Japan-Nepal Urgent Collaborative Projects
Regarding the April 2015 Nepal earthquake within the J-RAPID Program

１． Title of the Project：Identification of temporary evacuation sites and relocation of dangerous settlements in the Dolakha District: an approach by hazard mapping

２． Research/Investigation Period： 2014. 9～2016. 6

３． Amount of Funding： JPY

４． Main Investigators：

Japanese Team（up to 6 people including Principal Investigator）

	Name	Title	Affiliation	Project role
Principal Investigator	Teiji Watanabe	Professor	Hokkaido University	Supervision and overall investigation
Collaborator	Yusuke Kobayashi	PhD student	Hokkaido University	UAV analysis
Collaborator	Bhabana Thapa	PhD student	Hokkaido University	Social survey and HEC-RAS modeling
Collaborator				
Collaborator				
Collaborator				
Total Number of participating researchers in the project: 3				

Nepalese Team（up to 6 people including Principal Investigator）

	Name	Title	Affiliation	Project role
Principal Investigator	Lalu Paudel	Professor	Tribhuvan University	Geology survey and geo-hazard mapping
Collaborator	Narendra Raj Khanal	Professor	Tribhuvan University	Collecting the existing information and statistical data
Collaborator	Motilal Ghimire	Associate Professor	Tribhuvan University	Mapping land-use and other base maps
Collaborator	Dhananjay Regmi	President	The Himalayan Research Expedition	Logistics, geomorphological survey
Collaborator				
Collaborator				
Total Number of participating researchers in the project: 4				

５． Objectives and Challenges

This research, focusing in the Dolakha District with the devastating damages by the earthquake in 2015, aims (1) to identify the damaged sties and clarify geological and geomorphological characteristics of the sites, (2) to identify potentially dangerous sites in the case of future earthquake and other hazards, (3) to propose temporal evacuation sites in the case of future hazards (household level), and (4) to examine the necessity of relocation of dangerous settlements in the district.

This research prepares a detailed hazard map with combined approaches of an analysis of

photographs taken by a drone (UAV), remote sensing, field survey and HEC-RAS modeling. The map includes paths to temporal evacuation sites from dangerous sites. Moreover, interview surveys and questionnaire surveys will be conducted to identify the settlements that need relocation.

The detailed hazard map involving the state-of-art knowledge and technology, which will be the main product of this research, will be helpful to insure safety for the local residents as well as porters and guides who help international trekkers because such porters and guides use the road and settlements along the Tamakoshi River to the Rolwaling Himal. Further, transferring the methodology of the hazard mapping to Nepal will be included in this research.

6. Results of the research/survey activities

6-1. Contribution to the rehabilitation of the disaster affected areas and the disaster risk reduction management.

One of the outcomes of this project is a landslide/GLOF hazard map (Fig. 1). Although Fig. 1 does not show the potential inundation areas along the Tamakoshi River because of its scale, the detailed area to be inundated by future GLOF was included in the map. In addition, information obtained from the photographs taken by a drone (UAV) helped understand future prediction of inundation area and evacuation routes and sites.

The questionnaire survey shows that there are only one household among 140 households have known about a hazard map. Further, most local residents do not know a safe site for evacuation.

This study found that there were no settlements that should be relocated.

The produced hazard map (Fig. 1) suggests that landslides are more prone to occurring in the northern area, which is related to geology (high Himalayan gneiss). Also, the results by the HEC-RAS model suggest that five settlements including Gongar, Jagat and Shingati in the upper reaches and one settlement of Kattike in the lower area could be inundated by future GLOF.

Photographs were taken by a drone in Shingati and Gongar. In the case of Shingati, 869 photographs were analyzed by software, Photoscan to produce an orthophotograph (Fig. 2). This product has the 3-dimensional topography information, so that land surface analyses such as relationship between the inundation areas and surface topography became possible. Further, the orthophotograph enabled to identify the existing pedestrian routes that can be used for evacuation and to identify safe evacuation sites.

The village of Shingati is located on the three river-terrace surfaces (I to III) (Fig. 3). Terrace III, the lowest terrace, has more destroyed buildings, and the existing buildings are most concentrated on terrace II. When Figures 3 and 4 are overlapped, all area of terrace III and part of terrace II would be inundated when GLOF occurs. The houses on these terrace surfaces could be damaged or even washed away.

Here, it should be noted that some destroyed or damaged buildings are rebuilt at the same sites. This was witnessed in the field visit in November 2015 and June 2016. Rebuilding at such a site should be avoided, but this occurs because the local residents have no idea about hazards, which is found by the questionnaire survey.

Because it would be difficult to stop such locals' attitudes towards rehabilitation, alternative measures to be considered would be to improve evacuation routes and to provide drills to evacuate to the safe sites. This research, therefore, identified the possible evacuation routes by the orthophotograph and field-checked. The white arrows in Fig. 5 show the possible evacuation routes from terraces II and III to the safe terrace I. There are some routes in the west area of Fig. 5, but there is only one route in the east area. Therefore, it is recommended to develop more evacuation routes in the east area. Further, each route is composed of stone staircases with the width of 50 to 90 cm only. Considering the width of an adult shoulder, only one adult can walk on the existing routes. For quick evacuation, elderly people may need help from other people. The evacuation routes should be widened.

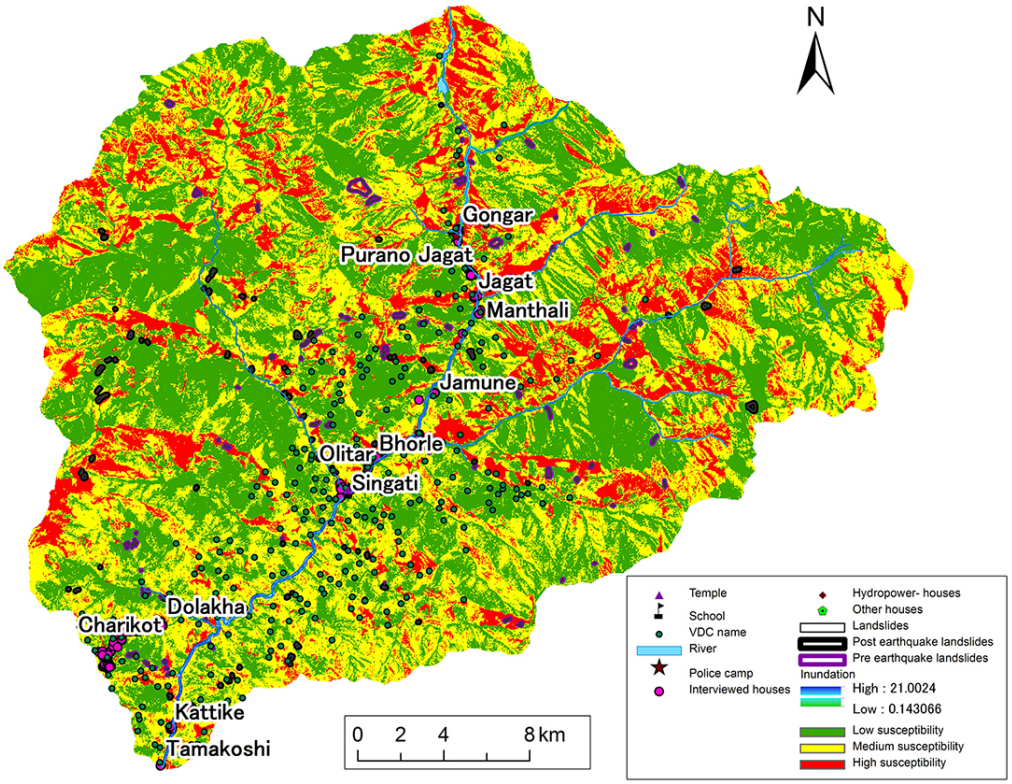

Fig. 1 Landslide/GLOF hazard map of the Tamakoshi watershed, Nepal


Fig. 2 Orthophotogrpah prepared by 869 photographs taken by a drone in Shingati.

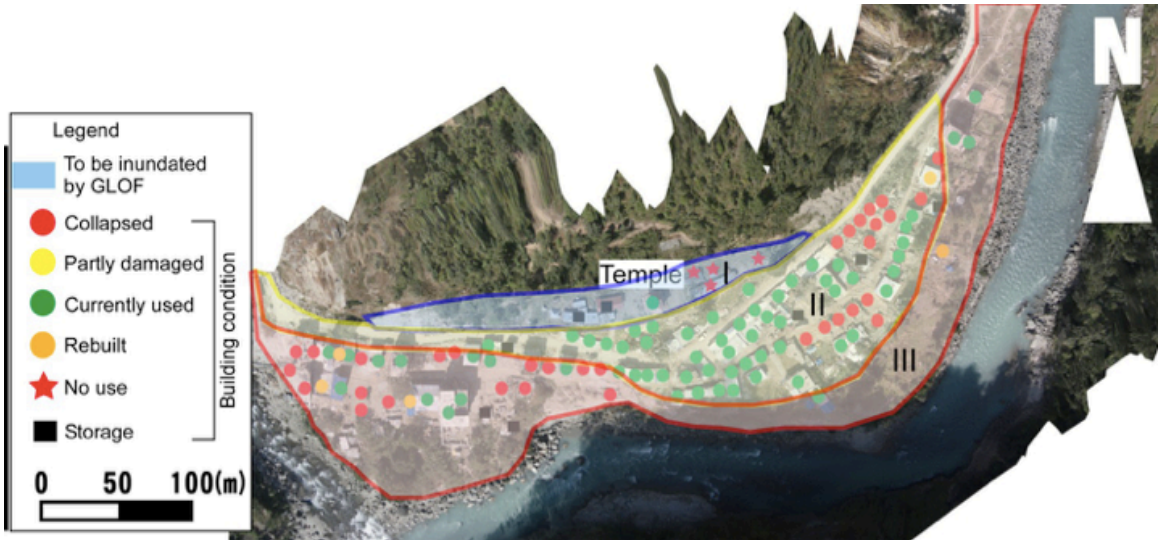

Fig. 3 Distribution of the buildings and the classification of landform of the eastern part of Shingati

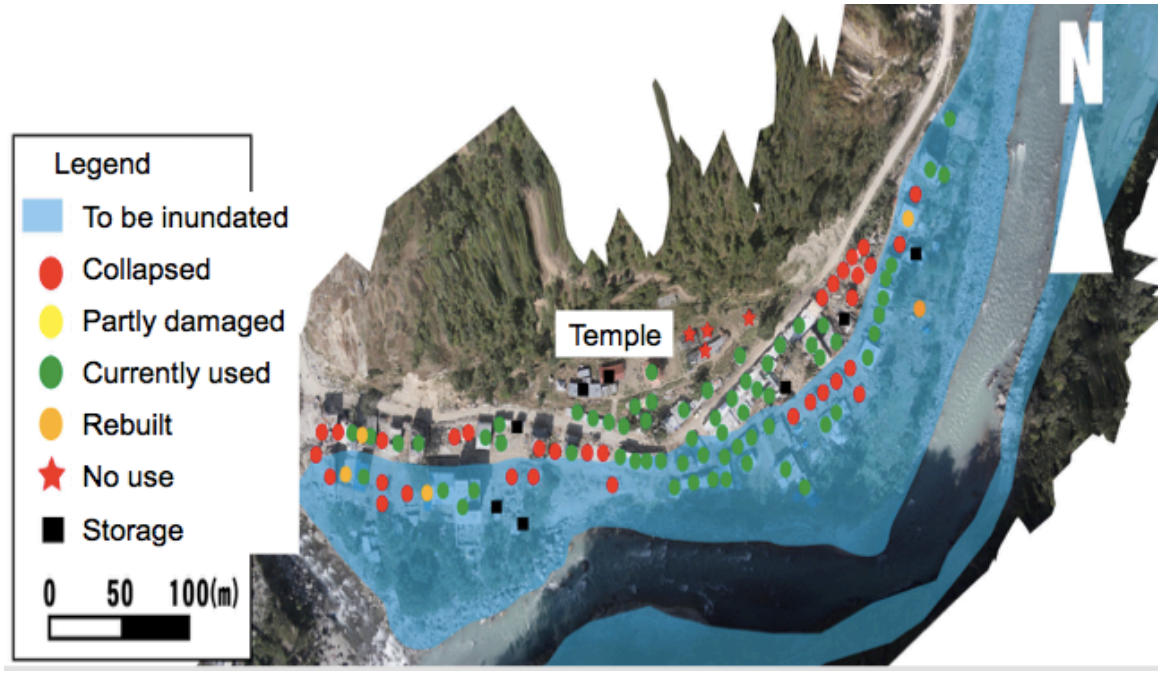

Fig. 4 GLOF flood estimate by HEC-RAS modeling (inundation area: blue) in the eastern part of Shingati

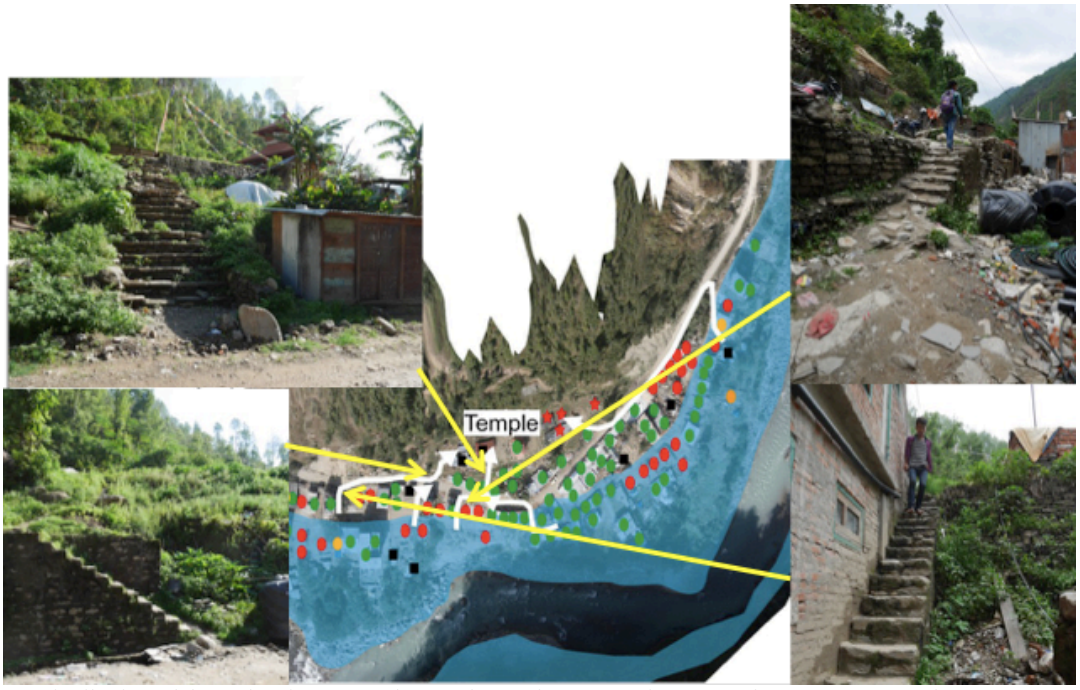

Fig. 5 Distribution of the pedestrian routes that can be used as evacuation routes from terraces II and III to terrace I (white arrows), eastern part of Shingati

6-2. Collaboration between Nepal and Japan

This project was conducted by the collaboration between Tribhuvan University and Hokkaido University, both have long-term research exchange agreement. Therefore, both universities have experiences in conducting collaborative research and organizing international symposium. However, providing a two-day training workshop to Master's students (about 70 participants) was the first experience for both universities.

During the workshop, students were able to learn various methodologies such as hazard mapping, 3-dimensional analysis of photographs, social survey and basic handling of a drone (Fig. 6). We believe that empowerment of students in Nepal is essential for future hazard issues of the country of Nepal. We concluded that we would continue to similar efforts to students in Nepal.


Fig. 6 Training course offered for Master's students at Tribhuvan University by the team members on 23rd and 24th June 2016.

7． Organized workshops/seminars, presentations, papers and other deliverables

	・Organized workshop/seminar: Title, date ・Presentation: Presenters, title, conference ・Papers： Authors、title、journals、vol、page、publish year ・Other deliverables: ・Media	comments
	Two-day training workshop of hazard mapping at Tribhuvan University, 23rd and 24th June 2016.	
	Kobayashi Y, Thapa B, Watanabe T, Paudel L, Khanal NR, Ghimire M, Regmi D: Survey on damage by earthquake occurred on May 2015 in settlements along Tamakoshi river in Dolakha, Nepal. Annual Meeting of Association of Japanese Geographers, Waseda University, 21 March 2016.	
	Watanabe T, Paudel L, Kobayashi Y, Thapa B, Khanal NR, Ghimire M, Regmi D: Floods occurred by a collapse of an earthquake-induced dam, Gongar, Dolakha, Nepal in April 2015. International Geographical Congress, Beijing, 21-25 August 2016.	
	Kobayashi Y, Thapa B, Watanabe T, Paudel L, Khanal N, Ghimire M, Regmi D: Inhabitants' awareness of prevention and preparation towards hazards in the settlements along the Tamakoshi River, Dolakha, Nepal. International Geographical Congress, Beijing, 21-25 August 2016.	
	Thapa B, Watanabe T, Kobayashi Y: Risk assessment of flood hazard in the Nepal Himalaya: Case studies of Seti River, Pokhara and Tamakoshi River, Dolakha. International Geographical Congress, Beijing, 21-25 August 2016.	