forests

MDPI

Editorial

Landslides in Forests around the World: Causes and Mitigation

Haijia Wen [1], Weile Li [2], Chong Xu [3,4,*] and Hiromu Daimaru [5]

1 School of Civil Engineering, Chongqing University, Chongqing 400045, China; jhw@cqu.edu.cn
2 State Key Laboratory of Geohazard Prevention and Geoenvironment Protection, Chengdu University of Technology, Chengdu 610059, China; whylwl01@163.com
3 National Institute of Natural Hazards, Ministry of Emergency Management of China, Beijing 100085, China
4 Key Laboratory of Compound and Chained Natural Hazards Dynamics, Ministry of Emergency Management, Beijing 100085, China
5 Tama Forest Science Garden, Forestry and Forest Products Research Institute, Tokyo 305-8687, Japan; hiromudaimaru@gmail.com
* Correspondence: xc11111111@126.com

1. Introduction

Landslides are a common natural disaster in forested mountainous regions. Because of the increased frequency of extreme rainfall events resulting from global warming, the risk of landslides in forested areas remains high. Forest landslide research has always been of great interest to scholars. Key areas of research include understanding the interaction between forests and mountain landslides, assessing the hazard and risk of landslides, and developing rainfall-induced landslide warning systems in forested areas. In recent years, the development of technologies such as artificial intelligence, remote sensing (including optical remote sensing, InSAR, LiDAR, and others), and big data has led to rapid advancements in the detection, monitoring, warning, and risk assessment of forest landslides. These developments provide reliable solutions for effectively and quickly responding to potential landslide prevention and mitigation measures in forested areas.

To showcase the latest advancements in this field, a Special Issue named "Landslides in Forests around the World: Causes and Mitigation" has been organized. The issue comprises 14 papers covering various topics such as the impact mechanism of tree roots on landslide stability, landslide deformation monitoring, landslide disaster prevention and control engineering technology, automatic identification of regional landslides, susceptibility and hazard assessment, and rainfall-induced mass landslide warning.

check for updates

Citation: Wen, H.; Li, W.; Xu, C.; Daimaru, H. Landslides in Forests around the World: Causes and Mitigation. *Forests* **2023**, *14*, 629. https://doi.org/10.3390/f14030629

Received: 14 March 2023
Accepted: 19 March 2023
Published: 20 March 2023

2. Mechanism, Monitoring, and Control of Large-Scale Landslides in Forested Areas

To gain a better understanding of the role that forests play in preventing landslides, Okada et al. conducted a study on the impact of Japanese cedar roots on the occurrence of shallow landslides [1]. They continuously monitored changes in root strength over the course of several years and calculated the safety factor of the slope every five years. The study revealed that root strength is at its lowest after approximately 10 years, and the risk of landslide increases between 5 and 15 years. These findings provide valuable insight for selecting the most appropriate time for forest operations and mitigating the occurrence of landslide disasters. Another study conducted by P. Li et al. investigated the effects of root distribution and stress path on the shear strength of root–soil composites using the consolidated undrained (CU) triaxial test method [2]. The results of this study contribute to a better understanding of the impact of tree roots on slope stability and provide insight into prevention and mitigation strategies for forest landslides.

In October 21, 2017, heavy rainfall triggered a significant landslide in Guang'an Village, Wuxi County, Chongqing City, China. To investigate the stability of the landslide accumulation, K. Zhang et al. analyzed the long-term deformation process of the accumulation after sliding using time series InSAR technology and LiDAR data [3]. Their study provides valuable insight into preventing the accumulation from sliding again and forming secondary disasters caused by landslides.

To gain a deeper understanding of the mechanism behind large-scale landslides, Guo et al. analyzed the formation process and mechanism of the Nuugaatsiaq landslide in Greenland in 2017 [4]. This was achieved through examining the similarity and amplitude characteristics of multi-temporal seismic waveforms. Their findings suggest that the landslide was likely caused by a series of small earthquakes that accelerated and migrated. This study provides a credible case study report for analyzing the nucleation process of large landslides based on seismic waveform data. In another study, Huang et al. investigated the macroscopic friction fluctuation of the spherical particle system and breccia particles [5]. Their results showed that the friction fluctuation of the spherical particle system is determined by the friction of the particle surface and the normal stress of the system. Similarly, for breccia particles, the macroscopic friction fluctuation is determined by particle surface friction, system normal stress, and shear velocity.

In light of the successful interception of a landslide near the entrance of a railway tunnel using a flexible barrier to ensure the safety of railway operations, Zhao et al. conducted an analysis of the interaction between the landslide debris and the barrier [6]. Their analysis was based on the numerical simulation method, and the results were validated by field measurements. The study analyzed the impact of landslide debris on the flexible barrier under different impact energy and velocity conditions. The findings suggest that such a barrier can resist landslide debris with a maximum energy roughly four times that of resisting rockfall. These results provide valuable support for the prevention and control of shallow landslide disasters in mountainous regions

3. Automatic Identification and Susceptibility Analysis of Regional Landslides

The automatic identification of landslides plays a vital role in mass landslide inventorying. Pang et al. focused on the automatic identification of coseismic landslides using the example of the Mw6.7 earthquake that occurred in Hokkaido, Japan, on September 6, 2018 [7]. They mapped 4000 landslide label samples and developed a convolution neural network model based on the YOLOv3 algorithm. The results demonstrated that the model is efficient, with high recognition accuracy and speedy processing. This research provides a reference method for rapidly extracting mass landslides.

The majority of papers in this special issue focus on landslide hazard and susceptibility assessment, highlighting its significance in research. L. Li et al. conducted their study in Hechuan District, Chongqing, China, utilizing the random forest method to assess landslide susceptibility based on 754 landslides and the associated impact factors [8]. Furthermore, by considering natural, social, and ecological factors in the region, they evaluated the suitability of construction land in mountainous areas. This research may support the spatial layout of urban land and critical infrastructure in mountainous areas. To compare the shallow machine learning method with the deep learning method for landslide hazard and susceptibility assessments, Xu et al. conducted experiments using logistic regression, random forest, deep fully connected neural network, and long short-term memory neural networks in the Three Gorges reservoir area of China [9]. The results showed that the random forest model performs comparably to deep learning models while being more efficient, making it a valuable reference for selecting a landslide susceptibility assessment model. W. Zhang et al. investigated how zoning based on qualitative information affects landslide susceptibility assessment with a machine learning model in Yunyang County, Chongqing City, China [10]. The results showed that considering zoning in the evaluation process leads to better accuracy than not taking zoning into account. The combination of qualitative analysis and a quantitative model demonstrates a promising application prospect in landslide susceptibility assessment. To assess the impact of forests on landslide susceptibility, Y. Zhang et al. conducted a study in Bijie City, Guizhou Province, China to establish a model for evaluating the contribution of forests at different levels to landslide susceptibility [11]. They also examined the impact of various forest indicators on landslides. The findings indicated that shrub forests have a stronger protection ability against landslides, while natural forests have a greater inhibitory effect compared with artificial forests. Additionally, middle-aged and near-mature forests showed better landsliding control ability. This work provides valuable insights into the impact of different forest types on landslides.

4. Rainfall-Triggered Landslide Warning

Early warning systems for landslides triggered by rainfall in forested areas have proven effective in mitigating landslide disasters. Liu et al. focused on Fujian Province, China, and developed six machine learning models for predicting landslide occurrences based on geological and meteorological data, as well as other factors affecting landslides [12]. The results showed that the random forest model performed the best, providing a reference for future landslide early warning systems. During 9–11 August 2019, heavy rainfall resulted in numerous landslides in Ningguo City, Anhui Province, China. Cui et al. utilized satellite images to identify 414 rainfall-induced landslides and constructed a distribution map of rainfall-induced landslides [13]. They also developed a probability model for landslide occurrence triggered by rainfall and calculated the absolute probability of landslides under different rainfall conditions. This study provides support for landslide assessment and early warning systems under various rainfall scenarios. Taking 1520 landslide events in Fengjie County, Chongqing, China in 2016 as samples, Sun et al. developed a landslide susceptibility model based on the random forest model and a landslide early warning model based on precipitation [14]. The results showed that the precipitation early warning model combined with landslide susceptibility, early effective precipitation, and daily precipitation threshold has a high early warning ability. The results can provide scientific and technological support for rainfall-triggered landslide disaster prevention and mitigation triggered by local rainfall.

5. Conclusions and Prospects

We are delighted to see that the articles featured in this Special Issue have contributed new knowledge to the field of landslides in forests, provided innovative ideas for future development, and opened up new opportunities for collaboration and innovation. We extend our gratitude to the staff of *Forests* for their tremendous support to our Guest Editor Team in organizing this Special Issue, as well as their assistance with the review, revision, and verification process. We also thank all authors for their insightful contributions to this Special Issue and all reviewers for their valuable comments and suggestions on the submitted manuscripts.

Funding: This study was supported by the National Key Research and Development Program of China (2021YFB3901205) and the Natural Science Foundation of Chongqing (CSTB2022NSCQ-MSX0594).

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Okada, Y.; Cai, F.; Kurokawa, U. Changes in slope stability over the growth and decay of Japanese cedar tree roots. *Forests* **2023**, *14*, 256. [CrossRef]
2. Li, P.; Xiao, X.; Wu, L.; Li, X.; Zhang, H.; Zhou, J. Study on the shear strength of root-soil composite and root reinforcement mechanism. *Forests* **2022**, *13*, 898. [CrossRef]
3. Zhang, K.; Gong, F.; Li, L.; Ng, A.H.-M.; Liu, P. Mapping the long-term evolution of the post-event deformation of the Guang'an Village Landslide, Chongqing, China using multibaseline InSAR techniques. *Forests* **2022**, *13*, 887. [CrossRef]
4. Guo, Z.; Hou, X.; Gao, D.; Liu, J. Nucleation process of the 2017 Nuugaatsiaq, Greenland Landslide. *Forests* **2022**, *14*, 2. [CrossRef]
5. Huang, Y.; Wang, Y.; Wang, S. Effect of particle form and surface friction on macroscopic shear flow friction in particle flow system. *Forests* **2022**, *13*, 1107. [CrossRef]
6. Zhao, L.; Zhang, L.; Yu, Z.; Qi, X.; Xu, H.; Zhang, Y. A case study on the energy capacity of a flexible rockfall barrier in resisting landslide debris. *Forests* **2022**, *13*, 1384. [CrossRef]

7. Pang, D.; Liu, G.; He, J.; Li, W.; Fu, R. Automatic remote sensing identification of co-seismic landslides using deep learning methods. *Forests* **2022**, *13*, 1213. [CrossRef]
8. Li, L.; Chen, X.; Zhang, J.; Sun, D.; Liu, R. Landslide susceptibility-oriented suitability evaluation of construction land in mountainous areas. *Forests* **2022**, *13*, 1621. [CrossRef]
9. Xu, S.; Song, Y.; Hao, X. A comparative study of shallow machine learning models and deep learning models for landslide susceptibility assessment based on imbalanced data. *Forests* **2022**, *13*, 1908. [CrossRef]
10. Zhang, W.; Liu, S.; Wang, L.; Samui, P.; Chwała, M.; He, Y. Landslide susceptibility research combining qualitative analysis and quantitative evaluation: A case study of Yunyang County in Chongqing, China. *Forests* **2022**, *13*, 1055. [CrossRef]
11. Zhang, Y.; Shen, C.; Zhou, S.; Luo, X. Analysis of the influence of forests on landslides in the Bijie Area of Guizhou. *Forests* **2022**, *13*, 1136. [CrossRef]
12. Liu, Y.; Huang, J.; Xiao, R.; Ma, S.; Zhou, P. Research on a regional landslide early-warning model based on machine learning—A case study of Fujian Province, China. *Forests* **2022**, *13*, 2182. [CrossRef]
13. Cui, Y.; Jin, J.; Huang, Q.; Yuan, K.; Xu, C. A data-driven model for spatial shallow landslide probability of occurrence due to a typhoon in Ningguo City, Anhui Province, China. *Forests* **2022**, *13*, 732. [CrossRef]
14. Sun, D.; Gu, Q.; Wen, H.; Shi, S.; Mi, C.; Zhang, F. A hybrid landslide warning model coupling susceptibility zoning and precipitation. *Forests* **2022**, *13*, 827. [CrossRef]