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Quantifying human response capabilities towards tsunami threats at community level

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Decision makers at the community level need detailed information on tsunami risks in their area. Knowledge on potential hazard impact, exposed elements such as people, critical facilities and lifelines, people's coping capacity and recovery potential are crucial to plan precautionary measures for adaptation and to mitigate potential impacts of tsunamis on society and the environment.

A crucial point within a people-centred tsunami risk assessment is to quantify the human response capabilities towards tsunami threats. Based on this quantification and spatial representation in maps tsunami affected and safe areas, difficult-to-evacuate areas, evacuation target points and evacuation routes can be assigned and used as an important contribution to e.g. community level evacuation planning.

Major component in the quantification of human response capabilities towards tsunami impacts is the factor time. The human response capabilities depend on the estimated time of arrival (ETA) of a tsunami, the time until technical or natural warning signs (ToNW) can be received, the reaction time (RT) of the population (human understanding of a tsunami warning and the decision to take appropriate action), the evacuation time (ET, time people need to reach a safe area) and the actual available response time (RsT = ETA - ToNW – RT). If RsT is larger than ET, people in the respective areas are able to reach a safe area and rescue themselves. Critical areas possess RsT values equal or even smaller ET and hence people whin these areas will be directly affected by a tsunami.

Quantifying the factor time is challenging and an attempt to this is presented here. The ETA can be derived by analyzing pre-computed tsunami scenarios for a respective area. For ToNW we assume that the early warning center is able to fulfil the Indonesian presidential decree to issue a warning within 5 minutes. RT is difficult as here human intrinsic factors as educational level, believe, tsunami knowledge and experience besides others play a role. An attempt to quantify this variable under high uncertainty is also presented. Quantifying ET is based on a GIS modelling using a Cost Weighted Distance approach. Basic principle is to define the best evacuation path from a given point to the next safe area (shelter location). Here the fastest path from that point to the shelter location has to be found. Thereby the impact of land cover, slope, population density, population age and gender distribution are taken into account as literature studies prove these factors as highly important. Knowing the fastest path and the distance to the next safe area together with a spatially distributed pattern of evacuation speed delivers the time needed from each location to a safe area.

By considering now the obtained time value for RsT the coverage area of an evacuation target point (safe area) can be assigned. Incorporating knowledge on people capacity of an evacuation target point the respective coverage area is refined. Hence areas with weak, moderate and good human response capabilities can be detected. This allows calculation of potential amount of people affected (dead or injured) and amount of people dislocated. First results for Kuta (Bali) for a worst case tsunami event deliver people affected of approx. 25 000 when RT = 0 minutes (direct evacuation when receiving a tsunami warning to 120 000 when RT > ETA (no evacuation action until tsunami hits the land). Additionally fastest evacuation routes to the evacuation target points can be assigned. Areas with weak response capabilities can be assigned as priority areas to install e.g. additional evacuation target points or to increase tsunami knowledge and awareness to promote a faster reaction time. Especially in analyzing underlying socio-economic properties causing deficiencies in responding to a tsunami threat can lead to valuable information and direct planning of adaptation measures.

Keywords: Community level, Risk and vulnerability assessment, Early warning, Disaster management, Tsunami, Indonesia