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Editorial

Natural Disasters Occurrence, Reduction, and Restoration in Mountain Regions

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1. Introduction

The Intergovernmental Panel on Climate Change's Sixth Assessment Report [1] posits that climate change is likely to exacerbate the severity and frequency of water- and sediment-related disasters on a global scale. Under the impacts of global warming and climate change, the spatiotemporal patterns of rainfall and other weather events have become more unevenly distributed, often with a more extreme magnitude and/or intensity of events. Empirical studies conducted within the European Alps have elucidated a suite of mechanisms by which climate change is implicated in the exacerbation of slope instability, with a notable escalation in meteorological and climatic conditions that predispose terrains to the initiation of debris flows [2]. Recent decades have witnessed a correlation between heightened debris flow activity and intensified pluvial events within this region [3,4]. In Asia, one practical example is Typhoon Morakot, which struck southern Taiwan in August 2009 [5], which incurred unprecedented pluviometric extremes exceeding 3000 mm within four days, culminating in the catastrophic Shiaolin landslide with over 400 fatalities. Similarly, Japan has experienced significant losses due to slope failures, with an average of 1241 sediment disasters recorded annually from 1990 to 2019, culminating in 678 fatalities and disappearances between 2000 and 2019 [6] (Contribution 1). The comparative inefficacy of search and rescue operations for hydro-meteorological disasters relative to seismic events [7] highlights the compounded challenges of such disasters. Furthermore, mountainous regions are particularly vulnerable to a spectrum of compound disasters, including droughts, flash floods, forest fires, debris flows, and landslides, with the vicissitudes of climate change amplifying the risk profile for physical, ecological, and socio-economic systems [8,9]. Accordingly, this Special Issue endeavors to elucidate the emergent characteristics of disasters concomitant with extreme rainfall events and to survey the recent progress in state-of-the-art in situ observational technologies, early warning models, and disaster risk-reduction strategies.

2. Review of New Advances

Mountain regions are recognized as critical areas of study due to their heterogeneous geological conditions [10], the dynamism inherent in their environmental transformations (Contributions 2–4), and their propensity for frequent natural hazards. High economic losses and human casualties are caused by geophysical- (rockfalls, earthquakes, and volcanic activities), hydrological- (floods, avalanches, and dammed-lake outbursts), and sediment-related hazards (landslides, driftwood, debris/mud flows, and surface erosion). Such environments are high-risk due to the propensity of an initial hazard event to induce subsequent and potentially more destructive secondary hazards, thus affecting not only the immediate vicinity but also far-reaching effects on upstream and downstream areas (Contributions 5,6). The complexity of mountain regions and the continued changes in the climate (Contribution 7) and land use (Contributions 8,9) have made it more challenging to predict mountainous hazards and their subsequent socio-economic impacts. Hence, the

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strategic management of sediment disasters, particularly those exacerbated by climatic change, necessitates focused academic inquiry and meticulous intervention strategies.

Mitigation strategies for mountainous disasters encompass a spectrum of structural and non-structural interventions [11,12]. Regarding structural measures, protective measures involve constructing or reinforcing embankments and levees along rivers and establishing sediment-control structures, such as check dams, which can mitigate the impact of debris flows. In areas prone to rockfalls or landslides, retaining structures can stabilize slopes, thereby consequently diminishing landslide incidence. Complementing structural approaches, non-structural strategies (Contributions 10–22) engage in delineating hazard potential zones (Contributions 16–18), wherein the probabilistic risk assessment informs spatial planning. The advancement and deployment of disaster-detection and -monitoring technologies are integral to this paradigm, enabling the establishment of early warning systems essential for prompt disaster response (Contributions 19–21).

Chiang et al. (Contribution 16) applied a deep learning algorithm to ascertain the distribution of rainfall thresholds for landslides in a potentially high-risk area. Their study further encompassed evaluating the distribution of recurrence intervals through probability density functions. The primary goal was to aid decision-makers in implementing early responses to landslides and mitigating the risk of large-scale events. Complementary to this approach, Tsai et al. (Contribution 19) gathered pertinent information from satellite imagery, field investigations, major event reports, and seismic data spanning 2004 to 2016 in the mountainous regions of Taiwan. The aim was to establish a specific relationship between large-scale landslides (LSL) and triggering rainfall to enhance early warning predictions for LSL events. By integrating real-time rainfall forecasts, the dynamic variation in statistical indicators offers trend information, contributing to an increased response time for relevant evacuation operations.

Land-use management and ecological conservation are also vital aspects (Contributions 22,23), particularly in maintaining the vegetation of mountainous areas [13], including trees and grasslands, to mitigate soil erosion and reduce the risks of landslides and debris flow. Educational initiatives targeting community residents are instrumental in cultivating an understanding of the risks associated with mountainous regions and in disseminating knowledge regarding appropriate safety protocols during such geohazard events. Moreover, infrastructural resilience is bolstered through the strategic construction of shelters designed to withstand natural disasters and the meticulous planning of evacuation routes. These measures are essential in safeguarding human life by facilitating timely and orderly evacuations in the event of a disaster (Contribution 21).

Restoration research has also been the focus of research in recent years to minimize the impact of structures on nature (Contributions 24–26). Within this domain, Chiu et al. (Contribution 24) pioneered the application of Nature-based Solutions (NbS) [14] within the Huyuan Stream watershed in southern Taiwan. This initiative represents a tripartite collaboration between industrial sectors, governmental bodies, and academic institutions. The project aimed to enhance ecosystem services, providing diverse aquatic habitats, leisure sites for urban residents, and support for local agriculture. Additionally, it integrated local culture, environmental education, and professional development. Under the aegis of research leadership, this pilot study championed a holistic management paradigm that engaged multiple stakeholders in addressing the dual challenges posed by urban expansion and climatic fluctuations, concurrently advancing the quality of ecosystem services. Concurrently, there has been a nascent shift in the appraisal of mountain stream facilities, transitioning from focusing solely on safety to a broader consideration of landscape aesthetics and environmental congruence (Contributions 25,26). Peng et al. (Contribution 25) have been at the forefront of this shift, employing visual language translation as a novel methodological approach in qualitative landscape assessment. Their research has culminated in developing a model that synergizes visual harmony and aesthetic preferences, underpinned by an extensive suite of physical indicators. Such a model promises to refine the visual impact of hydrological engineering projects and enhance the evaluative processes thereafter.

3. International Conference

Global initiatives have increasingly underscored the necessity for rigorous international collaboration to elucidate the etiology of natural disasters, particularly in mountainous regions, and to develop robust frameworks for monitoring, predicting, and mitigating the impacts of such hazards. From its inception in 1967, the INTERPRAEVENT International Society, with its origins in the alpine landscapes of Austria, is esteemed for its pivotal contributions to research on slope disasters and is a vanguard interdisciplinary body that synergizes efforts from academia, governance, and industry. The INTERPRAEVENT 2023 International Conference [15] took place in Taichung, Taiwan, and, for the first time in partnership with the 'WATER' journal, has curated a Special Issue titled "Occurrence, Reduction, and Restoration of Natural Disasters in Mountain Regions," dedicated to the dissemination of scholarly research in this domain. The conference program was comprehensive, addressing a multitude of topics ranging from phenomenological investigations and event monitoring to risk analysis, policy development, resilience enhancement, and strategies for disaster response and recovery, thereby encapsulating a holistic approach to disaster preparedness.

There has been a concerted shift in disaster governance strategies in response to this recognition. The focus has transitioned from the traditional approach of imposing resilience on the environment to fostering a societal ethos that seeks to thrive in synergy with ecological systems. This approach suggests that the sustainability of human societies is intrinsically linked to their ability to adapt and integrate within the natural dynamics of the environment.

4. Conclusions

The Special Issue presents the necessity for a holistic and sustainable approach to disaster governance that is transparent. It requires the establishment of a resilient infrastructure capable of withstanding environmental calamities and, more importantly, societal transformation. This transformation would cultivate a culture that respects and aligns with ecological principles, ensuring that society and the environment can sustainably prosper together. Such an alignment represents the optimal pathway for mitigating the risks associated with mountain disasters in the face of climate change and human development.

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