ESTABLISHING A SEDIMENT BUDGET IN THE 'KLEINE NOORDWAARD' AREA OF THE BIESBOSCH INLAND DELTA

E.C. VAN DER DEIJL[(1)], E. VERSCHELLING[(2)], M. VAN DER PERK[(1)], H. MIDDELKOOP[(1)]
[(1)] *Utrecht University, Department of Physical Geography Utrecht, The Netherlands,*
E.C.vanderDeijl@uu.nl
[(2)] *Utrecht University, Department of Physical Geography, Utrecht, The Netherlands;*
Deltares, Delft, The Netherlands,

1. INTRODUCTION

Many deltas in the world cope with drowning and loss of delta land by sediment starvation and accelerated soil subsidence, because of embankment of channels and drainage of land. The urgency of the problem is enhanced by sea level rise (Syvitski et al., 2009). Loss of delta land is a problem, since most deltas are densely populated and seen as valuable because of their ideal location for harbours, agriculture, aquaculture, or tourism (Kirwan and Megonial, 2013). Moreover, deltas encompass vast wetland areas of great ecological value. Delta restoration by re-introduction of natural processes and sedimentation is considered as a mitigation measure, but it is difficult to implement, since natural processes are often in conflict with current activities in the delta. Furthermore, several deltas are subject to sediment starvation, because of a decrease in sediment delivery from upstream. For these delta's it is uncertain whether delta restoration will be effective.

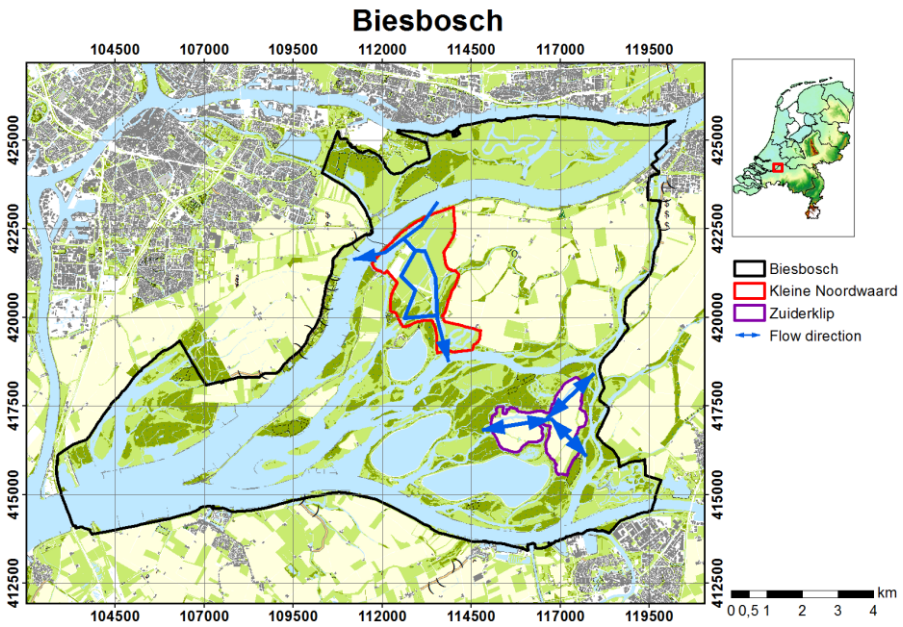

Figure 1. Study areas Kleine Noordwaard (1) and Zuiderklip (2) with their main flow pathways.

Effective delta restoration requires a thorough understanding of the mechanisms of delta aggradation and their controls. In the Biesbosch (Figure 1), an inland delta in the south-west of the Netherlands, water and sediment is reintroduced in former polder areas as part of a large project for improving the discharge capacity of the lower Rhine branches ('Room for the River' (RfR)). This makes the Biesbosch the ideal trial area to study the mechanisms and controls of delta aggradation.

This study aims to examine the sediment budget of the 'Kleine Noordwaard', one of the subareas of the Biesbosch inland delta where water and sediment flows recently have been reintroduced.

2. METHODS

Sediment budgets are established for two Room for the River (RfR) areas (Figure 1) that differ in river and tidal discharges and vegetation management (Grontmij, 2002 and Weijer, 2009).

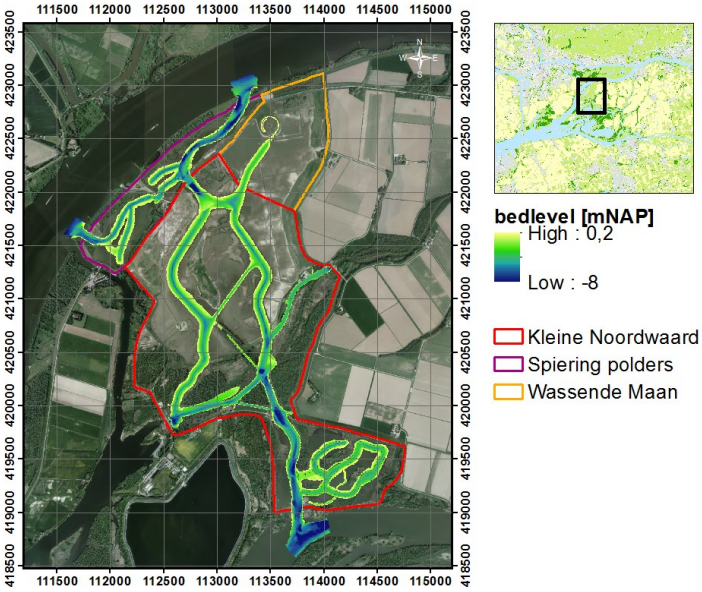

Figure 2. The bathymetry and subdivision of studyarea 1, Kleine Noordwaard.

The current study focuses on area1, 'Kleine Noordwaard' (Figure 2):

1. Existing data sets complemented by field surveys are used to calculate the sediment budget for the 'Kleine Noordwaard':
   - Digital elevation model (Actueel Hoogtebestand Nederland)
   - Multibeam echosounder data (bathymetry of main channels)
   - ADCP flow measurements
   - Suspended sediment concentration measurements (SDM, sample filtering)
2. The location of cutbanks is determined with a DGPS. Likewise are the heights of these cut banks and the slope between these banks and the channel measured.
3. Shallow cores are used to indicate the different sediment types, at the surface of the islands, flats and channels.

3. PRELIMINARY RESULTS

Consecutive measurements of channel bathymetry show a positive sediment budget in the channels. Figure 3 shows the difference in height between March 2009 and March 2013. Erosion took mainly place at the entrance and exit of the Kleine Noordwaard system. In the middle part of the system, sedimentation occured. During the period between 2009 and 2012 the total sediment budget of the channels in Kleine Noordwaard was 59.5 10^3 m^3. Deposition in the channels was on average 19.8 10^3 m^3/year.

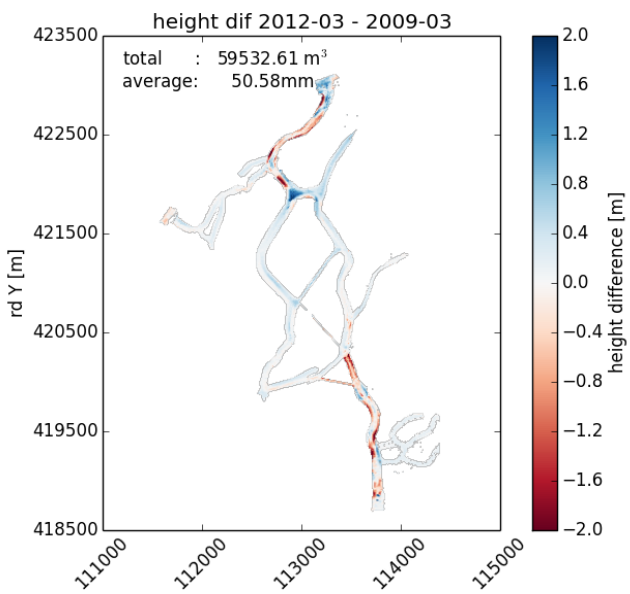

Figure 3. Difference in bottom elevation of the channels between March 2009 and March 2012.

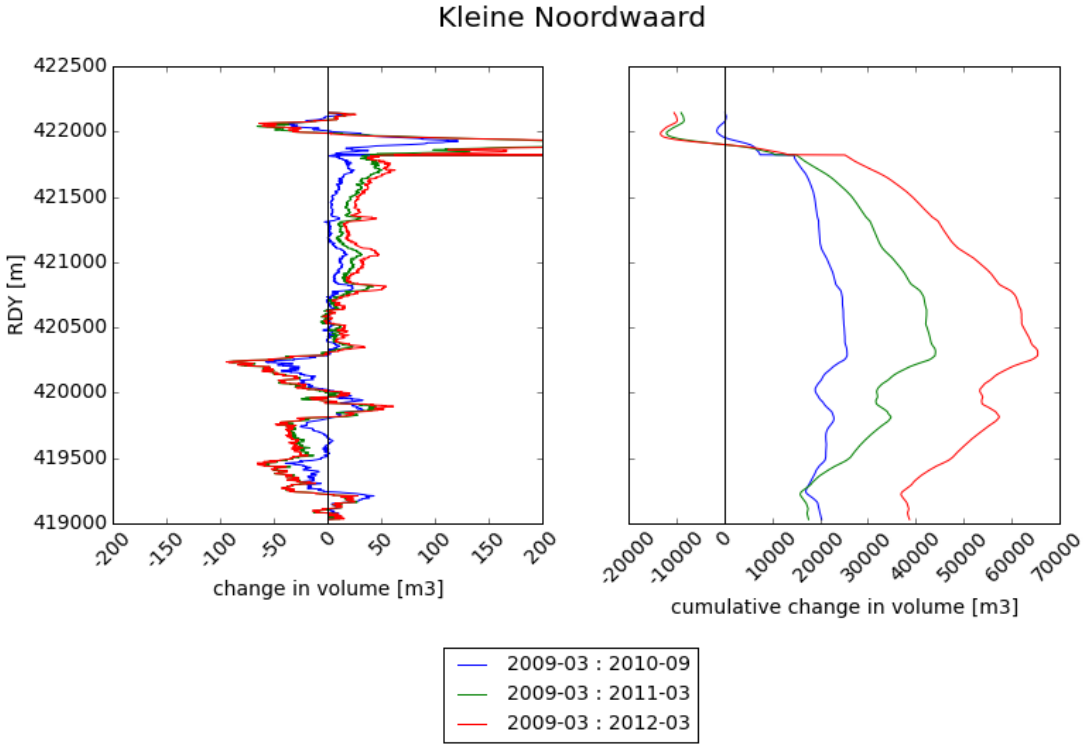

Figure 4. Channel bed volumes within the Kleine Noordwaard, along a N-S transect starting from the Spiering polders (purple outlined area in Figure 2) at y –coordinate 422366 to south. The budget of the Wassende Maan (orange outlined area in Figure 2) is added at y-coordinate 421821m. Left: difference in channel bed volume is for all successive years; Right: cumulative change in channel bed volume.

Figure 4 shows the cumulative change in channel bed volume from north to south in the 'Kleine Noordwaard' for the successive monitoring campaigns. For all consecutive years a decrease in channel bed volume was observed at the entrance and exit of the system. Most erosion in Spiering polders takes place between September 2010 and March 2011, triggered by the peak river discharge of 8315m^3/s at Lobith, between 8-19 Januari, 2011 (Rijkswaterstaat,2014). Around y-coordinate 421940, the cumulative change in bed volume turns positive, suggesting that the vast majority of the sediment eroded in the Spiering polders and near the entrance of the Kleine Noordwaard was deposited within 420m from the entrance. Furthermore, a large increase in channel bed volume was observed in the central part of the area. The sediment deposited in this part of the area originated likely from upstream sources (i.e. the Nieuwe Merwede River, a distributary of the Rhine River). The pattern of erosion and deposition across the polder was persistent over the years.

4. FURTHER RESEARCH

Field observations have shown that channel bed erosion and input from upstream sources are not the only sources of sediment, because the island and old dikes in the system also show erosion. Therefore, further research will focus on these sediment sources by quantifying the erosion rates and cut-bank retreats using available digital elevation models and successive GPS surveys. Furthermore, geochemical fingerprinting of sediment samples from the channel bed and tidal flats will be used to discriminate between the internal and external sources of sediment. The sampling will be spatially extended to other former polders within the Biesbosch, and the main channels feeding and draining the polders to obtain a comprehensive understanding of the key mechanisms and controls of water flow and sediment dynamics within this area.

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