Assessment of the impact of sea level rise on tidal freshwater wetlands – a case study

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Introduction

Wetlands in river deltas provide a great deal of natural resources. They are home to large numbers of plant and animal species, and supply local communities with many goods and services. They sequester carbon, provide water for irrigation and protect the shoreline from storm surges. At the same time, wetlands are affected by different forms of human activities: as most of them are located in fertile river deltas, they have to compete with other forms of land use like agriculture and settlements. This has resulted in the disappearance of about half of the original wetland area (Pendleton *et al.*, 2012).

Apart from direct conversion of wetlands, there are other factors that threaten their continued existence. Sea level rise (SLR) in combination with factors such as decreased river sediment loads, local subsidence and the construction of levees is a major contributor to salt and brackish wetland loss at sites around the world, for example in the Mississippi Delta (e.g. Bloom and Roberts, 2012) and the Ebro Delta (Ibáñez *et al.*, 2010).

More research is still needed to determine the effects of SLR, especially in the case of freshwater wetlands. Are they also at risk of drowning and if so, is there anything that can be done to prevent it? These are some of main questions that have sparked Utrecht University in September 2013 to start an STW-funded research project together with local stakeholders on the case of the Brabantse Biesbosch tidal freshwater wetland in the Netherlands. This wetland is suspected by the main stakeholders (State Forestry Service SBB and National Water Authority RWS) to be at risk of drowning.

The Brabantse Biesbosch is the name of a former inland delta in the Netherlands. It is located in-between the rivers Rhine and Meuse. It consists of a micro-tidal freshwater wetland as well as a number of polder systems used for agriculture. The wetland is part of “De Biesbosch” national park. A number of polders are currently being de-poldered, mainly as part of the Room for the Rivers project. The primary purpose of these activities is to increase the conveyance capacity of the river Rhine during extreme discharge situations and thereby lowering peak water levels upstream. A secondary purpose of the activities is to increase the space available for the wetland.

The PhD research project presented in this abstract focuses on the morphodynamic aspects of the effects of SLR for a number of future maintenance strategies and scenarios. It aims to quantify the water and sediment budgets of the area as well as the factors and mechanisms that affect these budgets.

Methods

There are many factors that determine whether the elevation of tidal wetlands is able to keep pace with SLR or not. These factors affect the primary components of the balance between SLR and net change in surface elevation. The net change in surface elevation is defined as the difference between deposition of sediments and autogenic primary production on the one hand and erosion and subsidence on the other hand (e.g. Reed and Cahoon, 1993).

When the different components of the balance are sufficiently quantified for different future scenarios, it becomes possible to evaluate the chance that the Brabantse Biesbosch will actually drown at some point in time.

The hydrodynamic and morphologic model Delft3D, developed by Deltares, will be used as a main method for the quantification of the different balance components. For two distinct pilot areas within the Biesbosch, detailed hydromorphologic schematizations will be constructed and calibrated based on the field data collected in a parallel PhD project. These schematizations will reflect both the current situation as well as possible future situations for a limited number of management strategies. Next, a number of future scenarios will be evaluated that consist of different combinations of climate-related variables (SLR, changes in discharges and sediment concentrations of Rhine and Meuse). The effects of local subsidence due to compaction will be included in the scenario simulations, possibly following the work of Van Asselen (2010). The effect of vegetation growth on wall friction, wetted area and autogenic primary production will be included as well, following on-going research (e.g. Van Oorschot, 2014).

When we consider SLR and local subsidence as a fact, the deposition of sediments and autogenic primary production remain as the two primary components that can be influenced in order to mitigate the effects of SLR. To this end, an optimization study will be carried out to determine the most effective way to increase the functioning of the pilot areas as 'sediment traps', using existing guidelines to enhance natural functions as much as possible.

After the methods have been properly validated on the scale of the pilot areas, they will also be applied to the Brabantse Biesbosch as a whole.

The research so far has focused on the "Kleine Noordwaard" pilot area. This is a former polder system that has been converted into a wetland by excavating a semi-natural channel network of ditches and creating openings in the surrounding embankments. During peak floods, this pilot area serves as a flood water storage and conveyance area. Daily tidal range is in the order of around 30-40cm. Average sediment concentrations in the system are in the range of 10-20 mg/L. The area was opened in 2008, allowing renewed flooding and sedimentation to take place. By 2014, most of the area is permanently inundated and vegetation is sparse.

Data sources available for model construction include AHN1 & AHN2 DEM, LIDAR elevations, yearly surveyed bathymetry (dual-beam echosounder) of the channel network, continuous water level measurements (diver), flow velocity measurements (H-ADCP) and sediment concentrations (STM) at a number of fixed gauging stations in and around the area. A Delft3D FLOW/SED/MOR model was constructed for the current situation. Calibration and validation of the model is currently underway.

Preliminary results

Since the research project only started recently, final results are not yet available. However, preliminary analysis of field experiments and model simulations has already provided some interesting results.

The sediment concentrations of the water entering the pilot area at the upstream boundary are low compared to other wetlands. This is reflected in the thickness of the sedimentation layer in the "Kleine Noordwaard" pilot area, which is estimated to be very thin (1-3cm in most places since the opening of the system in 2008) and appears to be very mobile due to the unconsolidated nature of the top soil.

The sedimentation pattern throughout the area is very non-uniform, and seems to be influenced by other factors than the distance from the inlet and the main channels (and subsequent gradients in flow velocities). We theorize that the process of (re)suspension due to wind may play an important role. It seems that the system depends on medium-high river discharge (with corresponding high sediment concentration) events for input of sediment and strong wind events for (re)distribution of sediment throughout the area.

It seems probable that different combinations of Rhine/Meuse river discharges, wind conditions and maintenance settings of the Haringvliet sluice barrier (which influences downstream boundary levels through backwater) will lead to very different net sedimentation rates in the pilot area. Some combinations will probably lead to net erosion.

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