

# Rivers2Morrow Project: sediment dynamics of the Benedenrivieren of the Rhine

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## 1. Project summary

The lower Rhine branches or Benedenrivieren are a complex network of river channels which make up the Rhine-Meuse delta. These tidally influenced channels provide access to multiple ports and harbours such as Rotterdam. The decline in sediment availability over the past 50 years has caused the erosion of many of the branches, whilst dredging activity further removes sediment from the system. As sea levels rise and discharge varies due to climate change, understanding how the Rhine-Meuse delta will respond and how the sediment availability and delivery will vary is a key issue. To predict how the sediment dynamics and availability will change, first a complete sediment budget for the recent past and present is needed (figure 1).

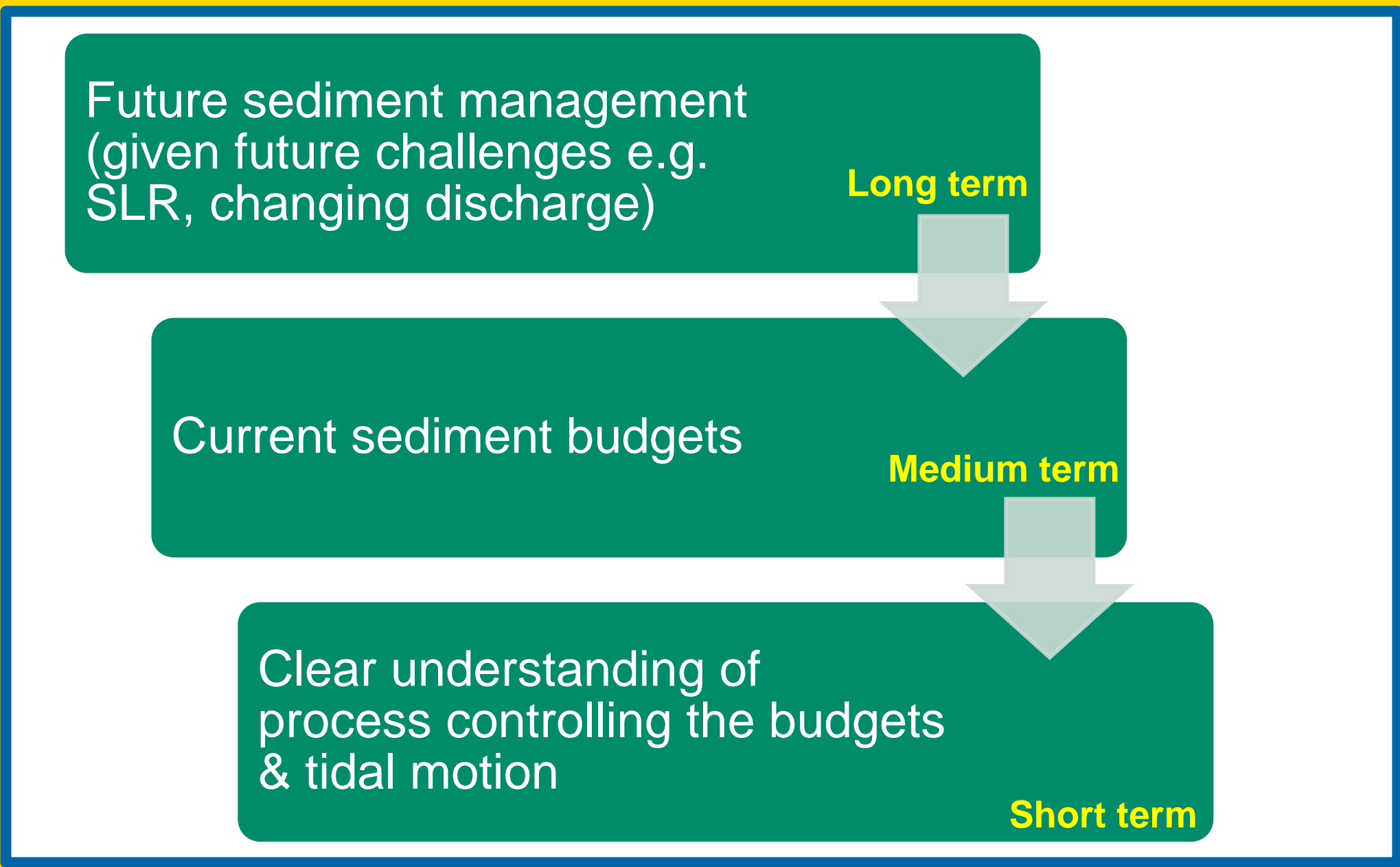


Figure 1: Workflow for the research

## 2. Study area & recent branch elevation trends

Figure 1 shows the cumulative change in bed elevation for the Benedenrivieren between 2000-2017. Some branches have large changes due to dredging whilst other un-dredged channels also show high levels of erosion. Conversely, some branches have a net sedimentation trend.

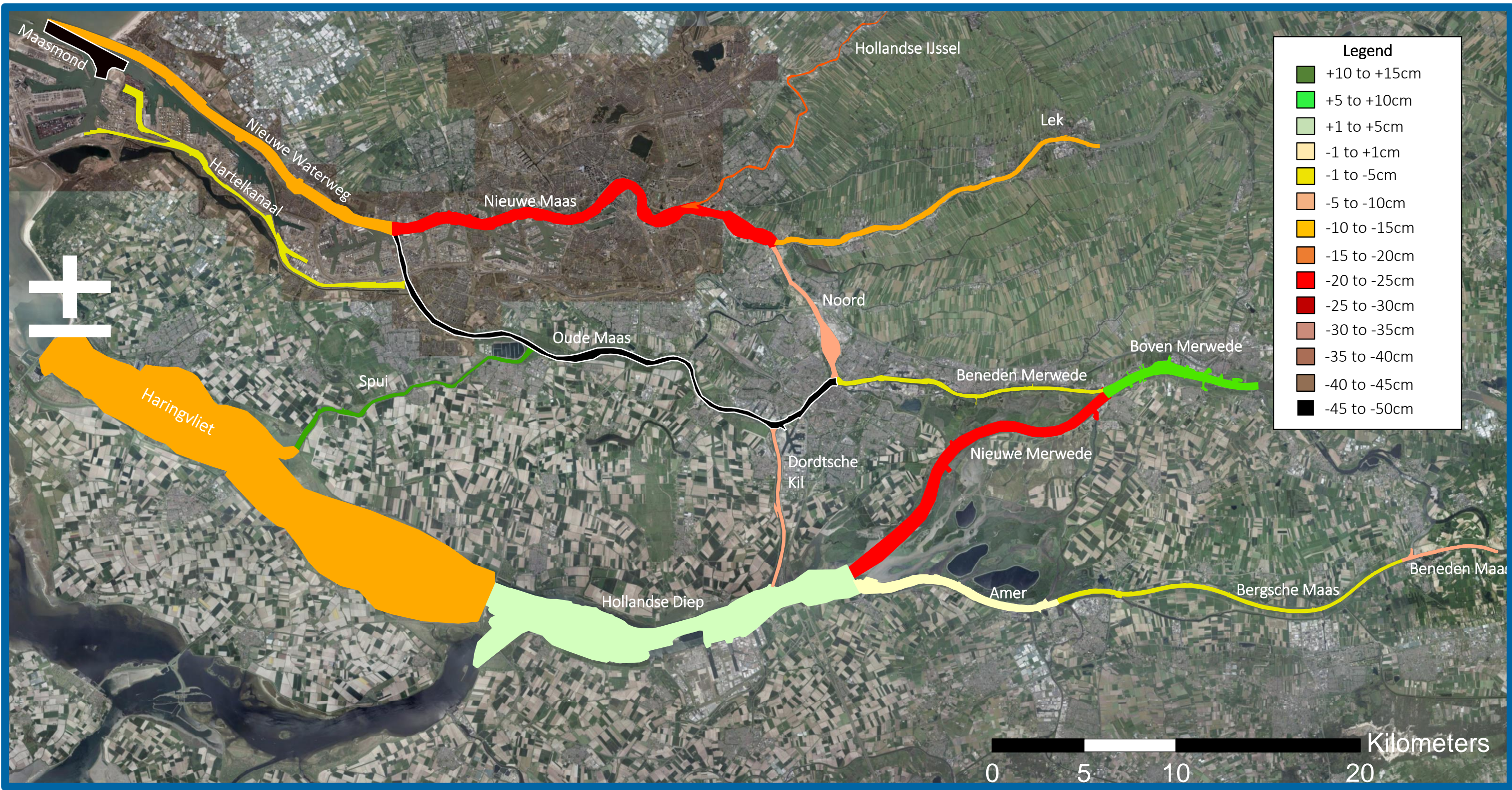


Figure 2: Branches of the lower Rhine and the cumulative change to bed elevation(cm) between 2000-2017

## 4. Creating a sediment budget: dredging and dumping

Dredging in the Rhine Meuse delta is a combination of dredging of branches and dredging of the ports and harbours. Dredged sediment is dumped either off the coast (90%) or in specifically designed dumpsites called sluffers (10%). Thus dumping does not influence the sediment budget.

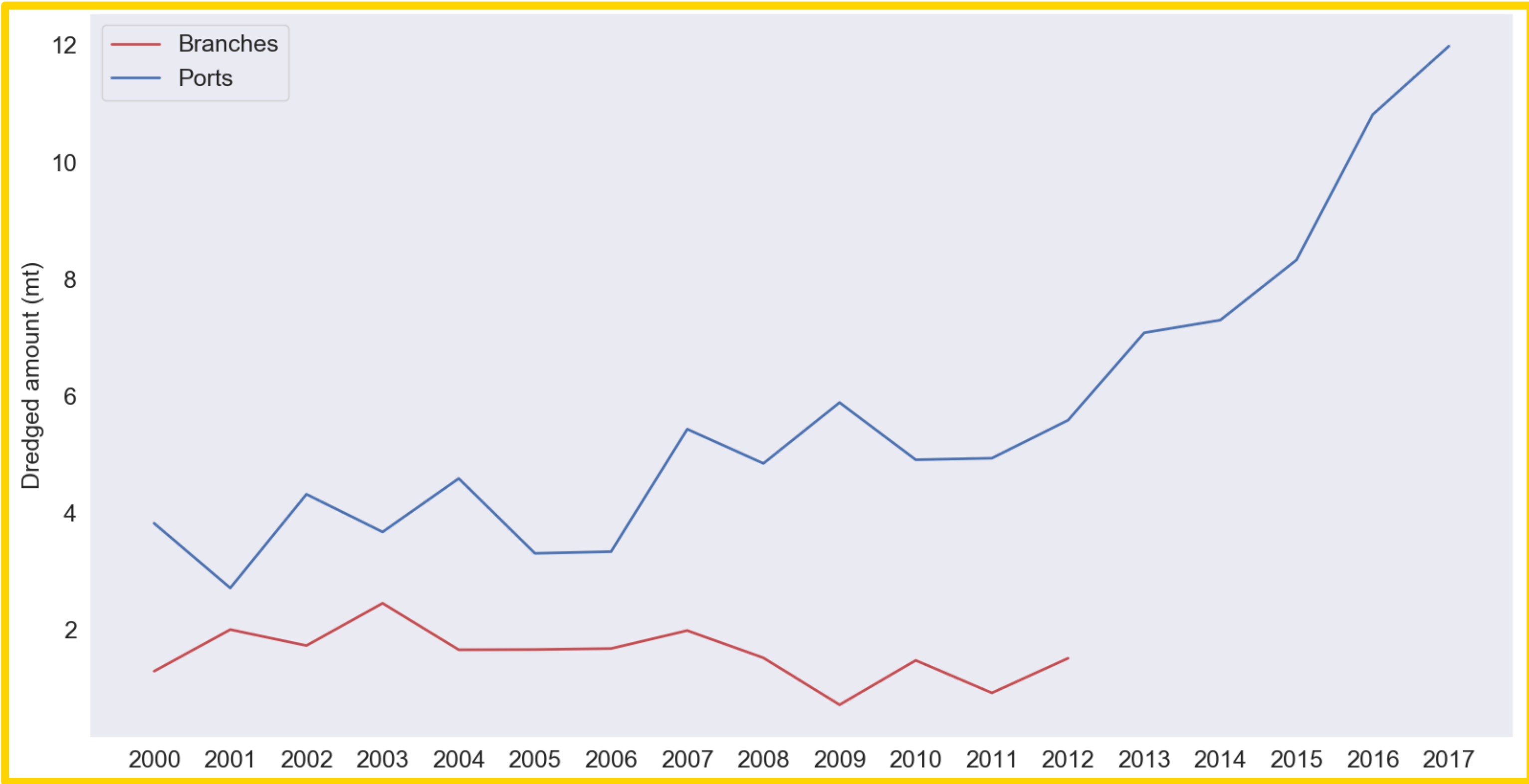


Figure 4: Dredging amounts for the branches of the Benedenrivieren and the ports and harbours in the area over time. Data for the branches since 2012 is in the process of being secured.

## 6. Relative importance of components in the sediment budget

Most dredging occurs in the ports and harbours near the Maasmond, which removes nearly the entire volume of sediment that is coming in from the North Sea. Then, the delta is reliant solely on sediment input from upstream which is decreasing due to use of dams and will become increasingly variable with variable discharge.

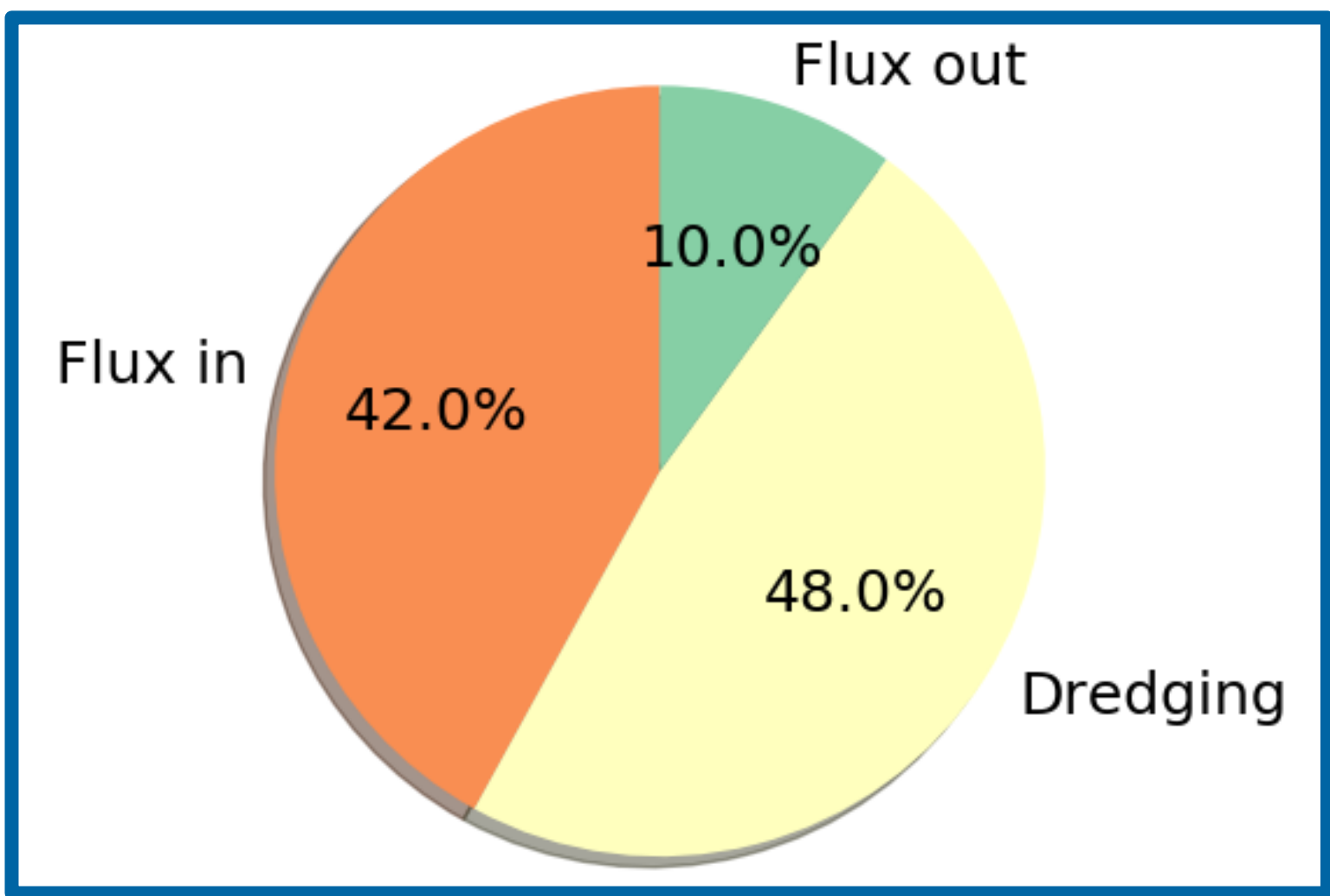


Figure 6: Percentage contribution of dredging, flux in and fluxes out to the overall sediment budget.

## 3. Methodology for calculating the sediment budget

Figure 2 shows the method used to calculate the sediment budget for the region. To create a sediment budget at scale of the entire Rhine-Meuse delta dredging and dumping activity and fluxes of sediment in and out of the sediment are the key parameters required.

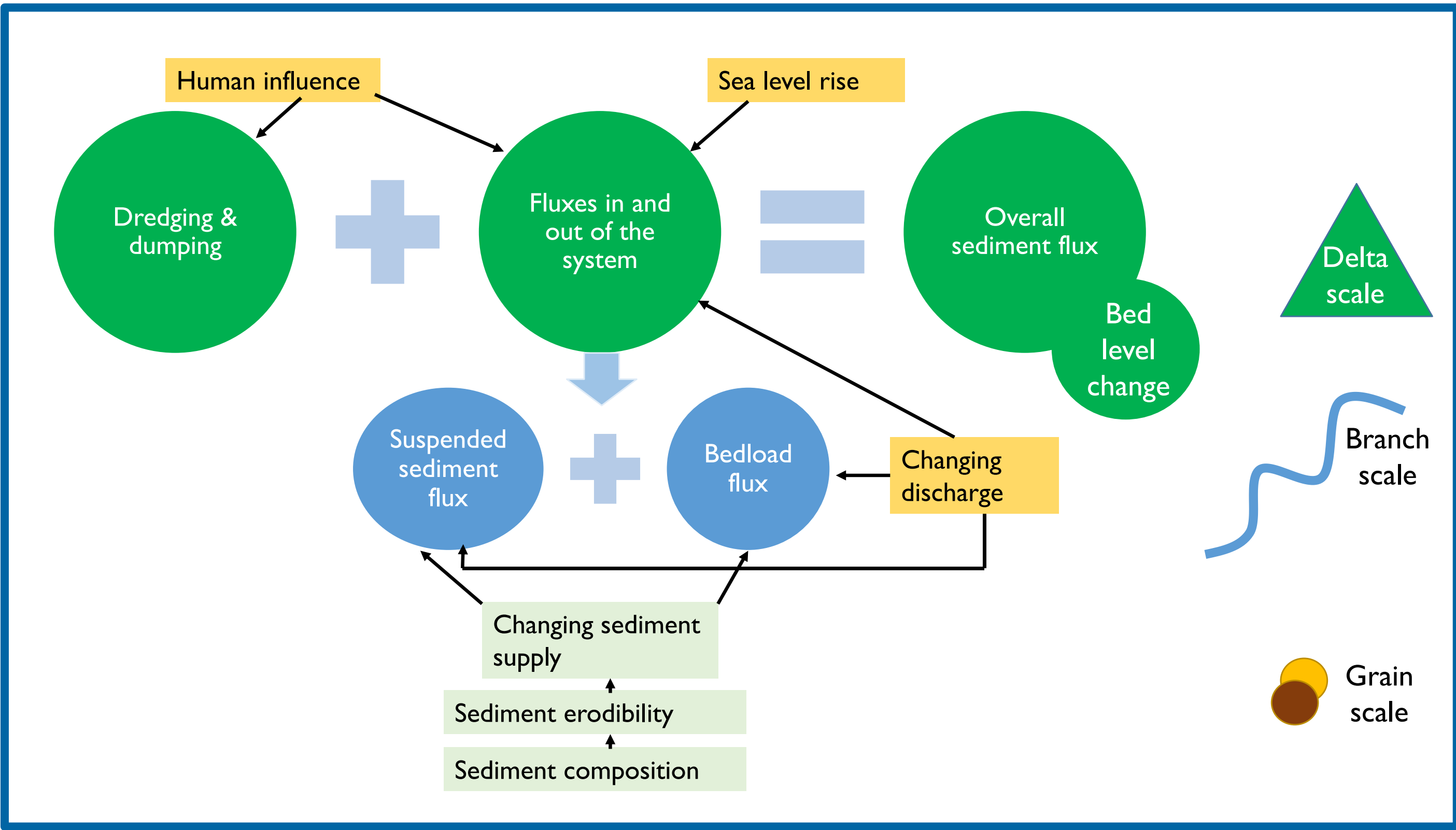


Figure 3: Equation for creating sediment budgets and processes which affect the different components and their relative spatial scales

## 5. Creating a sediment budget: fluxes in and out

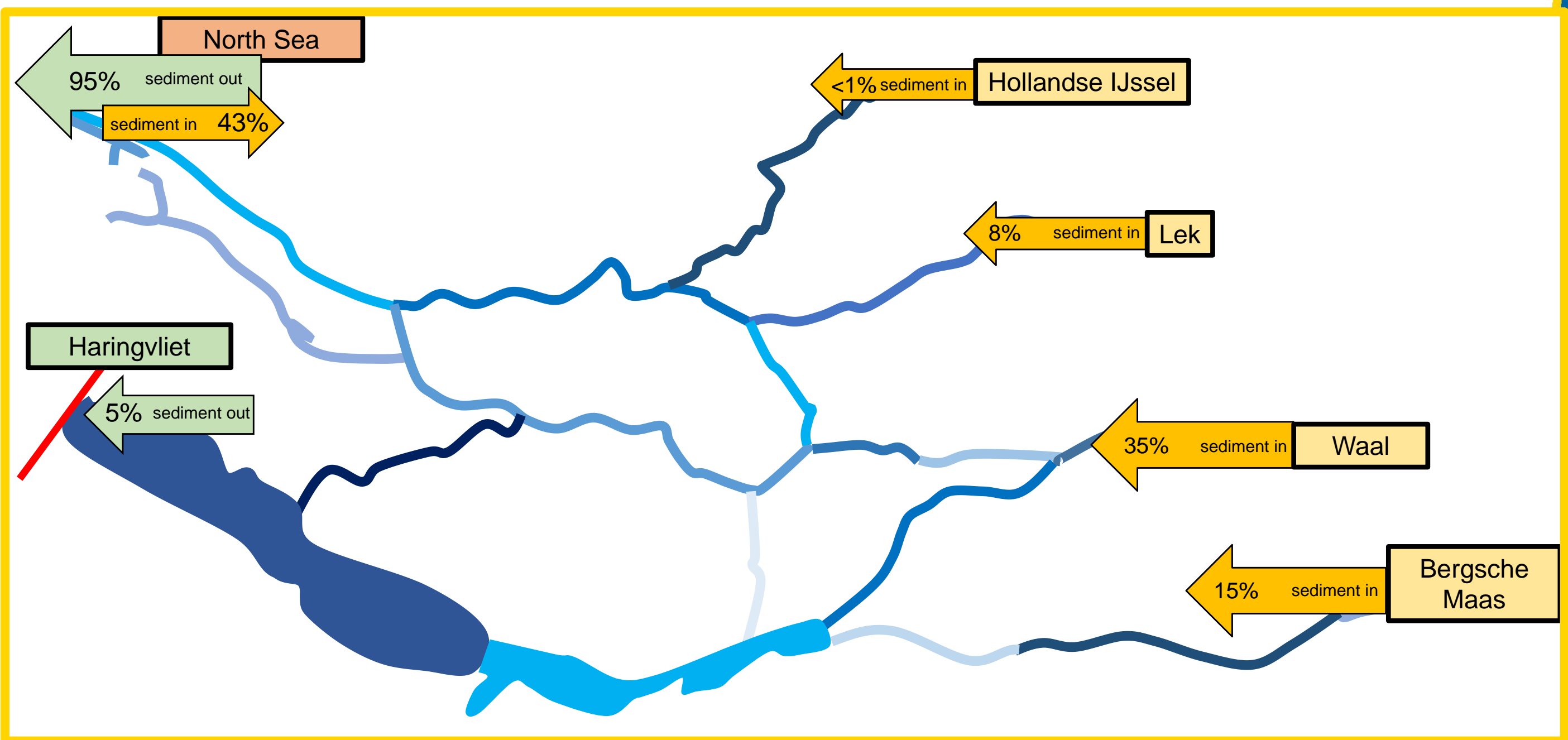


Figure 5: Map showing the relative percentage per location in the Rhine Meuse delta of the total sediment coming in and out of the system.

## 7. Sediment budget vs bed level change

The sediment budget of the Rhine-Meuse delta is decreasing over time, rapidly in recent years due to increased dredging. Since 2000 the area loses on average 1.6 megatonnes of sediment per year.

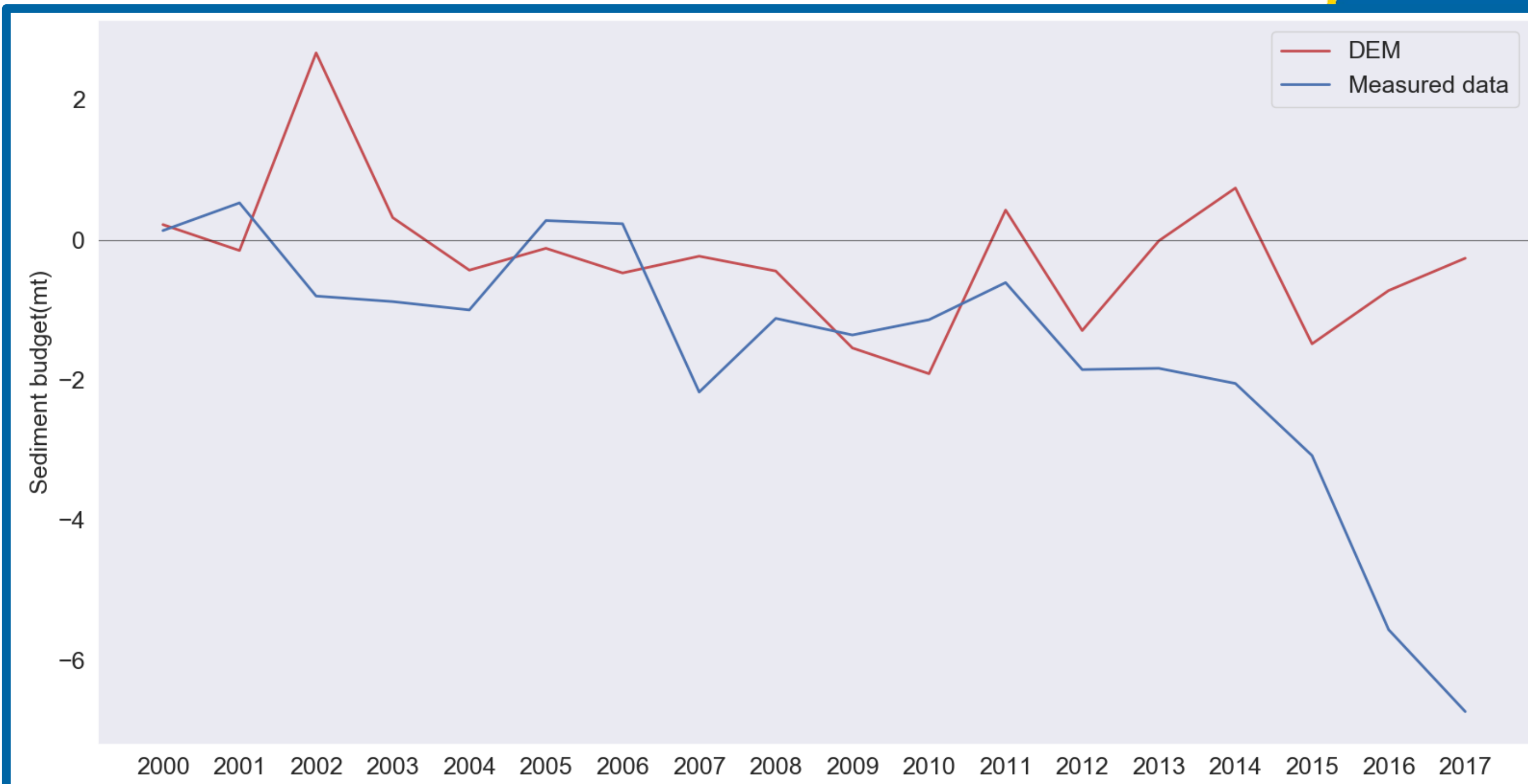


Figure 7: The sediment budget for the Rhine-Meuse delta as calculated using multibeam survey data and measured dredging and flux data. Note the DEM data is often missing the influence of the dredging of the ports and harbours.

The sediment budget of the Benedenrivieren is decreasing over time which is exacerbated by increased dredging activity in recent years. Sustainable sediment management in the future is therefore crucial to combat the negative effects caused by this lack of sediment.

