The effect of longitudinal training dams and groyne lowering on river dunes

Mathijs A. van Oostrum[a*], Lieke R. Lokin[a,b], Jord J. Warmink[a], Suzanne J.M.H. Hulscher[a]
[a]*University of Twente, Department of Water Engineering and Management*
[b]*HKV Consultants*

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Introduction

Rivers have several important functions in society, such as transport, recreation, and ecological functions. River dunes are present on the riverbed of many alluvial rivers and have an effect on the roughness of the riverbed, hereby affecting water levels. After the (almost) floods in 1993 and 1995, the Room for the River program was initiated. The Room for the River program aimed to improve flood conveyance by giving rivers in the Netherlands more space. Room for the River measures change the way discharge is distributed over the river profile; the main channel, groin fields, flood plains and secondary channels. Therefore, these measures can have an effect on the characteristics of river dunes. The aim of this research is to assess the effects of river interventions on the characteristics of river dunes.

Method

In the Waal River the bed level of the main channel is measured on average once per two weeks with multi-beam echo sounding (MBES). Bed level measurements from 2005 to 2020 are used in this study. Three study areas were chosen in the river Waal, a section in the Middle Waal (rkm 894-911), Lower Waal (rkm 934-944), and a section with longitudinal training dams (LTD) (rkm 914-921.5). These three sections allow for the analysis of the effect of groin lowering and LTD construction.

From each measurement river dunes have been identified using the method developed by Lokin et al. (in prep.). The method identifies river dunes using a wavelet analysis with Morlet wavelet function, similar to Gutierrez et al. (2018). Dune crests and troughs are identified from a smoothened riverbed profile, such that superimposed bedforms are ignored. The method from Lokin et al. (in prep.) can also determine dune celerity. Dune celerity is determined using spatial cross-correlation between two consecutive measurements. The displacement is determined from the largest spatial cross-correlation between the measurements. Dividing the displacement by the time between two measurements provides the dune celerity.

To identify the differences in dune characteristics before and after the construction of an intervention, the average dune characteristics in the study areas per measurement were plotted against the five-daily average discharge at Tiel. Isotonic regression was used to aid the analysis (De Leeuw et al., 2009).

Results

The results are shown in the figures in this abstract. Fig. 1 shows the average dune height (Fig. 1a) and length (Fig. 1b) in the LTD study area plotted against the five-daily average discharge for the centre of the main channel.

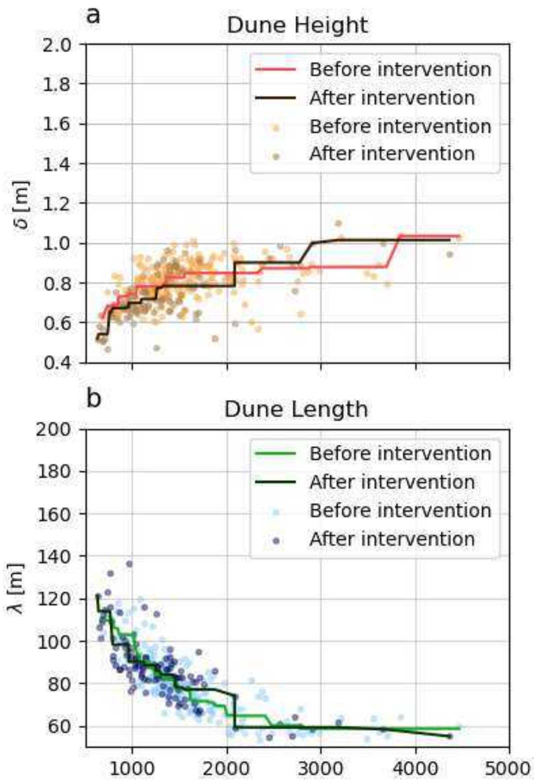

Figure 1. Average dune height (a) and dune length (b) in the LTD study area plotted against the five-day average discharge.

* Corresponding author
Email address: mathijsvanoostrum@gmail.com (Mathijs van Oostrum)

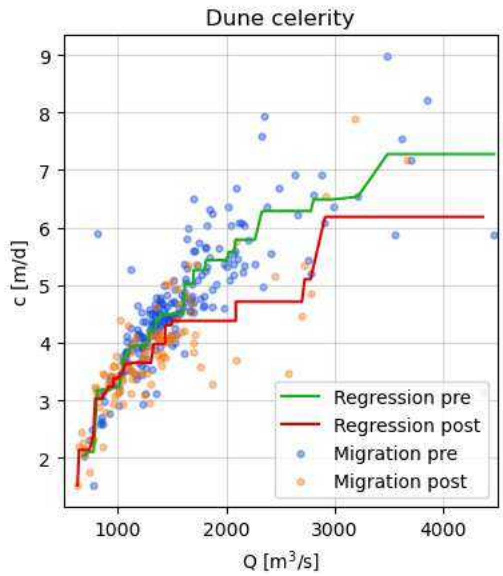

Figure 2. Average dune celerity in the LTD study area plotted against the five-day average discharge.

Fig. 2 shows the average dune celerity in the centre of the main channel for all three study areas plotted against the five-day average discharge.

Longitudinal training dams

Fig.1 shows that LTD construction leads to slightly smaller average dune heights for discharges below 2000 m³/s and larger average dune heights for discharges between 2100 m³/s and 3600 m³/s. The figure does not show a clear difference in dune lengths, the differences shown by the regression analysis around a discharge of 2000 m³/s are likely caused by limited data around those discharges after LTD construction. Fig. 2 shows that LTD construction lead to reduced dune celerity for discharges larger than 1100 m³/s.

Groin lowering

Groin lowering in the Middle Waal was observed to lead to larger average dune heights for discharges larger than 1900 m³/s at the centre of the main channel. The average dune celerity decreased after groin lowering for discharges larger than 1300 ³/s. In the Lower Waal groin lowering leads to slightly different results. Average dune lengths decreased after groin lowering at the centre of the main channel for discharges larger than 1200 m³/s. Dune celerity did not show a clear change after groin lowering.

Conclusion

The results show that the characteristics of river dunes have changed after groin lowering and LTD construction. LTD construction leads to slightly milder dunes for discharges below bankfull and steeper dunes for discharges larger than bankfull. Thus, for discharges below bankfull river dunes further contribute to lower water levels by LTD construction. However, for discharges above bankfull, river dunes are steeper and increase the roughness of the riverbed. Therefore, for discharges above bankfull river dunes could reduce the effectiveness of LTD construction to lower the water levels.

Groin lowering leads to steeper dunes for discharges larger than 1900 m³/s and 1200 m³/s in the Middle Waal and Lower Waal, respectively. Thus, river dunes could increase the roughness of the riverbed for larger discharges, possibly reducing the effectiveness of groin lowering to lower the water levels. The research also indicate river dunes can respond differently to groin lowering at different locations, potentially caused by differences in sediment grain size.

Reduced dune celerity caused by groin lowering in the Middle Waal and longitudinal training dam construction indicates reduced amounts of sediment transport. This is beneficial for the river Waal, as it mitigates the long term observed seen in the river Waal.

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