Introduction to Volume: *Dynamics of Disasters: Key Concepts, Models, Algorithms, and Insights*
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This volume is a collection of papers presented at the 2nd International Conference on Dynamics of Disasters held in Kalamata, Greece, June 29-July 2, 2015, with additional invited papers, all of which were reviewed. The conference was organized by Ilias S. Ktsireas, Anna Nagurney, and Panos M. Pardalos and brought together academics and practitioners to discuss their latest research on some of the most challenging problems associated with disasters from mitigation and preparedness to response and recovery. The collection of 17 papers is organized alphabetically by the first initial of the last name of the first author of each paper with highlights of each paper given below.

The co-editors of this volume thank the authors of the papers that appear in this volume and also thank the referees for their constructive reports on the papers. We hope that this volume demonstrates the breadth and depth of challenges associated with disasters and the underlying dynamics and also illustrates the different methodological as well as conceptual frameworks to address some of these challenges.

Fuad Aleskerov and Sergey Demin in their paper, "An Assessment of the Impact of Natural and Technological Disasters Using a DEA Approach," focus on disaster mitigation and prevention. The authors emphasize that regions differ in terms of their resistance to different disasters since they are characterized by, among other features, different sizes of populations as well as the distribution of sources of potential disasters, whether natural or technological. They propose a Data Envelopment Analysis (DEA) approach, consisting of two methods, a standard one, and one new one, with sequential exclusion of alternatives, in order to determine reasonable rankings of regions in terms of preventive measures. The approach takes into account the risks of the implementation of different preventive measures, their cost, and the heterogeneity of the regions. The application of their framework is illustrated through numerical examples for regions of the Russian Federation.

Burcu Balcik in her paper, "Selective Routing for Post-Disaster Needs Assessment," turns to rapid needs assessment that relief agencies conduct immediately following a disaster, in order to determine the effects of the disaster and the needs of the affected communities. The topic of needs assessment has not received much attention in the humanitarian logistics

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literature. Balcik identifies and introduces a new problem, the Selective Assessment Routing Problem (SARP), that addresses site selection and routing decisions for the needs assessment teams. She uses a purposive sampling strategy with assessment teams aiming to select sites that involve different community groups with distinct characteristics. She proposes both a mathematical model and greedy heuristics for SARP, accompanied by numerical analysis, that reveals that the heuristic version that balances the tradeoff between coverage and travel times provides reasonable solutions for realistic problem instances.

Rasmus Dahlberg in his paper in this volume, "Preparing for Long-Term Infrastructure Disruptions," provides an overview of infrastructure and what is meant by European Critical Infrastructure and then discusses the preparedness plans and alternative routes for passengers and freight in the case of a more than 30 day disruption of a fixed link. Specifically, the fixed link consists of the combined road and rail Oresund Bridge and the Drogden tunnel, which more than 70,000 people traverse on a daily basis, and which links Denmark and Sweden. A long-term disruption there could happen, for example, because of a ship collision with the bridge or a plane crash and although such events may be considered extreme, the Eurotunnel that connects France and England has already closed twice. Rasmus then discusses the preparedness plans of a working group and their findings and compares the possible fixed link closure scenario to the impacts of the Champlain Bridge closure in the eastern United States and the Forth Road Bridge closure in Scotland. He describes how the closures of the latter two bridges disrupted immediately local communities and affected them severely. He argues that swift and affirmative action from infrastructure operators and authorities is required in the case of such disruptive events as bridge closures that are important infrastructure.

Emil-Sever Georgescu, Cristina Olga Gociman, Iolanda-Gabriela Craifaleanu, Mihaela Stela Georgescu, Cristian Iosif Moscu, Claudiu Sorin Dragomir, and Daniela Dobre are the authors of the next paper in this volume. Their paper, "Multi-Hazard Scenarios and Impact Mapping for a Protected Built Area in Bucharest, as a Base for Emergency Planning," is inspired by earthquake disasters that have repeatedly struck Romania but with changes in patterns and dynamics, with increases in losses from 1940 to 1977, in contradiction with the positive developments in earthquake engineering, architecture, and urban planning. This paper presents multi-hazard scenarios of an area of Bucharest that suffered trauma in the 1980s and considers the effects of earthquakes, flooding, and terrorist attacks on public institutions. The authors used spatial databases and online tools in order to identify locations of shelters for evacuation purposes and security centers, in the case of an earthquake, as well as in the case of flooding, and other hazards.

Sulejman Halilagic and Dimitris Folinas in their paper, "Lean Thinking and UN Field Operations: A Successful Co-Existence?" strive to identify the supply chain management and lean thinking principles of the business world for humanitarian operations and the expected benefits of the application of both principles and best practices. They note that the "One-UN" culture is one of the biggest challenges in humanitarian operations for the United Nations, with major associated organizational challenges that include lower costs of operation, and offering better service to beneficiaries by bringing all of its operations under a single umbrella. The authors argue that humanitarian operations, especially in slow onset / man-made disasters, have a major potential of benefiting from lean principles and practices.

Georgios Marios Karagiannis and Costas E. Synolakis in the paper, "Collaborative Incident Planning and the Common Operational Picture," describe the common operational picture in disaster response, with a goal of reducing the gap between the technological and operational aspects. Disasters typically extend across jurisdictions, and the disaster response operational picture is filled with multiple agencies with different objectives. The authors use the incident planning process as a means to determine the information requirements of emergency managers during disaster response operations. In addition, they provide a typology of current capabilities and report on the major types of existing software, such as hazard modeling software, hazard mapping, vulnerability and risk mapping, alert notifications, among others, and discuss how software supports disaster response coordination. They emphasize that, although situational awareness is a necessity in disaster response, it is impossible to achieve without effective coordination and communication. They also identify the unmet modern operational needs in existing software products and suggest directions for product development of common operational picture software.

Thomai Korkou, Dimitris Souravlias, Konstantinos Parsopoulos, and Konstantina Kouri in their paper "Metaheuristic Optimization for Logistics in Natural Disasters.," recognize that logistics in natural disasters or emergencies involve highly complicated optimization problems with diverse characteristics and introduce a multi-period model aiming to minimize the shortages of different relief products in a number of affected areas during a disaster relief effort. The relief products are transported via multiple modes of transportation from dispatch centers to these areas, while adhering to traffic restrictions. A test suite of benchmark problems with is generated from the proposed model and solved to optimality with CPLEX. The aforementioned test suite is used for benchmarking a number of established metaheuristics. In addition, they provide the necessary modifications in the algorithms, in order to fit the special requirements of the specific problem type. Algorithmic performance is assessed in terms of solution accuracy with respect to the optimal solutions. Comparisons

among these metaheuristics offer valuable insight regarding their ability to tackle humanitarian logistics problems.

Andrey Kozelkov and Efim Pelinovsky in their paper, "Tsunami of the Meteoric Origin," address the modeling of a tsunami caused by an asteroid-meteorite. They first provide a review of such a hazard to planet earth. They note that the main danger on a global scale is from bodies of more than 1 kilometer in diameter, while major continental or regional destruction can be caused by falling bodies of much smaller diameters. They highlight that the first documented catastrophe on a regional scale was the Tunguska meteorite, after which, the forest was destroyed over an area of 2,000 square kilometers. The mathematical model that they construct is based on Navier-Stokes equations and captures the generation of disturbances in the water and the surface. The authors derive formulas that assess the parameters of such a tsunami and conduct numerical simulations of the effect of the angle of entry of the body into the water and the characteristics of the resulting waves.

Emmett J. Lodree, Derek Carter, and Emily Barbee in their paper, "The Donations Collections Routing Problem," rigorously study a problem that arises immediately following a large-scale disaster in the response phase and is motivated by the surge of donations of relief items as well as volunteers that often occurs after a disaster strikes. The problem, which they introduce a mathematical formalism for using integer programming, is the donation collections problem (DCP). It is a network routing problem that seeks to address a practical alternative to post-disaster logistics operations associated with materiel and volunteer convergence. They propose common sense heuristic procedures and evaluate their performance through computational experimentation. Simple heuristic procedures in humanitarian contexts may be warranted since these can more easily be implemented in practice. Their findings may seem, at first glance, counterintuitive, but are, indeed, plausible, since postponing collections at nodes (collection sites) with large accumulation rates of donations produces larger stockpiles of donated goods as compared to servicing modes with lower rates at the end of the collection route. The donation collection problem and the methodology described in this chapter to tackle it are also useful for food banks.

Evangelos Mitsakis, Josep Maria Salanova, Iraklis Stamos, and Emmanouil Chaniotakis in their seventh paper, "Network Criticality and Network Complexity Indicators for the Assessment of Critical Infrastructures During Disasters," focus on the improvement of disaster management through the use of network analytics/criticality indicators. Network criticality indicators provide powerful tools for the assessment of parts of networks, notably, transportation networks, the closure of which would affect the overall performance of the network to the greatest degree. The authors overview centrality indicators for disaster management and

provide an extended application of those metrics for the case of the Peloponnese region in Greece, which was subject to catastrophic fires in 2007. Their findings show that adopting interdisciplinary advances, as their synthesis of different network concepts and metrics reveals, can yield useful insights to decision-makers involved in all phases of disaster management: mitigation, preparedness, response, and recovery/reconstruction.

The next paper, "Freight Service Provision for Disaster Relief: A Competitive Network Model with Computations," by Anna Nagurney, presents a mathematical model in which freight service providers compete in order to deliver relief supplies provided by a humanitarian relief organization to points of demand post-disaster. Hence, this model focuses on the response phase. The behavior of the disaster relief organization assumes cost-minimization, since the organization must manage its budget wisely and also report to donors and stakeholders. Freight service providers, in turm, are profit-maximizers. The multitiered disaster relief supply chain network problem is formulated as a variational inequality problem and a path-based projection method proposed for the determination of the product relief item flows, The algorithm resolves the problem into specially structured network problems for which a special purpose exact equilibration algorithm is provided. Qualitative results in terms of existence and uniqueness of the solution pattern are also given. The author also introduces a cooperative system-optimized model for freight service provision for disaster relief and describes a price of anarchy in the disaster relief setting. In addition to illustrative numerical examples, a case study, focusing on the recent immense Ebola healthcare crisis in Western Africa, is presented for which the relief item flows as well as freight service provision prices are reported. This paper adds to the literature on game theory and disasters.

Anna Nagurney and Ladimer S. Nagurney in their paper, "A Mean-Variance Disaster Relief Supply Chain Network Model for Risk Reduction with Stochastic Link Costs, Time Targets, and Demand Uncertainty," construct an integrated computable model that incorporates features of disaster preparedness and mitigation as well as response. The model is an optimization model in which the humanitarian organization seeks to minimize its total expected operational costs and the total risk in operations with an associated individual weight, as well as to minimize expected costs of shortages and surpluses and tardiness penalties associated with time target goals at demand points. The model handles both the pre-positioning of relief items, whether local or nonlocal, and their procurement (also local or nonlocal), and the transport and distribution post-disaster. The proposed algorithm yields closed form expressions at each iteration for the variables. The numerical examples include smaller examples and a case study focusing on hurricanes striking Mexico, which is a country ranked as one of the world's thirty most exposed countries to three or more types of natural disasters.

Gabriela Perez-Fuentes, Enrica Verrucci, and Helene Joffe in the paper, "A Review of Current Earthquakes and Fire Preparedness Campaigns: What Works?" focus on preparedness campaigns in the case of natural disasters. They note that most of the natural disaster campaigns rely primarily on information delivery, although studies have consistently shown that this is not sufficient to affect behavior. In addition, many of the campaigns lack evaluation and, hence, their effectiveness can not be ascertained. The authors report the findings of an online search conducted to determine major earthquake and fire preparedness campaigns and analyze the content, design, and theoretical background of the campaigns and the results of their evaluation. The authors argue that there is a need for a multi-hazard approach to emergency preparedness interventions since a public that is better prepared for multiple hazards is better prepared for specific as well as unpredictable ones.

Denise Sumpf, Vladimir Isaila, and Kristine Najjar tackle an ongoing disaster in their paper, "The Impact of the Syria Crisis on Lebanon." Their paper vividly explores the impacts of the war in Syria and the dynamics and spillovers on its immediate neighbor, Lebanon, including the effects of the Syrian refugee crisis on Lebanon, which currently is hosting more than one million Syrian refugees, adding about 25% to the existing Lebanese population. The authors identify economic issues as well as social costs of the Syria crisis, specifically, on health and education. They also delineate the environmental costs and the impacts on agriculture and provide potential solutions. They discuss food security and waste management challenges and potential solutions. The authors note that the humanitarian crisis response has prioritized addressing immediate needs but for that to be effective in damping the impact of the continuing conflict the integration of a development perspective is essential in finding a medium- to long-term solution.

The next paper, "Absenteeism Impact on Local Economy During a Pandemic Via Hybrid SIR Dynamics," is by Edward W. Thommes, Monica Gabriela Cojocaru, and Safia Athar. The authors construct a hybrid model by combining a Susceptible-Infected-Recovered (SIR) model, with roots in epidemiology, and discrete probability transition matrices, to explore the costs of absenteeism and presenteeism (going to work while sick) during a pandemic in a local economy. Workers consist of those who live and work in the same city as well as those who are commuters between cities. The authors make use of projected dynamical systems theory for the dynamics. Thommes, Cojocaru, and Athar also conduct simulations to investigate the effects of a fear factor and the severity of the disease on the number of missed work days in the region, which they then translate into loss of productivity costs. The results reveal that higher fear parameter values lead to high absenteeism and lower infection levels. Nevertheless, in the case of severe pandemics, there exist scenarios in which there

is a unique value of the fear parameter which results in minimum economic costs for the regional economy. The implication for policy-makers is that "stay at home" policies during a pandemic could be implemented for workers, without resulting in a state of emergency.

Theodore B. Trafalis, Budi Santosa and Michael B. Richman in the paper, "Tornado Detection with Kernel-Based Classifiers from WSR-88D Radar Data," focus on the important problem of detection of tornadoes in a timely manner so that warnings for evasive action are possible, which has been an objective of weather forecasters. The prediction of tornadoes is challenging due to the small scale of their circulation and their rapid production in the atmosphere. Through the use of technology, there has been progress in increasing the lead-time of tornado warnings, which translates into lives saved. The authors use machine learning for weather prediction of tornadoes and introduce and apply two types of kernel-based methods: Support Vector Machines (SVM) and Minimax Probability Machines (MPM) to detect tornadoes through the utilization of attributes from radar derived velocity data. They compare their results to those obtained using Neural Networks (NN) and demonstrate that kernel approaches are more accurate for tornado detection.

Chrysafis Vogiatzis and Panos M. Pardalos in their paper, "Evacuation Modeling and Betweenness Centrality," consider the problem of evacuating people in an urban area from danger zones to safe zones. This is a large-scale problem, which has received much attention in the literature, and has been subject to formulation and solution using various methodological approaches. The authors' approach falls into the category of heuristics and their heuristic decomposes the large-scale evacuation problems into a series of smaller, scalable integer linear programming problems. In addition, Vogiatzis and Pardalos incorporate information on the transportation network using ideas from graph centrality, in order to ensure a more robust decomposition. Specifically, the decomposition approach takes into consideration the betweenness of a set of nodes in the transportation network, and tries to obtain clusters from those nodes that can be easily solved so as to divide the flow of evacuees more evenly towards multiple paths to safety. The authors provide results for their approach on both synthetic and real-life networks, including a large-scale network representation of Jacksonville, Florida. The authors' approach yields solutions to such challenging problems, which have, heretofore, been proven impossible to be solved via commercial solvers.

The final chapter in this volume, by Debbie Wilson, is entitled, "Ode to the Humanitarian Logistician: Humanistic Logistics Through a Nurse's Eye." It provides a first-hand, gripping, account of the Ebola crisis in Liberia through the lens of a courageous nurse (the author), who was deployed there for six weeks at a 120-bed Ebola Ttreatment Unit (ETU) with the humanitarian organization Medicins San Frontiers (MSF), known in English as Doctors

Without Borders. The focus of the paper is on the role of the humanitarian logisticians in battling, together with the healthcare providers, the greatest outbreak of this disease to-date. The tons of supplies that were provided to battle this terrible disease had to be effectively managed, recorded, transported, and set up by the logisticians. In addition, communications were established by the logisticians or "logs" as well as the procedures for the testing of blood samples, which needed to be transported, while the patients awaited the results and this took five days. The logs also oversaw the destruction of all infectious waste and were responsible for restoring the electric power generators. Their skillset and expertise were essential to the effectiveness of the work of the medical personnel.

The Disasters research area requires the development of multi-disciplinary theories, tools, techniques and methodologies that span a wide spectrum of disciplines, from the Social and Behavioral Sciences, Humanities and Government to Management, Engineering, Medicine, Mathematics and Computer Science. These characteristics make disaster research challenging and exciting and we hope that the present volume contributes to exemplifying these aspects. Disasters come in various forms, each with their own particular issues. Whether one studies hurricanes, floods, earthquakes, tsunamis, tornadoes, volcanic eruptions, hazardous chemical incidents/attacks, plane crashes, fires, civil disturbances, riots and so forth, researchers have identified important commonalities, such as organizational and community preparation, response, recovery and others. The interplay between researchers and policy makers is another important aspect of Disasters research. We hope that the DOD 2015 Book of Proceedings will stimulate further interest in Disasters research.

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