ASSESSMENT OF THE CO-BENEFITS OF STRUCTURES IN COASTAL AREAS FOR TSUNAMI MITIGATION AND IMPROVING COMMUNITY RESILIENCE IN SRI LANKA

Ratnayakage Sameera Maduranga Samarasekara, GPSS-GLI, ID 47- 146826

Advisor: Professor Jun Sasaki
Co-Advisor: Project Associate Professor Miguel Esteban
Project Associate Professor Hirotaka Matsuda

ABSTRACT

Tsunami risk along vulnerable coasts is rapidly increasing due to unplanned and rapid coastal development in many countries. Even though a variety of different tsunami countermeasures can be attempted, typically due to budgetary limitations early warning systems are the most common type attempted against far-field tsunamis. However, due to issues related to the poor maintenance of early warning systems, it has been argued that ultimately hard defensive structures can often be far more effective than early warning systems. Some of coastal structures have a variety of other benefits to a given community, aside from coastal development, which are often overlooked in research. . However, to date few researchers have applied multi-functionality of coastal hard infrastructure to reduce the tsunami risk of developing countries, and little research has been done on defining the exact tsunami mitigation benefits and measuring the economic feasibility of such countermeasures.

The engineering resilience of defensive structures needs to be upgraded if they are to withstand a tsunami, though upgraded structures can offer a multitude of co-benefits to a community, and all of these costs and benefits must be financially quantified. Two types of coastal infrastructure along the Southern coast of Sri Lanka were selected as case studies. The

authors used a combination of methodologies used in diverse filed of expertise, such as civil engineering, social science and finance. The proposed upgrades to the structures were developed after an extensive literature review. Drawings of coastal structures, information about construction costs, and socio-economic data were collected through field survey and expert interviews with representatives of government agencies, construction companies, and academia. Community willingness to pay (WTP) and the current level tsunami preparedness in the case study area were measured by conducting structured questionnaires with local residents. Using these results the willingness to pay was modeled using logits regression models. The benefits and drawbacks of an upgraded revetment and a coastal railway embankment were estimated considering housing sector, tourism, fisheries, etc. Both grade crossings and underpasses were considered as crossings of railway embankment. The extent of the inundated area for a variety of tsunamis cases was numerically estimated using ComMIT model (which was developed by pacific Marine Laboratory, National Ocean Atmospheric Association) for different scenarios with and without upgraded structures. Damage to housing was estimated using fragility functions proposed to Sri Lanka. Finally, the drawbacks of upgrading were identified through focus group discussions and field surveys of the area.

Both the upgrades of the coastal revetment and the coastal railway embankment were effective to protect against tsunamis generated by average and higher magnitude earthquakes along the selected fault-line. Revetment had a higher failure probability than that of railway embankment due to tsunami overflow to its proximity to coast. Hence, the tsunami mitigation potential of revetment was lower than that of railway embankment. However structural upgrading was reduced tsunami mitigation co-benefit of revetment and railway embankment. The revetment cannot resist under large tsunamis, but railway embankment can resist under large tsunamis. The expected reduction of damage of revetment is lower than that of railway embankment in lower earthquake magnitudes and vice versa. The tsunami mitigation co-benefit of railway embankment is higher than that of revetment. The results of the questionnaire survey show that the community's willingness to pay to upgrade the railway embankment was higher than that of revetment due to its negative influence on different sectors, such as tourism, fisheries and the environment. Railway embankment with underpasses gives slightly larger benefits compared to that of railway embankment with grade crossings. Therefore railway embankment with underpasses is recommended to this village. The railway embankment with underpass is the most suitable tsunami co-beneficial structure to the Dimbuldooa and Wenamulla villages.

The results clearly show that the co-benefits of tsunami protection coastal infrastructure are highly sensitive to a number of factors, and slight modifications of the proposed structures can significantly alter the economic benefits or cost of the project. Therefore, conducting a quantitative evaluation is essential when proposing coastal infrastructure upgrade for tsunami disaster mitigation, and the methodology proposed can help disaster risk managers to understand the best solution from a disaster risk prevention and economic development point of view.

Key words: Co-benefit, Tsunami, Coastal Structures, Sri Lanka, WTP, Expected Reduction in Damage