Establishing a sediment budget in the ‘Room for the River’ area ‘Kleine Noordwaard’

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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.

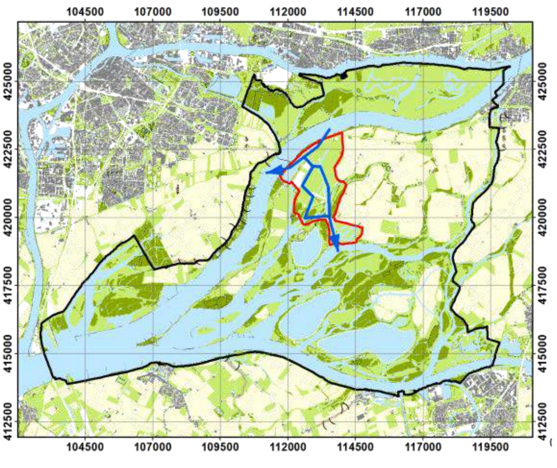

Fig.1. The Biesbosch (black) and the study area Kleine Noordwaard (red) with its main flow pathways.

Effective delta restoration requires a thorough understanding of the mechanisms of delta aggradation and their controls. In the Biesbosch (Fig.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.

Aim and Method

This study aims to quantify the amounts and spatial patterns of aggradation in the former polder area ‘Kleine Noordwaard’ (Fig.2), in which water and sediment have been reintroduced since 2008. The following data were used:

4. Channel bathymetry using Multibeam echo sounder data
5. Thickness of mud or sand deposited on the compact, former polder soil surface, sampled by a transparent corer tube.
6. Location and height of cut banks at the island measured using a dGPS device and ruler.
7. Digital elevation model (Actueel Hoogtebestand Nederland)

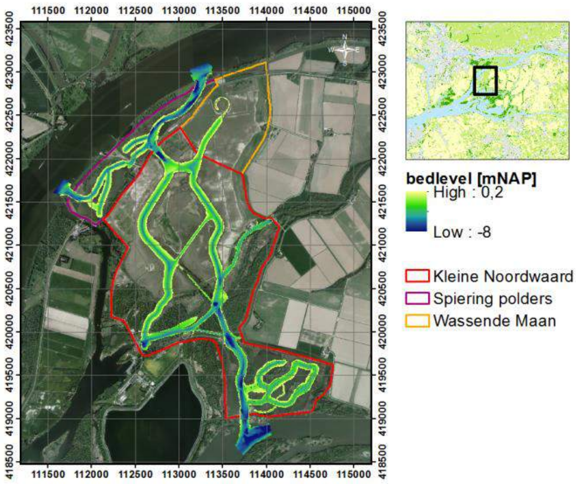

Fig.2. The bathymetry and subdivision of study area 1, Kleine Noordwaard.

Results

Channels

Consecutive measurements of channel bathymetry show a positive sediment budget in the channels. Fig.3 shows the difference in height between March 2009 and March 2012. During this period 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.

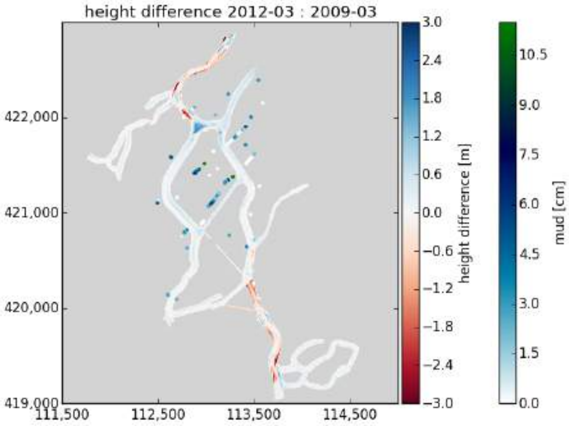

Fig.3. Difference in bed elevation between March 2009 and March 2012. Dots represent mud accumulation on the intertidal flats between May 2008 and October 2014.

Fig.4 shows the cumulative change in channel bed volume from north to south in the 'Kleine Noordwaard' for the successive monitoring campaigns. 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 January, 2011 (Rijkswaterstaat,2014).

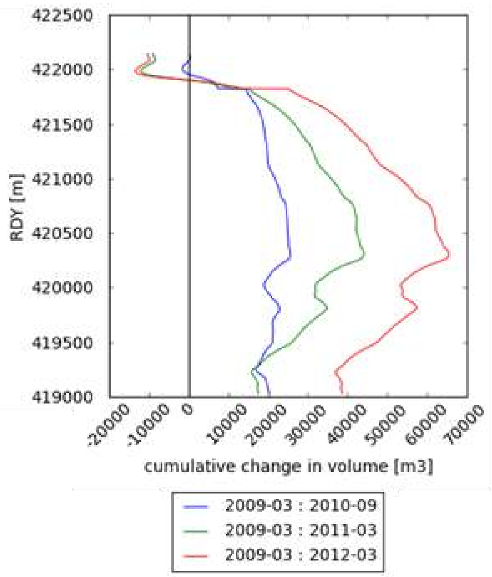

Fig.4. Cumulative channel bed volumes within the Kleine Noordwaard, along a N-S transect starting from the Spiering polders (purple in Fig.2) at y –coordinate 422366 to south. The budget of the Wassende Maan (orange in Fig.2) is added at y-coordinate 421821m.

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 pattern of erosion and deposition across the polder was persistent over the years.

Intertidal flats

Approximately 21 mm of mud accumulated in the intertidal area between May 2008 and October 2014 (Fig.3). This corresponds to an accumulation rate of 3.2 mm/yr.

Sand is mainly deposited near the entrance of the system and close to the channels, while deposition of mud varies locally.

Cut banks

Comparison of the current cut bank position and height with the digital elevation model of the area indicates that only 31 m^3 sediment eroded from the island between 2009 and 2014, which is not significant compared to the sediment deposition and erosion volumes in the channels and on the intertidal flats.

Conclusion

The total sediment budget of the 'Kleine Noordwaard' area amounted to 27.4 x 10^3 m^3/yr which corresponds to a net area-average sedimentation rate of 4.7 mm/yr during the first 5 years after depoldering of the area. The channels received 19,1 x 10^3 m^3/yr sediment and the intertidal area 8.3 x10^3 m^3/yr. Remobilization of sediment by erosion of cut banks occurred at a negligible rate of about -6 m^3/yr.

Acknowledgements

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