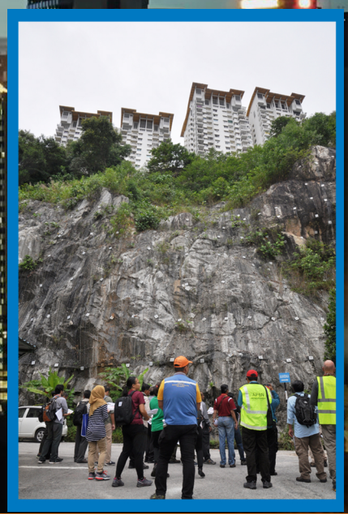
IRDR Working Paper Series
Integrated Research on Disaster Risk



MAKING CITIES DISASTER RESILIENT IN A CHANGING CLIMATE: THE CASE OF KUALA LUMPUR, MALAYSIA

Joy Jacqueline Pereira
Nurfashareena Muhamad
Choun Sian Lim
Sarah Aziz
Julian Hunt

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About the Series

This Working Paper Series is a new publication of Integrated Research on Disaster Risk (IRDR), following the decision of the IRDR Scientific Committee in April 2019 to act to 'Expand IRDR Network and Scientific Output' (No. 5 of the IRDR Action Plan 2018-2020).

IRDR is an international scientific programme under co-sponsorship of the International Science Council (ISC) and United Nations Office for Disaster Risk Reduction (UNISDR) and with support from China Association for Science and Technology (CAST) and Chinese Academy of Sciences (CAS). Started in 2010, the Programme has been pioneering in the promoting international and interdisciplinary studies on DRR and has made its contributions through scientific publication and policy papers as well as dialogue toward shaping international agenda in the understanding disaster risks, bridging science and policy gaps and promoting knowledge for actions, all required in the Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR) and its top priorities. Over time, the scientific agenda of IRDR has attracted many international renowned expertise and institutions. IRDR community is now, institutionally speaking, characterized by its strong Scientific Committee and six thematic working groups, thirteen IRDR national committees (IRDR NCs) and one regional committee (IRDR RC), sixteen international centres of excellence (IRDR ICoEs), a group of some one hundred fifty Young Scientists (IRDR YS) and a broad partnership with national, regional and international institutions working for SFDRR.

This Working Paper Series is thus specially made to facilitate the dissemination of the work of IRDR NCs, ICoEs, YS and institutions and individual experts that IRDR considers relevant to its mission and research agenda, and of important values for much broader range of audience working in DRR domains. As one will notice, all working papers in this series has anchored their relevance and contributions of their work toward SFDRR, IRDR, SDGs and Paris Agreement on climate change. It is the hope of the authors of the working papers and IRDR that this working paper series will not only bring new knowledge, experience and information toward disaster risk reduction, but also helped build better coherence of DRR with the mainstream agenda of UN today toward inclusive, resilient and sustainable human societies.

Team of IRDR-IPO

MAKING CITIES DISASTER RESILIENT IN A CHANGING CLIMATE:
THE CASE OF KUALA LUMPUR, MALAYSIA

Joy Jacqueline Pereira[1*]
Nurfashareena Muhamad[1]
Choun Sian Lim[1]
Sarah Aziz[1]
Julian Hunt[2]

[1] IRDR ICoE SEADPRI-UKM, Universiti Kebangsaan Malaysia
[2] University of Cambridge and University College London

[*]Corresponding Author: joy@ukm.edu.my

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Edit: Qunli HAN, Lucy JONES

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Content

Abstract of this Working Paper

Southeast Asia is expected to experience more severe and extreme events that will impact economic growth as global warming proceeds to 1.5°C. The effects will be severe in urban areas and this calls for scientifically robust research to identify vulnerable communities and exposed assets, to make cities resilient as the climate changes. The development of forecasting capacity is also critical, for both the short-term response and long-term planning, to support decision-makers. Universiti Kebangsaan Malaysia's Southeast Asia Disaster Prevention Research Initiative, the IRDR International Centre of Excellence on Disaster Risks and Climate Extremes (ICoE-SEADPRI-UKM), is addressing this future challenge through innovative research and knowledge sharing. With support from the Newton-Ungku Omar Fund and partners from the United Kingdom and Malaysia, ICoE-SEADPRI-UKM and the University of Cambridge are joint leaders of a 3-year pilot project referred to as Disaster Resilient Kuala Lumpur. The aim is to develop a city-level multi-hazard platform with forecasting capability that aims to enhance the resilience of Kuala Lumpur in a changing climate. The project has collated data and scientific knowledge on disaster risks, including information on exposure and vulnerability, which will benefit the City Hall of Kuala Lumpur. The multi-disciplinary expertise brought together to generate timely disaster alerts will be maintained beyond the project through multiple agreements. Project findings will be disseminated in the region through ANCST, the Asian Network on Climate Science and Technology (www.ancst.org), coordinated by ICoE-SEADPRI-UKM, with support from the Cambridge Malaysia Education Development Trust Fund.

Keywords

Disaster risk reduction, Climate extremes, Disaster prevention, Landslide susceptibility, Urban resilience, Kuala Lumpur

Indications of contributions to IRDR Science Plan and UN Agendas

IRDR Sub-objectives	**1.1, 1.2, 2.1 and 3.1**
SFDRR targets	SFDRR Target B, D, E, F and G
SDGs **and/or** *Climate Goals*	SDG 1 (Target 1.5), 11 (Targets 11.5, 11.b) and 13 (Targets 13.1, 13.2, 13.3)
S/T Roadmap actions	1.1; 1.2; 2.1; 3.1; 4.1

1. How does this study contribute to IRDR research objectives?

The Pilot Project on Kuala Lumpur commenced with the identification of six hazards that caused loss of lives and damage to property over the past decade. Preliminary findings have delineated landslide susceptible areas with exposed communities and critical facilities (IRDR Sub-Objective 1.1). Down-scaled meteorological parameters in combination with rainfall thresholds are being used to provide 3-day forecasts for landslides (IRDR Sub-Objective 1.2). Parallel to this process, the management of landslide risk including the emergency response measures within the City Hall of Kuala Lumpur was determined (IRDR Sub-Objective 2.1). A similar process will be used for each hazard, where GIS layers will be integrated into a Multi-hazard Platform with forecasting and disaster alert capability, linked to various departments (Rescue Squad, Traffic Management, etc.) in the City Hall. The Planning Department will use information on hazard susceptibility for zoning and development control (IRDR Sub-Objective 3.1).

2. How does this study contribute to SFDRR targets?

The Pilot Project on Kuala Lumpur has identified areas susceptible to landslides, which can now be subject to tighter land-use zoning and development control, to reduce the number of people affected in the future (SFDRR Target B). Critical infrastructure such as hospitals, schools, fire stations and police stations, etc. in such areas are being identified. The exposed facilities are targeted priorities for disaster-proofing, disaster preparedness and emergency response, to enhance their resilience to future events (SFDRR Target D). The availability of such information facilitates adoption and implementation of local action to support national strategies (SFDRR Target E). The Newton Ungku Omar Fund, with equal funding from the Governments of UK and Malaysia, have supported national agencies to channel science to inform local actions (SFDRR Target F). It has also made available a multi-hazard platform to provide communities in Kuala Lumpur with disaster alerts (SFDRR Target G).

3. How does this study contribute to SDGs and the Climate Goal?

The Pilot Project on Kuala Lumpur has delineated public flats, sheltering the poor and the bottom 40 per cent income group of the city population, exposed to landslides. Targeted interventions are now possible to build their resilience, prevent poverty and reduce increasing inequalities due to disaster events (SDG Target 1.5). The cost of damage due to previous landslides has been estimated in relation to the GDP of Kuala Lumpur, and efforts to forecast future damages will inform strategies, to make Kuala Lumpur safe, resilient and sustainable (SDG Targets 11.5, 11.b). Enhanced local level forecasting capability of the multi-hazard platform will support development of strategies to reduce the number of affected people, enhance ability to adapt to climate change, foster climate resilience and strengthen the institutional capacity of the City Hall of Kuala Lumpur in tackling climate change (SDG Targets 13.1, 13.2, 13.3).

4. How does this study contribute to Science & Technology Roadmap Actions?

The Pilot Project on Kuala Lumpur has updated data and scientific knowledge on disaster risks, to develop a multi-hazard platform with local level forecasting capability and information on exposure and vulnerability, to benefit the City Hall of Kuala Lumpur (S/T Roadmap Action 1.1). The multi-disciplinary expertise will be maintained beyond the pilot project through multiple formal agreements (S/T Roadmap Action 1.2). Routine application of the multi-hazard platform requires continuous use of science drawn from federal agencies, to inform policy- and decision-making within all sectors and departments in the City Hall of Kuala Lumpur (S/T Roadmap Action 2.1). Scientific evidence and economic evaluation procedures from the pilot project is expected to support decision-making of policy options for investment and development planning (S/T Roadmap Action 3.1). Scientific information and early warning is strengthening the adaptive capacity of the City Hall of Kuala Lumpur in tackling climate change (S/T Roadmap Action 3.1).

Main Text

1. INTRODUCTION

The frequency, intensity, spatial extent, duration and timing of extreme weather and climate events have altered due to climate change (IPCC, 2014). A dramatic consequence of 1°C of global warming is the increased occurrence of extreme weather, (IPCC, 2018). Extreme events may also trigger associated or cascading hazards depending on its nature, intensity, extent and locality. All types of fast and slow onset hazards are expected to increase as the climate changes. Ten key risks associated with fast and slow onset hazards have been identified for Asia, where a majority of these have direct impact on society in terms of health, well-being and safety (Hijioka et al., 2014). If global warming exceeds 1.5°C, tropical Southeast Asia is projected to experience a range of fast and slow onset hazards that will impact economic growth (IPCC, 2018).

Hazards influenced by climate change include extreme precipitation, flooding, landslides, high temperatures, heat stress and air pollution, among others. Many are concentrated in urban areas. "A first step towards adaptation to future climate change is reducing vulnerability and exposure to present climate variability" (IPCC, 2014). Scientifically robust research is increasingly important to identify vulnerable communities and exposed assets, to make cities resilient as the climate changes. More severe and extreme weather events are projected to increase losses, challenging insurance systems in offering affordable coverage while raising more risk-based capital. The communication, transfer, and development of climate-related knowledge is most effective when it is sensitive to context, diversity of decision types, decision processes and constituencies. Therefore, it is critical to develop knowledge and forecasting capacity both for the short-term response and long-term planning, to support decision-makers in cities, particularly in Southeast Asia, where the impacts extreme weather events are expected to be serious.

The paper commences with an overview of Universiti Kebangsaan Malaysia's Southeast Asia Disaster Prevention Research Initiative, an IRDR International Centre of Excellence on Disaster Risks and Climate Extremes (ICoE-SEADPRI-UKM). The role, core business and partnerships that supports the institution in advocating disaster prevention through localised inputs from Southeast Asia is briefly depicted. This is followed by a short description of a pilot project led by ICoE-SEADPRI-UKM with the University of Cambridge, to develop a city-level multi-hazard platform with forecasting capability that aims to enhance the resilience of Kuala Lumpur in a changing climate. Preliminary findings from the pilot project reveal the potential of open-source data in providing meaningful inputs for decision-makers in the City Hall of Kuala Lumpur as well as other stakeholders, particularly the community.

2. ADVOCATES FOR DISASTER PREVENTION

2.1 SEADPRI-Universiti Kebangsaan Malaysia

Operating since 1 June 2008, Universiti Kebangsaan Malaysia's Southeast Asia Disaster Prevention Research Initiative (SEADPRI-UKM) is a research centre under the administrative structure of the Institute for Environment and Development within Universiti Kebangsaan Malaysia, a public university in Malaysia. In 2016, SEADPRI-UKM received recognition as an IRDR International Centre of Excellence on Disaster Risks and Climate Extremes (ICoE-SEADPRI-UKM), serving as the regional leader in innovative research and knowledge sharing on holistic disaster prevention. The primary mission is to conduct research on hazards and disasters, enhance capacity in Malaysia and Southeast Asia, as well as support knowledge-based decision making on climatic, geological and technological hazards.

The core business of ICoE-SEADPRI-UKM includes research, postgraduate education, specialised workshops and training, as well as outreach and networking. Research programmes focus on exploring and expanding knowledge on climatic hazards, geological hazards and technological hazards (www.ukm.my/seadpri). The emphasis is on multi- and transdisciplinary approaches encompassing science, technology, impact, vulnerability and governance, involving multiple stakeholders, across various scales; to influence practice and policy on disaster risk reduction. Postgraduate education aims to develop trained human capital in addressing disaster issues for knowledge-based decision making. Graduate programmes are offered at the masters and doctoral levels through research in the areas of Policy and Disaster Management, Climatic Hazards Studies, Geological Hazards Studies and Technological Hazards Studies.

Workshops and training are conducted for specialised subjects targeting policy and decision-makers, professionals and early career researchers. Aspects covered include hazards assessment and forecasting, integration of disaster risks and climate adaptation as well as policy and management of hazards and disasters, including foresight and futures thinking as well as science communication. Outreach and networking focuses on issues related to science and governance for disaster risk reduction in Southeast Asia, to enhance knowledge, disseminate information and provide policy relevant guidance. Collaboration with government agencies, intergovernmental bodies, civil society organisations and the private sector is designed to create synergies and sustainable pathways for exchange of innovative practices and socially relevant technology.

2.2 Partnerships

The Asian Network on Climate Science and Technology (ANCST) was established in 2013 with seed-funding from the Cambridge Malaysia Education Development Trust Fund, Malaysian Commonwealth Studies Centre (CMEDT/MCSC) in Cambridge. Essentially, ANCST comprises several special topic groups on climate science of importance to the region led by Asian champions, which are self-organised and communicate virtually [www.ancst.org]. Capacity building workshops and science-policy interfacing are key

activities (Figure 1). ICoE-SEADPRI-UKM is the coordinating centre for ANCST, covering Southeast Asia with support from satellite centres at the City University of Hong Kong for East Asia and Indian Institute of Technology Delhi for South Asia.

Figure 1: ICoE-SEADPRI-UKM and ANCST were instrumental in bringing together the IPCC, APN, ISC-ROAP and other partners to convene the Workshop on Status of Climate Science and Technology in Asia on 15-16 November 2018 in Kuala Lumpur; to improve participation of early career researchers and coverage of sub-regional scientific information in the IPCC Sixth Assessment Cycle (IPCC AR6).

ICoE-SEADPRI-UKM also hosts the virtual network of ASEAN Partner Institutions on Climate Change Adaptation (ASEANadapt), which was formally recognised by the ASEAN Working Group on Climate Change (AWGCC) at its 7th Meeting on 21 July 2016 in Kuala Lumpur [www.aseanadapt.org]. The ASEANadapt Network is an outcome of the project on developing the ASEAN climate change adaptation programme for the region, which was funded by the ASEAN-India Green Fund. The network facilitates continuous exchange of information on good practices and communication on climate change adaptation among universities and other affiliated organisations in ASEAN Member States.

ICoE-SEADPRI-UKM has formal institutional linkages with key regional entities such as the Intergovernmental Agency for Geoscience Programmes in East and Southeast Asia (CCOP), MERCY Malaysia and Asia-Pacific Network for Global Change Research (APN). The engagement of individual researchers has helped to enhance the linkages of ICoE-SEADPRI-UKM with global and regional entities such as the Intergovernmental Panel on Climate Change (IPCC), UNISDR Asia Science, Technology and Academic Group (ASTAAG), Global Alliance of Disaster Research Institutes (GADRI) and Asian University Network on Environment and Disaster Management (AUEDM), among others.

The connection of ICoE-SEADPRI-UKM with the University of Cambridge has been instrumental in attracting the best scientific expertise to generate solutions that would help prevent or reduce the risk of disasters at the local level in Malaysia and the region, with a strong focus on bridging the science-policy interface. The relationships established over the past decade has served the centre well in taking research to action, through transdisciplinary work and multi-sector linkages. Recognition as the IRDR ICoE on Disaster Risks and Climate Extremes has expanded its strategic partnerships to the International Science Council – the Regional Office for Asia and the Pacific (ISC-ROAP) and Digital Belt and Road (DBAR) Working Group on DRR. These linkages have provided many opportunities for participation, joint activities and areas for scientists, early career researchers and practitioners to connect, interact and advance knowledge through

development of joint projects. The role of IRDR ICoE-SEADPRI-UKM is to provide localised inputs from Southeast Asia, through its capacity building programmes, case studies and pilot projects.

3. PILOT PROJECT: DISASTER RESILIENT KUALA LUMPUR

3.1 Context

Kuala Lumpur aspires to be a sustainable city where physical, economic, social and environmental aspects are kept in balance and harmony. Kuala Lumpur has developed tremendously under the administration of its local authority, the City Hall of Kuala Lumpur (Figure 2). In 2016, the city population was estimated at 1.79 million with a 100% level of urbanisation, the highest in the country (Census, 2010). Notwithstanding this, Kuala Lumpur has been facing enormous challenges to ensure continuous dynamism and be outstanding as an integral centre of administration, finance, industry, trade and tourism in the world.

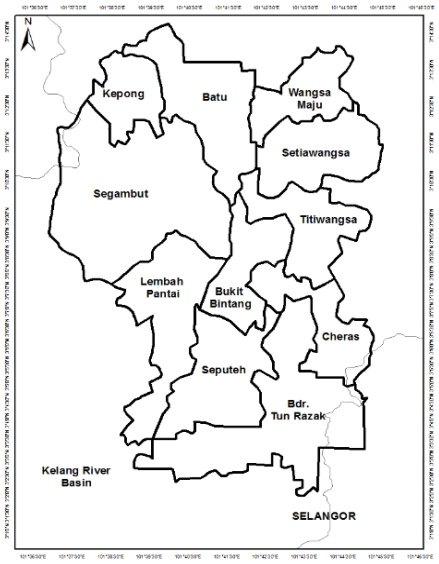

Figure 2: The administration and delivery of services by the City Hall of Kuala Lumpur is guided by parliamentary boundaries within the city.

It is anticipated that global warming of 1.5°C will contribute to intense rainfall extremes that could result in the escalation of climate-induced hazards in the tropics (IPCC, 2018). Climate change and the presence of humans, infrastructure and other forms of vulnerabilities in susceptible areas have exacerbated natural hazards, resulting in disasters (McEntire, 2001; Coppola, 2007; IPCC, 2012). Kuala Lumpur is experiencing floods, flash floods and landslides (including slope failures), which pose a threat to the urban population.

Flash floods (Bhuiyan et al., 2018; Norashikin et al., 2018; KL Structure Plan, 2020) and landslides (Ahmad Shazrin et al., 2013; Mahmud et al., 2013; Nurul Iffah & Wan Zuhairi, 2018) have caused tremendous inconvenience, damage and loss of productive hours in Kuala Lumpur. In extreme cases, there have been loss of lives. These incidents may be small and unimportant on the global scale, but they are significant to Kuala Lumpur and can be considered a city level disaster. The impact of disasters will depend on the city's preparedness and the way the public perceive and react to the impacts. The importance of cities taking steps towards becoming more resilient and protecting their residents and assets while remaining functional has been stressed. Resilience not only means preparing

cities to better respond to natural disasters; even more importantly, it also means taking steps to prevent disasters.

Resilience has become an important goal for cities, particularly in the face of climate change. Resilience is what helps cities to adapt and transform in the face of challenges; to prepare for both the expected and the unexpected (100resilientcities, 2019). Resilience refers to the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management (UNISDR, 2009). From a city's perspective, resilience is a measure of the ability of a city to avoid or recover from an adverse event. In the case of Kuala Lumpur, it is important that the city has the capacity to adapt and expand despite the stresses and shocks that may be experienced as the climate changes.

In order to make Kuala Lumpur resilient, the city will require an incredible level of coordination across multiple levels of stakeholders and sectors. The City Hall of Kuala Lumpur and related stakeholders must be supported with adequate scientific inputs to make informed decisions. Such information relates to aspects of reducing risk, vulnerability and the impact of disasters. When a disaster strikes, the city has no choice but to respond and cope with the event. But why do some cities cope and adapt better than others in the face of adversity? Disasters leave some form of adaptive capabilities at various levels, which make resilience to a particular disaster an important subject of interest (Kamara et al. 2018). Kuala Lumpur has been coping with frequent flash floods and this has resulted in the development of the Storm Water Management and Road (SMART) Tunnel (Bhuiyan et al., 2018). Communities have also taken several precautions after experiencing many episodes of flash floods, such as relocating their belongings to a safer location, constructing shelves above the ceiling to accommodate their belongings and to prevent them from being stolen when occupants temporarily evacuate their houses, among others (Rustam Khairi & Raja Noriza, 2013).

Are these steps enough to make Kuala Lumpur resilient? We seldom realize that the success of making decisions for the betterment of a city is dependent on the availability of efficient information to make informed decisions. Efficient data collection, archiving and analytics are essential to address disaster issues (Rahman et al., 2017). Availability and access to information has a significant impact on decision making. The absence of up-to-date information can impede the generation of impressive products that support decision-making. However, the use of data from open sources also offer tremendous potential and encouraging results, particularly in making disaster risks visible (Fung, 2013; Iskandaryan, 2016; and Yu et al., 2018). Findings on disaster risks that serve as the basis for decision-making by local authorities and other stakeholders must be transparent to the public so that they are aware of the threats that they are facing and be better equipped to cope with oncoming events.

3.2 The Pilot Project

Many hazards associated with climate change have the greatest impact on urban areas where most people and property are concentrated. Severe and extreme weather events are projected to increase losses, challenging Governments and insurance systems worldwide. Communication, transfer and development of climate-related knowledge is most effective when it is sensitive to contact, diversity of decision types, decision processes and the requirements of constituencies. This is the basis for the 3-year pilot project entitled "Disaster Resilience Cities: Forecasting Local Level Climate Extremes and Physical Hazards for Kuala Lumpur", also referred to as Disaster Resilient Kuala Lumpur. Supported by the Newton-Ungku Omar Fund, with matching funds from the Governments of the United Kingdom and Malaysia, the pilot project is led by the University of Cambridge (Prof. Lord Julian Hunt) and ICoE-SEADPRI-UKM (Prof. Joy Jacqueline Pereira).

There are 16 organisations involved representing academia, government agencies, non-government organisation and the private sector from both countries (Figure 3). The ten organisations from Malaysia are Universiti Kebangsaan Malaysia, University of Malaya, Meteorology Department of Malaysia, Minerals and Geoscience Department of Malaysia, Department of Environment Malaysia, UKM Pakarunding Sdn. Bhd., Geomapping Technology Sdn. Bhd., Param Agricultural Soil Surveys (M) Sdn. Bhd, Geological Society of Malaysia and CoRE Expert Systems Sdn. Bhd. The six organisations from the UK are the University of Cambridge, British Geological Survey, University College London, Cambridge Environmental Research Consultants, Cuesta Consulting and JBA Risk Management UK.

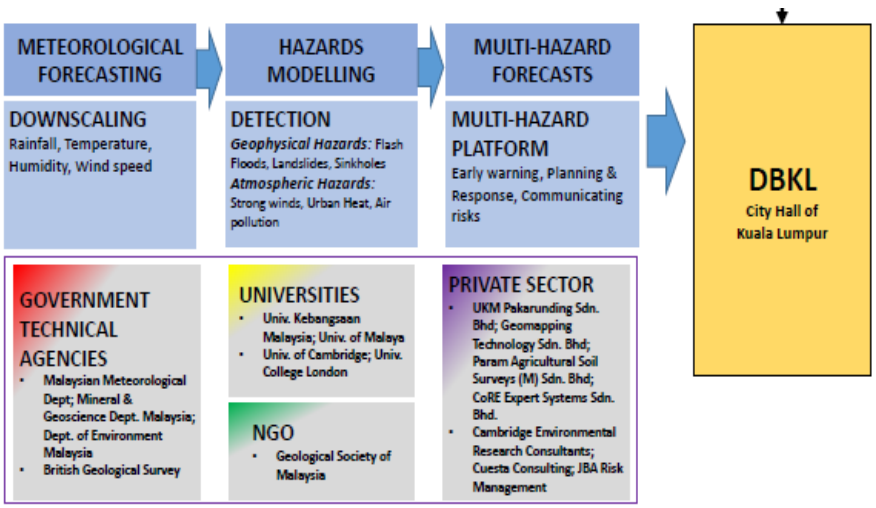

Figure 3: The Pilot Project on Disaster Resilient Kuala Lumpur involves downscaling of meteorological parameters to drive hazard models, which are then assembled in a multi-hazard platform, with neighbourhood scale forecasting capabilities. The City Hall of Kuala Lumpur (DBKL) receives disaster alerts that enable them to strengthen disaster preparedness, emergency response and issue public warnings, if required.

The pilot project takes into account six hazards, which are prevalent in Kuala Lumpur. These include three geophysical hazards i.e. flash floods, landslides and sinkholes as well as three atmospheric hazards i.e. heat, air pollution and strong winds. Products from the geophysical hazards group include the city's first hazards inventory, surface water and fluvial flood model, landslides susceptibility and forecast model, sinkhole susceptibility model and an appraisal protocol for disaster damage. The products from the atmospheric hazards group consist of the city's first ever database for strong storms, heatwaves and air pollution as well as a system for atmospheric hazard forecasting.

3.3 Preliminary Findings for Geophysical Hazards

The pilot project on Disaster Resilient Kuala Lumpur is still ongoing and is expected to be completed by late 2019. The following section highlights the preliminary findings for geophysical hazards in Kuala Lumpur. Geophysical hazards modelling led by University of Malaya and the British Geological Survey has resulted in the development of a landslide susceptibility map for Kuala Lumpur. The susceptibility map was derived from several parameters than influence the occurrence of landslides. Depending on the weighted importance of each parameter, the level of susceptibility is categorised as very high, high, moderate, low and very low. The susceptibility map is verified by official landslide data from the Minerals and Geoscience Department. The landslide forecasting component is being developed using rainfall threshold values, obtained from the Meteorology Department of Malaysia. Three-day forecasts are being developed to be channelled to the Multi-hazard Platform, to be located in the City Hall of Kuala Lumpur. The findings of the project on susceptible areas is being refined and the focus is on developing peer-reviewed papers on the methods employed.

Parallel to the efforts on geophysical hazards modelling, ICoE-SEADPRI-UKM has been investigating the landuse planning system, development control, management processes of landslides, flash-floods and sinkholes as well as emergency response procedures in Kuala Lumpur. These are handled by a variety of departments within the City Hall of Kuala Lumpur i.e. the Planning Development, Development Control, Traffic Management Department, Rescue Squad, among others. The cost of previous landslide events and its impact on the GDP of Kuala Lumpur has also been evaluated. In addition, the risk assessment framework was developed, by delineating elements at risk in Kuala Lumpur, using information from open sources. The purpose of using such information is to ensure that the final products can be shared with the public, with the appropriate legal caveat.

Elements at risk is a generic term that signifies everything that might be exposed to hazards, ranging from individual persons to communities and buildings to economic supply chains. Fundamentally, hazards are seldom considered a problem in areas without people or critical facilities (van Westen, 2014). The elements at risk have `value', which can be expressed in monetary terms, in the number of persons affected or in less quantifiable units such as cultural importance or environmental quality. There are many different types of elements at risk and they are classified in various ways, several of which can be spatially depicted (van Westen, 2014).

In the pilot project, concepts such as susceptibility, exposure and vulnerability are linked using an area approach (Figure 4). In the area approach, vulnerable communities and critical facilities are considered elements at risk if they exist in an area that is susceptible to hazards. Information on people and critical facilities in Kuala Lumpur was gathered from various open-source platforms including government department websites and readily available online reports. The information was then mapped using Geographic Information System (GIS).

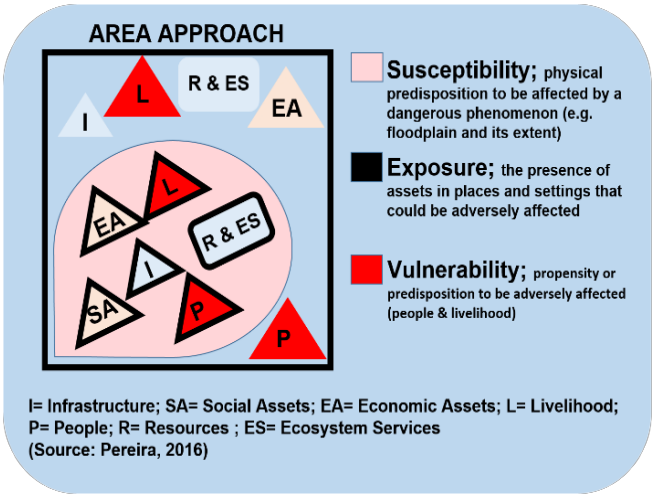

Figure 4: Notional linkages of susceptibility, exposure and vulnerability in an area based approach, modified from IPCC terminology and definitions (IPCC, 2014).

Communities at Risk in Kuala Lumpur

Information on communities that could be spatially displayed is very limited. Population density maps are useful to provide a very crude estimate of the population in Kuala Lumpur that is exposed to a specific type of hazard, such as landslides, flash floods or sinkholes. The spatial distribution of communities based on their income has been depicted in Kuala Lumpur using proxies. Open source information is available on the People's Housing Program (PPR), a government initiative for relocation of squatters to meet the housing need of low-income groups. The poor and bottom 40% income group in Kuala Lumpur are collectively represented by residents in PPR public flats. In contrast, private condominiums represent the high-income population.

There are nearly 50 public flats in Kuala Lumpur to meet the housing needs of the low-income group (Figure 5). Preliminary screening reveals that about 12 public flats have medium exposure to landslides, 10 have high exposure and one unit has very high susceptibility to landslides. This will be carefully verified through field visits. The underlying characteristics of this low-income group makes them inherently vulnerable. Should a disaster event occur, they will become more vulnerable, with lower capacity and resources to cope with the impacts. Significant attention and planning is needed to develop strategies to manage the risk of landslides in such areas. The ongoing development of the Multi-hazard Platform with forecasting and disaster alert capability will be very useful to monitor these areas. Targeted interventions are also required to increase the resilience of this group. This could include government sponsored insurance coverage, awareness building on disaster preparedness and development of a community emergency plan, among others. The City Council of Kuala Lumpur can now take more proactive action and targeted action, with this information. The dissemination of information on landslide exposure will serve to mobilise communities from the high-

income groups, which have higher capacity and resources, to self-organise and take action.

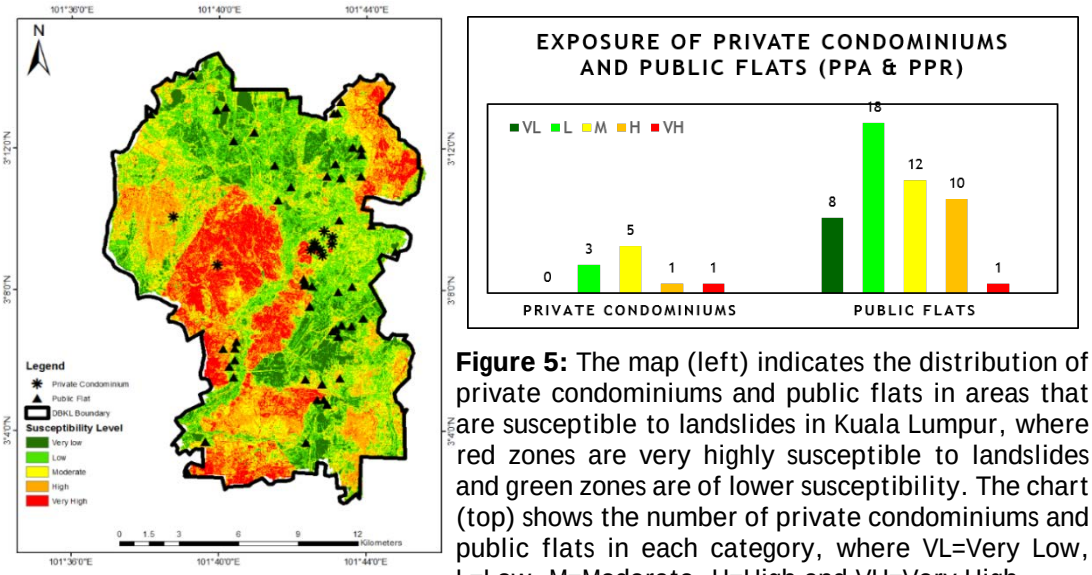

Figure 5: The map (left) indicates the distribution of private condominiums and public flats in areas that are susceptible to landslides in Kuala Lumpur, where red zones are very highly susceptible to landslides and green zones are of lower susceptibility. The chart (top) shows the number of private condominiums and public flats in each category, where VL=Very Low, L=Low, M=Moderate, H=High and VH=Very High.

Critical Infrastructure at Risk in Kuala Lumpur

More data is available on critical facilities in Kuala Lumpur from open access sources, compared to information on communities. This encompasses information on hospitals, schools, fire stations, police stations, evacuation centres, power stations, water treatment plants, sewage treatment plants and former landfills. Critical facilities in Kuala Lumpur were broadly grouped according to the categories of the Sendai Framework on Disaster Risk Reduction (Target D). The five categories include hospitals, schools, fire stations, police stations and other facilities (Table 1). Of the facilities recorded, the highest proportion constitute schools, followed by police stations, hospitals and fire stations. The facilities are widely scattered throughout the city (Figure 6).

Table 1: Number of critical facilities in Kuala Lumpur

Critical Facilities	Total No. in Kuala Lumpur
Hospital	33
School	187
Fire Station	15
Police Station	51
Others *[Evacuation Centre; TNB Power Station; Water Treatment Plant; Sewage Treatment Plant; Closed Landfills]*	70

There are about 187 schools in Kuala Lumpur and the majority of them are located in areas that are not susceptible to landslides. The preliminary screening reveals that a small number of about 13 schools are located in landslide prone areas. Field visits will be conducted to verify the actual risks (Figure 6). A few fire stations, police stations and other facilities are also located in landslide prone areas. These localities will also be carefully checked. The final verified information is important for the City Hall of Kuala Lumpur and

other stakeholders to prioritise their resources to take structural and non-structural measures to reduce the risk of landslides. Targeted efforts on raising awareness on disaster preparedness and emergency response are important. The development of the Multi-hazard Platform with forecasting and disaster alert capability will be very useful for the City Hall of Kuala Lumpur, to monitor these areas.

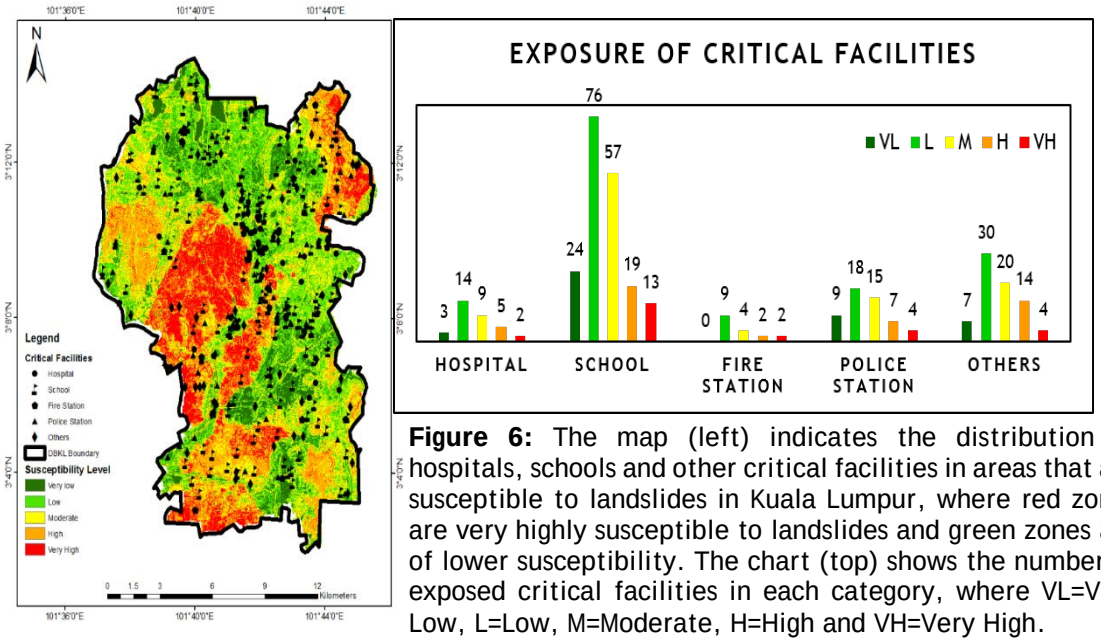

Figure 6: The map (left) indicates the distribution of hospitals, schools and other critical facilities in areas that are susceptible to landslides in Kuala Lumpur, where red zones are very highly susceptible to landslides and green zones are of lower susceptibility. The chart (top) shows the number of exposed critical facilities in each category, where VL=Very Low, L=Low, M=Moderate, H=High and VH=Very High.

The pilot project on Disaster Resilient Kuala Lumpur has introduced a new approach in the country. It has synthesised information from open access sources to reveal communities and critical facilities that are exposed to landslides, which will be made accessible to the public so that they can be informed and empowered to take action to enhance their resilience. Similar approaches in Indonesia have revealed that nearly 3900 schools are located in tsunami prone areas (UNDP, 2018). The revelation of this information has mobilised schools to conduct tsunami-awareness training for teachers and students. The new element from the pilot is the development of the Multi-hazard Platform with forecasting and disaster alert capability. The City Hall of Kuala Lumpur will find it useful once it becomes operational. Other stakeholders including insurers and the private sector will also find it useful.

4. CONCLUDING REMARKS

Universiti Kebangsaan Malaysia's Southeast Asia Disaster Prevention Research Initiative is an IRDR International Centre of Excellence on Disaster Risks and Climate Extremes (ICoE-SEADPRI-UKM), serving as the regional leader in innovative research and knowledge sharing on holistic disaster prevention. In conducting its work, ICoE-SEADPRI-UKM strives to integrate science into policy and practice by creating a unity of intellectual frameworks, beyond disciplinary perspectives, with the involvement of multiple stakeholders and inputs from multiple disciplines, scales and sectors.

The Pilot Project on Disaster Resilient Kuala Lumpur, which is funded by the Newton Ungku Omar Fund, has collated and updated data and scientific knowledge on disaster risks. The project aims to develop a multi-hazard platform with local level forecasting capability and information on exposure and vulnerability, which will benefit the City Hall of Kuala Lumpur. The multi-disciplinary expertise brought together to generate timely disaster alerts will be maintained beyond the project through multiple agreements. The City Hall of Kuala Lumpur has formal arrangements with federal agencies such as the Meteorology Department of Malaysia and Department of Environment Malaysia on continuous provision of local level weather and disaster alerts. The pilot project leader from Malaysia, ICoE-SEADPRI-UKM is also developing a collaborative agreement with the National Disaster Management Agency (NADMA) Malaysia, to facilitate scaling-up and widespread dissemination as well as capacity building, through the National Platform on Disaster Risk Reduction.

The multi-hazard platform will require continuous involvement and use of science to inform policy- and decision-making within all sectors and departments in the City Hall of Kuala Lumpur. For this purpose, linkages will be maintained with federal government agencies and ICoE-SEADPRI-UKM. Scientific evidence used to delineate areas susceptible to landslides in conjunction with economic forecasts for disaster losses being established for Kuala Lumpur is expected to support decision-making of policy options for investment and development planning in the City Hall of Kuala Lumpur. The pilot project is providing a wealth of scientific information to strengthen preparedness, response and to "Build Back Better" from the previous decade of economic losses due to landslides, enhance the resilience of vulnerable communities and exposed assets, and more importantly strengthen the adaptive capacity of the City Hall of Kuala Lumpur in tackling climate change.

The role of ICoE-SEADPRI-UKM and ANCST is to build capacity on the approaches and methods used for assessing risk, developing multi-hazards platforms with local level forecasting capability and evaluating economic loss and damage for climate-induced hazards. Good practices on informed decision-making and science–based solutions as well as innovative measures that enhance disaster preparedness and climate resilience, deployed by the City Hall of Kuala Lumpur could also be documented and disseminated via the ANCST website, to the region. The aspiration is to enhance replication of the multi-hazard platform for tropical cities in Southeast Asia. Future work will involve the development industry standards, specifically technical guidance for geoscientists in the private sector. The standards will comprise procedures and good practices, for example on conducting terrain mapping for geological hazards, developing area business continuity plans and performing multi-hazard susceptibility assessments. The standards are expected to be submitted to professional bodies that regulate geoscience practice, to be considered for adoption at the country level. The intention is to ensure that the provision of geoscience information is of high quality, so that urban policy and decision-makers as well as the insurance and financial sectors, can reduce their exposure to the risk of geophysical disasters.

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