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Astrid Blom, Laura M. Stancanelli, Jelle A. Dercksen, Clàudia Ylla Arbós, M. Kifayath Chowdhury, Shelby M. Ahrendt, Carolina Piccoli, Ralph M.J. Schielen, Kees Sloff & Jill H. Slinger (eds.)

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Channel Bed Erosion Characteristics in the Upper Dutch Rhine Bifurcation Region

Mohammad Kifayath Chowdhury[a,*], Astrid Blom[a], Clàudia Ylla Arbós[a], Merel C. Verbeek[b], Max H.I. Schropp[b], Ralph M.J. Schielen[a,b]

[a] *Faculty of Civil Engineering and Geosciences, Delft University of Technology, The Netherlands*
[b] *DG Rijkswaterstaat, Ministry of Infrastructure and Water Management, Utrecht, The Netherlands*

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Introduction

Flow and sediment partitioning in the Upper Dutch Rhine bifurcation region largely influences flood risk management, navigation, and freshwater supply. Generally, water discharge partitioning at a bifurcation has a dynamic relationship with local morphological development at the bifurcation region (Kleinhans et al., 2013). Therefore, knowledge about morphological development at a bifurcation region is important. This abstract focuses on the local channel bed erosion characteristics at the Upper Dutch Rhine bifurcation area. The knowledge can be used to signal trends in the partitioning of water and sediment and prepare mitigation measures to maintain a safe situation.

Method

The bed level of the Bovenrijn and its bifurcates were measured using single beam echo sounders roughly until 2000 and multi-beam echo sounders since then. We used a 5 km long moving average window, and the window does not cross the bifurcations. This allows us to assess the discontinuities in bed level at the bifurcations. Details of data treatment (including harmonizing single beam and multi-beam measurements) are available at Ylla Arbós et al. (2021).

Results

Channel bed of roughly the first 10 km of the Waal and Pannerden Channel bifurcates downstream of the Pannerdense Kop has eroded 2 to 3 times more than the surrounding area over the last century (Fig. 1a and b). The Bovenrijn has also eroded about 1.5 m close to the Pannerdense Kop since 1934.

We assessed the difference in bed level compared to the bed level averaged over the period 1958-1962. There seems to be an erosion wave along the Waal starting at the Bovenrijn and the upstream end of the Waal (Fig. 2a). The erosion appears to intensify around 1990,

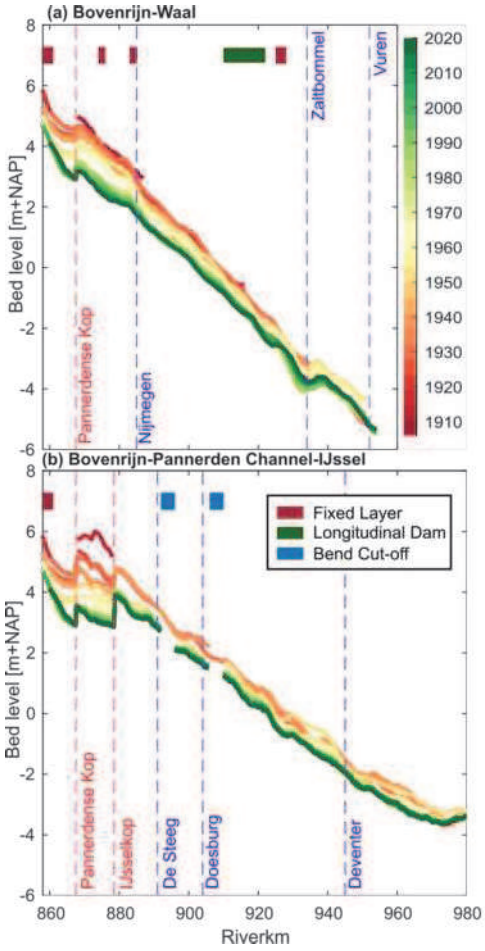

Figure 1: Longitudinal profile of bed level along (a) Bovenrijn-Waal and (b) Bovenrijn-Pannerden Channel-IJssel.

likely due to the intense dredging activity during that period (Visser, 2000) and gradually migrated downstream up to Nijmegen. For the Pannerden Channel, the erosion intensified roughly in the 1980s and travelled downstream up to IJsselkop (Fig. 2b). Another erosion wave originates at the IJsselkop along the IJssel river, spanning up to De Steeg.

It is important to note that the erosion rate in the bifurcation region has reduced over the last two decades. The erosion rate in the upstream end of the Waal has lowered to approximately 1.5 cm/yr in the last two decades (Fig. 3a). In the same period, the Bovenrijn has aggraded

*Corresponding author
Email address: m.k.chowdhury@tudelft.nl (Mohammad Kifayath Chowdhury)

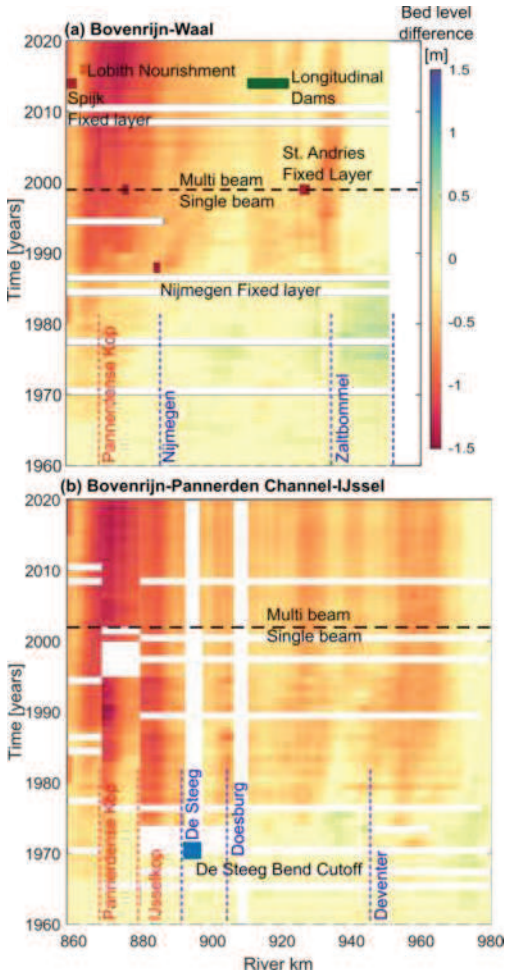

Figure 2: Space time plot of bed difference along (a) Bovenrijn-Waal and (b) Bovenrijn-Pannerden Channel-IJssel relative to the bed level averaged over the period 1958-1962.

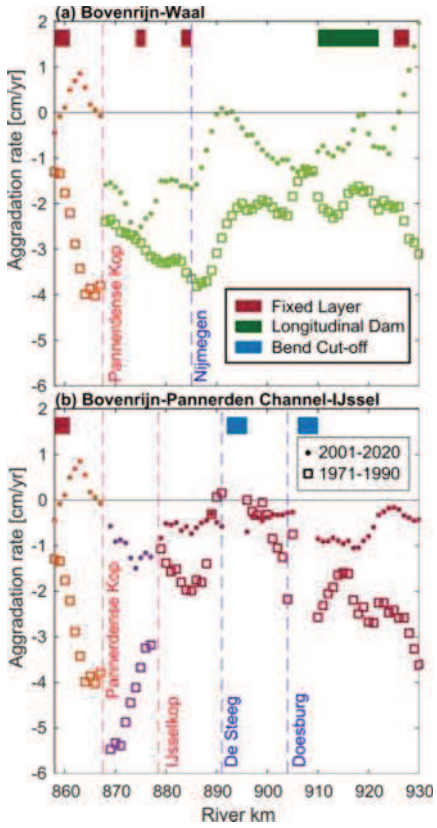

Figure 3: Comparison of bed aggradation rates between 1971-1990 (squares) and 2001-2020 (dots) along (a) Bovenrijn-Waal and (b) Bovenrijn-Pannerden Channel-IJssel

up to 1 cm/yr at some parts close to the Pannerdense Kop, compared to about 4 cm/yr erosion in the period between 1971-1990. Particularly for the upstream end of the Pannerden Channel, the erosion rate has dropped from 5.5 cm/yr in 1971-1990 to roughly 0.5 cm/yr in the last two decades (Fig. 3b).

The current situation has led to a difference in erosion rates between the upstream part of the Waal and Pannerden Channel. The erosion rate difference causes the depth of the Waal to increase faster relative to the Pannerden Channel, hence attracting more water. In addition, the difference in erosion rate promotes the development of inlet step at the bifurcation that influences sediment partitioning of bed material load (Bolla Pittaluga et al., 2003).

The reduction in erosion rate in the bifurcation region is associated with a gradual coarsening of the bed surface texture previously observed in this region (Ylla Arbós et al., 2021). The coarsening is likely associated with the downstream migrating gravel-sand transition and sediment nourishments in the Niederrhein (Ylla Arbós et al., 2021).

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