Guest editorial

Early warning systems to reduce tsunami impacts

Professor Samantha Hettiarachchi, PhD (Lond), DIC, was a Senior Professor in Civil Engineering at the University of Moratuwa, and a Fellow of the National Academy of Sciences, Sri Lanka (NASSL). He made exceptional national and international contributions in the areas of coastal engineering, coastal zone management and disaster risk reduction. He was the Vice-Chairman and Acting Chairman of the steering group that installed the Indian Ocean Tsunami Warning and Mitigation System (IOTWS), collaborating with 26 Indian Ocean rim states under the auspices of UNESCO/IOC. Under his leadership UNESCO/IOC produced a definitive guideline on Tsunami Risk Assessment, now in its second edition (UNESCO, 2015). In Sri Lanka, his expertise was used by Coast Conservation Department, the Lanka Hydraulic Institute (LHI), the Disaster Management Centre (DMC) and the National Science Foundation. He was consulted by the Governments of Indonesia and Oman, in addition to that of Sri Lanka.

Professor Hettiarachchi died at the relatively young age of 62 in April 2018, after a courageous battle against cancer. This special issue is meant to celebrate his life and work. It is appropriate that this *gedenkschrift* is carried in IJDRBE, because he collaborated very closely with its Chief Editors, being an editorial board member from its inception. He was also a keynote speaker at the 3rd International Conference on Building Resilience at Ahungalla in 2013, a conference series that is closely associated with this journal. The issue will be launched, fittingly in partnership with UNESCO too, at the 9th conference in the series to be held in Bali in January 2020. The actual call for papers was issued at a memorial lecture in Prof Hettiarachchi's honour, delivered in Colombo by Professor Eduard Kissling, Professor of Geophysics at ETH Zurich, under the auspices of the NASSL.

There are nine contributions in this issue, titled Early Warning Systems for Reducing Tsunami Impact. Three of them are from Sri Lanka, which is to be expected given Prof Hettiarachchi's rootedness in his home context. However, there are others from Japan, Canada, Indonesia and Sweden; and two from the United Kingdom. The UK is where Prof Hettiarachchi engaged in most of his initial academic collaborations. He obtained his doctorate from Imperial College London working under Prof Patrick Holmes, in the course of which he developed links with HR Wallingford; and subsequently worked for a year in the Maritime Engineering Group of Ove Arup and Partners, London. It is only after the Indian Ocean tsunami of 2004 that he broadened his travels and interactions, many of which are reflected by the author affiliations in this issue.

Japan is a country that extended significant technical assistance to Sri Lanka soon after the tsunami. The Canadian paper is from the University of Calgary (jointly with LHI), which launched the International Institute for Infrastructure Resilience and Reconstruction (IIIRR), largely spearheaded by some Sri Lankan academics there. Indonesia is a key country that was involved in the IOTWS. The Swedish Lund University link is thanks to the European Union funded seven-country ASCENT project, intended to strengthen research and innovation capacity for the development of societal resilience to disasters. This project was led by Professors Dilanthi Amaratunga and Richard Haigh of Huddersfield University, who are the joint chief editors of IJDRBE and authors in two of the papers herein. Many of the other authors are Professor Hettiarachchi's students, two of them full professors – one at the

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University of Swansea and the other at the University of Peradeniya. The last paper in the issue is from a group at Moratuwa University that Professor Hettiarachchi was leading at the time of his demise.

The papers are arranged roughly in the sequence of a tsunami and its effects. The first one deals with tsunami propagation to the Bangladeshi coast; and the second with an assessment of the adequacy of the wave buoy and tide gauge system for sensing such propagations, with respect to generating warnings for Sri Lanka. Both these papers draw attention to lesser known tsunamigenic sources, namely, the Arakan segment of the Sunda trench, the Makran fault, Carlsberg Ridge and the Chagos Arcipelago. The third paper, although on storm surges, looks at the way that coastal phenomena could affect coastlines, and physical mitigation measures against the same. It also accounts for climate change, something that every coastal manager would need to consider. This paper also compares hard and soft intervention measures for mitigation. The latter has been recognized as being especially important for tackling low frequency (though high impact) tsunami hazards – which would be the case for the Indian subcontinent and the East African coast – since it may be difficult to justify high investments for hard solutions. The fourth paper is about tsunami impact on building structures, an area in which this writer himself has collaborated on with Professor Hettiarachchi (UNESCO, 2015; Hettiarachchi and Dias, 2013).

The fifth paper focuses on the interface between the upstream and downstream components of an early warning system. The second paper is a good example of upstream issues, which are mostly technological – e.g. the adequacy of buoys and gauges. The sixth and seventh papers are largely concerned with community (or downstream) aspects – the former with the identification and utilization of social networks for warning and the latter with cultural dimensions and community inclusiveness. But the fifth paper deals with matters such as decision making for issuing warnings and ordering evacuation, and holds a central position within the entire early warning process. It also happens to be in the middle of this collection, with four papers before it and four after. The last two papers are more generally on disaster management, the penultimate one still focusing on coastal and tsunami hazards, but the last on disasters in a generic way. In Sri Lanka at least, it was the 2004 Tsunami that highlighted the importance of disaster management, which also included the creation of the DMC.

The papers in this issue also incorporate a range of research methodologies. The first, third and fourth papers are genuinely quantitative in nature, involving numerical analysis. The fourth paper uses pushover finite element analysis; and the other two hydrodynamic modelling – while the third paper uses extreme events, the first attempts a probabilistic approach. The other six papers are qualitative. The second and seventh papers are reflective desk studies; while the other four use either questionnaires or structured interviews and/or focus group discussions, in some cases combined with document analysis. The fifth paper uses thematic analysis; the sixth one the graphical elements of social network analysis; and the last one correlation and regression analysis.

Hence this special issue is rich in methodological variety. This reflects the multi-disciplinary nature of mitigating tsunami impacts. The papers at the start of the list, on tsunami propagation and impact, require quantitative approaches; while those at the end, dealing with community warning and response, are better tackled using qualitative ones. Professor Hettiarachchi's evolving career also displayed this move from the quantitative to the qualitative. The first and third papers that use hydrodynamics are authored by his students in the nineteen eighties and nineties – they are Professors Janaka Wijetunge and

Harshinie Karunarathna referred to earlier. The last paper, based on a questionnaire survey, is authored by his students within the past two decades.

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