ABSTRACT

Sea Level Rise (SLR) is one of the major manifestations of climate change and may cause a threat to the coastal regions. Whereas some clear evidences of SLR at global scale are well recognized, its trend varies significantly from location to location. In this thesis, initially the role of different meteorological variables on Sea Level Change (SLC) is explored. Later, it is hypothesized that the role of such variables varies from location to location and modelling of local SLC requires a proper identification of specific role of individual factors. After identifying a group of various meteorological variables, a location-specific Combined Index (CI) is developed using Supervised Principal Component Analysis (SPCA). The CI is developed considering the influence of both local-scale and regional-scale variability of meteorological variables. The methodology of SPCA ensures the highest possible association between the SLC and developed CI. Furthermore, using the developed CI, the local SLC is modelled to capture the effect of the changing climate. In this regard, hydroclimatic semi-empirical approaches are developed using local and regional-scale variability of meteorological variables. The developed approaches are found to be potential for the estimation of local SLC at different coastal locations. The validated hydroclimatic models are used for future projection of SLC at those coastal locations till 2100 for different climate change scenarios, i.e., different Representative Concentration Pathways (RCPs). Recognizing the importance of regional SLR, the developed methodology of hydroclimatic semi-empirical modelling approach is further utilised to study the spatial distribution of past and future regional SLR. The association between the satellite altimeter measurements of grid wise Sea Level Anomaly (SLA) and meteorological variables is investigated by developing grid-point specific CI. A hydroclimatic reconstruction model is developed by combining the coarse gridded 'climate-induced' sea level with the tide-gauge observations to reconstruct the spatially varying regional sea level. Furthermore, the regional sea level is projected till the year 2100 for different RCP scenarios using the developed semi-empirical models. Next, the thesis focuses on coastal inundation, which is one of the direct implications of the rising sea level along the coastlines. On-shore coastal inundation during a tropical cyclone can have detrimental effects on the coastal regions and its population. With the future SLR under changing climate, the coastal inundation will increase during a tropical cyclone in future.

This study attempts to develop an approach to assess the future coastal inundation by considering the concurrent effects of future SLR and tropical cyclones. The association between the surges induced by the tropical cyclones and the enhanced sea level over which those surges occur forms the basis of proposed methodology. As a case, the proposed methodology is applied to the low-lying head Bay coastline in the Bay of Bengal considering the forcing from the tropical cyclone Aila and rising local sea level by the end of year 2025, 2050, 2075 and 2100. The coastal inundation and storm tide are projected utilizing the state-of-art ADvanced CIRculation (ADCIRC) hydrodynamic model. The coastal inundation is projected for different RCP scenarios till the end of year 2100. Finally, the risk associated with the future SLR and coastal inundation is quantified to classify the coastal region into different vulnerability classes. A Combined Vulnerability Index (CVI), representing the combined risk of future SLR and coastal inundation along with other non-climatic variables, is proposed and projected in future for the year 2100 following different RCP scenarios. As a case, the developed methodology is applied for the projection of vulnerability along the head Bay region of Bay of Bengal. The combination of the local sea level as a direct consequence of climate change and the forcing from a tropical cyclone Aila (actually occurred in the year 2009) is used to develop the projected vulnerability map along the head Bay region. The estimates of the projected sea level and information on the coastal inundation, as the outcomes of the thesis, are expected to be useful for various coastal development activities, such as coastal flood disaster warning and designing of coastal protective embankments. The developed approaches for local and regional sea level modelling, coastal inundation and coastal vulnerability are general in nature and can be applied to other coastal regions across the world.

Keywords: Sea Level Rise (SLR), Semi-empirical hydroclimatic model, Local and regional sea level, Coastal inundation and vulnerability, Climate change.