Sea level rise and the impact on the material stock in small developing island states a case study in the Republic of Fiji

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1. Introduction

The Intergovernmental Panel on Climate Change's (IPCC) Climate Change Synthesis Report from 2014 calculates the sea level rise (SLR) as a consequence of future greenhouse gas emission scenarios. The predicted SLR ranges from 0.26 m to 0.95 m by 2100 (IPCC, 2014).

According to the United Nations, small developing island states (SDIS) are particularly vulnerable to the effects of the SLR. This is mainly caused by their dense population in coastal areas and a high sensitivity of the nation's economy to slight changes. (UNFCC, 2005).

This research provides governments and research institutions statistics about the lost material stock caused by the SLR and there a foundation for sustainable long-term planning. It can be used as baseline data for processes of development planning, especially resettlements and future resource demands. The data contributes in protecting natural resources and in identifying highly areas where large amounts of material will be lost. Additionally, future demolition and recycling processes can be planned more sufficiently. This model is an important contribution to the mitigation of environmental migration and uncontrolled urban expansion.

This research aims to show the consequences of different SLR predictions on SDIS focusing on the impact on the material stock of buildings and infrastructure as well as the number of people directly exposed to inundation. The main construction material of buildings and streets will be investigated and quantified. The two main islands of the Republic of Fiji were chosen as a case study area. No research about this topic has been published.

2. Methodology

2.1 Digital Sea Level Model

While some areas will be permanently flooded due to the SLR, flooding caused by Mean High Water Springs (MHWS) returning every 14 days and tropical storms will inundate some areas in a frequency which makes them uninhabitable on a long term view. Therefore, permanent and temporary SLR were considered in this study. A Geographic Information System (GIS) was implemented for data processing and visualizations.

2.1.1 Data

The permanent SLR prediction ranging from 0.26 m to 0.95 m was retrieved from the IPCC. The MHWS and the inundation caused by storms were withdrawn from a vulnerability assessment conducted by Gravelle et al in 2008. They used tide gauge measurements of the MHWS and calculated storm return intervals based on historic data. An elevation model provided by the Ministry of Lands and Mineral Resources of the Republic of Fiji was used.

2.2 Material Stock Analysis

Buildings were classified by their location (rural/urban) their usage (residential/business) and their construction type. Subsequently, material intensities in [kg/m^2 floor area] were calculated for every building type focusing on timber, corrugated iron and concrete. The materials stocked in inundated buildings can be calculated using

equation (1) (Tanikawa et al., 2014):

$$MS_i = \sum_j (A_j * MI_{i,j}) \quad (1)$$

MS_i is the total material stock of a specific construction material i, A_j is the area per construction type j and $MI_{i,j}$ is the material intensity per material i per construction type j.

Roads will be classified and given material intensities. The stocked material will be calculated similar to equation (1).

2.2.1 Data

The material intensities for rural buildings were calculated based on various construction surveys and compared to data cited by Tanikawa et al in 2014. Buildings in rural areas only consist of one floor (Caimi, 2016). Material intensities for urban areas yet have to be calculated. The GIS data will be provided by the Ministry of Lands and Mineral Resources of the Republic of Fiji.

3. Results

Results will be calculated by the end of 2018. Table 1 shows the material intensities calculated for rural buildings.

Construction Type based on	Corrugated iron (steel)	Timber	Concrete
Concrete	4.89	1.46	1824.29
Corrugated iron	8.83	60.83	107.56
Timber	4.89	93.60	107.56

Table 1. Material intensities [kg/m2] of rural buildings

A linear relation between the affected points of interest and the SLR is expected. This study does not consider that storms are likely to increase as a consequence of climate change ((IPCC, 2014). The quantity of the lost material will be the highest in urban areas even though rural areas are more vulnerable to the direct effects of the SLR. The results will be used to discuss the current climate change adaptation plans of the Republic of Fiji.

4. Summary

The results will give an adequate overview on the natural resource demand and on the demolitions SDIS will be challenged with in the future. Rural and urban areas were considered, even though urban and industrial areas are more likely to directly adapt to the SLR rather than to relocate buildings and infrastructure (Gravelle et al., 2008). Further research about the consideration between resettlements and adaptation measures can be conducted based on the results of this research.

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