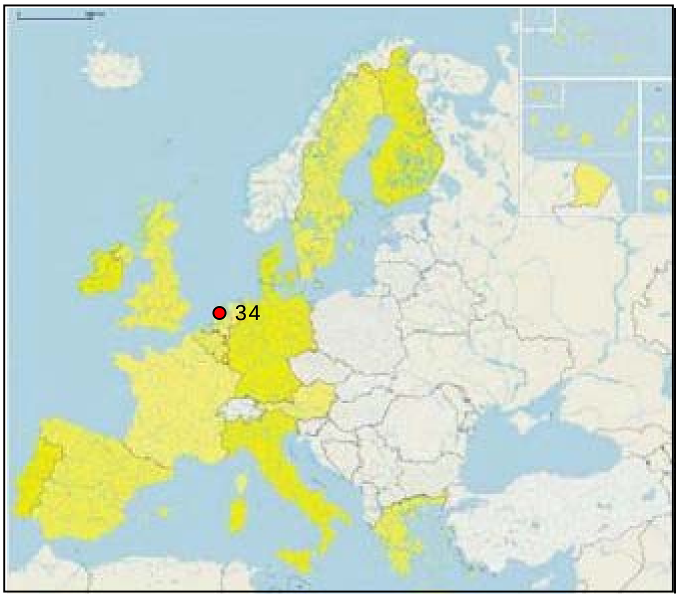
HOLLAND COAST
(THE NETHERLANDS)



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1. GENERAL DESCRIPTION OF THE AREA

The Netherlands is situated at the North Sea, in the deltas of the rivers Rhine, Meuse and the Scheldt. The coast is subdivided in three types of coast: the Delta coast, the Holland coast and the Wadden coast. Currents waves, wind, sediment deposits from the rivers and human made structures have resulted in the present geomorphologic features of the Dutch coast.

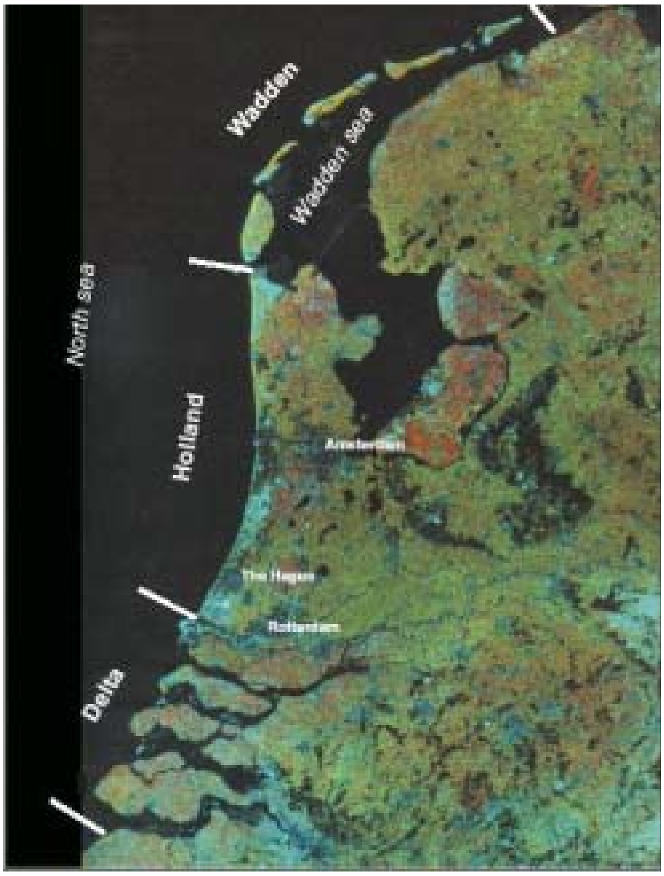

Fig. 1: Morphology of the Dutch coast (satellite image).

1.1 Physical process level

1.1.1 Classification

- General: sandy coast
- CORINE: beaches
- Coastal guide: coastal plain

The Holland coast consists of sandy, multi-barred beaches and can be characterised as a wave dominated coast. Approximately 290km of the coast consists of dunes and 60km is protected by structures such as dikes and dams. The dunes, together with the beach and the shore face, offer a natural, sandy defence to the sea. About 30% of the Netherlands lies below sea level.

1.1.2 Geology

At the end of the last Glacial (Pleistocene), 10,000 years ago, the area of the southern North Sea was completely dry. With the melting of the ice crusts the sea level rises (the rate of sea level rise fluctuated) and the coastline shifted eastward until about 5000 years ago the present position of the Dutch coastline was reached.

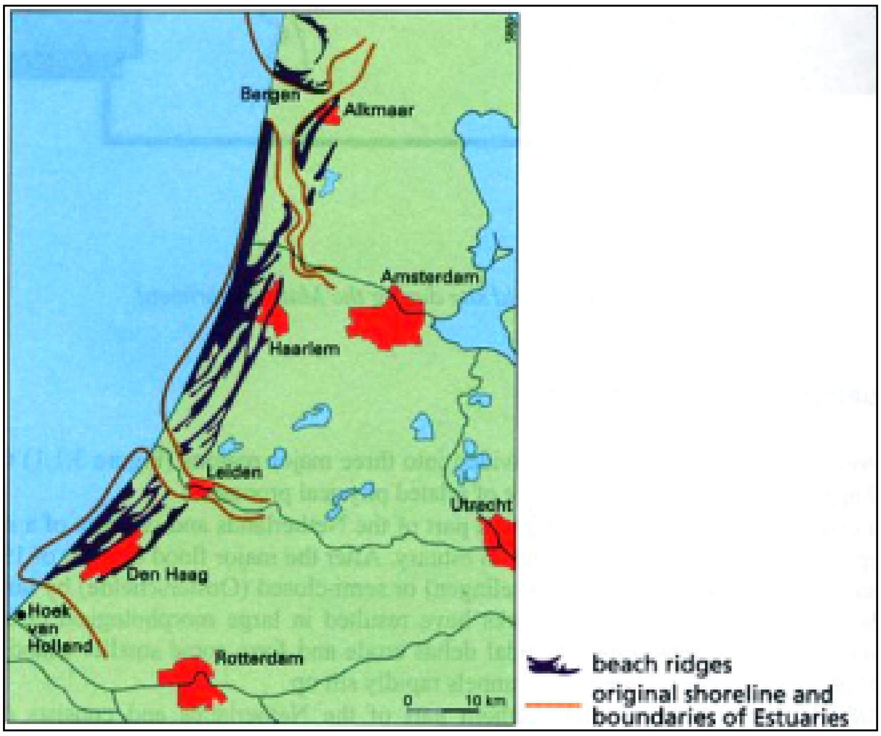

Fig. 2: Pattern of beach ridges and tidal inlets at 3000 BP (Berendsen, 1997).

The coast consisted of beach ridges, walls of sand from the bottom of the sea. Between 5000 and 4000BP, barriers started to shift westward and the tidal inlets gradually filled up from south to the north (Beets et al., 1992 op. cit. Van Rijn et al., 2002). Between 3500 and 3000 BP, during stagnating sea level rise, the sand supply decreased and the formation of the beach ridges has been stopped. On the beach ridges started the formation of low and broad dunes (old dunes) (Strategische visie Hollandse kust 2050). Between 3000 and 1800BP young dunes were formed on top of the old ones and there is an inversion of the coastline migration. Later on when seawater breaks through the dune row, during storms, men started to defend the land by building primitive dikes and walls.

The sediment of the Holland coast is well sorted and composed of fine to medium sand with a mean grain size between 250 and 350μm.

1.1.3 Morphology of the coast

The Holland coast consists of 120 kilometres of almost continuous shoreline, without the presents of tidal inlets, sea arms and islands. The orientation of the coastline of the provinces Noord- and Zuid-Holland is approximately north-south (10°–190°) and has a slightly concave shape. *Because of this concave shape of the coastline gradients in sand transport occur as a result of the transport of sand in longshore direction.* The beaches have a width of 100 to 200m from the dune foot to the low water line and have an average slope between 1:35 and 1:60 (Stolk, 1989 op cit. Egmond). Along a great part of the gently sloped Holland coast, sandy-multibarred beaches are present. The morphology of the beach is often characterised by a swash bar.

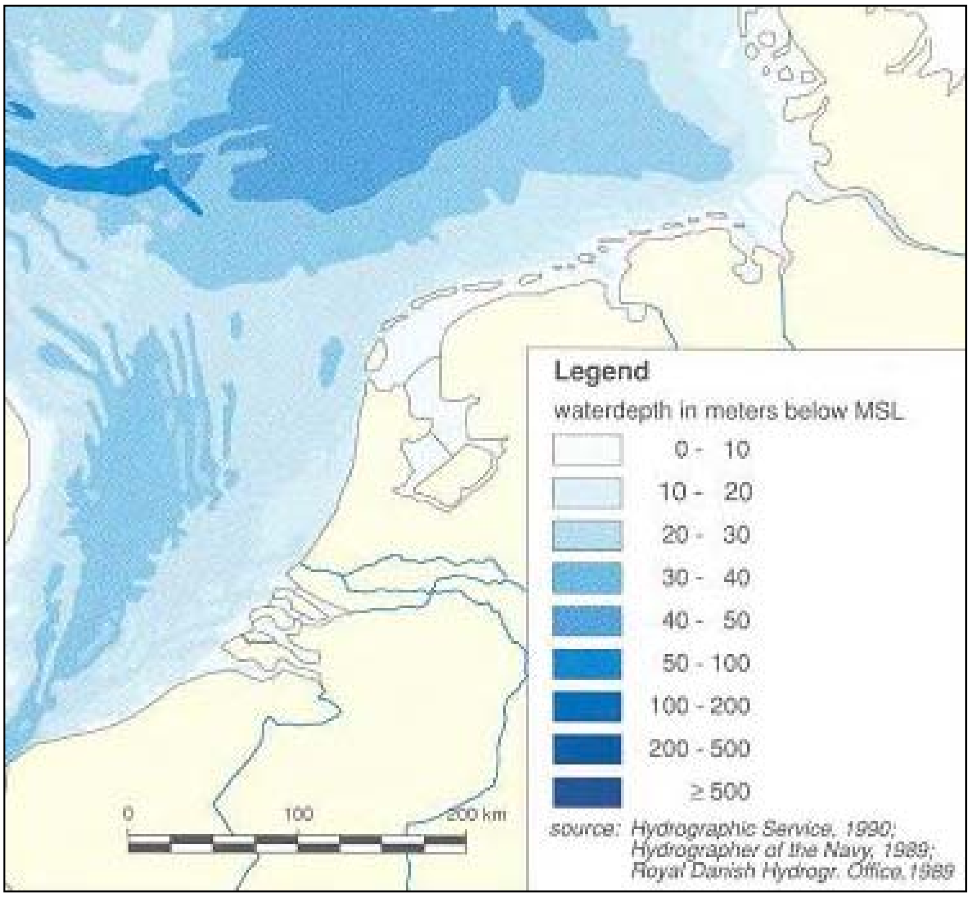

Fig. 3: Bathymetry of the North Sea (ICONA, 1992).

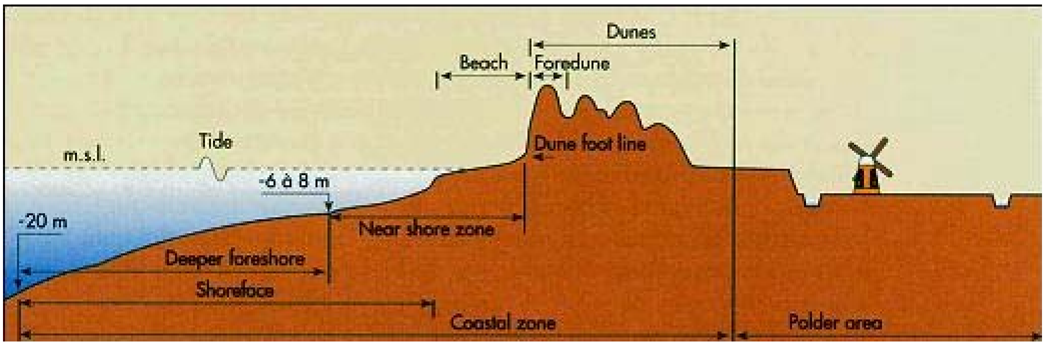

Fig. 4: Cross section of the dune area of the Holland coast (NHV & IAHS, 1998).

1.1.4 Physical processes

The wave climate is dominated by sea waves with a mean annual significant offshore wave height of about 1.1m. Most of the winds along the Holland coast come from the North Sea. The prevailing wind direction is southwest (23%), followed by west (16%), east (13%) and northwest (12%) (Stolk, 1989). The storm winds causing the largest wind set-up along the coast are coming from northwest. (Van Rijn et al., 2002).

The periods of high tide and low tide along the Dutch coast vary. In Vlissingen, the mean tidal range is 3.80m. Moving northwards along the coast the mean tidal range declines to 1.40m at Den Helder and then increases again to 3m at Delfzijl. The tidal currents are northward directed during the flood period of 4 hours and southward directed during ebb period of 8 hours near Egmond coast. Sea level rise for the period between 1965 and 1992 was in the order of 20cm/century. Along the Holland Coast the tidal range is the smallest of the Netherlands and can be characterised as a wave dominated coast.

Fig. 5: River of Sand ('Beleidsagenda voor de kust, 2002).

The Dutch coast consists mostly of sand, which serves as the foundation of the coast. The coastal foundation zone is dynamic and constantly changing in terms of location and shape (sand waves-Figure 5). Approximately 12 million m^3 of sand is transferred annually from the North Sea to the Wadden Sea as a result of rising sea level (see Table 1) and coastal erosion (Mulder, 2000).

Table 1: Scenarios of sea level rise (V&W, 2002).

Scenarios of sea level rise
The exact scope of the expected climate change is as yet uncertain. Depending on the term of the issue at hand, policy and management is geared to one of the following sea level rise scenarios*.
'Low' scenario: 20 cm/century
This scenario is applied to take decisions regarding projects with a short design period (approx. five years), requiring limited investments and flexible solutions, such as sand replenishments.
'Median' scenario: 60 cm/century
This scenario is applied to take decisions regarding projects with a longer design period (50-100 years), requiring major investments and little flexibility, such as the construction of dikes and storm surge barriers.
'High' scenario: 85 cm/century and a 10% increase in wind
This scenario is applied to make spatial reservations for the purpose of flood defence.
This document applies a 200-year policy horizon in accordance with the Third Coastal Policy Document and the recommendations of the Technical Advisory Committee for Flood Defence Structures.
The 'high' scenario is used to determine the weak links.
*These scenarios were taken from the Third Coastal Policy Document and are based on Intergovernmental Panel on Climate Change (IPCC) reports. They involve relative sea level rise, which means that the effects of soil subsidence have been taken into account.

1.1.5 Erosion

Over the last 30 years sand loss of approximately 1 million m^3/yr has occurred from the Holland coast on deep water. In most northern coastal sections (Ijmuiden) erosion occurs on deep water and in the nearshore zone. In most southern sections sedimentation occurs in the nearshore zone and erosion on deep water. Structural erosion is due to sea level rise and, in some spots, it occurs because of build harbour dams. The Holland coast as a single unit shows erosive behaviour ($-9.6x10^5$ m^3/yr).

As a result of the regular measurements of the bottom depth along the Dutch coast, the large-scale trends in volume change can be calculated over the last 30 years (see Figure 6). In the northern part of the Holland coast (the Province of Noord-Holland) the erosion in the nearshore zone is -0.5 till $-0.7x10^6$ m^3/yr and in deep water -0.3 till $-0.1x10^6$ m^3/yr. At IJmuiden sedimentation occurs; +0.6 till $+0.9x10^6$ m^3/yr. In deep water of the southern part of the Holland coast (the Province of Zuid-Holland) erosion occurs(-0.6 till $-0.4x10^6$ m^3/yr), while the nearshore zone is gaining sediment (-0.2 till $–0.05x10^6$ m^3/yr). These national trends give an indication for the behaviour of the coastline. I

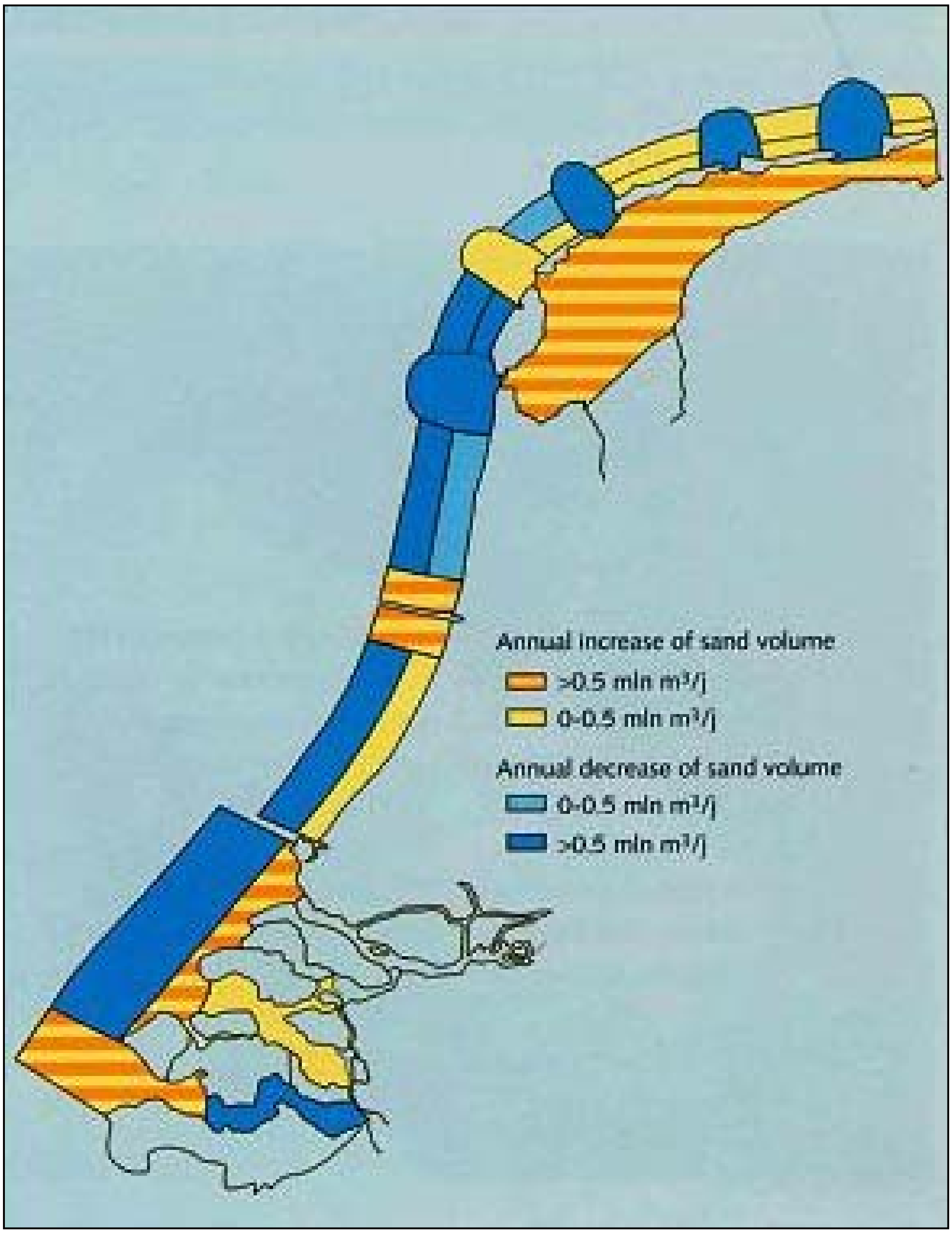

Fig. 6: Annual increase and decrease of sand volume for the Dutch coast (V&W, 1996).

1.2 Socio-economic aspects

1.2.1 Population rate

The number of inhabitants per km^2 is 465 (see Figure 7). The coastal zone as a whole has shown only a little increase in population in the period 1980-1999: about 21.000 inhabitants (only 2% in 20 years). Large differences occur locally: The Hague (Den Haag) looses 22.300 inhabitants (5%) in this period and Ijmuiden increases with more than 10.000 (7%).

Prognoses of the total population development show a decrease of 2% in 2020 relative to 2000.

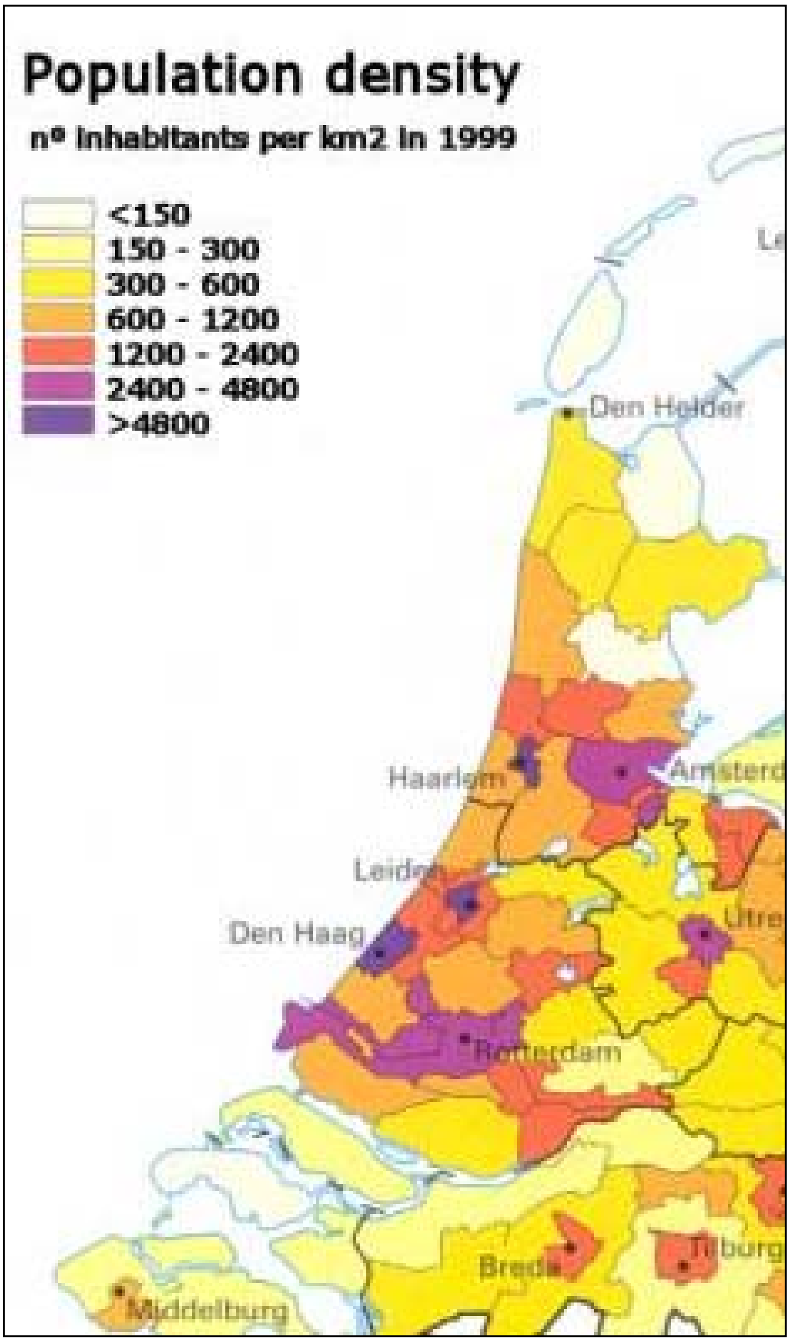

Fig. 7: Population density of North and South Holland in 1999 (ed. Wolters Noordhoff, 2001).

1.2.2 Major functions of the coastal zone

- **Agriculture and horticulture**: in the north and south Holland coastal zone, the main specialised agricultural fields are the bulb-growing industry and the cultivation under glass. At present The Netherlands is still a large exporter of agricultural products. However the export products mainly exists of flowers, vegetables and dairy . Basic food products are largely imported.

- **Fisheries and aquaculture**: offshore fishing is mainly restricted to the North Sea, and the sector has the higher productivity of the EU and a strong exporting position. The relevant fish species are herring, mackerel, codfish, shrimp, shellfish and flatfish.

- **Urbanisation**: the pressure on the coastal zone is still increasing, and therefore the spatial use becomes more intensive in the Holland coastal zone. There is an increasing need for high qualitative urban locations in a high quality living environment and the coastal zone can offer this. This is the major pull-factor for urbanisation in this zone.

- **Water management**: water is of great economic significance to The Netherlands. Investing in effective water management (protection and exploitation) will lay the foundation for the development of a high-quality industrialised society.

- **Industry, transport and energy**: Dutch industry is both high-tech and varied. Practically every sector is represented in the Netherlands. Nevertheless, there are two sectors that clearly dominate as regards the volume of production: the chemical and food processing industries. The Netherlands has a long tradition of transport: Seagoing vessels annually carry tens of millions of tonnes of goods in and out of Rotterdam, the world's largest seaport. And Schiphol Airport, near Amsterdam, is Europe's fourth largest airport for both goods and passengers. It supplies energy to Europe, serves as the entrepot for oil products for the whole of northwestern Europe, and is an international champion of sustainable energy.

- **Tourism and recreation**: the Holland coast is one of the most important tourist destinations in the Netherlands: 30% of the short holidays are spent at the coast. The growth of coastal tourism has been reduced by international competition, lack of innovation, and the absence of coastal resorts with an own identity.

1.2.3 Assessment of capital at risk

According to the climatologists the climate is changing; the frequency of storms will increase, as will the sea level rise. Without interference the risk of flooding will increase considerable. As a result of the urbanisation of the coastal area and the presence of a large part of the Dutch population and economy in the low-lying polders (beneath sea level) behind the dunes, the damage will be enormous. In view of the uncertainty to the extent of the change in climate, the exact capital at risk is uncertain. Further investigation is needed to understand the climate changes. If the changes are understood the capital at risk can be estimated.

The disaster in the South West Netherlands in 1953 claimed 1835 victims and caused a total damage of about 0.7 billion Euro. The total loss potential of the Holland coastal zone, is estimated to be approximately 300 billion Euros (Kok et al., 2002). Due to this high possible financial-impact there is no flood insurance since the flood event of 1953 (due to possible bankruptcy of insurance companies). Currently, the Calamities Compensation Act' (WTS) compensates most of the flood damage which is not to be insured.

2. PROBLEM DESCRIPTION

2.1 Eroding sites

For the Holland coast the main eroding sites are north of IJmuiden: Callantsoog - Petten and Bergen aan Zee – Egmond aan Zee. Cross-shore division indicates that, generally, the dune system accretes while the beach, surf zone, middle and lower shoreface erode. The dune region is generally gaining sediment, through entrapment by dune management activities, although north of Ijmuiden they also undergo erosion over short distances. The beach region shows accretion south of Ijmuiden and erosion in the north of Holland.

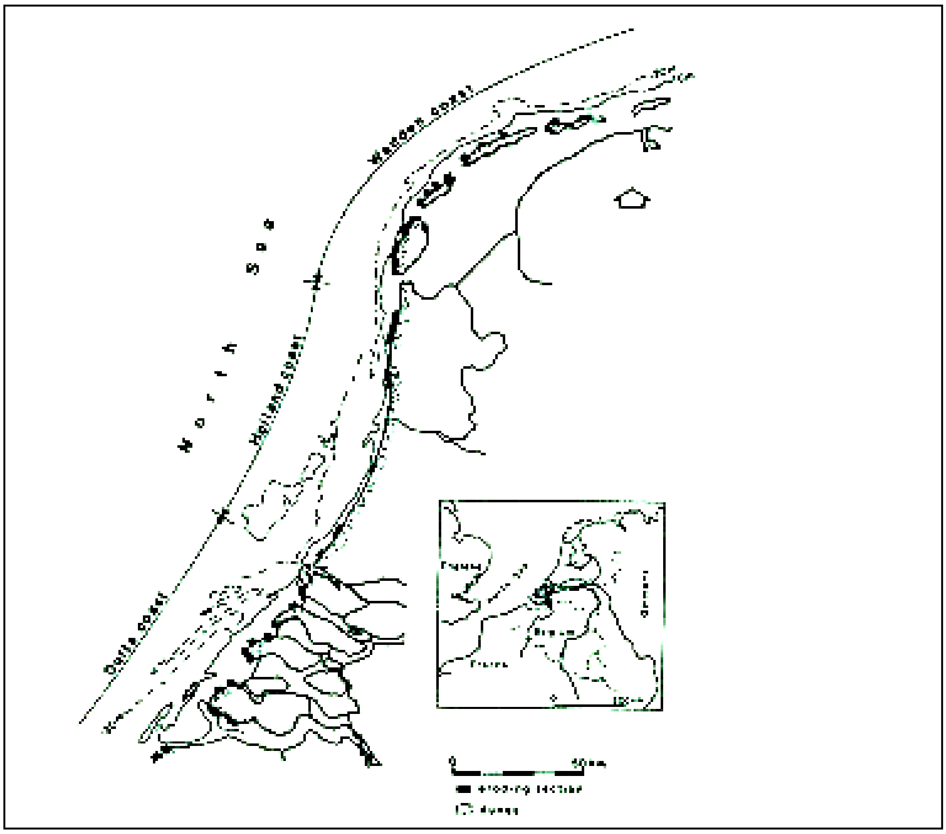

Fig. 8: The Dutch coast - eroding areas (Editors, Louisse et al., 1990).

2.2 Impacts

At the moment the defence action mostly exist of sand nourishment. Sand nourishment involves the deposition of a layer of sand on the seabed or beach, causing burial of its habitats, but also providing new surface area to be colonised. After sand extraction and nourishment a decrease in species abundance and biomass occurred, followed by a development of opportunistic species.

As a result of beach nourishment the safety of the dunes can increase. The sand nourishment may have effect on the local morphology of banks and gullies. This might have consequences for the navigation, especially close to the harbour.

3. SOLUTIONS/MEASURES

3.1 Policy options

Hold the line.

In 1990 Parliament adopted the envisaged policy of the Dutch government to stop further structural coastal recession. The Ministry of Transport, Public Works and Water Management established the 'basal coastline' as the position of the coastline on 1ste January 1990 and determined that the coastline should be prevented from moving inland. The coastal policy of 1990 is referred to as 'dynamic preservation', because where possible (from a safety point of view) maximum freedom is offered for natural processes.

3.2 Strategy

3.2.1 Approach related to the problem

Before 1990 the policy with regard to coastal protection was to make use the natural processes along the coast. After the policy 'dynamic preservation' was put into practice a 'soft approach', like sand nourishment, was adopted. Coastal defence actions are merely based on sand nourishment. This is a relatively cheap method and it fits with the natural characteristic's of the Dutch coast.

3.2.2 Issues concerning threat to life and property

Since 1990, the number of buildings in the erosion zone is increasing and buildings already located in this zone face an even greater chance of erosion. For this reason, supplementary measures are required. There are three options:

- <u>Keeping pace</u> with sea level changes entails maintaining the current location of the erosion lines.
- <u>The inland scenario</u> allows for the inland shift of the erosion lines. Narrow dunes are widened by creating sand buffers.
- <u>The offshore solution</u> focuses on reducing the level of erosion during storms by moving the erosion lines offshore.

3.3 Technical measures

3.3.1 Historic measures

Throughout history, the Netherlands has fought a continuous battle to control water (see Figure 9). Since the storm surge disaster of 1953, large parts of the sea defences along the Dutch coast have been strengthened. Before 1990 the policy with regard to coastal protection was to utilise the natural processes along the coast wherever possible.

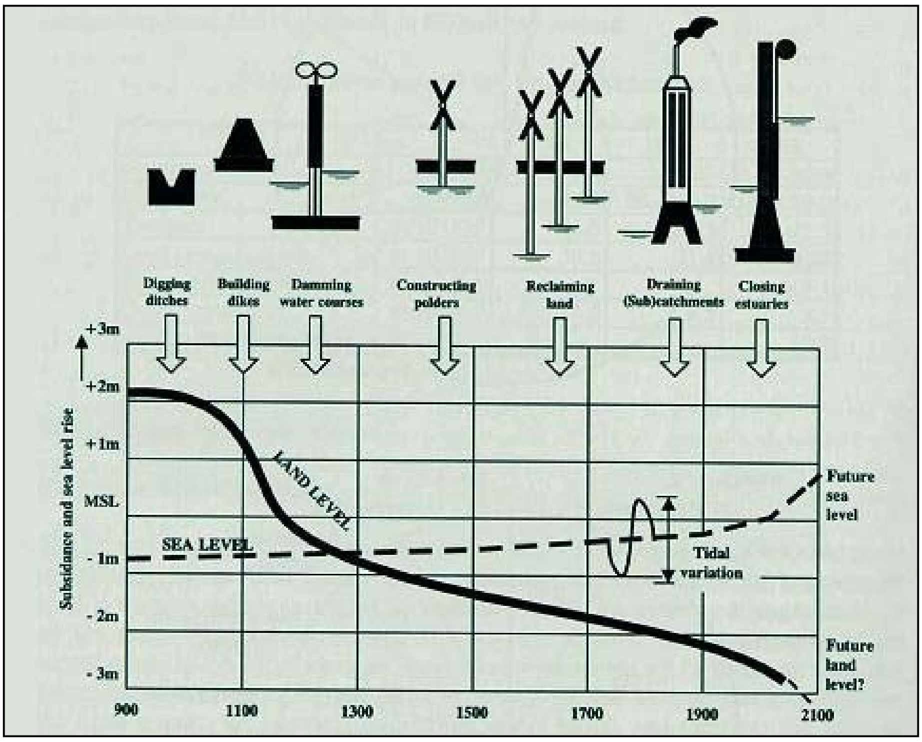

Fig. 9: Stepwise respons to the increasing subsidence of land and sea level rise over time (Editors Louisse et al., 1990).

3.3.2 Type / Technical details

In the Netherlands coastal defence actions are merely based on sand nourishments. The sand nourishment method has been chosen because it is relatively cheap method and because it fits with the natural characters of the Dutch coast. Besides it is flexible approach towards combating coastal recession (soft approach).

Fig. 10: Sand nourishment in Schouwen-Duiveland (Dutch coast).

The sand is extracted from outlying sea bottoms of depths greater than 20 meters in order to minimize disruption of life on the sea bottom and to ensure that the coast is not undermined. With suction-hopper-dredgers the sand is brought to the coast where pipeline connections make the nourishment possible (NORCOAST, 1999).

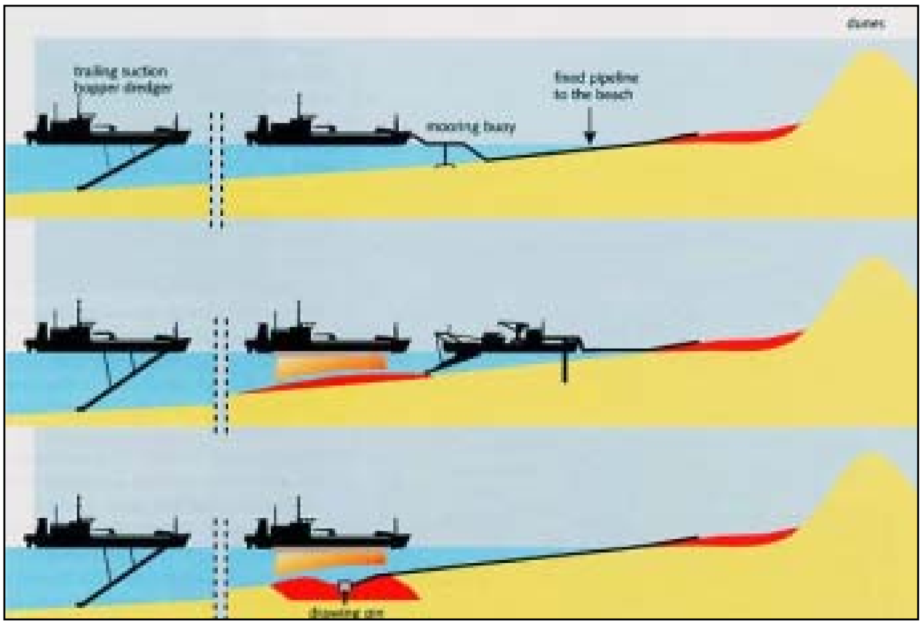

Fig. 11: Methods of extracting sand by trailing suction hopper dredgers (V&W, 1996).

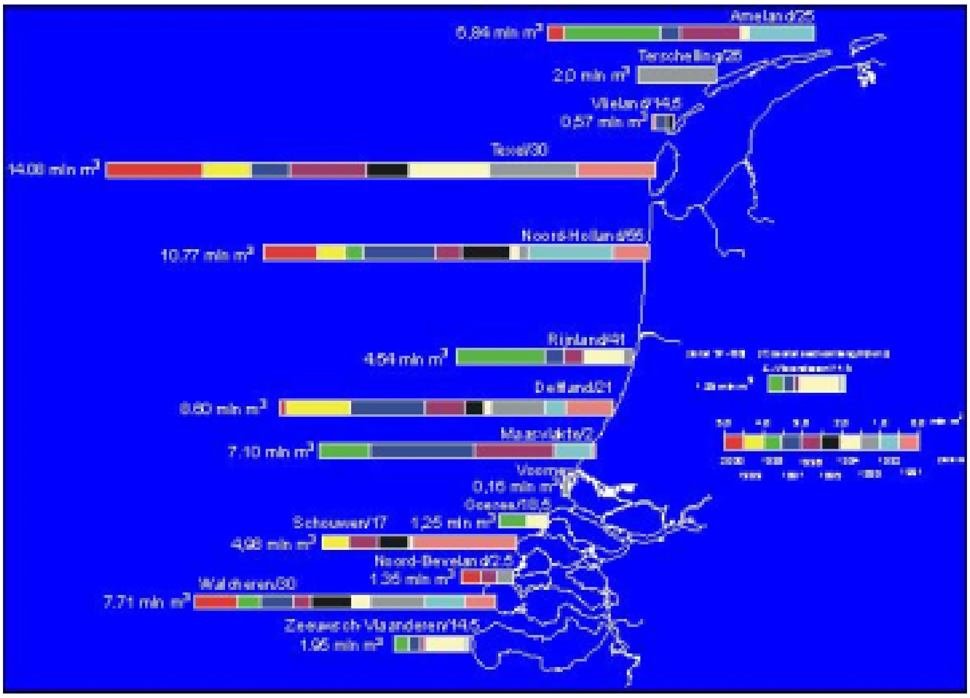

Fig. 12: Amount of sand nourishment between 1991 and 2000.

But despite the extended soft measures, some hard structures, such as groins at Ijmuiden, were performed.

3.3.3 Costs

An annual budget for coastline management of € 40 million, which is 12 million m3 sand per year. These costs per km are comparable with maintenance costs of 1 km motorway.

For an indication of cost of hard structures see the Wadden Case.

4. EFFECTS AND LESSONS LEARNT

4.1 Effects related to erosion

The extraction of sand causes the removal of sediment and its associated organisms, leaving the remaining sediment open for recolonization. Sand nourishment involves the deposition of a layer of sand on the seabed or beach, causing burial of its habitats, but also providing new surface area to be colonised. Colonization of a disturbed area may take place by immigration from its surroundings and by settlement of larvae from the water column. Both after sand extraction and nourishment a decrease in species abundance and biomass occurred, followed by a development of opportunistic species. (Dalfsen & Essink, 2001).

4.2 Effects related to socio-economic aspects

Research will be done after the co-operation between sand nourishment for safety reasons (Rijkswaterstaat) and for recreation target ends (Provincial and Municipal authorities along the coast).

4.3 Effects in neighbouring regions

The breakwaters constructed at Ijmuiden are blocking sand flow, as a result of which sand is able to accumulate on both sides. This enabled the development of the Kennemerstrand beach on the southern side. Further to the north (Heemskerk, Wijk aan Zee) and to the south (Bloemendaal, Zandvoort), the effects of the breakwaters are still visible in increased coastal erosion, thirty years after their construction. The construction of breakwaters at Hook of Holland has had a similar result.

4.4 Relation with ICZM

Since 1990 the policy of the coast is based on coastline management. In 1995 the policy changes to coastal zone management, sustainable safety with spatial quality and since 2000 the emphasis lies on the next step, ICZM. Integrated spatial policy is required to combine functions optimally and responsibly. The policy for the coast should focus on sustainable spatial quality, while maintaining safety. Safety- demands and risk management are a factor in the discussion concerning coastal policy, with the other objects.

4.5 Conclusions

The effects of using artificial constructions to retain sand are unpredictable and will affect the coast for years. The breakwaters constructed at IJmuiden in 1870 – extended at the beginning of the 1960s – are blocking sand flow, as a result of which sand is able to accumulate on both sides. This enabled the development of the Kennemerstrand beach on the southern side. Further to the north (Heemskerk, Wijk aan Zee) and to the south (Bloemendaal, Zandvoort), the effects of the breakwaters are still visible in increased coastal erosion, thirty years after their construction. The construction of breakwaters at Hook of Holland has had a similar result. As a result the technique of sand nourishment is used to fight structural erosion. Erosion is combated by soft measurements first and when this does not work by hard measurements.

After almost 10 years of experience with Dynamic Preservation (the soft approach) an evaluation has been carried out. The results of the evaluation are satisfactory. The task, which the national government undertook in 1990, the fighting of structural erosion, can be carried out with sand nourishment. Only on a few locations in the province of Zeeland that have very steep underwater slopes, there is concern about the sustainability of the method. Attention is being paid to it in the coastal research programme.

It can be concluded that with the new coastal policy the structural erosion is under control. The control of the coastal development is offering opportunities for new developments. There are opportunities for allowing natural fluctuations, breaches in the foredune and drifting dunes. Unwanted developments may be stopped or reversed by sand nourishment.

5. REFERENCES

Beets, D.J.; van der Valk, L.; Stive, M.J.F. (1992). *Holocene evolution of the coast of Holland*. Marine Geology 103, 423-443.

Berendsen, H.J.A. (1997). *De vorming van het land: inleiding in de geologie en geomorfologie.* (In Dutch)

Louisse, C.J.; Stive, M.J.F.; Wiersma, H.J. *Eds*. (1990). *The Dutch coast*. Report of a session on the 22nd International Conference on Coastal Engineering 1990. Preprints of the papers to be published by the American Society of Civil Engineers.

Ministry of Transport, Public Works and Water Management (V&W), Directorate-General of Public Works and Water Management, National Institute for Coastal and Marine Management/RIKZ (1996). *Coastline Management: from coastal monitoring to sand nourishment.*

Ministry of Transport, Public Works and Water Management (V&W), Directorate-General of Public Works and Water Management (2002). *Towards an Integrated Coastal Zone Policy: Policy Agenda for the Coast.*

Mulder, J.P.M. (2000). *Zandverliezen in het Nederlandse kustsysteem – Advies voor Dynamisch Handhaven* in de 21e eeuw. RIKZ/2000.36.

Netherlands Hydrological Society (NHV); Netherlands National Committee of the International Association of Hydrological Sciences (IAHS) (1998). *Water in The Netherlands.*

Norcoast (1999). *Review of national and regional planning processes and instruments in the North Sea regions – Full study.* European regional development fund interreg IIC, north sea region. Community Initiative concerning Transnational co-operation on spatial planning 1997-1999.

Provincie Noord-Holland & Provincie Zuid-Holland (2002). *Strategische visie Hollandse kust 2050.* (In Dutch).

Stolk, A. (1989). *Zansysteem kust – morfologische karakterisering*. Kustverdediging na 1990, Report GEOPRO 1989-02, Department of Physical Geography, Utrecht University, 97 pp. (in Dutch).

Van Rijn, L.C.; Ruessink, B.G.; Mulder, J.P.M. *Eds*. (2002). *COAST3D – EGMOND The behaviour of a straight sandy coast on the time scale of storms and seasons. Process knowledge and guidelines for coastal management.* EC MAST Project No. MAS3-CT97-0086.

Wolters Noordhoff (2001). *De Grote Bosatlas*, 52e editie.

Internet:

www.cbs.nl

www.coastbase.org

www.provincie-noordholland.nl

www.waterland.net

www.ihe.nl