Course: TPM801A Model-based Water systems assessment

Assignment: Coastal environments

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Background

The Netherlands has a coastal management policy aimed at preserving flood risk levels and values and functions of dune areas through maintaining the (relative) sediment budget of the coast. The strategic goal of the dynamic conservation policy aims at sustainable maintenance of flood protection levels and sustainable preservation of values and functions of dune areas (Lodder & Slinger, 2022). From a tactical approach, this entails conserving the sediment budget using soft solutions, allowing natural dynamics, holding the line, maintaining sediment budget in equilibrium with sea level rise, and ensuring that flood defences comply with the flood risk reduction standard (Lodder & Slinger, 2022).

Research question

This analysis will focus on the following research questions:

1. “How has the sediment budget for the island of Texel changed between 1965 and 2023?”
2. “In what sense are the strategic goals of sustainable maintenance of flood protection levels and sustainable preservation of values and functions of dune areas met for the island of Texel?”

Approach

For this analysis, annual bathymetry data from 1965-2023 has been used, as well as the coastal viewer application.

To understand how the sediment budget for the island of Texel has changed between 1965 and 2023, the volume development over time for different regions of Texel has been analysed. First, the different bathymetry transects have been grouped in regions, using insights from the Coast Viewer application. The following regions were identified: South-West Texel (transects 900 – 1298), Texel’s National Park (transects 1312 – 1853), De Koog (1873 – 2091), and the Slufter (2111 – 3081). By using different groups of transects, dune volume development and whether this evolution over time is fitting for its ecosystem services can be better understood. Second, the dune area was selected by slicing Z data using a dune threshold set to 3 m above NAP, following the demarcation of the Coast Viewer. Consequently, the total volume of the different regions was approximated using the XYZ coordinates denoted in the bathymetry data. This was done by first calculating the base area using the X and Y coordinates, and then multiplying this base area by the average height of the dune area divided by 2. This was done for each transect within a region, after which the total volume of the dune in that region for a certain year was calculated by adding the separate dune volumes.

To account for the diverging starting points of bathymetry transect measurement across the years, the choice was made to use the starting point from 2022. This way, the transects of a specific location for each year starts at the same point.

Sediment Budget Analysis

Figure 1 shows an overview of the total sediment budget development over the years for the different regions in Texel. Important to note is the difference in scale of the y-axis for the different

regions. Figure 1 shows that the regions have differences in dune volume developments over the years, both in terms of relative growth in volume and in terms of their slope.

As for the South-West region (upper blue graph), Figure 1 shows a growth in dune volume of approx. 5000 m^3 in 1965 to a dune volume of approx. 32000 m^3 in 2023. In terms of growth rates, this would mean a compound growth rate of approx. 3.2% per year.

The National Park region (2nd from above, green) shows a growth in dune volume of approx. 12.000 m^3 in 1965 to approx. 111.000 m^3 in 2023. In terms of growth rates, this would mean a compound growth rate of approx. 3.9% per year.

De Koog region (3rd from above, red) shows a growth in dune volume of approx. 17.000 m^3 in 1965 to approx. 41.000 m^3 in 2023. In terms of growth rates, this would mean a compound growth rate of approx. 1.5% per year.

The Slufter region (4th from above, magentha) shows a growth towards a volume of approx. 15.000.000 m^3 in 2023. In terms of growth rates, this would mean a compound growth rate of approx. 18% per year, when assuming that in 1965 there was approx. 1000 m^3 of dune volume.

The graphs for the regions South-West, National Park and De Koog show interesting drops in dune volume around the years 1973 and 2010, and a smaller drop for the Slufter region. It remains unclear what this drop means. One explanation may be that the data contains missing data or data was misregistered. Another explanation might be that a storm occurred which swept away part of the newly formed embryonic dunes that were not as stable as older dunes. As for the year 1973, a short investigation on storms shows that there were a series of large storm events with their centre at the Waddeneiland around 1973. This might explain these drops in volumes. However, a search on storm data of 2010 in the region was not successful. Due to time constraints for this assignment, the choice was made to not further investigate this but rather to look at the relative global growth between 1965 and 2023.

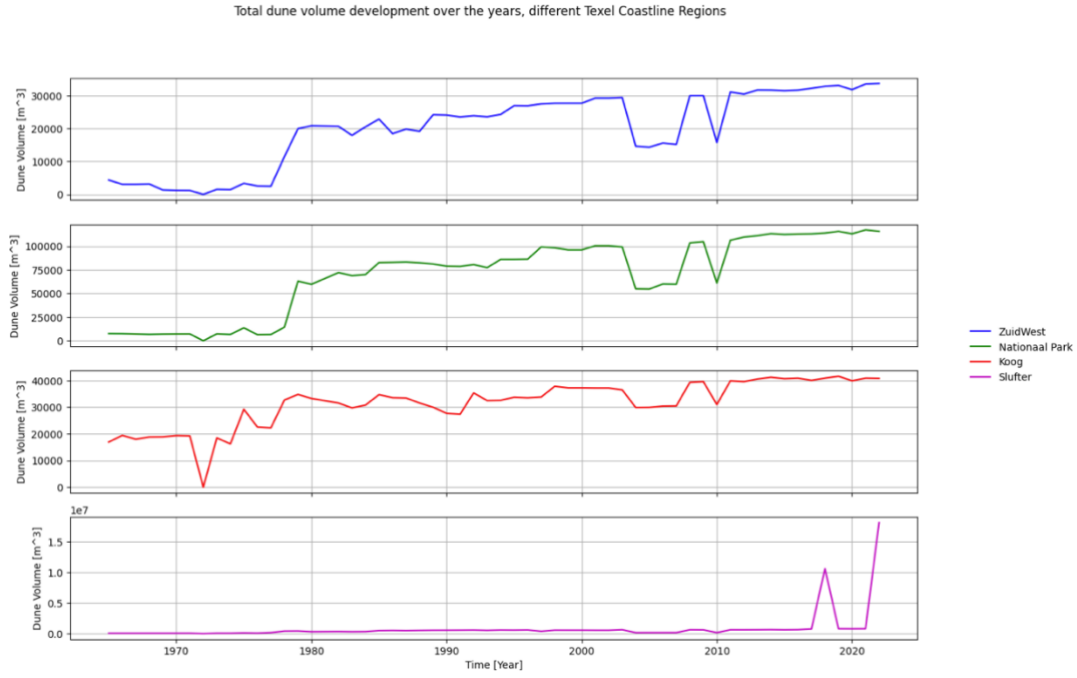

Figure 1: Total dune volume for different regions in Texel over the years. Note that each graph is plotted against a different Y-axis.

Whereas Figure 1 shows the total dune volume development for four different regions over the years, Figure 2 highlights specific locations within these regions and their coastal development and bathymetry over the years. With regard to the South-West part of Texel, the bathymetry of location 900 shows that the main dike has been heightened. The same holds true for location 1763, located near the National Park of Texel, yet this dike has been made wider over the years too. In contrast, location 1972 near De Koog has not benefited from dike heightening or widening; the bathymetry of this part of the coast in 2020 is similar to years before. Lastly, de Slufter has benefited from a significant increase in dike heightening over the years. Its main dike has been made steeper, even more so compared to locations in South-West Texel and near the national park. Overall, Figure 2 shows that most dunes have developed over the years, whereas the coastal development near De Koog has not benefited from progress.

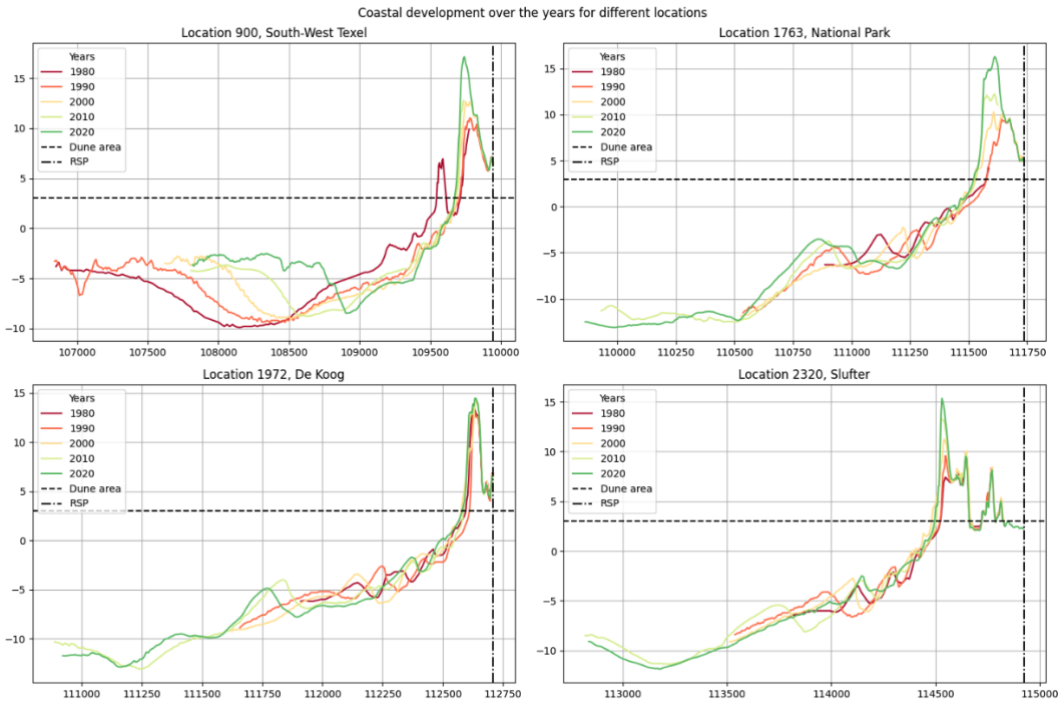

Figure 2: Coastal development and bathymetry of locations within the four regions over the years.

Conclusion and Discussion

The analysis has shown that the different regions of Texel- South-West, National Park, De Koog, and Slufter- have varying rates of growth in dune volume over the years. The largest growth is observed in the Slufter region (~18%), whereas the lowest growth is observed in the Koog region (~1.5%). Ranked in between are the National Park (~3.9%) and South-West (~3.2%) regions.

To understand whether the strategic goals of sustainable maintenance of flood protection levels and sustainable preservation of values and functions of dune areas are met for the island of Texel, it is relevant to view the growth rates of dune volume for the different regions in light of their values and functions. Whereas the South-West, National Park and Slufter regions are primarily natural reserve areas ensuring biodiversity and coastal protection, the Koog area is primarily designed for urban activities and serves an economic purpose. As for the Slufter area, the dune volume has seen a major growth over the years. This suggests a success of strategic objectives in this region. As for the other two nature regions, South-West and National Park, there is smaller growth as opposed to the Slufter area. However, considering the earlier dune existence in these areas and the observation that the volume has increased, we consider the strategic objectives in these areas

to be met as well. Yet, the compound growth rates and transects from the different regions show that Dune volume and width growth in the Koog area stays behind as opposed to the other areas. With such a relatively small growth rate, this raises the question whether this area stays protected in the years to come, considering the expected acceleration of sea level rise and land subsidence (Lodder et al., 2019).

To conclude, whereas progress has been made in the last years to increase dune volume to sustainably maintain flood protection levels and preserve values and functions of dune areas for the Texel Island, there is still work to be done. Especially in the urban Koog region, growth rates of dune volume development stay behind, leaving urban regions vulnerable.

References

Q.J. Lodder, & J.H. Slinger. (2022). The 'Research for Policy' cycle in Dutch coastal flood risk management: The Coastal Genesis 2 research programme. *Ocean & Coastal Management, 219.* https://doi.org/10.1016/j.ocecoaman.2022.106066

Lodder, Q.J., Wang, Z.B., Elias, E.P.L., van der Spek, A.J.F., de Looff, H., Townend, I.H., 2019. Future response of the Wadden Sea tidal basins to relative sea-level rise: an aggregated modelling approach. Water 11 (10). https://doi.org/10.3390/w11102198

Annual bathymetry data 1965 – 2023

Coastal viewer https://www.openearth.nl/coastviewer-static/