

## 論文の内容の要旨

論文題目 Uncertainties in tsunami risk management: A case study for the southern coasts of Iran

(津波リスクマネジメントにおける不確定性：イラン南部の海岸を例として)

氏 名 パラストー サラ

Tsunami Risk Management is a very complex process which requires knowledge of tsunami sources, wave propagation, subsequent inundation, and geographical condition of the affected area along with socio-economic factors. To date the outcome of various risk management implemented in the world have been less effective than hoped by their planners. It is mostly because of the uncertain nature of hazards and individuals. Based on world's experience from previous disasters there are various sources of uncertainties that may cause failure on the implication of a risk management. These uncertainty indicators are scattered in different fields (e.g., engineering, sociology, and psychology), and a holistic perspective is needed to connect various disciplines and stakeholders in order to develop a universal framework to minimize the uncertainties.

To this purpose, in this study, after introduction in Chapter 1, a systematic literature review from different subjects was conducted in Chapter 2 to evaluate the most important uncertainty indices and factors which caused failure on the previous disaster risk managements. Accordingly, a holistic framework of uncertainty indicators that includes the failure roots and their drivers was developed. It is concluded that the inefficiency of protection infrastructures (i.e., hard measures), awareness and experience, belief system, normalcy bias, too much reliance on warning system and sea walls, demographic characteristics (e.g., aging society and gender discrimination), and trust are the main sources causing the failure. Furthermore, it is indicated that to propose an optimal mitigation measure, mitigation strategies have to acknowledge heterogeneity in each community characteristics. This remains an important gap in regions where risk probability is low and the lack of empirical data are considered a serious shortcoming. Thus, Makran region was selected as the study area that is -- due to the relatively infrequent coastal disasters and its low population -- not as important in literature as other tsunami prone areas. The identified uncertainty indicators for Makran were evaluated in order to promote resilience and minimize the prolonged uncertainty.

Chapter 3 provides a general methodology to how to incorporate each uncertainty. In Chapter 4 an interdisciplinary approach to tsunami hazard assessment in Makran Subduction Zone (MSZ) was illustrated via developing a methodology that incorporates uncertainties stemming from the lack of researcher knowledge and the random nature of the hazards. Former is represented by epistemic uncertainty in literature while the latter is known as aleatory variability. The method combines statistical, geological, historical tsunami assessment and simulation modeling. The threat of tsunami hazard posed to the coast of Iran by the MSZ were assessed and a comprehensive probabilistic tsunami hazard assessment for the entire coast regardless of population density was presented. The sources of epistemic uncertainties were taken into account by employing event tree and ensemble modeling. Aleatory variability was also considered through probability density function. Further, the contribution of small to large magnitudes was considered and multitude of scenarios were created as initial conditions using the developed event trees. Funwave-TVD was employed to propagate these scenarios. The results of this chapter are of vital for various stakeholders for developing and implementing tsunami risk activities such as insurance activity, land use, critical facility design, and guiding risk-aware city planning.

On the other hand, a mere reliance on engineering measures, i.e. hard, could lead to more vulnerability since people at risk neglect self-protection. Furthermore, implication of this type of measures is very costly yet not efficient enough. Hence, the importance of soft measures to minimize vulnerability should be taken into account and more research has to be done along these lines. Accordingly, a cost-benefit disaster management should be applied in developing countries like Iran, where there is a limited budget for developing hard measures in the area. Having said that, one of the challenges nowadays is how to apply the methods of performance of soft measures to disaster preparedness. A very first step is to assess local awareness, knowledge, perception, and willingness to evacuate, which is discussed in Chapter 5. In order to assess the aforementioned factors in Makran region, a mixed methodology was used, using questionnaire survey, interviews and group discussion amongst the local residents, beach users and authorities. Some initial steps were taken including systematic literature review and expert's consultation. The questions were distributed to 6 experts in the field of disaster from Iran by email and their comments were applied on the questionnaire. In addition, the questionnaire was first tested on 10 residents through face to face interviews. The modified questionnaire covers the following topics: knowledge, awareness, experience, trust, evacuation behavior, socio-demographic factors (age, income, gender, occupation, religion, and education), family composition, vulnerable groups and sense of belonging. The survey was conducted by various convenience sampling methods at four locations along the Makran coast in the period September 10-30, 2018. In total, 198 valid questionnaires were collected. 24 households' face to face surveys, three group discussions (about 3 hours and 45 minutes in total) were held in 3 fishery ports. Finally, the quantitative and qualitative analysis were done.

From the analysis of both questioners and interviews, it was learned that the solid faith in destiny and lack of belief in their will and determination are among the personal characteristics of individuals living in the area. The improper belief in destiny and neglecting one's part (ability) to change his or her situation lead to have less plans and almost dismiss the role of mitigation strategies. It should be noted that getting used to any circumstances blindly together with "actions" that come with no action, make any change and acceptance of new thoughts and methods difficult. Also, the results showed that the level of people's trust to government for disaster education and information is very low. This is comparable with the SVS framework (Salient Value Sharing Framework) that was furthermore modified to incorporate this study's findings.

The results, limitations and future direction were discussed in chapter 6. Finally, this research's findings were concluded and summarized in Chapter 7. The results of this study shed light on the uniqueness of the community characteristic in a less known region (Makran), expands upon the empirical evidence of them, provides accurate and reliable tsunami hazard maps, and help policy-makers to understand how to shape a cost-effective and sustainable tsunami risk planning and provide valuable information for diverse stakeholders to underpin tsunami activities, and risk-aware city planning, and mitigation measure design.