Research on Increasingly Severe and Frequent Sediment Disasters and Their Countermeasures

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1. Condition and challenges of sediment damage in recent years

In Japan, the number of sediment disasters has increased in recent years. During the 10-year period from 2010 to 2019, the number of sediment disasters (annual average) increased by approximately 1.5 times in comparison with the earlier annual average (average for 1982-2018: 1 081 cases). In particular, a historical high of 3 459 sediment disasters occurred in 2018, and the numbers for 2019 (1 996 cases) and 2020 (1 316 cases) also greatly exceeded the average. Moreover, extremely heavy rain (50 to 80 mm/h) has also increased in numbers due to the effects of climate change. Accompanying this, sediment disasters have shown an increasingly severe tendency, and serious sediment disasters occurred in various parts of Japan in 2020, beginning with the western island of Kyushu. New modes of sediment disasters different from those in the past have also become apparent, and the phenomenon called "sediment and flood inundation" has caused heavy damage in various areas (**Photo-1**). This type of sediment disaster has shown a tendency to become more severe, to extend over wide areas and to occur simultaneously in many locations. Thus, elucidation of its mechanism, appropriate risk assessment and study of effective countermeasures are demanded.

Photo-1 Scene of sediment and flood inundation at Sendai River, Kuma Village, Kumamoto Prefecture (photographed in August 2020)

With local disaster preparedness continuing to decline to depopulation, the advancing age of the Japanese population, the vulnerability of communities in urban areas, etc., effective evaluation of information that leads to evacuation action is required. This includes improved accuracy of sediment disaster warning information.

On the other hand, the occurrence of deep-seated catastrophic (rapid) landslides and emergence of natural dams caused by large-scale earthquakes is also a concern, and with a gigantic Nankai Trough earthquake and a major earthquake directly under Tokyo now considered imminent, evaluation of the risk of sediment disasters triggered by earthquakes and study of countermeasures are required (**Photo-2**).

Photo-2 Condition of slope collapse caused by 2018 Hokkaido Eastern Iburi Earthquake

2. Priority research subjects

Based on these circumstances, the Sabo Department is currently grappling with the following research as high priority subjects.

Sediment and flood inundation is a phenomenon that occurs when large amounts of sediments are washed out by heavy rains in an upper river basin and accumulate in the river channel downstream from the mouth of the valley. This causes river bed aggradation (river bed rise) and channel blockage, and results in inundation by sediments and muddy water. In some cases, inundation includes driftwood in addition to sediments. This phenomenon had always occurred in varying degrees, but has emerged as a critical issue in recent years due to the increased amount and intensity of rainfall when a disaster strikes. Because large amounts of sediments accumulate together with the flood waters in valley plains and downstream areas, the countermeasures for such areas are partially different from those for the mud flows and landslides that occur in mountainous upstream areas. Elucidation of the phenomena as such, and study of effective countermeasures for these areas are also necessary. To

address this problem, the Sabo Department is conducting research including studies of a high accuracy predictive model of sediment production and downflow related to sediment and flood inundation countermeasures, evaluation techniques and planning and design techniques for countermeasures facilities.

(2) Development of sediment disaster risk evaluation system supporting warning and evacuation, and research on improvement of its accuracy

Linear rainbands have caused severe damage in recent years. To improve the accuracy of the sediment disaster warning information currently in use, the Sabo Department is developing a function that enables quick automatic identification of the occurrence of these rainbands, and is studying techniques which will make it possible to evaluate the risk of sediment disasters with higher accuracy by using this function in combination with primary factor data based on topographical and geological conditions (**Fig.-1**). In joint research with Kyoto University, we are also studying improvement of the accuracy of judgments of the degree of sediment disaster risk by combining various rainfall indexes, with the largest value of past rainfall in which a disaster did not occur as a standard.

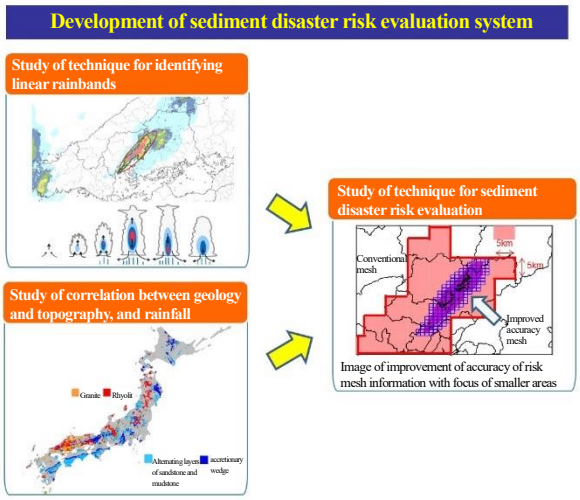

Fig.-1 Image of sediment disaster risk evaluation system

(3) Processing and use of sediment disaster information by applying digital technology

The Sabo Department has applied digital technology to sediment disaster analysis and information collection, and is working to employ these technologies more efficiently in disaster countermeasures by further utilization. For example, investigations to determine whether new slope collapse has occurred after heavy rain are currently carried out by visually interpreting satellite SAR (synthetic aperture radar) images, but we are now studying the possibility of automatic extraction of slope collapse information, and are constructing various types of databases of information related to sediment disasters.

3. Large-Scale Sediment Disaster Countermeasures Research Center

In 2011, Typhoon No. 12 (Typhoon Talas) caused record-breaking heavy rains in Japan's Kii Peninsula, resulting in massive damage that included many deep-seated catastrophic (rapid) landslides. Since 2017, NILIM has dispatched a senior researcher to the Large-Scale Sediment Disaster Countermeasures Research Center (located in Nachikatsuuracho Town) of the Kinki Regional Development Bureau. The Center was established in 2014 following the above-mentioned disaster, and conducts research necessary to establish countermeasures for deep-seated landslides and other large-scale sediment disaster with the cooperation of the NILIM Sabo Department, the Center itself and Wakayama Prefecture. Up to the present, the Center has achieved a large number of research results, including elucidation of the mechanical of deep-seated landslides. The results of research to date are scheduled to be compiled on the 10-year anniversary of the disaster in fiscal year 2021.

4. Conclusion

This report has described the condition and challenges of sediment disasters and the efforts of the NILIM Sabo Department to solve those problems. Nature is inherently diverse, and no lands are the same in their richly varied topographies, geologies, etc. The weather phenomena that cause these natural features are also diverse, and the sediment disasters that occur as a result are extremely varied. Amid the constant change in social structures and the environment surrounding people's lives, research on sediment disasters was realized through the challenging efforts of our many predecessors, and is continuing to progress through a process of trial and error even today. Precisely because the related phenomena are so diverse, in our research efforts, it is necessary to firmly face the actual site, look at the events in the field with both a "bird's eye" and an "insect's eye" while grasping the total image, and slowly-but-surely accumulate a strong basis of facts and verification. This will enrich our thinking, and will make it possible to implement the results of our research in society in a way suited to the site. In the future, our aim is prevention and mitigation sediment disasters in collaboration with MLIT proper.

☞**See the following for details:**

1) Development of Sediment Disaster Occurrence Probability Frequency Maps Using Topographical and Geological Thematic Maps, p. 59

2) Elucidation of Mechanism of Deep-Seat Catastrophic (Rapid) Landslides Utilizing Drone Airborne Electromagnetic Survey Technology, p. 56