak of the Panama Disease Tropical Race 4 (TR4) is of great concern. Different stakeholder interactions in this case study are described, including focus groups, semi-structured interviews, and a workshop with 21 key stakeholders. The authors conclude that the framework and the visualization of the cost-effectiveness of the stakeholder engagement options in an efficient frontier graph, were very

useful. The framework allowed decision-makers to examine the trade-offs between costs and benefits in a practically feasible and transparent way; and the authors recommend transferring the approach to other areas of environmental management.

Schito et al. (this issue) extend the application of MCDA to the spatial dimension, which is an important aspect in many environmental decisions. Their overarching goal is to provide infrastructure planners and governmental regulators with new methodology and visualization to support decision-making in power transmission. To this end, a spatial 3D Decision Support System (DSS) that combines MCDA with GIS is tested and discussed in a Swiss case study concerning the most suitable corridor for power transmission lines. The problem of power transmission planning is multidimensional in nature and requires careful coordination with urban planners, local populations, energy experts, and other stakeholders. Ensuring everybody is on the same page is a challenge that the authors resolved by integrating stakeholder values with advanced decision analytics and visualization. Follow-up interviews were focused on finding the utility of this approach to decision-makers. This paper is a good example of how MCDA coupled with GIS can be used to solve emerging and multifaceted problems in the field.

Similarly, Guay et al. (this issue) consider the spatial dimension of decision problems by combing MCDA, specifically PROMETHEE and GAIA, with GIS. They present a novel GIS-based MCDA platform, SOMERSET-P, for strategic environmental assessment of regional planning. They illustrate their approach by developing four regional planning scenarios for a municipality in Québec, Canada. The stakeholders' preferences are modelled by assuming five typical stakeholder profiles that often have opposed interests, such as farmers or civil administrators. Guay et al. (this issue) then demonstrate the stepwise analytic process: First, they exemplify the formulation of land use change scenarios, resulting in different land use and coverage for integration in ArcGIS. Second, they asses each scenario on twelve decision objectives (performance indicators) with the MCDA method PROMETHEE, including local sensitivity analysis. Additionally, they introduce GAIA, a visualization tool allowing for the quick detection of conflicting scenarios (for some stakeholders) and possible compromises. The richness of the results demonstrates the usefulness of comprehensive and integrated spatial decision analysis. Hopefully, methodologically sound, but easy-to-implement procedures, such as the SOMERSET-P platform, will make their way into practical land use planning, management, and monitoring procedures.

As shortly outlined above, large uncertainty and risk are inherent in most, if not all, environmental decision-making processes. Even though hardening of the system can be used to reduce the risk, fundamentally, residual risk will remain, and addressing these smaller risks may be a costly and unpractical proposition (Linkov and Trump, 2019). Two papers emphasize the importance of increasing the resilience of systems in order to better respond to unknown and unpredictable risks. The paper by Mustajoki and Marttunen (this issue) focuses on resilience management as an appropriate way to increase the ability of an environmental system–in this case an aquatic system–to respond to adverse effects. Resilience is defined as the ability to recover and adapt following an event. Based on the resilience matrix of Linkov et al. (2013), the authors develop a structured MCDA framework for assessing resilience in Finnish watercourses. The application of the resilience matrix requires close cooperation with reservoir operators and supervisors of watercourses. MCDA can be an important part of resilience quantification given that it is essential for resilience analytics to integrate critical foundations with comparative evaluation of management alternatives. The authors call for a better integration of risk and resilience analytics in environmental decision-making.

Leyerer et al. (this issue) also focus on increasing the resilience of a system, in this case in an urban context for the last mile delivery of parcels. Similarly to Wood et al. (2019), they demonstrate the use of the resilience matrix as a diagnostic tool to identify stakeholder needs across multiple system domains (physical, information, cognitive, and social), and temporal phases of resilience (prepare, absorb, recover, and adapt). Furthermore, they present a resilience-oriented framework for fleet optimization and implement it as a Decision Support System (DSS) for a case study in Germany. The aim is to assist decision-makers in designing an eco-friendly and resilient parcel delivery network for the last mile, allowing them to explore and quantify the economic and environmental impacts of different parcel delivery scenarios. As result, optimization of hub locations and transportation logistics can be provided.

The paper of Reichert et al. (this issue) also has a strong mathematical rigor, but additionally leaves room to include extensive stakeholder engagement. The applied aim of the case study is to co-develop a value

function that best reflects the stakeholders' preferences concerning the ideal morphological state of a Swiss lakeshore. The stakeholder engagement process extended over a period of two years with various interactions and preference elicitation exercises with authority representatives and environmental consultants. This process is embedded into a larger strategy to introduce formal decision analysis methods into surface water management in Switzerland. As result of the stakeholder interactions, it became evident that the additive model, commonly used to aggregate lower-level values to a higher-level value function in MCDA (MAVT/ MAUT), did not suitably represent the stakeholders' preferences. Many of the elicited aggregation functions were strongly non-additive and partly even non-concave. The paper presents and discusses the implications of different aggregation functions, including additive aggregation (the weighted arithmetic mean) and concave value functions (minimum, additive-minimum, and power transformation). However, especially at higher levels of the objectives hierarchy, these functions still did not represent the stakeholder's preferences concerning trade-offs well. Newly-developed aggregation functions better met their preferences, namely the bonus and malus aggregation, and the split power transform aggregation. These are visualized and discussed in the paper. In their conclusion, Reichert et al. (this issue) emphasize the importance of carefully testing the assumptions underlying parameterized (often additive) value aggregation techniques during the preferences elicitation process. They suggest that decision analysts should have some flexibility to respond with other aggregation models if value functions deviate strongly from the standard.

We end the overview of the papers in this collection by inviting the readers of this Feature Issue to engage in a conversation about the concept of Records of Engagement and Decision-making (RoED). In their opinion paper, Cockeril et al. (this issue) introduce an idea that goes back to an interdisciplinary meeting in 2019 with participants from 18 organizations from many disciplines. As result of the discussions on similar, interrelated concepts and practices from different fields, this opinion paper is a call to the readers to consider implementing the RoED concept in their environmental projects, and to share their experiences as well as collected information. In their paper, Cockerill et al. (this issue) first delineate the growing need to more effectively anticipate and respond to urgent and critical challenges brought on by rapid and accelerating change, including population growth, environmental degradation, land-use change, and public health concerns. The authors argue that modern society faces numerous "wicked (environmental) problems" (Rittel and Webber 1973). We as a society need to learn from past decisions, actions, and their consequences in order to adaptively manage the complexly intertwined Social-Ecological Systems (SES; Berkes and Folke 1998) we live in, and to learn to design for change. To this end, Cockerill et al. (this issue) propose creating and maintaining Records of Engagement and Decision-making (RoED). The article includes an overview of different types of such documentations, from historic documentation of engagement activities (dating back to paintings in the Lascaux Cave in France), evolving to modern approaches that embrace multimedia technologies. Two case studies illustrate RoED. One stems from the Klamath River basin and discusses how RoED might have made a difference in decision-making about conservation of threatened species, competition for resources, and cultural identities. The second case discusses environmental health governance in Michigan.

The world urgently needs sound research that supports decision-makers, stakeholders, practitioners, and society in addressing the current pressing environmental problems we are all facing. This collection of papers demonstrates the richness and diversity of approaches to environmental decision-making. Environmental problems offer ample exciting research opportunities to a broader scientific community and we hope more scientists will try solving these real world problems. To conclude this editorial, we cordially thank the authors for their valuable contributions to this Feature Issue, and their willingness to adhere to our tight timeline. We also warmly thank the many anonymous reviewers for their careful, timely, and constructive feedback, and we thank the editor Vincent Mousseau for his friendly support throughout. Finally, we wish to encourage the readers of this Feature Issue–and the readers of EJDP in general–to engage in environmental decision-making projects.

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