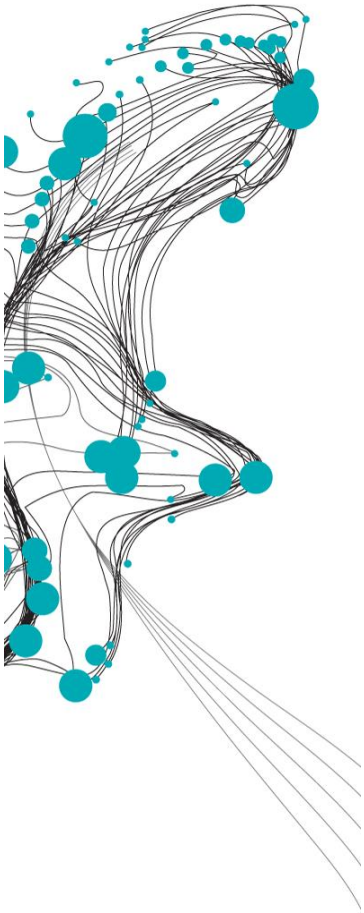
SHIFTING SHORELINES

FINDING RELATIONS BETWEEN HYDRODYNAMIC FORCING AND SEAWARD EDGE EROSION RATE OF A SEMI-NATURAL SALT MARSH IN A MESO-TIDAL ENVIRONMENT



This master's thesis explores the processes driving salt marsh edge retreat, with a particular focus on the relationship between erosion rates and hydrodynamic forcing. Salt marshes serve as vital coastal ecosystems, attenuating wave energy, reducing hydraulic loads on engineered defenses, and supporting biodiversity. However, increasing lateral retreat of marsh edges, driven by tides and waves, threatens their ecological and protective functions. This study examines the Wierum salt marsh in the Wadden Sea, which formed through historical semi-natural land reclamations and experiences ongoing erosion at its seaward edge. The marsh edge is characterized by a near-vertical cliff approximately 0.5 m in height.

The study investigates the relationship between spatially averaged hydrodynamic forcing and both the average erosion rate and its spatial variability. It also examines the potential influence of edge morphology and vegetation density on localized erosion rates. The research integrates morphological and hydrodynamic data spanning from 2016 to 2024. Marsh edge retreat was quantified using aerial imagery and digital elevation models, while hydrodynamic forcing was analyzed using wave power and wave thrust, derived from wave height and water depth.

Findings indicate a positive relationship between hydrodynamic forcing and average marsh edge erosion rate, following both linear and power law relationships. The linear relationship aligns well with comparable studies in the literature, but substantial data dispersion introduces uncertainties. Additionally, a negative correlation was found between the frequency of inundation (percentage of hours per year with cliff inundation) and dimensionless erosion rate. This suggests that wave intensity during inundation, rather than the total duration of inundation, plays a more significant role in driving lateral cliff retreat.

While spatial variability in erosion rates was observed across different marsh sections, the relationship between erosion and hydrodynamic forcing remained consistent. Edge morphology also influenced erosion rates, with smoother marsh edges eroding faster than more complex, irregular edges. This finding aligns with existing theories on erosion mechanics. Vegetation density was low along the marsh edge, as indicated by Normalized Difference Vegetation Index (NDVI) values. Despite this, a weak negative correlation between vegetation density and erosion rate supports theories suggesting vegetation plays a stabilizing role in marsh resilience.

By using the Wierum marsh as a case study, this research enhances understanding of salt marsh retreat in meso-tidal environments. The findings contribute to broader knowledge on salt marsh edge erosion and provide valuable insights for conservation and management efforts in Wierum and similar coastal ecosystems.

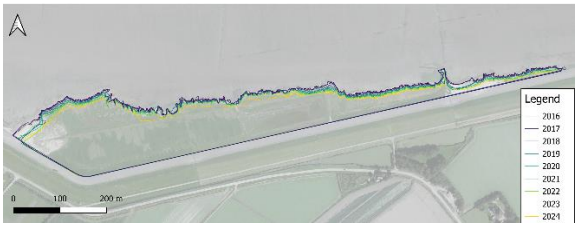


Figure 1: Map of the Wierum marsh edge retreat from 2016 until 2024 using PDOK data. As background map the aerial image of 2016 is used.

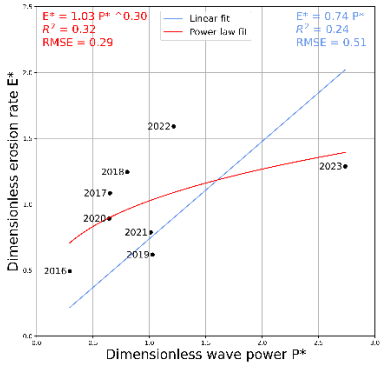


Figure 2: Relation between dimensionless wave power (P) and dimensionless erosion rate (E*) including a linear fit of the shape E* = α*P* (blue) and a power law fit of the shape E* = kP*^n (red).*

Juliana Bruil

Graduation Date:
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Graduation committee:
University of Twente
Dr.ir. V. Kitsikoudis
S. Dzimballa MSc
Dr.ir. E.M. Horstman

UNIVERSITY OF TWENTE.