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How to make Integrated Coastal Erosion Management a reality

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ABSTRACT

Coastal-erosion management actions require a knowledge of sediment behaviour and interchange in all related offshore, shore and inland environments. Approaches to managing erosion include hard/soft protection measures (hold/advance the line), accommodation, managed retreat, use of ecosystems and sacrifice (do nothing). In reshaping these options, an essential addition is the most attractive but usually the least used strategy: Intervention Concerning the Erosion Causes (ICEC). Minimizing erosion via ICEC not only means specific local actions, but certainly also involves the restoration of natural protective habitats, and even the removal of anthropogenic structures that block sediment production and its flow to and through coastal systems. The spatial and temporal environmental, physical and social knowledge related to the area of interest forms the core of the ICEC approach to solve or at least minimize coastal erosion.

1. Introduction

Coastal erosion is a process whereby a coastal zone loses its subaerial land part (beaches, dunes, bluffs or cliffs) resulting in a net sediment imbalance and subsequent retreat. This process includes a broad range of processes such as wind, wind-induced waves, water currents, amongst others that are acting at different temporal and spatial scales, and that are commonly self-related (van Rijn, 2011).

Coastal erosion is a typical primary natural process that has shaped the surface of the earth. Erosion can be related to slow shoreline behaviours working for decades and that often affect long coastal reaches covering large areas. It can also be linked to rapid processes, sometimes comprising not more than movements during a time span of seconds, and usually involving the movement of small particles, less than a few millimetres or even micrometers in size (Larson and Kraus, 1995).

Coastal erosion can either directly or indirectly be related to human activity (de Jonge, 2009). Since the time that humans started to change from a nomadic lifestyle to one related to permanent settlements, they also began to influence their living environment with sometimes dramatic consequences. A good example is the vast inundations caused by a combination of storm events and early dike building and large-scale peat digging. The peat digging activities were accompanied by the required dewatering which resulted in accelerated peat oxidation and accelerated sediment compaction due to which the difference between the mean sea level and that of the terrestrial area dramatically increased (up to 6 m). In north-western Europe, these conditions started during medieval times until the period that organized ‘water boards’ were created (de Jonge, 2009). In this period, large parts of the north, the west and the southwest of the Netherlands were lost (de Jonge, 2009). In the Netherlands, this more organized modern water management started in the 1200s. However, when looking at the historical developments since ∼1600 (Fig. 1) then it is clear that erosion and accretion are processes that occur simultaneously (left side of Fig. 1 where accretion and erosion are indicated), and both vary in intensity over time (right side of Fig. 1 indicating eroding and accreting coastline of the Netherlands). The background of these changes between ∼1600 and ∼2000 were most likely (Ligtendag, 1990) indirectly caused by processes such as tectonics, sediment compaction, isostasy and the proceeding basin formation of the Southern Bight of the North Sea.

Under today's complicated situation of human technical developments and related infrastructure, shoreline retreat due to the slow long-term sea-level rise may affect regional coastal areas, while beach erosion due to the construction of a groin, for example, may take place within a restricted number of days. Usually, the human engineering approach (seawall, groin, jetty development) has an impact on a defined area and as far as we know a ‘restricted’ stretch of the coastal zone (Komar, 2000). All the above processes, however, act simultaneously, and the coastal erosion recorded in a given area is thus a consequence of the interaction of all the processes. The analysis of causes and extent of coastal erosion needs to include all of the spatial and temporal scales at which these processes work. The information required to analyse every coastal process must take into account the natural scale.

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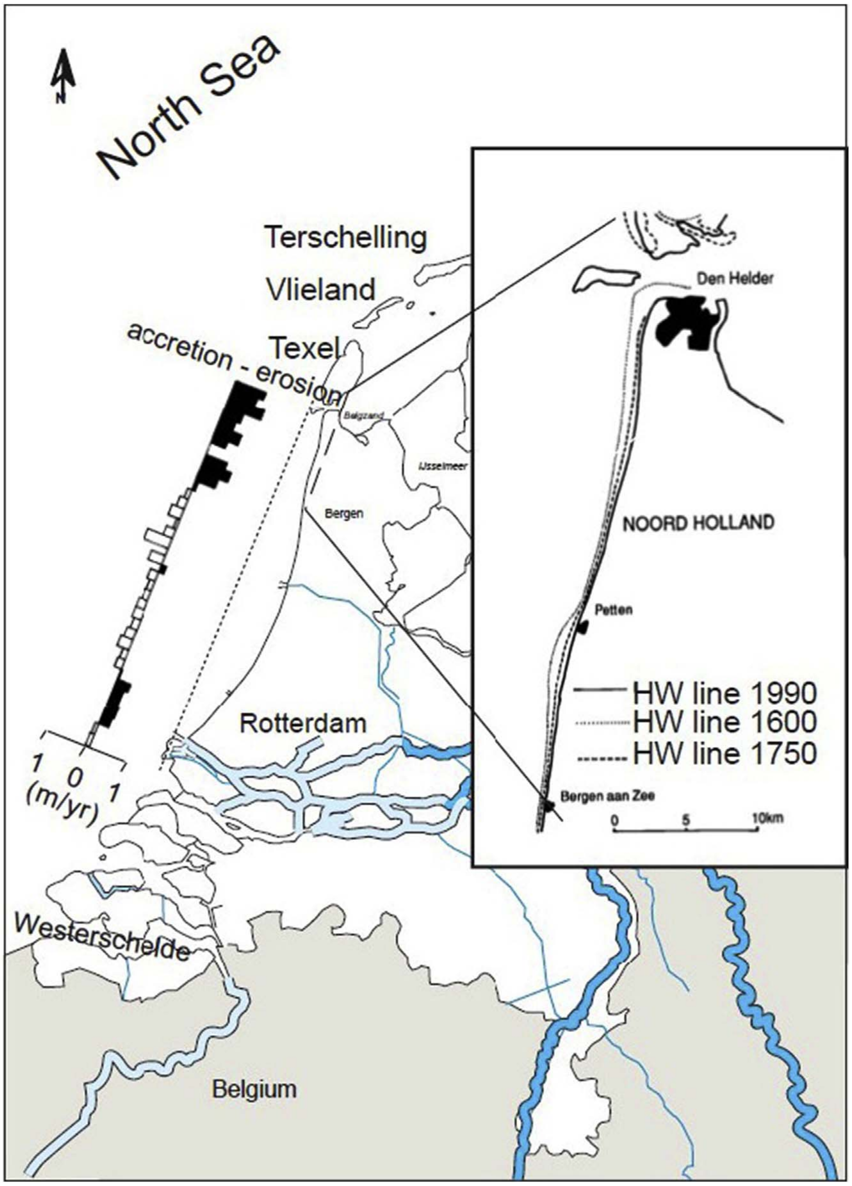

Fig. 1. Changes of the North Sea coastline in the Netherlands since ~1600 and the present annual erosion and accretion of the Dutch coast between the first tidal inlet of the international Wadden Sea near Den Helder in the north and the Rhine and Meuse delta in the southwest of the country (near Rotterdam harbours). The figure is a recomposite based on material published in a Rijkswaterstaat report in Dutch by Ligtendag (1990).

A significant point is that coastal erosion only becomes a problem when there is no space to accommodate the occurring changes. In this sense, coastal erosion is not an issue for those areas where high elevated and stable grounds back up the coast, but it is a severe problem for low elevated rural areas and urbanized areas. In fact, in many regions, coastal erosion is necessary for the preservation of some coast related functions and features (e.g., sediment supply to adjacent and down-drift beaches, dunes, intertidal sand flats, mud flats and salt marshes). This is the case along the east coast of the United Kingdom where the strong annual erosion of the 'Holderness Coast' contributes to the accretion of the Wash area and even the Thames area (Fig. 2).

Currently, many coastal communities around the world face serious problems related to coastal erosion (Pilkey and Cooper, 2014; Rangel-Buitrago et al., 2015; Williams et al., 2017). These issues are quickly magnified by the changing conditions related to a warming climate that has resulted in increasing precipitation and inundation, and increased risk of flooding during extreme events with related severe wind and wave conditions (Donnelly et al., 2004; Rangel-Buitrago and Anfuso, 2013; Jin et al., 2015). Coastal erosion issues become more critical as most of our coastal zones are attractive places for population settlement and concentration, and for the development of economic activities, such as industry, transportation, and tourism (Barragan and Andreis, 2015).

From 1950 to the present, the coastlines of the world have experienced a rapid development with an annual average urban growth of 2.6% (World Bank, 2017). For the same period, the number of coastal cities has multiplied by a factor of ~4.5 from 472 coastal cities in 1950 to 2129 cities in 2015. It has been estimated that almost 30% of the residences within 200 m of the shoreline along low-elevated coasts, may be severely affected by erosion-related property losses over the next 50 years (World Bank, 2017).

Over the last 50 years, and while tourism grew, coastal erosion became a severe problem because of its rising magnitude trend (Williams et al., 2016; Rangel-Buitrago et al., 2017a, b). Currently, coastal erosion results in beach loss, deterioration of coastal landscape quality, and high financial investments for protective structures. Thus coastal erosion is regarded as an obstacle hindering economic growth (Fig. 3). Coastal retreat and flooding affect coastal zones worth billions of dollars in regard to tourist income, industrial development, other human activities, and the associated infrastructure (Clark, 1996).