Chapter 1

# Introductory Chapter: Environmental Risks between Conceptualization and Action

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Additional information is available at the end of the chapter

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## 1. Risk-related concepts

Changes in the contemporary world materialized in particular through population growth and mobility, urbanization, and economic expansion also result in an increased exposure of people and assets to extreme events and impose, implicitly, adequate management of induced risks.

The occurrence of natural and anthropogenic risk phenomena, known as hazards, puts a heavy tribute on disaster-sensitive human communities regardless of their level of development. The magnitude of the disasters and their increasing frequency and severity imply the need for their approach by the entire world community and for global action. It is, therefore, necessary to find answers to questions: Is the world really a more dangerous place? If so, what are the causes? Why is the dimension of disasters much higher in poor countries? What are the best ways to reduce the impact of hazards and disasters in the future?

In this context, knowledge of risks becomes a sine qua condition in carrying out impact studies, risk prevention plans, spatial planning plans, and, in general, a condition for effective management of natural resources or sustainable development projects. This explains a large number of specialized studies, the extent of research in the field, and the sustained efforts to achieve the transfer from theory to practice.

A multidisciplinary scientific field has emerged over the past decades, in which there is a specialized terminology that wants to be as precise as possible, eliminating the semantic ambiguities and the difficulties of communication between the theoreticians and practitioners. Within this multidisciplinary research field, the methodology, taken from different fundamental domains, gradually improved, new methods and models of integrated analysis were imagined, and the possibilities of applying the research results were diversified. The necessity to develop conceptual models of risk, well-argued scientifically, derives from the complexity of the risk and the necessity of its holistic approach.

Frequently, the *risk* is defined as the product of the probability of a phenomenon occurrence and its negative consequences, thus associating two distinct elements: on the one hand, the hazard and, on the other hand, the sensitive element of destructive effects, which most of the times the man is considered. In other words, the risk arises from the spatial overlap of hazards and the elements at risk. Recently, United Nations General Assembly (2016) formulates the definition of risk as "the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity" [1].

Regarding the concept of *hazard*, most often it is defined as a potential source of danger, being associated or identified with those natural or anthropogenic processes and phenomena that can cause material or human losses or impair the quality of the environment. The term brings together all those processes and phenomena with destructive potential and whose occurrence cannot be predicted with certainty. Hazards are associated with random processes and phenomena, at least in appearance, which can occur in a well-determined environment and whose mechanisms are known by the researcher but for which the moment and place of the next occurrence cannot be determined by simply knowing the prior states. They are characterized by a certain probability of occurrence and a certain intensity or magnitude, which refers to the impact force in time and space. The central idea of hazard is not the phenomenon itself but the likelihood of its occurrence; in other words, the hazard is a threat, not the event itself. It can manifest as a harmful event, and, when measured in terms of real damage, deaths, or injuries, it becomes a disastrous or catastrophic event.

The specific categorization is difficult and contentious, but it is generally considered that environmental hazards are "extreme geophysical events, biological processes and technological accidents that release concentrations of energy or materials into the environment on a sufficiently large scale to pose major threats to human life and economic assets" [2]. Natural events can be considered here (volcanic eruptions, tropical cyclones, drought, epidemic diseases, wildfires, etc.), but also major technological accidents (transport accidents, industrial explosions and fires, release of toxic or radioactive materials, public facilities structural collapse, storage, transport and improper use of hazardous materials) and the so-called context hazards that are driven by forces operating on mega-scales, hemispheric to planetary, and are able to produce environmental change (international air pollution that can lead to climate change and sea level rise, deforestation, desertification, loss of natural resources, land pressure, impact from near-earth objects, etc.).

*Exposure* is another component of risk that is considered, in simple terms, as the number of people and/or other elements at risk that may be affected by a particular event. The United Nations General Assembly (2016) defines exposure as "the situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas" [1]. Thus, exposure involves the overlapping of socioeconomic systems with hazard favorable factors, which is, in other words, a precondition for risk and disaster.

The main component of risk is *vulnerability*, a concept that has been progressively developed over the past decades, registering a great number of definitions and points of view. The United Nations General Assembly (2016) considers vulnerability as "the conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards" [1].

The peer-reviewed literature shows that the key element in defining and assessing vulnerability can differ from exposure, preparedness, and prevention, to coping ability, adaptive capacity, and recovery, and each approach identifies the essential peculiarities of human structures (from individual to societal) in their relation with different hazards [3].

Some authors provide conceptual comparative analysis of different vulnerability models putting in balance distinct conditions of vulnerability: multiple contexts, multiple dimensions, temporal variability, multiple scales, and scale interdependency [3–5].

## 2. Risks in the environment

The analysis of the risks that threaten today's human society highlights several characteristics: recrudescence, diversification, and organic link between risks and urban. The recrudescence of catastrophic events and the increase in their global costs can be attributed to global changes, especially climatic changes, and to the way in which man himself exhibits the risks through countless ways: the occupation of vulnerable zones and of exposed sites to hazards, increasing in urbanization and industrialization, pressure on resources, etc.

Risk diversification is also a feature of today's geographic systems, increasingly anthropized. Besides the risks already assumed by society, there are many others risks, either passive (which can be reactivated at any time) or unknown (technological or from the social sphere) risks.

The connection between the urban and the risks is also becoming increasingly obvious. By its basic feature, that of concentration of people and activities on narrow spaces, the city becomes a vulnerable place to any exogenous or endogenous disruptive agent. Urban risks have multiple causes and consequences. Urban fabrics in a continuous expansion, multiplication of uses, and close interdependence between the different systems and processess that ensure the functioning of urban settlements favor, in case of extreme events, the occurrence of chain effects (domino effects). It is possible that future disasters will occur on increasing scales, precisely not only of the concentration of the population in urban areas but also of the increasing complexity of human society.

In 2017, according to the EM-DAT database of the Center for Research on the Epidemiology of Disasters (CRED) in Louvain, 318 natural disasters occurred, affecting 122 countries (96 million people suffering in one way or another), causing the death of 9503 people and economic damages of US$314 billion [6]. If the number of deaths in the year 2017 was far below the average of the last 10 years, instead, in terms of costs, in the year 2017, it is ranked second, due to the impact of three hurricanes affecting the United States and the Caribbean: Harvey (US$95 billion), Irma (US$66 billion), and Maria (US$69 billion). The majority of losses were caused by weather-related disasters. Almost 90% of deaths were due to climatological, hydrological, or meteorological disasters; the floods were responsible for nearly 60% of affected people, while the storms (mainly hurricanes) have caused 85% of economic damages.

As far as the spatial distribution is concerned, the situation in 2017 reflects the trend of previous years when the Asian continent experienced the highest disaster occurrence (43% of the total). The most affected were China and India, followed by a number of Caribbean island states, affected by hurricanes, and Africa (in particular, Mauritania, where 88% of the population was affected by a drought). Overall, the high mortality and number of people affected correlated to the country's population, as well as economic losses correlated to GDP, highlighting the burden of disasters on small islands in 2017 [6].

Even the more localized and more reversible extreme events, like hurricanes, floods, droughts, technological accidents, etc., are of particular concern, mega-scale events capable of cutting across regional geographical units and existing socio-economic systems have to be considered. The most extreme adverse impacts could come from climate change (e.g., the worst 1 percent of scenarios) and may account for a large portion of expected losses [7]. In urban areas, this is projected to increase risks for economies and ecosystems, including risks from storms and extreme precipitation, inland and coastal flooding, landslides, etc. [8]. These risks are amplified for those lacking essential infrastructure and services or living in exposed areas.

It is considered that the mechanism through which climate change mega-catastrophe could arise is that of the climate's crossing a systemic threshold, referred to as abrupt climate change, developed in a few years or decades, due to atmospheric pollution, in particular to greenhouse gas (GHG) emissions. According to different scenarios, the global average temperature could increase by 2–4°C by the end of the twenty-first century [8]. Heating may be exacerbated by the faster melting of the snow cover and ice that reflects the heat but also the release of liquefied methane in the tundra or even from oceans.

One of the impacts of wide-scale climate change could be the global rise in sea level by collapse and melting of the Antarctic and Greenland ice sheets. The breakage, in July 2017, of a piece of a 2500-square-mile (about three billion tons) iceberg from the Larsen-C ice shelf, as well as numerous cracks and melting lakes, which continues to spread both in the west and east of Antarctica, may be signs of destabilizing the ice sheet, which could lead to an irreversible process of flowing and melting into the sea. Thus, given the continuing increase in population, infrastructure, and other facilities in coastal areas of the world, rising sea levels are becoming a serious threat.

Another category of risk scenarios involves weakening and other disturbances of ocean currents, assuming changes in precipitation and temperature models, severe disturbances of ocean ecosystems, and intensification of extreme phenomena, with severe effects on agriculture as well as on other economic and social sectors. The unusually warm and dry weather in Western Europe in July 2018, with temperatures above 30°C and the numerous forest fires produced beyound the polar circle in the Scandinavian Peninsula or rains of extreme intensity in the Japanese archipelago that have generated the most severe flooding in the last 60 years, even if they are assigned to the oscillation of the jet streams system in the atmosphere, they also could confirm the scenario of ocean currents disturbance.

There is also the risk of changes in ecosystems, significant biodiversity loss due to climate variation, rainfall, and temperature changes. There is the prospect of very large ecosystem disruptions, of continuous and extensive vegetation, and also desertification or irreversible conversion of forests into pastures. IPCC (2014) specifies that "A large fraction of species faces increased extinction risk due to climate change during and beyond the twenty-first century, especially as climate change interacts with other stressors. Most plant species cannot naturally shift their geographical ranges sufficiently fast to keep up with current and high projected rates of climate change in most landscapes" [8].

Particular attention must be paid to the so-called cascading-event catastrophes, when a number of hazards can occur within a relatively short period of time, especially in the immediate vicinity, and can potentiate each other so as to result in a cascade of consequences of much greater severity (e.g., prolonged drought can result in a severe lack of food, which, in turn, can generate disputes breaking down the civil order, which can cause destabilization of the government and political disturbances, and which can further lead to large-scale migration for survival or even regional conflicts) and thus to overcome the resilience of certain socioeconomic systems.

As far as anthropic hazards are concerned, serious threats are improper industrial and agricultural activities and environmental pollution combined with poor environmental legislation enforcement. Poverty and rural migration toward urban areas concentrate the population in slum areas across developing and transition countries which frequently lack access to sanitation and proper hygiene conditions. The so-called informal settlements are predisposed to massive pollution, exposing their inhabitants to disease and infections.

Many cities and rural regions are facing the lack of sound public utilities such as improved drinking water and sanitation facilities, wastewater treatment or basic solid waste management services. At the global level, there are huge disparities between high-income countries and developing ones regarding the population access to such critical amenities broken down per urban and rural population [9].

The greatest short-term danger to humans from untreated excreta, wastewater, septage, and wastewater sludge is from pathogens, microorganisms that can cause severe diseases [10]. Diseases caused by pollution were responsible for an estimated 9 million premature deaths in 2015 approximately 16% of all deaths worldwide [11].

Furthermore, The Lancet Commission on Pollution and Health stipulates that "all forms of pollution combined were responsible for 21% of all deaths from cardiovascular disease, 26% of deaths due to ischemic heart disease, 23% of deaths due to stroke, 51% of deaths due to chronic obstructive pulmonary disease, and 43% of deaths due to lung cancer worldwide" [11].

An emerging environmental threat in the last decade is the plastic pollution, with a multilevel coverage from local water bodies (creeks, rivers, lakes) to the remote or deepest locations across the planet's oceans. River and marine ecosystems across the globe have been loaded with macro- and microplastics, and impact on wildlife is critically endangered.

Even rural communities may significantly contribute to river plastic pollution if there are no sound waste collection schemes. As an example, over 290 tons of plastic bottles were collected during 2005–2012 in the proximity of Izvoru Muntelui dam lake (Eastern Carpathians), most of them generated by the upstream villages [12].

Solid waste management is a critical sector of public health and environment; however, most of the transition and developing countries are facing real challenges concerning the collection efficiency and proper disposal of solid waste. It is also a major contributory factor to urban flooding across the globe with examples from Asia, Africa, and Latin America [13]. Poor waste management services lead to open dumping practices, blocked drainage and channels, and clogged rivers by waste which further favor the flood of surrounding communities. Floods and tropical storms favor the water stagnation within built-up areas among various debris which increases the epidemic outbreak risks.

Landfills are the main disposal option despite these sites are a source of complex pollution (air-soil-water nexus) if it is not updated to best available techniques. Conventional landfills or dumpsites pose serious risks for surroundings, particularly those sites who serve the mega-cities and larger cities across Africa, Asia, South and Central America, and South and Eastern Europe.

Landfills are an important source of anthropogenic methane contributing to GHG emissions being the main disposal option including for high-income countries. Due to methane accumulation, internal combustion may generate spontaneous, uncontrolled fires being dangerous for surrounding households and emitting toxic pollutants in the air. Landfills located in low-lying areas are also exposed to flash floods or those located in hilly regions to landslides or erosion. The collapse of landfills killed 130 people (including children) in Africa during 2017, the most devastating being the waste landslide of Koshe site in March (Addis Ababa, Ethiopia) with 115 deaths [14].

Frequently, informal settlements are located near large urban dumpsites where the people face numerous threats. Improper location of waste disposal sites increases the pollution and health risks for surrounding communities. Peripheral areas of cities are exposed to industrial pollution, poverty and poor connection to public utilities such as drinking water, sewage, sanitation, and waste management facilities. Rural areas are more vulnerable to the negative effects of industrial energy and agriculture systems which support urban areas [15].

In Africa, where drought and conflicts are dominant disasters, there is a migration of people toward neighboring regions and countries where refugee camps face improper sanitation and waste management facilities [14]. Similar poor housing conditions are encountered in other refugee camps of the Middle East (e.g., Syrian refugees in Lebanon, Jordan) or Europe. The conflict areas and refugee crisis is an emerging social and political crisis with repercussions on the environment. Refugee camps must have access to basic utilities and their environmental impact to be analyzed [16].

Closely with the limited waste management services and poor socioeconomic conditions is one of the widespread practices such as the open burning of household waste. It poses serious health risks because hazardous substances are released at a low burning temperature such as dioxins, polycyclic aromatic hydrocarbons (PAHs), or black carbon. These toxins are carcinogenic and powerful short-lived air pollutants, and the impact of open burning practices should be further investigated across transition and developing countries. Developed countries are facing the environmental issues associated with more expensive technologies such as municipal waste incineration plants or co-incineration facilities (e.g., cement industry).

Poorer households rely on solid fuels as a domestic energy source. Rudimentary household furnaces expose the inhabitants to dangerous indoor air pollution (carbon monoxide poising) or fire risk. Fossil fuel combustion in developed and transition countries and burning of biomass in developing countries account for 85% of airborne particulate pollution and for almost all pollution by oxides of sulfur and nitrogen [11].

Another widespread bad practice across the world is illegal dumping of waste, affecting water bodies, public lands, roadsides, forest, floodplains, and coastal areas. Improper disposal of hazardous wastes leads to severe public health issues at the regional level as shown in Southern Italy where 2000 toxic substance dumping sites were detected in Campania beside the illegal burning practices of wheels, plastics, textiles, and other industrial residuals [17]. In addition to risks caused by heavy metals, uncontrolled dumping of waste is a potential threat of pathogenic infections, chronic diseases, and the infestation of vermin [14].

Illegal traffic of e-waste and obsolete electronics from the EU and United States toward developing countries of Africa and Asia reveals the global interconnections of environmental crimes. In such destinations, the toxic wastes are frequently treated in rudimentary conditions using manual labor. Severe health issues are associated with exposure to e-waste recycling sites including vulnerable population such as pregnant women and children [18]. Notorious ewaste dumps such as Guiyu in China and Agbogbloshie in Ghana are worst-case scenarios where the environment is heavily polluted contaminating the soil, groundwater, rivers, crops, and livestock.

Other waste streams, such as medical wastes, animal waste, batteries and accumulators, used tires, obsolete vehicles, bulky items, construction and demolition waste, and sewage sludge need special attention for treatment and disposal in order to prevent the environmental contamination.

Obsolete pesticides and other agricultural chemicals are a serious environmental potential threat for most of the countries where agriculture still plays a key role in their economies. Chemical pollution is a severe global concern with a diverse range of contaminated sites by toxic chemicals, persistent organic pollutants, radionuclides, and heavy metals (e.g., mercury, lead, chromium, and cadmium) released into air, water, and soil by active and abandoned factories, smelters, mines, and hazardous waste sites [11].

Another critical environmental issue is found in sub-Saharan Africa and Asia, where 892 million people still practice open defecation [19]. In such regions, soil and water infestation with human excreta and solid waste is highly probably due to the lack of basic facilities. Furthermore, at the global level, rural households rely on outside toilets with a poor connection to sewage systems or septic tanks. This fact leads to groundwater contamination with the critical impact on human health. Provision of safe drinking water facilities is challenging for rural population compared to urban areas as for sanitation sector. In 2015, 0.8 million deaths were estimated to be caused by unsafe sanitation and 1.3 million to unsafe water sources [11]. Almost 3 billion people lack sound waste collection services with a critical situation across rural areas of low- and middle-income countries [9].

In sub-Saharan Africa and parts of Asia and Central and South America, wastewater treatment systems, if they exist, are minimal or function poorly, while in eastern Europe, Turkey, the Russian Federation, Mexico, South America, and other areas, wastewater treatment has advanced, but wastewater sludge and biosolids management are emerging concerns, and complex regulatory structures are being developed [10]. The poor and the marginalized communities are most exposed to health pollution threats in every country of the globe. The Agenda 2030 aims to end open defecation and to provide universal access to basic utilities as part of sustainable development goals (SDGs).

Cross-border pollution issues via air, water bodies, or emerging transportation systems challenge the current international relations. Plastic pollution, oil spills, chemical pollution, industrial accidents, and other environmental threats raise several governance issues, and frequently, the local communities have few options to combat such events.

## 3. Addressing environmental risks

As previously mentioned, the possibilities of addressing the risk issue and of applying the research results have been continuously diversified. Different viewpoints or approaches can be framed either in a behavioral paradigm, a structural paradigm, or a complexity paradigm [2].

Behavioral paradigm is the hazard-based point of view that emphasizes the role of human adjustment to natural hazards through defensive technical measures, scientific acquirements, and emergency plans for disaster mitigation [3].

The structural paradigm is rather a cross-hazard and a disaster-based viewpoint that focuses on the characteristics of socioeconomic and political structures, the lack of resources or human exploitation of nature. Nowadays, these two approaches coexist, but it should be noted that physical scientists have a distinct preference for the behavioral perspective, while the social scientists and human geographers rather prefer the second one [3].

The complexity paradigm is built on the foundations of the two paradigms already mentioned, taking from each of them the most valuable aspects and pursuing a more comprehensive approach, considering that disasters are the result either of the interactions between the natural and social worlds and within each of them.

A recent addressing is the multi-hazard approach which is related to the complex nature of the interaction between the hazards [20]. For risk assessment, it is important to evaluate the widest possible range of impacts, including low-probability outcomes with large consequence [8]. Different methods for risk assessment can be applied: quantitative and qualitative risk assessment methods, the event-tree analysis (very useful for analyzing complex chains of events and the associated probabilities), the risk matrix approach, the indicator-based approach, etc.).

Of great importance is the development of spatial decision support systems with the aim to analyze the effect of risk reduction planning alternatives and to support decision makers in selecting the best alternatives. They are composed of a number of integrated components such as risk assessment, risk reduction planning, temporal scenario, and communication and visualization components [20].

Important advances in addressing risks are due to new technology, including applications of satellite remote sensing, airborne laser scanning (ALS), global positioning systems (GPS), and geographical information systems (GIS). They provide strong support in all phases of the risk management process through monitoring, evaluation, warning, and mobilization of emergency aid.

There is currently a shift of efforts from post-disaster responses and measures to a more responsible, pre-disaster attitude and action. If the events themselves cannot be prevented from occurring, their disastrous consequences can be reduced by a well-established prior plan and by preparing emergency measures for the community at risk. Experience of past events, centralization of the results in disaster observation, and use of modern methods and techniques for evaluating vulnerable areas, can reduce the degree of unpredictability of destructive phenomena occurrence.

Thus, pre-disaster protection becomes a priority within the cycle of disaster management and includes risk assessment (hazard identification, probability and scenarios, exposure and vulnerability evaluation and mapping, loss estimation); mitigation (construction of engineering works and protective structure, insurance, land planning); preparedness (forecast systems, warning schemes, safe refuges, stockpile aid); and emergency plans (evacuation routes, practice drills, first aid supplies).

In the case of climate change mega-hazard, traditional responses to the risk are of limited value in mitigating risk, so different types of possible ex ante responses are considered [7]: global abatement to rapidly stabilize the concentration of GHGs in the atmosphere to a sufficiently low level; development and deployment of controlled geoengineering (e.g., technologies to reduce the amount of solar energy the planet absorb or to remove the $CO_2$ from the atmosphere); and large-scale adaptation measures to reduce the consequences of mega-catastrophes or short-circuit the cascading of more localized disasters.

The subject of environmental risks continues to be of great interest to various national and international institutions. Among the efforts of the United Nations, the Sendai Framework for Disaster Risk Reduction 2015–2030 underscores that disaster risk reduction is essential to achieve sustainable development. It strongly supports the integration of the disaster and climate risk reduction, at the global, regional, national, and local level, into the 2030 Agenda for Sustainable Development frame [21].

There are still a number of future needs in the field of environmental risks research, such as multilevel cooperation; interdisciplinary research; integration between natural and social approaches; selection of relevant evaluation indicators, especially vulnerability indicators [22]; transferability of methods; the use of GIS techniques; and the existence of output maps, considering scale and hierarchy, etc. [23].

## 4. Conclusions

Environmental risks are associated with various natural phenomena and human activities which are potential threats to urban and rural communities and natural and seminatural ecosystems, creating disturbances from local to global level. Population growth, urbanization, resources depletion, pollution and climate change amplify the current risks and emerge new threats to natural and socioeconomic systems.

Risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development [8]. Most vulnerable places, countries, and regions are those with poor socioeconomic conditions, lack or improper access to basic utilities (such as drinking water supply, sanitation, hygiene, sludge and solid waste management services), poor land use and agricultural management, and uncontrolled industrial activities. Usually, poor countries pay a higher tribute to death, while wealthy countries account for the highest levels of material losses.

Environmental policies must be continuously updated supported by relevant data and proper monitoring process to mitigate the environmental risks from local to international level. Multilevel cooperation is compulsory on this matter, and further mechanisms must be developed in the context of climate changes, urban expansion, and emerging economies of low- and middle-income countries.

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## References

[1] United Nations General Assembly. Report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction.

December 2016. Available at: https://www.preventionweb.net/files/50683_oiewgreport-english.pdf [Accessed: June 28, 2018]

[2] Smith K, Petley DN. Environmental hazards. In: Assessing Risk and Reducing Disaster. 5th ed. New York, USA: Routledge; 2008

[3] Stângă IC, Grozavu A. Quantifying human vulnerability in rural areas: Case study of Tutova Hills (Eastern Romania). Natural Hazards and Earth System Sciences. 2012;**12**:1987-2001. DOI: 10.5194/nhess-12-1987-2012

[4] Hufschmidt G. A comparative analysis of several vulnerability concepts. Natural Hazards. 2011;**58**:621-643. DOI: 10.1007/s11069-011-9823-7

[5] Birkmann J, Kienberger S, Alexander DE, editors. Assessment of Vulnerability to Natural Hazards. A European Perspective. San Diego, USA: Elsevier; 2014

[6] Cred Crunch 50. EM-DAT The International Disaster Database. Center for Research on the Epidemiology of Disasters-CRED. Natural Disasters in 2017: Lower mortality, higher cost. 2018. Available at https://www.cred.be/sites/default/files/CredCrunch50.pdf [Accessed: June 26, 2018]

[7] Kousky C, Rostapshova O, Toman M, Zeckhauser R. Responding to Threats of Climate Change Mega-Catastrophes, Policy Research Working Paper 5127. The World Bank Development Research Group, Environment and Energy Team; November 2009. Available at: http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-DP-09-45.pdf [Accessed: June 28, 2018]

[8] IPCC. Climate change 2014: Synthesis report. In: Pachauri RK, Meyer LA, editors. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland: IPCC; 2014: 151 pp. Available at: https://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full.pdf [Accessed: June 26, 2018]

[9] Mihai FC. One global map but different worlds: Worldwide survey of human access to basic utilities. Human Ecology. 2017;**45**(3):425-429. DOI: 10.1007/s10745-017-9904-7

[10] UN-HABITAT. Global atlas of excreta, wastewater sludge, and biosolids management: Moving forward the sustainable and welcome uses of a global resource. 2008. Available at: https://esa.un.org/iys/docs/san_lib_docs/habitat2008.pdf [Accessed: June 26, 2018]

[11] Landrigan PJ et al. The Lancet Commission on pollution and health. The Lancet. 2018; **391**(10119):462-512). DOI: 10.1016/S0140-6736(17)32345-0

[12] Mihai F-C. Rural plastic emissions into the largest mountain lake of the Eastern Carpathians. Royal Society Open Science. 2018;**5**(5):172396. DOI: 10.1098/rsos.172396

[13] Lamond J, Bhattacharya N, Bloch R. The role of solid waste management as a response to urban flood risk In developing countries. A case study analysis. WIT Transactions on Ecology and the Environment. 2012;**159**:193-205. DOI: 10.2495/FRIAR120161

[14] UNEP. Africa Waste Management Outlook. Nairobi, Kenya: United Nations Environment Programme; 2018

[15] Kelly-Reif K, Wing S. Urban-rural exploitation: An underappreciated dimension of environmental injustice. Journal of Rural Studies. 2016;**47**:350-358. DOI: 10.1016/j.jrurstud.2016.03.010

[16] Price RA. Environmental impact assessments in refugee crises. K4D Helpdesk Report. Brighton, UK: Institute of Development Studies; 2017. Available from: https://assets.publishing.service.gov.uk/media/5a5f2cdbed915d7dfea66cd8/229-EIA-in-refugee-crises.pdf [Accessed: June 26, 2018]

[17] Mazza A, Piscitelli P, Neglia C, Rosa GD, Iannuzzi L. Illegal dumping of toxic waste and its effect on human health in Campania, Italy. International Journal of Environmental Research and Public Health. 2015;**12**(6):6818-6831. DOI: 10.3390/ijerph120606818

[18] Grant K et al. Health consequences of exposure to e-waste: A systematic review. The Lancet Global Health. 2013;**1**(6):e350-e361. DOI: 10.1016/S2214-109X(13)70101-3

[19] WHO Progress on Drinking Water, Sanitation, and Hygiene: 2017 Update and SDG Baselines. Geneva: World Health Organization (WHO) and the United Nations Children's Fund (UNICEF); 2017. License: CC BY-NC-SA 3.0 IGO

[20] van Westen CJ, Greiving S. Multi-hazard risk assessment and decision making. In: Dalezios NR, editor. Environmental Hazards Methodologies for Risk Assessment and Management. London: IWA Publishing; 2017. pp. 31-94

[21] UNISDR 2017. United nations plan of action on disaster risk reduction for resilience. Towards a Risk-informed and Integrated Approach to Sustainable Development. Available from: https://www.preventionweb.net/files/49076_unplanofaction.pdf [Accessed: June 26, 2018]

[22] Birkmann J. Indicators and criteria for measuring vulnerability: Theoretical bases and requirements. In: Birkmann J, editor. Measuring Vulnerability to Natural Hazards—Towards Disaster Resilient Societies. Tokyo: United Nations University Press; 2006. pp. 55-77

[23] Fuchs S, Birkmann J, Glade T. Vulnerability assessment in natural hazard and risk analysis: Current approaches and future challenges. Natural Hazards. 2012;**64**:1969-1975. DOI: 10.1007/s11069-012-0352-9