QUANTIFYING PHYSICAL STRESSORS CONTROLLING MANGROVE SEEDLING DYNAMICS

A COMBINED OBSERVATIONAL AND NUMERICAL ANALYSIS

Mangrove forests thrive at the interface between land and sea and are exposed to a wide range of physical conditions and forces, such as waves, currents, sediment supply, bed level changes, etc. Vegetation in mangrove forests has an important role in attenuating hydrodynamic forces and contributes to the reduction of coastal erosion. Mangroves are also an important ecological habitat and they provide food and wood and sequester carbon. Yet, a mechanistic understanding of feedbacks between hydro- and morphodynamic stresses and mangrove seedling dynamics is lacking. By combining field measurements and numerical modelling, these processes can be analysed to obtain a better understanding how these dynamics affect the long-term development and resilience of mangrove forests and their stability.

The driving factors of bed level changes and seedling dynamics were determined. Waves, tides, flow velocities, seedlings and bed level changes have been monitored in the Sungei Buloh Wetland Reserve mangroves in Singapore from December 2019 until March 2020. Field observations showed that the water depth and wave heights are the main driving factors of the bed level changes. During low water, waves were the main cause of bed level changes. The number of seedlings was found to decrease consistently during the fieldwork period. The inland plot showed greater seedling diameters and heights compared to the forest fringe plot. Via a multiple linear regression (MLR), the main cause of the decrease in the number of seedlings were found to be bed level changes. Based on the MLR, an empirical growth formula is composed in order to simulate the change of the number of seedlings as a function of the bed level changes.

A Delft-FM model was set-up, with a newly developed mangrove seedling growth module. The model was calibrated based on the observed dynamics. Via the vegetation module, the number of seedlings is modelled for every week, using the obtained growth formula. Additionally, wave scenarios were set-up to analyse the effect of the increase of wave heights on bed level changes and seedling establishment. The model successfully represented the observed seedling dynamics, but did not show any differences as a consequences of increased wave heights. At increased wave heights erosion was found to happen, which was not occurring at a constant wave height of 0.02 m representing the present conditions.

This thesis combines fieldwork and numerical modelling to get a better understanding of seedling establishment and the effect of increased wave heights on seedling establishment. Furthermore, the new model is one of the first of its types for mangrove systems. The model, and field observations, shows that waves have the greatest impact on bed level changes, which subsequently have the greatest impact on seedling establishment. Changes in wave heights were found to cause erosion, but did not affect seedling establishment. This research forms the starting point for the numerical modelling of mangrove seedling dynamics using empirical parameterizations.

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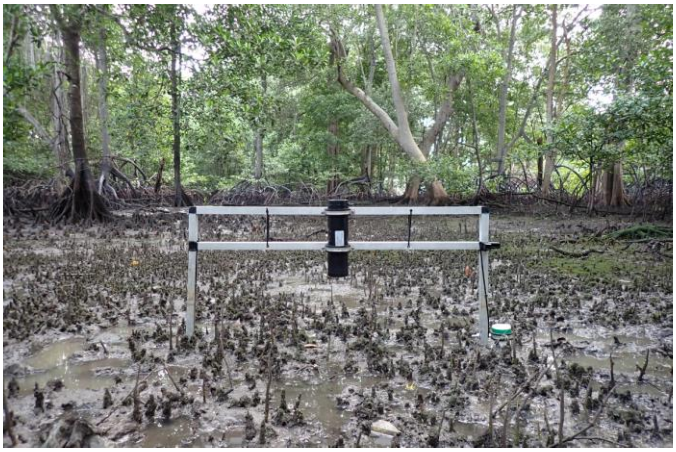

Figure 1: Monitoring station with bed level dynamics and water level instruments in Sungei Buloh Wetland Reserve.

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