Communication and Application of Engineering Geology for Community Based Disaster Preparedness

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Abstract: Climate change has led to increasingly extreme weather events all over the world. In Japan, also the frequency of torrential rains has increased, and the number of rainfall–induced disasters occurrence annually continues to increase. Therefore, it is necessary for everyone to consider how to protect themselves from the rainfall-induced disasters beforehand. In Japan, mountainous areas account for about 70% of the land area, yet the population is concentrated in the 30% of flatlands. Consequently, dwellings and buildings in mountain villages are scattered. In mountainous area, local government-designated evacuation shelters are often distant. Evacuating to these shelters during heavy rain frequently requires traversing hazardous areas, making it an inappropriate action in many cases. Therefore, for living on mountain slopes, protecting oneself during heavy rain requires personally evacuation planning that consider the disaster risks around one's home and the surrounding roads. In Japan, since hazard information on mountain slopes is defined only for the immediate vicinity of residences, the hazard information is sometimes lacking for evacuation routes. This study conducted terrain analysis using a Digital Elevation Model (DEM) to explore the geotechnical support that can be provided to assist with evacuation planning in mountainous areas. It also examined, through field surveys and discussions within the study area, whether the terrain analysis results were useful for residents when formulating their evacuation plans.

Keywords: ***Hazard, Mountainous area, Topography, Evacuation.***

Introduction

In recent years, rainfall patterns have changed in several regions due to the effects of climate change. In Japan, the annual frequency of heavy rainfall events has increased, leading to increase in the number of disasters caused by torrential rains. In mountainous and hilly areas, the risk of landslides and debris flows triggered by heavy rains has grown. Particularly, cases of disasters occurring and causing damage due to unprecedented heavy rainfall are increasing.

To protect oneself from torrential rain, it is essential to understand where the dangerous locations are when heavy rain falls and to understand where the relatively safe locations are. This allows one to consider methods for ensuring personal safety during heavy rains in advance and to plan responses for such times. It is necessary to consider whether evacuation outside the home is required, when and by which route to evacuate.

While research exists predicting slope movement through numerical simulations targeting individual slopes for landslide risk (Lee et al., 2022), considering evacuation at the regional level requires a broader area of this study. Since the simulations are based on specific assumptions and cannot account for rainfall exceeding those assumptions, evaluating slope disaster risk using topographic information allows for assessment of the target area regardless of assumptions. Therefore, this study evaluates slope disaster risk using topographic information and introduces slope disaster prevention initiatives utilizing these evaluation results, based on case studies.

Study Area

The study area was in Iuchi, Miyoshi City, Tokushima prefecture, where settlements spread across landslide terrain in Shikoku, Japan (Figure 1). The Shikoku region features a mountainous area in its central part, with elevations around 1,800 to 2,000 m. Geologically, three structural zones extend east-west. Each zone has distinct characteristics. In Iuchi district, the residential areas are located at landslides in Sambagawa Metamorphic Zone.

Settlements are scattered across landslide-prone terrain, with numerous hazard zones situated between them and the evacuation shelters designated by the city office. Sediment disasters may occur even before reaching National Route 192, which could isolate the area during heavy rain. Roads in the Iuchi district, originally built as pedestrian paths along ridges, now accommodate vehicles, altering the locations of hazardous spots. For these reasons, evacuation planning in mountainous and hilly areas must carefully consider local terrain, historical disaster records, and road conditions. It is essential to develop tailored evacuation plans and prepare measures to ensure personal safety within the settlement itself.

Visualizing Terrain for Identifying Slope Hazard

By utilizing a Digital Elevation Model (DEM) to visualize slope hazard potential, it is conceivable that information on slope disaster risk could be provided even to areas where landslide hazards cannot be confirmed via hazard maps. This study conducted terrain analysis using a 5-m resolution DEM.

Firstly, to visualize slopes prone to high seepage and those with high collapse risk, slope types were classified into nine categories by using horizontal curvature and vertical curvature (Shary et al., 2002). Since this study aims to create support information for heavy rain evacuation planning, valley-type slopes were extracted as catchment terrain. Secondary, non-valley-type terrain was considered relatively safe slopes since the risk of water flow during heavy rain is low. However, steeply inclined areas pose a risk of slope failure. Therefore, we set a slope gradient threshold of 30 degrees based on general knowledge and Japanese law regarding slope failures. Ridge-type slopes with gradients of 30° or greater were classified as high-risk failure zones, while ridge-type slopes with gradients less than 30° were considered relatively stable slopes. Furthermore, since particularly water-prone areas exist within valley-type slopes and outside them, the average curvature was calculated. Thresholds were set to extract valley lines, which were then overlaid. This terrain information analysis created a map indicating hazardous and safe areas during heavy rainfall.

Applying The Visualizing Topography to The Community Evacuation Planning

As part of our collaboration with residents, a workshop involving a neighborhood walk within the district was conducted and discussion using maps to plan actions during heavy rain. The survey was conducted along a selected route within the district. During the walk, participants identified areas with frequent seepage, spots prone to water flow during heavy rain, locations with past slope failures, and topographically hazardous areas during heavy rain by sharing the experience

The discussion on heavy rain evacuation plans took place in the community meeting room. Participants reviewed the results of the walk and then they were instructed on how to interpret the terrain analysis information map. Subsequently, they examined the A0-sized printed terrain information analysis map to consider evacuation locations and routes during heavy rain.

Participants who discussed evacuation sites and routes suggested that the visualizing terrain analysis map is somewhat useful for considering evacuation sites and routes. However, it does not clarify when they should start evacuation. The visualized terrain map show what kind of phenomena tend to occur during the heavy rainfall. However, it does not show when it will occur. To make evacuation plans, we believe future efforts should include activities where individuals consider their own timeline for heavy rainfall, such as determining when and where to evacuate.

Conclusion

This study created a visual topographic map using a DEM to identify slope hazards, complementing hazard maps for developing evacuation plans against rainfall disasters. Field surveys confirmed that this map accurately reflects the disaster history of the area.

References

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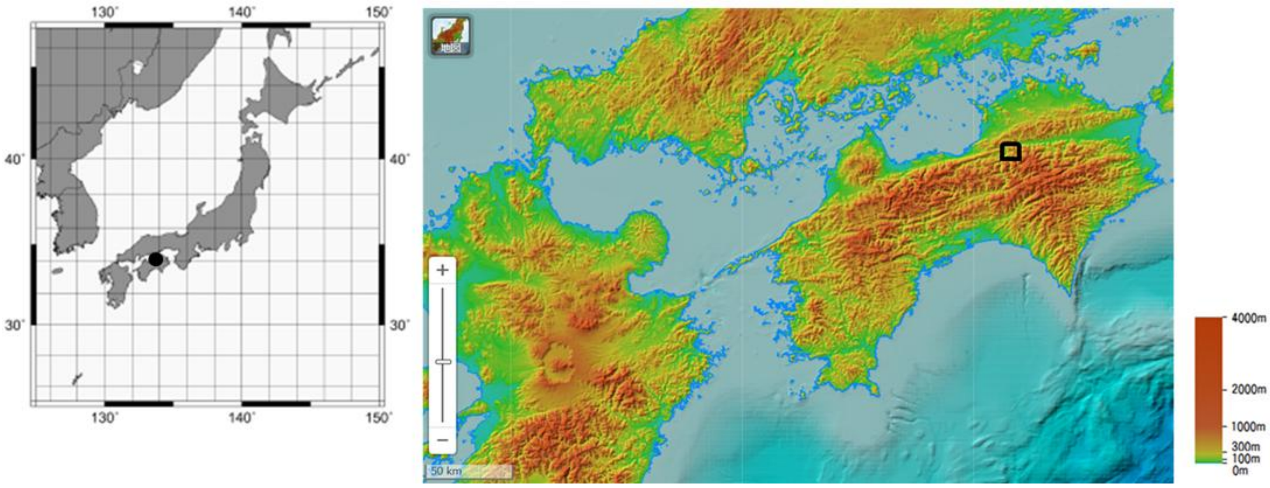

Figure 1, Location and elevation of the study area.