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| **Institution:** University of East London (UEL) | | |
| **Unit of Assessment:** 12 Engineering | | |
| **Title of case study:** Protecting the beaches; Disaster prevention mechanisms against tsunamis, floods and coastal erosion | | |
| **Period when the underpinning research was undertaken:** 2004 – 2020 | | |
| **Details of staff conducting the underpinning research from the submitting unit:** | | |
| **Name(s):** | **Role(s) (e.g. job title):** | **Period(s) employed by submitting HEI:** |
| Dr Ravindra Jayaratne | Reader in Coastal Engineering | 2008 – present |
| Dr Ali Abbas | Senior Lecturer in Structural Engineering | 2010 – present |
| **Period when the claimed impact occurred:** 2014 – 2020 | | |
| **Is this case study continued from a case study submitted in 2014?** No | | |

## 1. Summary of the impact (indicative maximum 100 words)

The research focuses on novel coastal engineering modelling and design tools that mitigate against tsunamis, extreme waves, and floods for stakeholders worldwide through;

1. Development of a new tsunami breakwater design formula, incorporated in the design standard ASCE/SEI 7 of the American Society of Civil Engineers (ASCE) and applied in projects in Japan and Sri Lanka.
2. Reduction in construction costs for earthquake- and tsunami-prone areas in Malaysia.
3. Public engagement on coastal erosion in Sri Lanka.
4. Preparedness of tsunami-prone communities in Indonesia.
5. Developing a novel disaster category used in Japan and UK.

## 2. Underpinning research (indicative maximum 500 words)

### *1) Improvements to design standards against tsunamis*

Coastal defence structures in Indonesia, Sri Lanka, Thailand, Tanzania and Japan, designed using the Hudson formula suffered extensive damage by the 2004 Indian Ocean and the 2011 Great East Japan tsunamis. Dr Jayaratne conducted post-disaster field surveys in partnership with three Japanese universities (Waseda University, Yokohama National University and the University of Tokyo) and found that the damaged structures had provided insufficient protection. A modified Hudson breakwater design formula for differed tsunamis was developed (R1) and was incorporated into new ASCE/SEI 7 design standards.

*Figure 1. Displacement of artificial armour units after 2011 Tsunami*

Concrete coastal defence walls require reinforcement to provide energy absorption against the seismic and impact loads generated by tsunamis, making them difficult to construct. Dr Abbas and the team developed a numerical model to examine the replacement

of conventional bars with steel fibres under cyclic/seismic loads **(R2)**, improving the design of earthquake and impact-resistant concrete structures.

***2) Coastal erosion***

In collaboration with the Sri Lankan Coast Conservation and Coastal Resource Management Department (CC&CRMD) and Japanese and Sri Lankan academics, Dr Jayaratne investigated coastal erosion problems in Marawila, one of the most vulnerable coastlines in Sri Lanka. Four decades of data were analysed; field investigations were undertaken (**R3**); numerical modelling of wave propagation was conducted (**R4**). They recommended sustainable coastal erosion mitigation measures to CC&CRMD and Lanka Hydraulics Institute (LHI).

***3) Preparedness of local communities and risk reduction against tsunamis***

After the 2018 Sunda Strait tsunami, Dr Jayaratne and colleagues conducted a field survey of structures, coastlines and communities and developed a novel 2D numerical simulation model of tsunami events (**R5**). The model identified locations vulnerable to extreme inundation in Legundi island and South Lampung, Indonesia.

Dr Jayaratne, with colleagues from UCL and Kansai University, researched the differing perceptions between Disaster Risk Reduction (DRR) experts and laypersons on natural disasters, and implications of perception gaps for the realisation of 'community-based' and 'participatory' DRR. He visited disaster-prone communities in the UK (Sturmer, Slapton) and Japan (Inami, Hita), to conduct interviews and inspect field locations. From this investigation, a novel disaster category-scale was developed. **(R6)**.

## 3. References to the research (indicative maximum of six references)

**R1.** Esteban, M., **Jayaratne, R.,** Mikami, T., Morikubo, I., Shibayama, T., Thao, N.D., Ohira, K., Ohtani, A., Mizuno, Y., Kinoshita, M., and Matsuba, S. (2014). Stability of breakwater armour units against tsunami attack, *Journal of Waterway, Port, Coastal & Ocean Engineering*, 140(2), 188-198. doi.10.1061/(ASCE)WW.1943-5460.0000227.

**R2. Abbas**, A.A., Syed Mohsin, S., Cotsovos, D.M. (2016). A simplified finite element model for assessing steel fibre reinforced concrete structural performance, *Computers & Structures* 173, 31-49. doi. http://dx.doi.org/10.1016/j.compstruc.2016.05.017

**R3.** Samarasekara, R.S.M., Sasaki, J., **Jayaratne, R.,** Suzuki, T., Ranawaka, R.A.S., and Pathmasiri, S.D. (2018). Historical changes in the shoreline and management of Marawila beach, Sri Lanka from 1980 to 2017, *Journal of Coastal & Ocean Management*, 165, 370-384. doi.org/10.1016/j.ocecoaman.2018.09.012

**R4.** Samarasekara, R.S.M., Sasaki, J., Suzuki, T., **Jayaratne, R.,** Ranawaka, R.A.S., and Pathmasiri, S.D. (2020). On the status and mechanisms of coastal erosion in Marawila Beach, Sri Lanka, *Natural Hazards,* 103, 1261-1289. https://doi.org/10.1007/s11069-020-04034-4

**R5. Jayaratne, R.,** Fauzi, M.A.R., Hendra, A., and Shibayama, T. (2020). Modelling of Krakatoa tsunami wave propagation and community engagement based on SWOT analysis in Southern Lampung, Indonesia, *International Conference on Coastal Engineering (vICCE),* Session #125: Tsunami – Landslide Sources. http://coastal.usc.edu/ICCE/abstracts/Jayaratne%20.pdf

**R6**. Shiroshita, H., **Jayaratne, R.,** and Kitagawa, K. (2019). Community engagement in preparing for natural water disasters of different time and magnitude scales – A comparative

study between Japan and England, *10th Conference of the International Society for Integrated Disaster Risk Management (IDRiM),* Nice, France. https://repository.uel.ac.uk/item/89014

## 4. Details of the impact (indicative maximum 750 words)

### *1) Preparedness of Local Communities and Risk Reduction against Tsunamis*

*Figure 2 and 3. Devastation after tsunami in Lampung*

In 2018, the collapse of Anak Krakatau island into the sea caused an enormous tsunami to wash over vulnerable coastal areas in Banten, Java and Lampung, Sumatra. The toll of this disaster was 426 people dead; 14,059 people injured; 25 people missing presumed dead; 2,752 houses destroyed and 510 boats damaged beyond repair.

Focus group meetings and seminars with stakeholders were conducted in Lampung, Sumatra. Over 1000 online participants were invited. These seminars serve to strengthen community resilience and reduce anxieties pertaining to future mega tsunamis in the area (**S1**).

The provincial council letter of Lampung states:

*"The education workshop of 50 stakeholders has increased community engagement and contributed to building local capacity to reduce the environmental risk from tsunamis... The research will provide valuable input to the planning of evacuation routes and organisation of mock tsunami drills; these efforts are considered to be vital for the protection of the population of approximately 8,500 people residing in the coastal town of Kalianda"* (**S2**).

Discussions and seminars held with 40 local council DRR teams and community leaders made our research widely accessible to the DRR community in the UK, Japan and beyond. The Inami Town Council testimonial letter states:

*"We learned new and effective disaster management practices… to reduce the environmental risk from these natural hazards. Furthermore, as a government organisation in Japan and responsible for population of 8,000, we can adopt the methodological approach based on the DRR advice to make strategic decisions and re-shape policy documents of the council"* (**S3**).

### *2) Progressing tsunami protect design*

Dr Jayaratne has developed a new version of the universal breakwater design formula for different structure types and tsunami levels.

The formula was presented to LHI, the Institution of Engineers, CC&CRMD, and the Kanagawa Prefectural Government of Japan providing consultation advice for the development of fishery ports and coastal protection schemes in Sri Lanka **(S4)** and estimating tsunami flood defence levels in Kanagawa. This new design method plays a key role in strengthening the long-term

viability of new coastal defence structures and resilience of coastal communities in Sri Lanka, Japan and beyond.

Dr Abbas developed a novel analytical and experimental research programme to examine modern construction materials, such as steel fibre, reducing the economic and environmental repercussions of structural concrete. The work on steel-fibre-reinforced concrete led to design recommendations for structures under cyclic/seismic and impact loading, such as coastal defences subject to tsunami waves. Fibres are added to the concrete mix, thus reducing construction time and cost. This has been successfully applied in housing complexes in Malaysia **(S5).**

***3) Coastal erosion***

Coastal erosion is a major problem in Sri Lanka. CC&CRMD's 2018 Coastal Zone Management Plan found that 40% of Sri Lanka's GDP comes from the assets and businesses around the 1,700 km of coastline at risk. The project "Marawila beach" has an economic value for the country, contributing to reduced environmental risk and improved quality of life for 220 fishing communities and business confidence for 6 hotels and 5 leisure centres in the area. Analysis of wave and sediment data collected over 39-years have revealed the current status and mechanisms of coastal erosion in Marawila, while new coastal management interventions and numerical models have led to changes and benefits to CC&CRMD's national agenda.

The CC&CRMD testimonial letter states:

*"We felt that Dr Jayaratne and his team's project focused on Marawila beach is a valuable piece of study, worth of Rs. 5 million (Sri Lankan rupees)"* (**S6**).

Following educational meetings, the awareness, attitudes and understanding of the fishing industry and local residents was surveyed, and their ability to make informed decisions on using sustainable coastal resources has been strengthened (**S7a, S7b**).

**5. Sources to corroborate the impact** (indicative maximum of 10 references)

**S1.** *Multi Disasters Seminar* in MKG Webinar Series of Institute Technology Sumatra (ITERA) in Indonesian, August 2020. 1000+ online participants from Indonesia. https://www.itera.ac.id/itera-libatkan-para-pakar-kaji-multibencana-di-indonesia/

**S2.** Official letter from Provincial Council of South Lampung, Indonesia.

**S3.** Official letter from Inami Town Council, Wakayama Prefecture, Japan.

**S4.** Official letter from the Lanka Hydraulic Institute (LHI - www.lhi.lk), Sri Lanka.

**S5.** Official letter from a Civil Engineering Construction Company, Malaysia.

**S6.** Official letter from the Coast Conservation and Coastal Resource Management Department (CC&CRMD - http://coastal.gov.lk/), Sri Lanka.

**S7a**. Newspaper article on "Marawila Beach Case Study: Coastal Zone Management Practices" in *Ceylon Today,* page A9, 17 July 2020. https://uploads.ceylontoday.lk/epapers/files/2020-07-17-%20CeylonToday.pdf
**S7b.** What are the appropriate measures to reduce coastal erosion in developing countries in *Mawbima,* page 6 in Sinhala, December 2020. https://mawbima.lk/.../e_paper/MB-1-16-2020-12-29-MB.pdf