Advancing disaster resilience: Insights on landslide and karst susceptibility assessments

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INTRODUCTION

The United Nations General Assembly adopted the Report of the Open-ended Intergovernmental Expert Working Group on Indicators and Terminology Relating to Disaster Risk Reduction at its 71st session on 2 February 2017. The Report comprised terminology relating to disaster risk reduction to support coherence in implementing the Sendai Framework on Disaster Risk Reduction (2015-2030), a global agreement that was accepted by governments in 2015. Among the terms defined include nomenclature that is common in geoscience such as disaster, disaster risk, disaster risk assessment, exposure, hazard, hazardous event and vulnerability, among others. The term susceptibility, which is an integral concept in the assessment of hazards in geoscience is not explicitly defined in this global policy document. The term is only mentioned once in the entire document, in the context of vulnerability. Vulnerable conditions are expected to increase the "susceptibility of an individual, a community, assets or systems to the impacts of hazards".

It is not possible to conduct a hazard or risk assessment without first evaluating an area for the presence of physical factors that may cause the hazard. These physical factors contribute to the susceptibility of an area to hazards, and include aspects that relate to both the surficial features as well as subsurface geology, which have to be evaluated in a systematic manner depending on the type of hazard that is being assessed. Given the absence of a common terminology for susceptibility in global policy, governments will have to develop operational definitions at the national level to

Selected terminology on disaster risk reduction in the Sendai Framework:

Disaster: A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts.

Disaster Risk: The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity.

Disaster Risk Assessment: A qualitative or quantitative approach to determine the nature and extent of disaster risk by analysing potential hazards and evaluating existing conditions of exposure and vulnerability that together could harm people, property, services, livelihoods and the environment on which they depend.

Exposure: The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas.

Hazard: A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation.

Hazardous Event: The manifestation of a hazard in a particular place during a particular period of time.

Vulnerability: The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.

promote standard, comprehensive and robust susceptibility assessments for natural hazards. A sound definition would require drawing on current approaches and practices for assessing the susceptibility of hazards, and its linkage to the evaluation of risks.

This was partly the motivation for convening the Workshop on Landslide and Karst Susceptibility Assessment on 1 March 2018 at Pulse Grande Hotel, Putrajaya. The workshop was organised by partners of the project on "Disaster Resilient Cities: Forecasting Local Level Climate Extremes and Physical Hazards for Kuala Lumpur", funded by the Newton-Ungku Omar Fund (NUOF) under the aegis of the Malaysian Industry-Government Group for High Technology (MIGHT) and Innovate-UK. The purpose of the workshop was to discuss processes and methodologies for assessing the susceptibility of landslide and karstic hazards. This would implicitly provide insights for advancing efforts to develop a national lexicon for enhancing disaster risk reduction in the country. Key matters from the workshop are highlighted in the following sections.

HIGHLIGHTS

The one-day workshop focused on landslide and karst susceptibility assessment approaches in Malaysia and the UK, commencing with a discussion on terminology. It was conducted primarily by geoscientists from the British Geological Survey with support from the Department of Mineral and Geoscience Malaysia (JMG) and other NUOF project partners. A total of 67 participants from various local organisations attended the workshop. This included officials from the City Hall of Kuala Lumpur (DBKL) and State Disaster Management Unit of Selangor as well as geoscientists from Universiti Kebangsaan Malaysia (UKM), University of Malaya (UM), Universiti Tenaga Nasional (UNITEN), Geological Society of Malaysia (GSM), Institute of Geology Malaysia (IGM). Also present were representatives of the private sector.

Susceptibility maps delineate areas where a hazard event could occur. The susceptibility of an area depends on contributing surficial and subsurface factors as well as processes that vary depending on the hazard. The methods used for assessing susceptibility depends greatly on the objective and scale of the evaluation, type of hazard, size and complexity of the area, resource allocation and, most importantly, the availability of spatial and non-spatial data (Arnhard & Reeves, 2018). Susceptibility maps must be subjected to spatial and temporal validation to ensure that the product is of high quality. Emphasis on analysis of appropriate input data, integration of geological and structural geology information and inclusion of expert opinions are also important for quality assurance. The operational definition of susceptibility at the national level should be harmonised with current terminologies used in the global policy domain. Terms such as disaster risk, exposure, hazard, hazardous event and vulnerability, should also be clarified and linked to susceptibility for improved understanding of geoscientists in Malaysia. The definition of susceptibility should emphasise the spatial component and take into account approaches that are currently being used to assess both fast and slow-onset hazards in the country. It is imperative that approaches adopted for susceptibility assessments result in products that remain valid in a changing climate.

In the UK, the national landslide inventory was initially produced in the 1990s, and currently, it has over 17,300 records of landslides and man-made engineered slope failures, with continuous addition of data (Reeves, 2018). Information in the landslide inventory includes, among others, the name and location of events, dimensions, type and style, material, age, cause, wider slope information, adjacent slope factors (angle, height, vegetation), damage caused by landslide, geology (only if vertical slope, or if map cannot be obtained), fatalities and injuries as well as costs. The source of the information includes BGS geological maps (historic and current), reports (confidential and mainstream), peer-reviewed journal papers and conference proceedings, regional and responsive surveys, graduate thesis, mainstream and social media reports as well as local government offices, among others. The national landslide inventory serves as the backbone to a variety of important landslide susceptibility projects in the UK. Susceptibility maps have been produced at the national level for using a heuristic/expert judgement-based approach while detailed assessment used bivariate statistical analysis. Susceptibility assessment has potential for rotational and translational failure but needs more work for debris flows, rock falls and earth flows. The UK is now advancing from static susceptibility modelling to dynamic landslide forecasting. A range of forecast scenarios for precipitation feeds into a water balance model to produce probabilistic landslide hazard assessment, based on the probability of exceeding a threshold.

Landslide susceptibility assessment in Malaysia commences with the preparation of an inventory, followed

Dr. Helen Reeves, Dr. Christian Arnhard and Dr. Vanessa Banks (front row on the left) shared the experience of BGS in producing reliable landslide and karst susceptibility maps for the UK.

by classification of causal parameters, analysis of susceptibility and validation of results (Tating, 2018). The landslide assessment of Sepanggar, Kota Kinabalu drew on an inventory of the occurrence and extent of landslides as well relevant factors that influence susceptibility, obtained from multiple sources including aerial photographs, satellite imagery, LiDAR, historical records and extensive field investigation. Causal parameters mapped include slope aspect, slope gradient, elevation, lithology, landuse, etc. Statistical bivariate analysis (information value method) and heuristic methods were used to yield a landslide susceptibility map of the area. Susceptibility assessment in Malaysia is limited to static modelling. The rainfall forecasts are not sufficiently advanced to facilitate dynamic landslide forecasting. Work led by the Malaysian Meteorology Department (MMD) and University of Cambridge is now ongoing under the NUOF project to develop the first mesoscale weather forecasting model for Kuala Lumpur. The products from this model, particularly for rainfall is expected to improve landslide assessment at the local level and lay the groundwork for dynamic landslide forecasting.

Karst susceptibility assessment is much more advanced in the UK compared to Malaysia. In the UK, karstic rocks are separated into five categories centred on age and characteristics (Banks, 2018). Maps, cave surveys and local knowledge enable further differentiation based on superficial deposit domains, thickness and permeability and glacial limit, which form the basis for a susceptibility assessment. There are many challenges in assessing karst susceptibility in Malaysia. These include clarification of karst terminology, processes and structural complexity as well as development of event inventories and methodologies for karstic hazard assessment. For example, the understanding of processes and conditioning factors for the Kuala Lumpur Limestone is challenged by limited information, particularly on subsurface conditions. The resolution of these issues require strong national leadership, particularly from the JMG to bring together geoscientists and other experts from government, universities and the private sector. This is currently being undertaken with support from the NUOF project.

The NUOF project is designed to adapt and test the viability of carefully selected meteorological and hazard models for tropical circumstances, and to integrate them into a multi-hazard platform designed for managing and communicating risk and enhancing disaster resilience in a changing climate. The project jointly led by SEADPRI-UKM and University of Cambridge, in partnership with JMG, UM, GSM, BGS, MMD and other entities in the UK and Malaysia can serve as the avenue for advancing local level susceptibility assessments in Kuala Lumpur. The approach could then be replicated in other cities, towns and settlements to enhance disaster resilience in the country.

CONCLUDING REMARKS

There is urgent need for a national lexicon on disaster risk reduction in the country, which is in harmony with current global terminologies in the policy domain. An operational definition of susceptibility should be developed and linked to common terms such as disaster risk, exposure, hazard, hazardous event and vulnerability. There is room for further improvement of hazard susceptibility maps in the country, particularly at the local level. The possibility of advancing from static susceptibility modelling to dynamic landslide forecasting based on the probability of exceeding rainfall thresholds merits investigation. A national level initiative is required to develop comprehensive event inventories and methodologies for karstic hazard assessment in the country. Approaches adopted for susceptibility assessments in Malaysia should be carefully developed to yield products that remain valid in a changing climate. The project on "Disaster Resilient Cities: Forecasting Local Level Climate Extremes and Physical Hazards for Kuala Lumpur", funded by NUOF, will lay the pathway to resolve these issues and enhance disaster resilience in the country.

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