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Tsunami prevention and mitigation necessities and options derived from tsunami risk assessment in Indonesia

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Risk and vulnerability assessment is an important component of an effective End-to-End Tsunami Early Warning System and therefore contributes significantly to disaster risk reduction. Risk assessment is a key strategy to implement and design adequate disaster prevention and mitigation measures. The knowledge about expected tsunami hazard impacts, exposed elements, their susceptibility, coping and adaptation mechanisms is a precondition for the development of people-centred warning structures, local specific response and recovery policy planning.

The developed risk assessment and its components reflect the disaster management cycle (disaster time line) and cover the early warning as well as the emergency response phase. Consequently the components hazard assessment, exposure (e.g. how many people/ critical facilities are affected?), susceptibility (e.g. are the people able to receive a tsunami warning?), coping capacity (are the people able to evacuate in time?) and recovery (are the people able to restore their livelihoods?) are addressed and quantified. Thereby the risk assessment encompasses three steps: (i) identifying the nature, location, intensity and probability of potential tsunami threats (hazard assessment); (ii) determining the existence and degree of exposure and susceptibility to those threats; and (iii) identifying the coping capacities and resources available to address or manage these threats.

The paper presents results of the research work, which is conducted in the framework of the GITEWS project and the Joint Indonesian-German Working Group on Risk Modelling and Vulnerability Assessment. The assessment methodology applied follows a people-centred approach to deliver relevant risk and vulnerability information for the purposes of early warning and disaster management. The analyses are considering the entire coastal areas of Sumatra, Java and Bali facing the Sunda trench. Selected results and products like risk maps, guidelines, decision support information and other GIS products will be presented. The focus of the products is on the one hand to provide relevant risk assessment products as decision support to issue a tsunami warning within the early warning stage. On the other hand the maps and GIS products shall provide relevant information to enable local decision makers to act adequately concerning their local risks.

It is shown that effective prevention and mitigation measures can be designed based on risk assessment results and information especially when used pro-active and beforehand a disaster strikes. The conducted hazard assessment provides the probability of an area to be affected by a tsunami threat divided into two ranked impact zones. The two divided impact zones directly relate to tsunami warning levels issued by the Early Warning Center and consequently enable the local decision maker to base their planning (e.g. evacuation) accordingly. Within the tsunami hazard assessment several hundred pre-computed tsunami scenarios are analysed. This is combined with statistical analysis of historical event data. Probabilities of tsunami occurrence considering probabilities of different earthquake magnitudes, occurrences of specific wave heights at coast and spatial inundation probability are computed. Hazard assessment is then combined with a comprehensive vulnerability assessment. Here deficits in e.g. people's ability to receive and understand a tsunami warning and deficits in their ability to respond adequately (evacuate on time) are quantified and are visualized for the respective coastal areas. Hereby socio-economic properties (determining peoples ability to understand a warning and to react) are combined with environmental

conditions (land cover, slope, population density) to calculate the time needed to evacuate (reach a tsunami safe area derived through the hazard assessment). This is implemented using a newly developed GIS cost-distance weighting approach. For example, the amount of people affected in a certain area is dependent on expected tsunami intensity, inundated area, estimated tsunami arrival time and available time for evacuation. Referring to the Aceh 2004 Tsunami, an estimated amount of people affected (dead/injured) of 21000 for Kabubaten Aceh Jaya and 85000 for Kab. Banda Aceh is in a comparable range with reported values of 19661 and 78417 (JICA 2005) respectively. Hence the established methodology provides reliable estimates of people affected and people's ability to reach a safe area.

Based on the spatial explicit detection of e.g. high tsunami risk areas (and the assessed root causes therefore), specific disaster risk reduction and early warning strategies can be designed. For example additional installation of technical warning dissemination device, community based preparedness and awareness programmes (education), structural and non-structural measures (e.g. land use conversion, coastal engineering), effective evacuation, contingency and household recovery aid planning can be employed and/or optimized within high tsunami risk areas as a first priority. In the context of early warning, spatially distributed information like degree of expected hazard impact, exposure of critical facilities (e.g. hospitals, schools), potential people dead/injured depending on available response times, location of safe and shelter areas can be disseminated and used for decision making.

Keywords: Tsunami risk, hazard and vulnerability assessment, early warning, tsunami mitigation and prevention, Indonesia