Evaluating urban hazard risks under extreme rainstorms

Half of the world's population lived in urban areas at the end of 2008. The United Nations predicted that by 2050 about 64% of the developing world and 86% of the developed world will be urbanized. A recent example is the rapid expansion of the Guangdong-Hongkong-Macau Bay area, which has a population of over 60 million.

In recent severe rainstorm and storm surge events, such as Hurricane Katrina in New Orleans in 2005, Typhoon Haiyan in the Philippines in 2013 and Typhoon Jebi in Japan in 2018, most catastrophic consequences indeed occurred in urban areas. In the future, more population and wealth will flux to large cities. How to cope with natural hazard risks in urban settings under the changing climate is an emerging issue.

Under extreme rainfall conditions, multiple hazardous processes such as landslides, debris flows and flooding may occur simultaneously or sequentially, resulting in cascading hazards increasing the risk. In the worst cases, interactions among these hazards can generate new hazards of greater destructive power such as formation of landslide dams and dam breaching. It is important to identify catastrophic hazard scenarios that could be generated, to identify the bottlenecks of the urban disaster prevention systems, and to make recommendations for improved preparedness and system safety.

A large city is a system of many highly interactive systems: social, transport, utilities, communications etc. How such a complex system responds to a single hazard or multiple hazardous processes is hardly known.

We are in the process of developing a stress-testing framework for assessing urban risks under extreme rainstorms caused by the changing climate. Stress testing is defined as a targeted reassessment of safety margins of a given system in light of extreme events. It involves testing beyond normal operational capacity, often to a breaking point. The scientific tasks of this research include (1) identification of future critical storm scenarios considering climate changes, (2) evaluation of urban system response under extreme rainstorms using advanced multi-scale hydrological and geotechnical processes modelling algorithms, (3) multi-hazard risk assessment, and (4) formulation of a unique stress-testing framework. The stress-testing framework is first applied to identify bottlenecks of the present Hong Kong slope safety system, and then extended to evaluate the urban system responses and risks in the Guangdong-Hongkong Macau Bay area.