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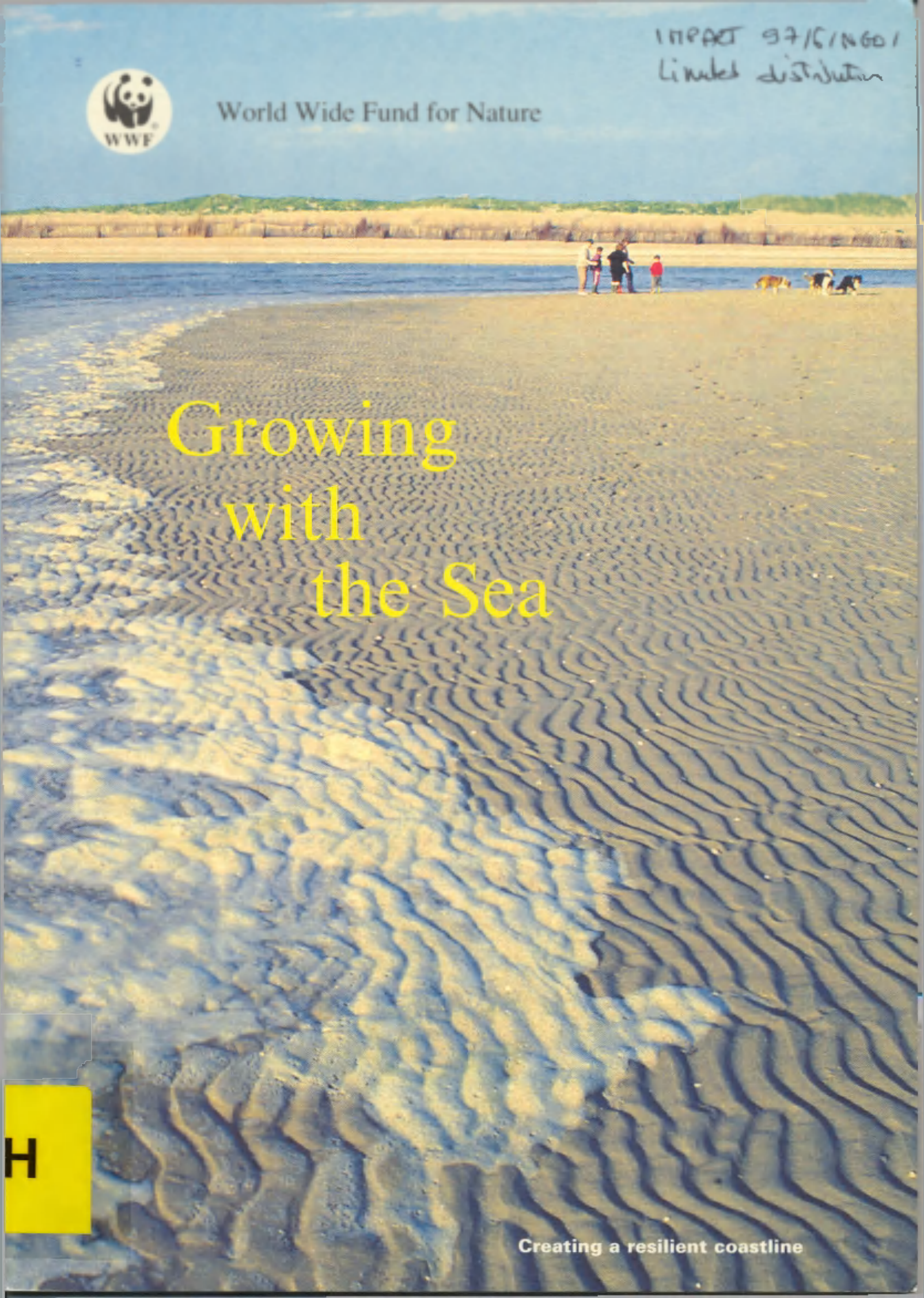


Growing with the Sea

Creating a resilient coastline

World Wide Fund for Nature

WWF

Growing with the Sea

Creating a resilient coastline

Contents

Foreword

The Netherlands' relationship with the sea is entering a new era. Slowly but surely, rising sea levels and subsidence of the land are compelling us to adopt a new approach to physical planning. Activities in coastal areas will henceforth have to be assessed more critically to determine their impact on the resilience of the Dutch coastline.

Subsidence is by no means a recent phenomenon. Large areas of this country are now several metres lower in relation to the North Sea than they were in the Middle Ages. This process, which is already relatively rapid, may well be further accelerated by climatic change.
Our coastal policy therefore needs to be drastically revised. Higher dykes and more powerful pumping-stations may offer a temporary solution, but in the long run such technology merely brings Atlantis closer. Rigid defences of this kind will further upset the water, sediment and salt balance of the Dutch coastline and so undermine the Netherlands' most valuable ecosystems.

Long-term solutions can only be found if the Dutch coastline is placed in a broad geographical context – from the southern estuary to the Wadden Sea, from the peat bogs and rivers of the hinterland to the North Sea.
This huge, fertile delta – the lifeblood of the Dutch economy – needs space in order to preserve the sediment and water regime on which its survival depends. As this booklet makes clear, by creating more space for the natural process of delta formation, we will ultimately create more space for ourselves.

The title of this study – 'Growing with the Sea' – well expresses its essential philosophy:

- First of all, our estuaries, dunes, lagoons and peat bogs have a natural capacity to grow in response to rising sea levels. At the moment they lack the space to do so, but there are many places where this can be remedied. This will also create large, gradient-rich nature areas in which a wide variety of plants and animals can more effectively withstand fluctuations in the climate.
- At the same time, large nature areas which can grow with the sea are ultimately our best means of protection against flooding. They will also be ideal places for recreation and housing, and excellent sources of drinking water. By reducing the cost of flood control and, at the same time, taking the fullest possible advantage of rising sea levels, the Netherlands can even derive economic benefits from its position as an 'urban waterland'.

The fertile **delta** needs space in order to preserve the **sediment** and **water regime** on which its survival depends

Broad dunes which can grow with the sea are ultimately our best means of protection against flooding.

- Finally, there is the psychological aspect. The Dutch need to realize that, in the long run, a dynamic approach to the sea offers better prospects than unyielding confrontation.

'Growing with the Sea' is a contribution to the current debate on the Dutch Government's Coastline Report and Fourth Water Management Report. It also sheds new light on the future development of the highly urbanized western Netherlands. New ways of thinking are suggested for the future, and relevant current initiatives are identified. The study is based on ideas already put forward by the Ministry of Transport and Public Works, the Ministry of Housing, Physical Planning and the Environment, the Ministry of Agriculture, Nature Management and Fisheries, environmental organizations, district water boards, drinking-water supply companies and numerous other organizations in coastal areas. The authors have combined these ideas with new ones of their own to produce a comprehensive plan for the entire Dutch coastline.

Only by continuing to cooperate in this way can we truly make a virtue of necessity and put these ideas into practice. For the sake of future generations, I hope we have not left things too late.

Drs. F.H.T.M. Nijpels
Chairman, World Wide Fund for Nature (Netherlands)

1 Creating a resilient coastline

Originally, the Dutch estuary was an upward growing area. Sand and silt were steadily carried in by the sea and the rivers, the sand dispersed into dunes and peat bogs developed in the isolated wet low-lying areas. In thousand of years, sedimentation and peat forming caused the estuary to rise by dozens of metres and relatively little land vanished into the rising North Sea. They also created a landscape with great variety of water and soil types and a rich flora and fauna.
As a result of these natural processes, land and water achieved a dynamic balance and it seemed a simple matter to protect the relatively high land against the extremes of the climate.

But things have turned out differently. By artificially maintaining the coastline, enclosing the salt-marshes, draining the peat lands, damming the estuaries and extracting gas we have manoeuvred ourselves into an awkward position. Large parts of the Netherlands have subsided below the level of the sea and are protected only by a narrow line of dunes with a dwindling sand supply. Our already limited freshwater supply is used to counteract saltwater seepage.
The economic advantages of land reclamation once seemed evident, but it will make us more and more vulnerable in the future. It will force us to protect the land at ever increasing expense, and the consequences of a flood will be increasingly disastrous.
The combination of rising water and subsiding land is reducing the space available for natural transitions and the quality of life of the local people.

Now that world-wide climatic change is predicted, it is important to develop a strategy for the Dutch coast which would give long term guarantees of safety while maintaining or even enhancing our freedom of movement and quality of life. In this connection, the concept of 'resilience' stands for the ability to deal flexibly with both natural and social dynamics in the coastal area.

By developing resilient nature areas as vast buffers for sediment (in broader dunes and salt-marshes) and water (in large lagoons and peat bogs), we will create room for ourselves to counteract unpredictable climatic change.
Besides discontinuing certain forms of land use and emphasizing others, we must also promote functions that are compatible with a flexible coastal management, such as recreation and drinking-water supply.
What is more, the natural system will then be in a better position to anticipate climatic changes. Broader gradients will allow plants and animals to respond more flexibly and give them more room to manoeuvre.

By artificially maintaining the coastline, we have manoeuvred ourselves into an awkward position

Large gradient rich nature areas are needed to allow species an escape route when the climate changes

2 The urban waterland

In the last few decades, the Netherlands has swiftly developed from an agricultural into an urban society. The days when we needed every inch in the Netherlands for growing food are long past. As a result of international market developments, the agricultural sector is producing more effectively using less space and causing less environmental pollution.
It could be said that these developments in agriculture are allowing a more flexible use of space. This is a great advantage in coastal areas where such flexibility is badly needed.

This is therefore a crucial moment for physical planning. Developments in agriculture are making it possible for us to break out of the vicious circle of drainage and subsidence. At the same time there is the risk that any available space will instantly be used up for expanding housing estates, infrastructure and industrial areas, making protection against flooding even more necessary.
The longer we delay intervening in urban development, the less space there will be for natural buffers and the more difficult (and expensive) it will be to anticipate climatic change.

In the Netherlands, the development of towns, industry, agriculture, transport and services was increasingly independent of nature. At the same time nature areas are in demand for recreation, drinking-water supply, housing, and as a means of flood protection. This contrast must form the basis for future developments in the coastal area. This means concentrating or relocating capital-intensive functions so that the area requiring drainage can be reduced. Such wetlands are the ideal environment in which to combine such important features as flood protection, (buffer zones for water and sediment), drinking water supply, nature conservation and recreation. Nature development must therefore be integrated more often into large urban development and infrastructure projects, not as a token gesture, but as a positive investment in the future.
This will create the prospect of an urban waterland in which the link between town and nature can grow into a multi-faceted relationship by:

- letting natural areas function as drinking water reservoirs;
- letting housing development projects contribute to the financing of new nature areas by 'mark constructions' (*see chapter 5*) and by adjusting them in accordance with the natural environment;
- increasing the freedom of movement of the inhabitants in readily accessible nature reserves close by towns;
- creating extensive nature reserves to buffer the impact of extreme water levels at sea or in rivers. Excess rainwater can then be stored close to towns and agricultural areas, and the agricultural sector can benefit from this in periods of drought;
- improving the quality of surface waters in extensive marshes and flood plains;
- storing carbon in expanding peat bogs and marshy woodland, helping to reduce the greenhouse effect;
- using building materials (sand, clay) from nearby conservation areas in such a way as to stimulate natural processes. Deep sand pits can encourage sludge to settle and so increase the transparency of the shallow water in the vicinity. Removing earth can also have a positive effect on the acquisition of land for new nature areas.

Developments in **agriculture** are making it possible for us to break out of the vicious circle of **drainage** and **subsidence**

3 Restoring natural resilience

To counteract the rough side of its climate, large sediment and water buffers are needed to give the Dutch coastal area long-term protection.
If natural processes are used sensibly, extensive nature reserves can provide the necessary buffer capacity. The possibilities that this approach provides are specified below, and the details of the particular areas are given on the following pages. Their relevance to the whole coastal area will always be kept in mind.

Rivers
For the supply of water and sediment from the hinterland it is important that the enthusiastic application of the principles from 'Living Rivers' be continued. If more space is given to brooks and rivers (along the forelands and between the main dykes), the bed is less severely scoured which causes the surrounding area to be less drained. Broadening the flow profile will contribute to a safer transport of water and will increase the natural purification process. For the latter a more natural vegetation is very important. Developing alluvial forests in the valleys of streams and the upper reaches of large rivers will also be a contributory factor in the downstream safety because the water flow is slowed down. Removal of the summer dykes of the upper reaches will give a better sediment transport to the estuary and will break the vicious circle of accretion and dyke reinforcement in the river area itself.

Estuaries
Broadening the sea arms and river mouths at the estuaries serves more than one purpose. The area of mud flats and salt marshes, which keeps on growing with the sea as a result of accretion, will increase. At the same time, the tidal volume will increase and the channels will deepen. The sand from these channels will be available to form outer deltas and coastal dunes. An open connection with the sea is of course very

Growing with the Sea' is building with water. The cleaner the water, the more value it has as drinking water and for nature, recreation and living conditions.

increasing resilience

the coloured sections are areas in which important measures to increase resilience are planned

Broader dunes
- Broadening narrow dunes (on the inland side: North-Holland; on the seaward side: South-Holland)
- Sand supplementation

Indented coastal strip with tidal gullies and lagoons
- More dynamic interactions in broad dunes, more room for sand deflation, including in and
- Restoring the natural water regime, freshwater supply

New brakish water areas
- Restoring the saltwater/freshwater gradient
- Broader natural shorelines
- Increasing tidal action

Open waters
- Expanding the tidal plain
- Larger sedimentation area
- Expanding the area of mud flats and salt marshes

Wetlands along the northern coast (The Wadden)
- Reducing "thirst for sand" caused by seepage extraction
- Expanding the area of salt marshes

Freshwater lagoons
- Higher levels in winter / lower levels in summer
- Broader belts of marshland

Rising marshland
- Reducing the area of land requiring coverage
- Water storage of peak water levels in reflooded areas
- Storage of water in subsiding peat bogs

Living rivers
- Water retention in broader flood plains
- Better sediment transportation

Development of marine wildlife reserve in coastal areas and parts of the North Sea to restore the ecological balance including large species with a long life span.

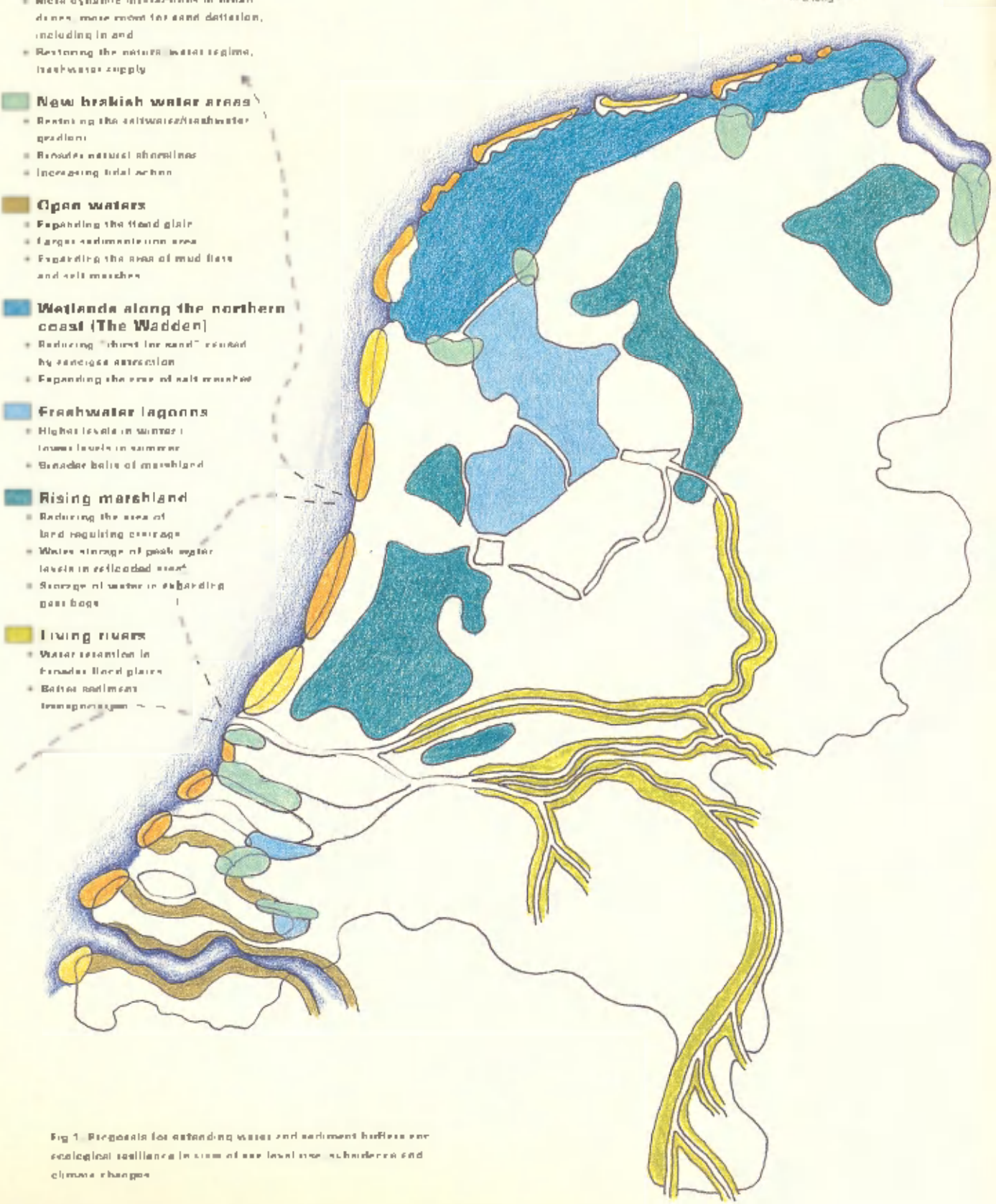


Fig 1. Proposals for extending waters and sediment buffers and ecological resilience in view of sea level rise, subsidence and climate changes

To counteract the rough side of its climate, the Dutch coastal area needs long-term protection

important here. By partially opening up the dams and locks and upgrading them to storm surge barriers, both the ecologically important freshwater saltwater gradient and the open connection with the rivers and the sea can be restored. By removing the dykes at the rear of the estuaries high water levels will be reduced considerably. These wider floodplains are urgently needed in case high river water coincides with spring tide in the sea.

Coastal dunes
To maintain sufficient width, the coastal dunes need sand which can be obtained from the sea by both sand supplementation from the deeper parts of the North Sea and, as mentioned above, the increase of tidal volumes in the southern estuary and the wetlands that line the shores of the north of the Netherlands. On the landward side, the sand from the undersoil can be mobilized by local extension of the coastline.

Lagoons
More natural fluctuations in water levels can encourage the formation of marshes in a great number of large lagoons (the IJsselmeer, the Volkerak), which will contribute to the purification of the passing river water. It will also counteract the erosion of the banks. If surplus dredging is processed in a controlled way to isolate pollutants from the environment, the area of marshland can be extended by tens of thousands of hectares in the next century.

Peat bogs and reclaimed land
Drainage of peat bogs and reclaimed land should gradually be reversed by raising the water level which means that in large areas the subsidence of land will come to a standstill. For each polder we can opt for either storage of clean drinking water in expanding peat bogs or for buffering peak drainage (rain and/or river water) in a more dynamic aquatic environment. Should the lower parts of the Netherlands become more independent of water supply (less drainage and less salt water seepage to be flushed out) there is the possibility that water management in other parts of the country could be handled with much more flexibility.

Water quality
We must stress the point that it is of vital importance for the Netherlands to clean up its water sources and to keep them that way. Many waters are still too polluted for shoreline and aquatic plants to develop. As a result, there is hardly any natural purification and we have to spend relatively large amounts of money on removing nitrogen and phosphates artificially. Indirectly, cleaner water also means cleaner sediments. Large quantities of dredging which could be used to bring the sediment balance to the required level in some areas cannot be utilized because of its poor quality. The forming of larger inundation areas, more natural water levels and new marshes will contribute to both the quantity and the quality of the sediment and water regime in the Netherlands.

On the next page a specification is given for the various locations.

4 The coastal sea

Much can be gained by taking advantage of the natural variations of the coastline at the seaside of the Dutch delta. This may be reached by promoting seaward development of the Voordelta but also by allowing the sea to enter the broader dunelands, provided that it doesn't jeopardize the safety of the hinterlands. New sand flats, tidal gullies and lagoons will strengthen the function of the coastal sea as spawning and maturing grounds for numerous marine animals.

Man-made operations upon the coastal sea may increase the resilience and the quality of the coastal area if they are in harmony with the natural erosion and sedimentation patterns or may perhaps intensify them.

Thoughtfully located and supplied with sand, possible land reclamation projects ('Kustlocatie', 'Tweede Maasvlakte') or marine energy parks can also contribute positively to the sediment balance of the nearby coastal area.

The North Sea has so much more to offer than sandy beaches, and filled herring-barrels

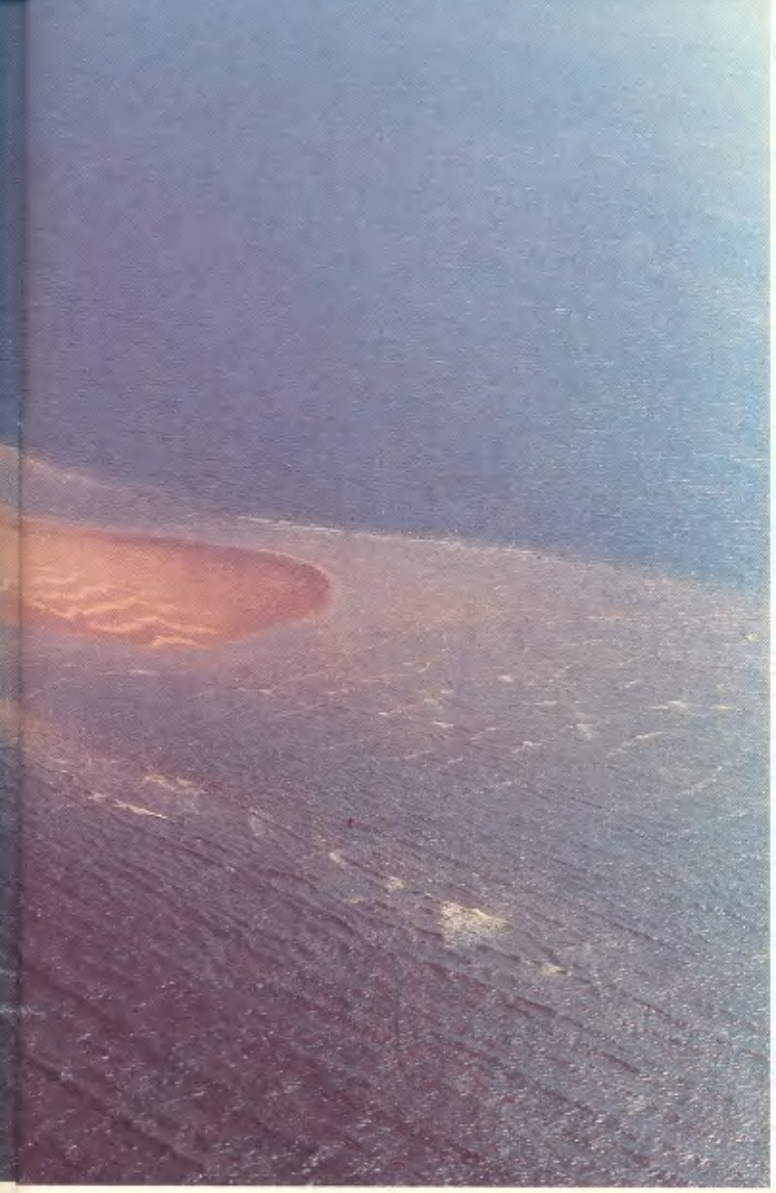
Fisheries and nature development

It is recognised that in the Dutch part of the North Sea [illegible] there is at present an excess in overall fishing for human consumption, too large a loss of bycatches and destruction of bottom fauna because of coarse fishing methods. This is already resulting in severely impoverished bottom fauna and in a considerable reduction of the other species. It is an increasing conflict with natural predators like the cormorant and the [illegible]. As it occurs in agriculture, the solution must be found in technical improvement of fishing methods but also in the protection of important spawning and maturing grounds. The result of the combination of these measures will be a larger supply of fish from the protected areas and a more efficient catch of fish, and the commercial fisheries will have more use of area by these protected areas. Modernizing the fishing methods means in the first place reducing the capacity of the fishing fleet. Redundant fishing vessels can be converted and used for amateur fishing and other recreational purposes.

By switching from fishing on fish to [illegible] the harvest from nature reserves can be cut down. What is happening now with [illegible] a marginal [illegible] in the [illegible] can be [illegible] other fish species. Improving fishing gear will also reduce bycatches, which are often larger than the catch for human consumption.

At the same time, we can work on improving the natural fish stock by:

- protecting the major spawn and maturing grounds in the North Sea. This will give a more stable fish population which is better equipped to ensure a healthy balance in fish generations;
- restoring the saltwater/freshwater gradient in waters like Haringvliet, Amstelmeer, and the Afsluitdijk [illegible] from the North Sea and Wadden Sea. As a result it will be beneficial for the migration of fish and more favourable for mussel and oyster farming;
- improving [illegible] freshwater by more natural [illegible] flood plains, [illegible] marshes, [illegible] water in Markermeer, etc.



A new reef has developed along the coast of the province of Zeeland, a breeding ground for fish, birds and seals, but also a breakwater for the hinterland.

sunsets

A change of the agricultural functions to nature-oriented recreation may also smooth the way for broadening the coastline on the landward side. Adjusting human activities to the dynamic and indented coast will have, in the long term, more prospects than artificially maintaining the coastline, taken the increasing shortage of sand into consideration.

At sea, the quality of productive coastal waters should be further improved by setting up strategically located marine wildlife reserves of sufficient dimensions where a marine ecosystem can develop in all its riches. In speaking of the abundance of the sea we are broaching a subject that is virtually unknown to the Dutch. As it is, the North Sea has so much more to offer than sandy beaches, sunsets and filled herring-barrels. One of the largest shallow seas in the world and influenced by the warm North Atlantic Drift and dozens of discharging rivers, the North Sea has the potential to be a wonder of nature and has a protein production that is larger than that of the entire European agriculture.

In the last century, a walk along the beach was a confrontation with hundreds of darting sea rays. Dolphins and porpoises were turning somersaults along the coast amongst dense shoals of herring and cod. Seals lay in the thousands on the sandbanks and big sturgeons flocked in the river mouths. These scenes may for a great deal be recaptured by restoring marine biotopes, but particularly by further modernizing the fishing industry (see box) giving larger creatures with a long lifespan more chance to survive and minimizing the risk of 'by-catch'. Not only will there be profit for the fishing industry but also for the visitors of the beaches and resorts, the anglers, and of course the consumer, who will find more variety in the fish supply at the markets.

To foster the involvement in the North Sea of the Dutch, former oil platforms could be converted into tourist centres with expositions, fish restaurants and the possibility to visit a wrecked ship.

By accepting the fishing industry and setting up massive wildlife reserves, the Dutch coastal waters may once again harbour dolphins, sharks, rays and whales.

Southern estuary

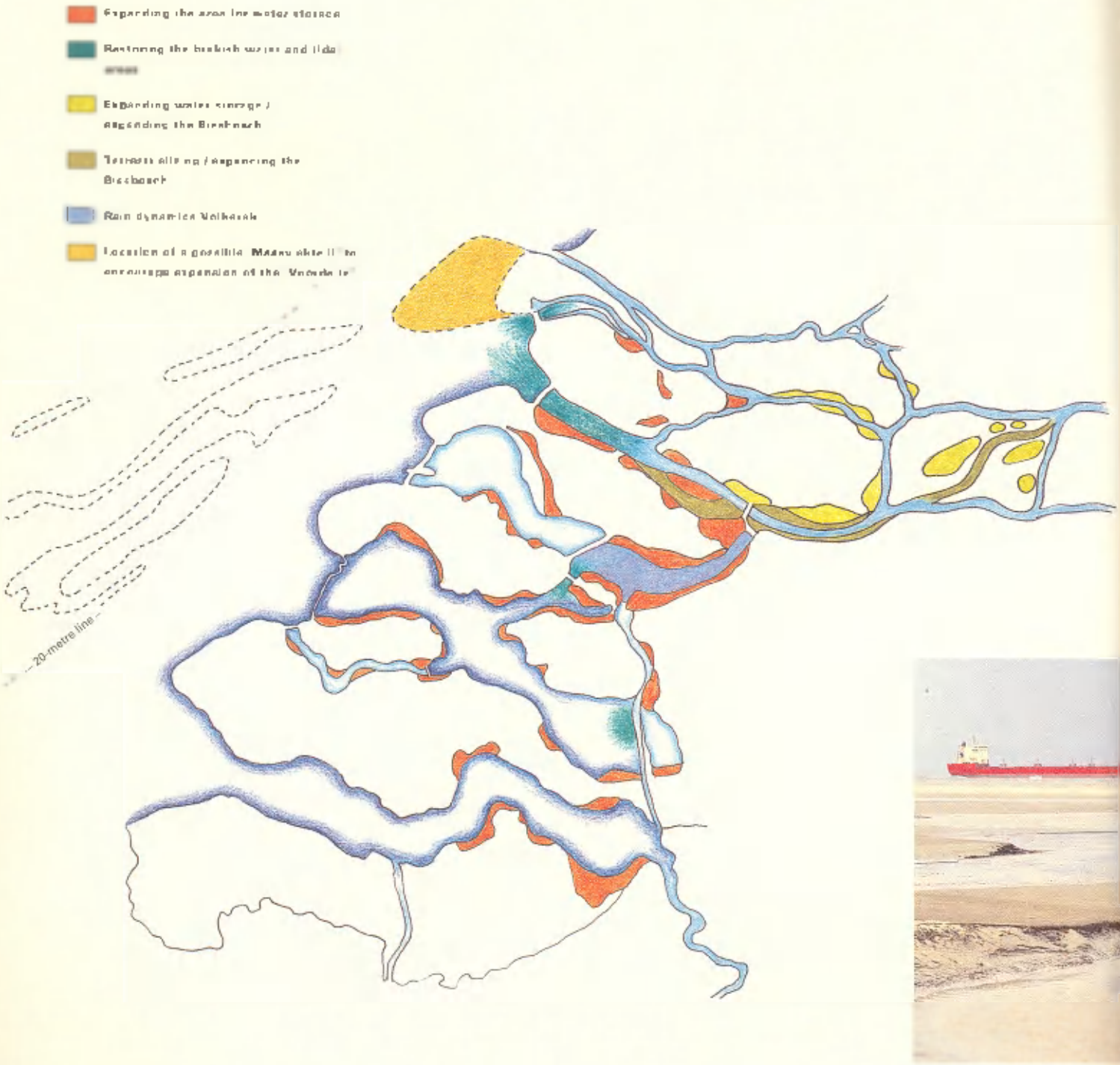


Fig. 2. Working with the sea in the southern estuary

Water storage Westerschelde

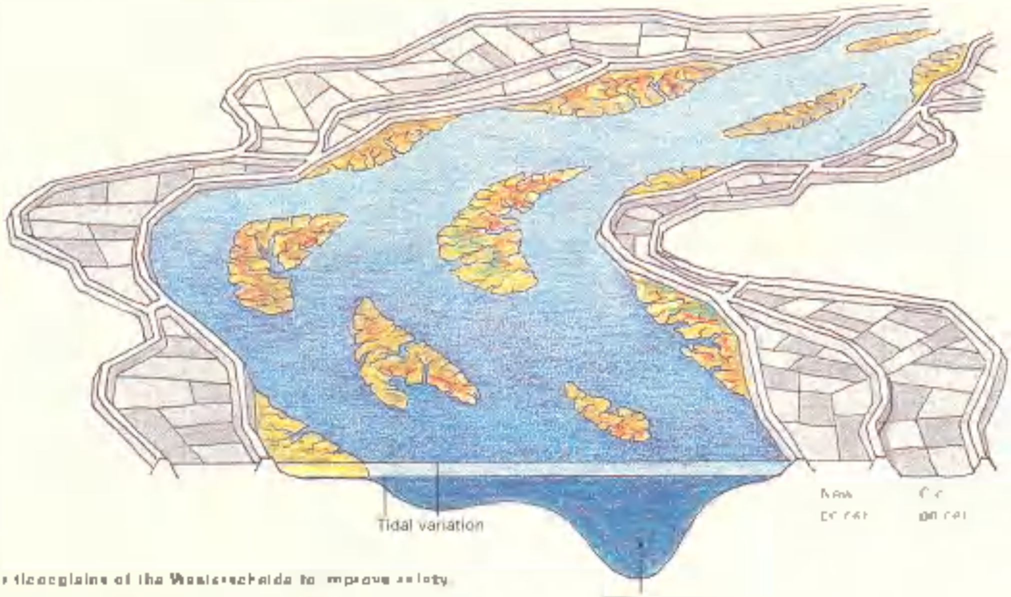


Fig. 3 Wider floodplains of the Westerschelde to improve safety, accessibility of the Antwerp port and to expand the salt marshes and mud flats.

Rotterdam is a prime ecological location

Conservation in an urban environment

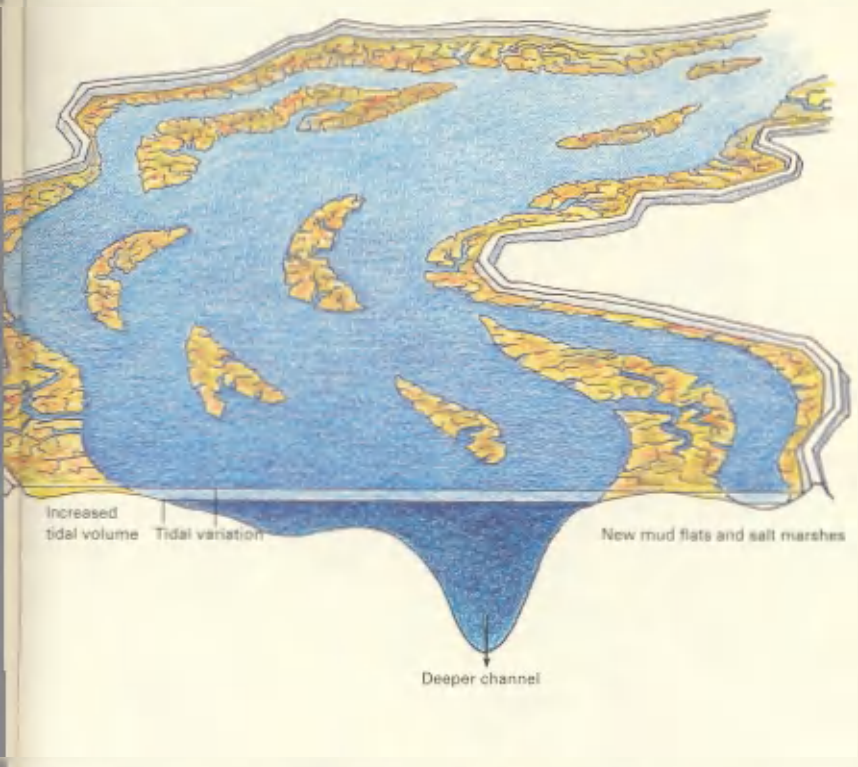
Creating a resilient coastline has implications for urban development. Compact or "feasting" construction is to be preferred to the notion that "every village should have its own new housing estate". Compact housing developments should be developed with new nature areas which are readily accessible on foot, by bicycle or by boat.

New housing developments can contribute directly to the development of nature areas. The money now spent on constructing water reservoirs for new housing estates can be used to create nature areas which perform the same function. In addition, people can be expected to pay a premium for the privilege of living in a natural environment. This extra income can be used for the benefit of nearby nature areas.

In some parts of the highly urbanised western Netherlands, the costs of acquiring and preparing land, together with the constraints imposed by the existing infrastructure, are so great that housing construction can hardly generate any income to help create such nature. Elsewhere, however, income from housing construction can be used to establish large new nature areas.

The public's sense of commitment to local nature areas could be increased if their finances were given long-term form through joint ownership (a so-called "nature" system).

This would make them stakeholders in the nature area, in return for certain privileges such as mooring places for boats, though visitors from elsewhere would still have free access to the area.



Situated at the mouth of the River Meuse and the River Rhine, Rotterdam is among other things a prime ecological destination. Large breeding grounds for seabirds could be developed on the seaward side of the city. Aquatic animals use the Nieuwe Waterweg as their main route between the rivers and the sea.

6 The dunes

A large area of natural dunes is, and will continue to be, of incalculable importance to the Netherlands. One reason why this densely populated country has managed to preserve such a large, unique nature area (40,000 hectares, or 75,000 hectares if the beaches and the fringes of the duneland are included) along its coast is the vital contribution which the dunes make to our safety, drinking-water supply and recreational amenities.

When sea levels rise, the natural tendency is for the coastline to shift inland. The sand thus exposed enables the coast to grow with the sea. In the Netherlands, however, agriculture and urban development have stood in the way of this natural landward shift. Instead, the dunes have been artificially held in place by planting marram grass and conifers and by other measures aimed at maintaining the existing coastal strip. However, erosion on the seaward side has continued unabated, and the shoreline is becoming increasingly steeper.
In order to preserve the various functions of the dunes, this reduction in the volume of sand must be halted. Sand supplementation has so far proved an effective method, especially in areas with shallow coastal waters. Additional sand supplementation could even be used (possibly in combination with newly reclaimed land along the coast) to extend the dunes out to sea. Where coastal waters are deeper, however, the shoreline will continue to get steeper unless more drastic steps are taken.
In the long term, then, it is doubtful whether sand supplementation will suffice. In any case, it seems advisable to keep sand depletion in the Wadden Sea and the southern estuary (see chapters 5 and 7) to a minimum, in particular by increasing the tidal volume. Serious thought will also have to be given to creating additional space for dunes on the landward side.

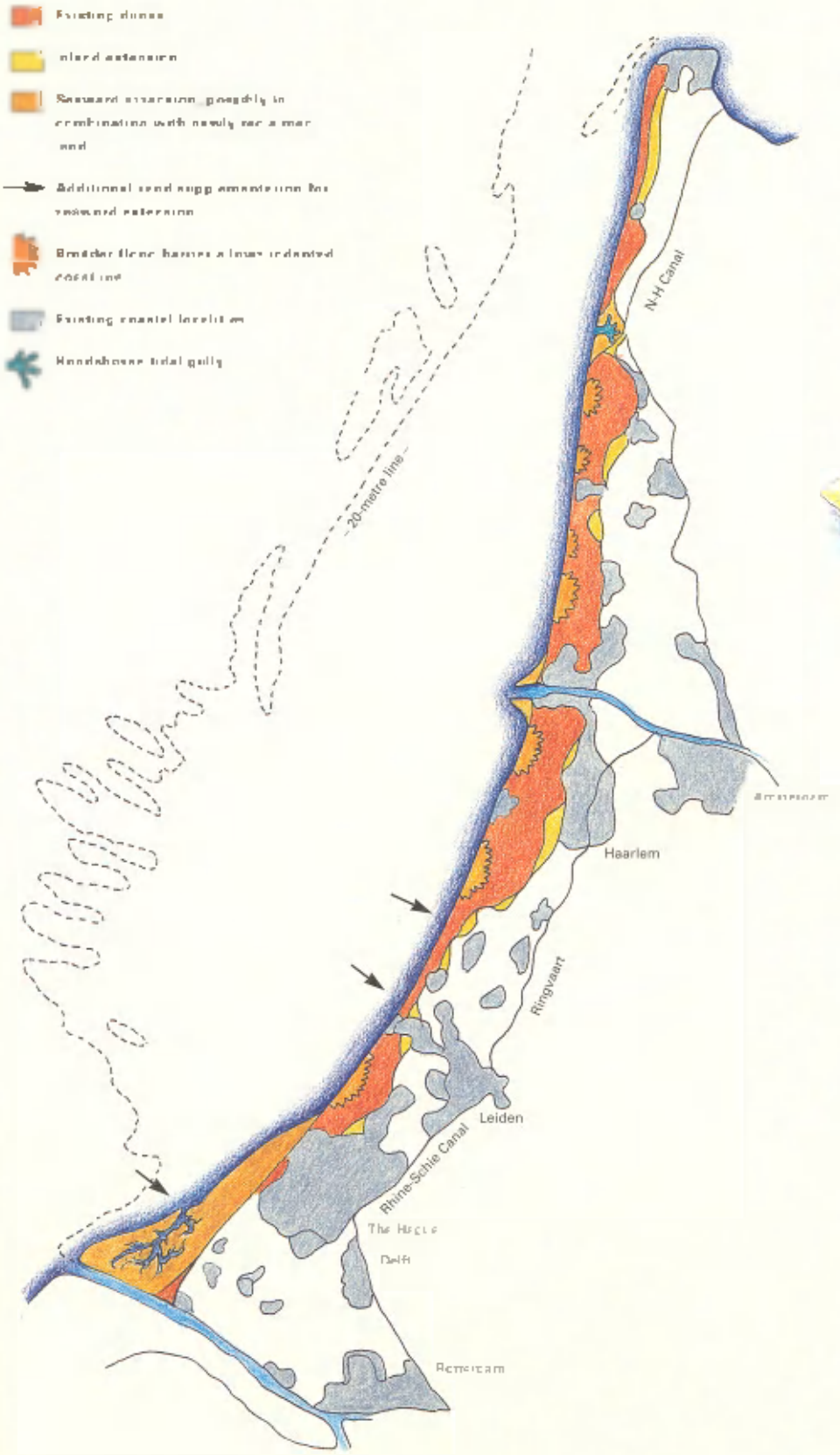
Even disregarding built-up areas and the vast areas currently occupied by glasshouses, there are thousands of hectares of salinized agricultural land which could be purchased for this purpose (see map on page 19). The resulting benefits in terms of nature conservation, flood protection, recreation and drinking water supplies justify the changes in zoning plans that this would entail.

Deflation creates not only new dunes, but also water-filled hollows where sand has been blown away. Once marram grass is no longer needed to hold the dunes in place, dune vegetation will become more varied.

The restoration of natural dynamic processes depends on broadening the dunes. Only then can artificial maintenance of a narrow coastal strip be abandoned in favour of broader flood defences in which deflation (the process whereby sand is blown from place to place by the wind) and encroachment by the sea are allowed to occur. Broader dunes are also needed if the present marram grass and conifers (of which there are currently over 6000 hectares) are to be replaced by shifting dunes with deciduous trees, natural grazing and streams. Fewer conifers and more sand will improve the quality of the natural freshwater deposits in the dunes (a vital feature of the coastal area, both as a drinking-water supply and as a buffer against saltwater). Finally, a broad, natural transition between the dunes and the peat bog areas further inland would be an ideal location for mass recreation.

In such an area, the relationship between nature conservation and recreation is a complicated one. Although water-filled hollows, shifting dunes and itinerant flocks of animals will make the dunes less accessible, this can be amply compensated for in newly created dunes (e.g. land hitherto used for defence purposes, infiltration areas, or new nature areas established on the landward side of the dunes). At the same time, broader dunes can be made more accessible from the beaches; people walking through the dunes will help reactivate the natural process of deflation.

Coastal dunes



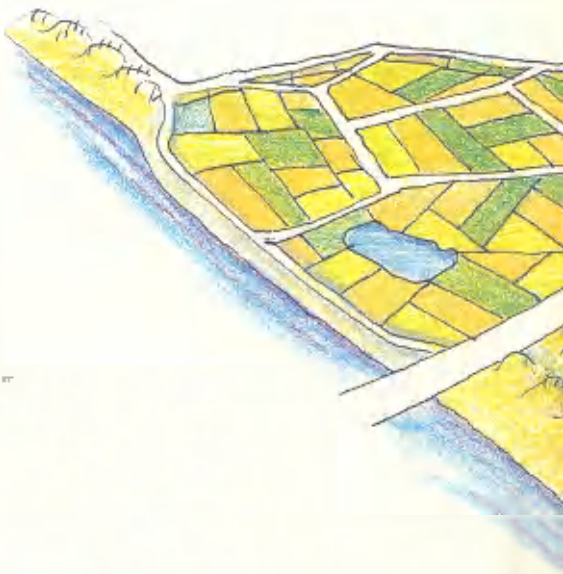


Fig. 4 Growing with the sea in the dunes of North and South Holland

Three types of coast

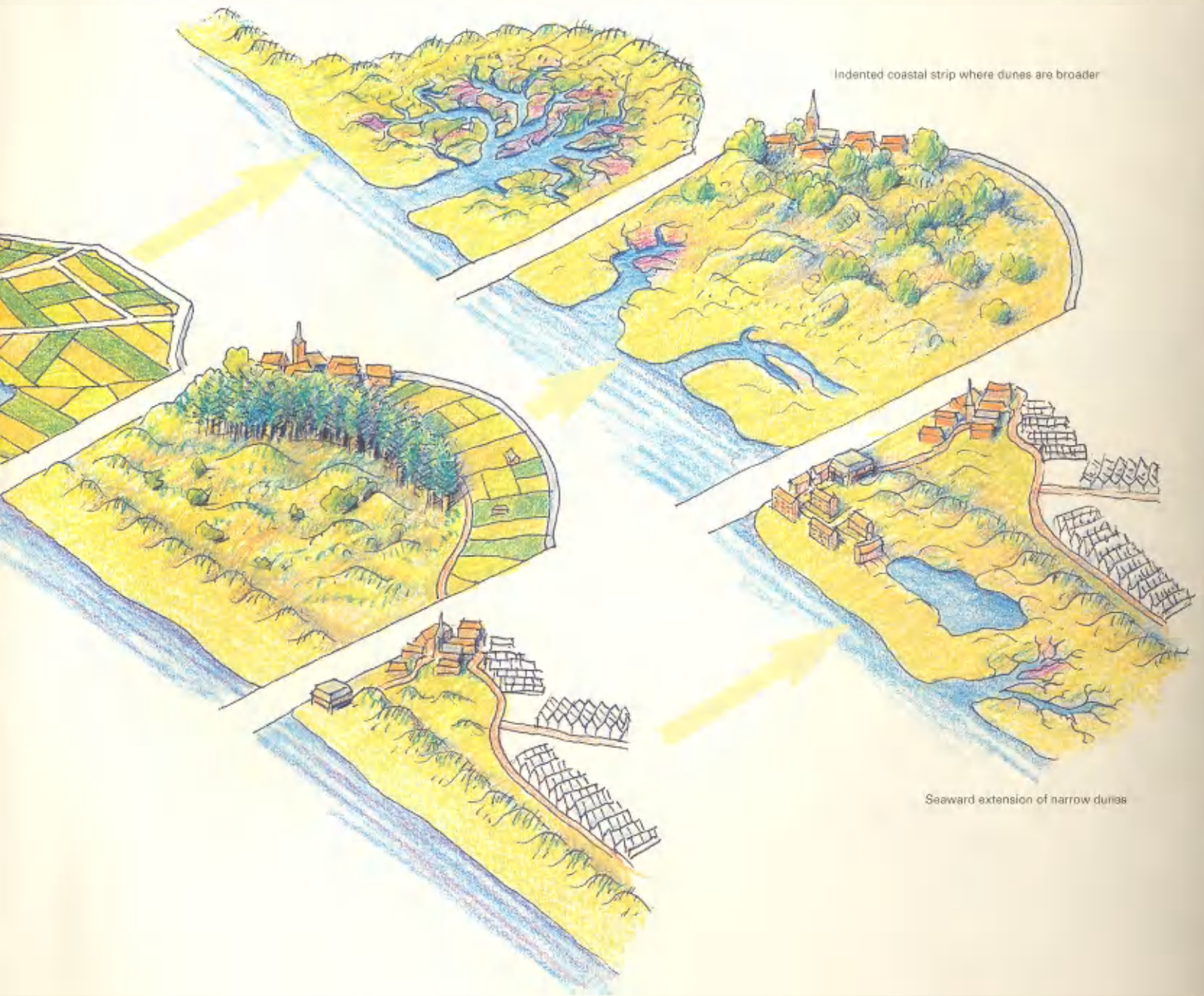


Fig. 5. Effects of the ideas for three types of coast.

The dunes are a natural habitat for red deer. If several large nature areas can be linked up, this species will have more space to develop.

The dunes around The Hague are an ideal place to demonstrate the benefits of more dynamic coast management to the general public. Natural grazing and tree growth measures to restore the groundwater regime and reclaimed coastline can all be exhibited here within easy walking distance of the city

Dynamic coast management around The Hague

Recreation and nature conservation

The establishment of large nature areas offers plenty of opportunities for recreation, but only if conservationists and the recreation sector work together more closely.

While recreational activities are often unnecessarily restricted in nature areas, too little is done to conserve nature in recreation areas. This impasse can be avoided by working together to create new, more accessible nature areas and more natural recreation areas. This will require more active involvement by the recreation sector in the development of major nature areas, and a new, more welcoming attitude on the part of many conservationists.

The main advantage of this will be that inhabitants of coastal areas, as well as visitors, will come to see nature as something which increases, rather than restricts, their freedom of movement. This is the only way to create sufficient long-term public support for nature conservation. Many people will also discover the advantages of converting agricultural land into nature areas.

Tourist taxes may be one of the keys to this new alliance between conservationists and the recreation sector. If tourists can clearly see that their taxes have been used to create readily accessible nature areas, they will feel greater attachment to such places, go there more often, and stay longer, with obvious benefits for the recreation sector.

7 The Wadden

Much of the original process of erosion and growth of sandbanks, salt marshes and islands has been preserved in this area. As a result of sedimentation, the Wadden Sea is also gradually growing (at a rate of about 20 cm a century) as sea levels rise. However, the enclosure of parts of the sea (the Zuider Zee and Lauwerszee) and the conversion of salt marshes into polders have considerably reduced the tidal volume, and the main channels in the area are filling up more quickly. This has attracted large quantities of sand, mainly from the coastal dunes of North Holland and the deltas off the islands. Recently, this process has been accelerated by sand and gas extraction, which have lowered the bed of the Wadden Sea (particularly its eastern section) by several decimetres in some places. In this area of the Wadden Sea, the edges of the salt marshes are also subject to considerable erosion.

Appropriate use of locks can create brackish marshland which will perform an important function in buffering and purifying surface waters and as an ecological link between freshwater and saltwater areas.

The Wadden area

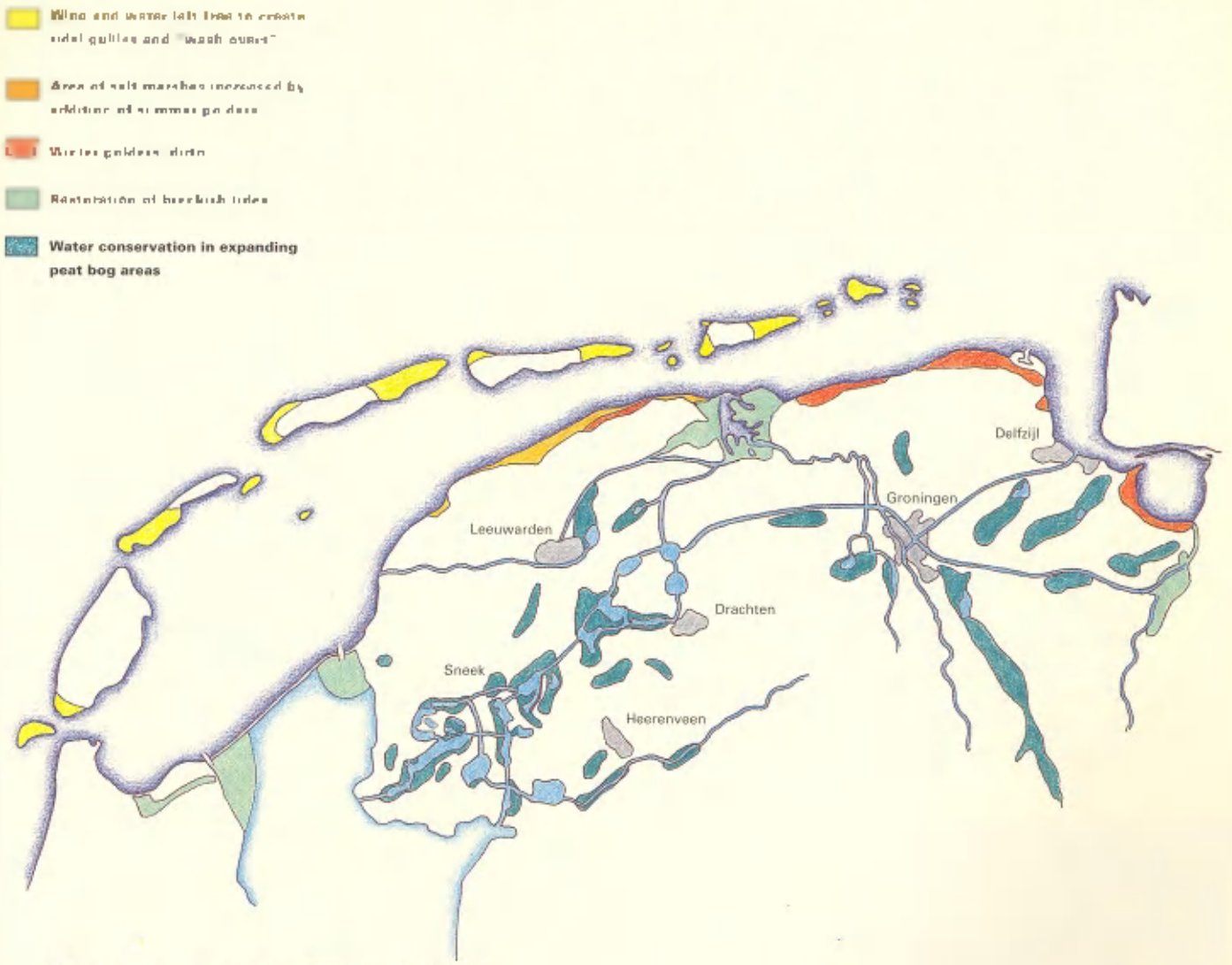


Fig. 6. Growing with the sea in the north of the Netherlands.

In order to reverse this process, the following measures can be taken on the seaward side of the dykes:

- less rigid control of deflation, so that islands (or parts of them) can begin to shift once more and more sediment can circulate within the system;
- income from gas extraction can be used to counteract the lowering of the sea bed and help restore the sediment balance;
- summer polders can be allowed to flood, so as to increase the tidal volume and restore the sediment balance. Salt marshes are at present too narrow to withstand local erosion;
- sand extraction can be transferred to the Markermeer (see chapter 8).

Behind the dykes, much can be done to improve the water regime at the boundary between the Wadden Sea and the mainland of Friesland and Groningen. This used to be a gradient-rich area in which sea water came into contact with clean water from the streams of the Drente Plateau, but there is now a clear division between the Wadden Sea and the land behind the dykes, which is often flushed with freshwater from the Rhine. Conservation of autochthonous water in the Friese Venen peat bogs and the low-lying marine clay areas of Groningen would reduce the demand for freshwater from the Rhine, and at the same time would improve the quality of the water flowing out into the Wadden Sea. In many areas, higher water levels would encourage the formation of peat bogs. The brackish transition between the Wadden system and the freshwater of the mainland could be re-created on a small scale through former 'encroachment channels'. Tides could be reduced in a controlled manner by appropriate use of existing locks, which would then act as a kind of storm surge barrier.

Agriculture in coastal areas

"Growing with the sea" means drastically revising the settlement and water regime in coastal areas in order to take account of rising sea levels and climatic change. In general, more space will be needed for the expansion of dunes and salt marshes, for absorption of peak flows and for freshwater reservoirs.
If we look more closely at agriculture in coastal areas, we would find that arable and livestock farming require a particularly large amount of space whereas they contribute relatively little to gross national product. Since these sectors require land with good drainage and low salinity, they are also the main causes of subsidence in peat bog areas, freshwater shortages during the summer and [illegible] in other areas [illegible].
A reduction in the amount of land devoted to agriculture in coastal areas (which is already happening, since more land is usually required for purposes of urban development) could therefore usefully be linked to the development of large aquatic nature areas performing a number of different functions (drinking-water supply, nature conservation, recreation, protection against flooding, reduction of salinity, waterside housing, etc.).

There would also be benefits for other agricultural sectors:
- freshwater supplies in dry periods
- buffer against salinization
- buffer against urban development.

Money now being spent on [illegible] and environmentally ineffective management schemes could often better be [illegible] in areas [illegible] the [illegible] and water regime.

Prospects remain good for knowledge-intensive and capital-intensive sectors of agriculture which can achieve high production levels on relatively small areas of land with minimal environmental impact. Such sectors could successfully maintain the strong international position of Dutch agriculture.
At the same time, a small-scale local specialist market could be created for environment-friendly products (meat, fish, reed, etc.) from the large new nature areas.

Large expanses of brackish marshland would assimilate nutrients from the water and make them available to a complex food chain.
The brackish lakes thus created at the freshwater/saltwater boundary would perform the following functions: (1) absorption of peak flow, which would then be gradually released into the Wadden Sea (such additional storage capacity is now particularly important in Eastern Groningen, where subsidence due to gas extraction is making natural drainage more and more difficult), (2) an ecologically valuable tidal basin during the summer and when water levels are low in winter, (3) purification of surface waters, (4) helping to increase the tidal volume in the Wadden Sea, and (5) increased opportunities for migration of aquatic fauna.

In the Wadden area, "growing with the sea" means – among other things – more scope for erosion and sedimentation, so that sandbanks and islands can start to shift once more.

8 The IJssel lagoon

In the IJsselmeer area, 'growing with the sea' primarily means achieving a more natural water level. In the winter this will need to be considerably higher than the current 0.4 m below sea level, whereas in the late summer it can be allowed to fall to more than 0.2 m below sea level.
This will facilitate drainage into the Wadden Sea when water levels are high in the winter (an increasing advantage as sea levels rise in the future).
New marshland will form as shallow shoreline areas emerge from the water in the summer, thus expanding an essential natural component of the IJsselmeer. Between sea level and 0.5 m below sea level, every additional fall of ten centimetres in the water level will yield 400 hectares of new marshland; between 0.5 m and 1 m below sea level, this can rise to over 1000 hectares. Such marshland can capture sediment and nutrients from the lake and so help to purify surface waters, and will gradually grow higher.
This new marshland can greatly help to assimilate nutrients (especially nitrogen) from the IJsselmeer. Cleaner water will encourage the establishment of aquatic plants, which will also help to purify the water. More stringent measures are needed in order to increase the current degree of transparency (0.6 m) to 1 m; this will create some 2500 hectares of new aquatic flora.

The positive impact of a more natural water level in the IJsselmeer will be counterbalanced by an adverse impact on the peat bogs of North Holland and Friesland. These will be short of water in dry summers, and will have more difficulty in discharging high water levels into the IJsselmeer. However, these problems can be tackled at the source by increasing the area of the

Many species of photolitic plants and aquatic birds have adapted to annual fluctuations in water levels. Egrets will benefit from more natural water levels in the lagoons.

IJssel lagoon

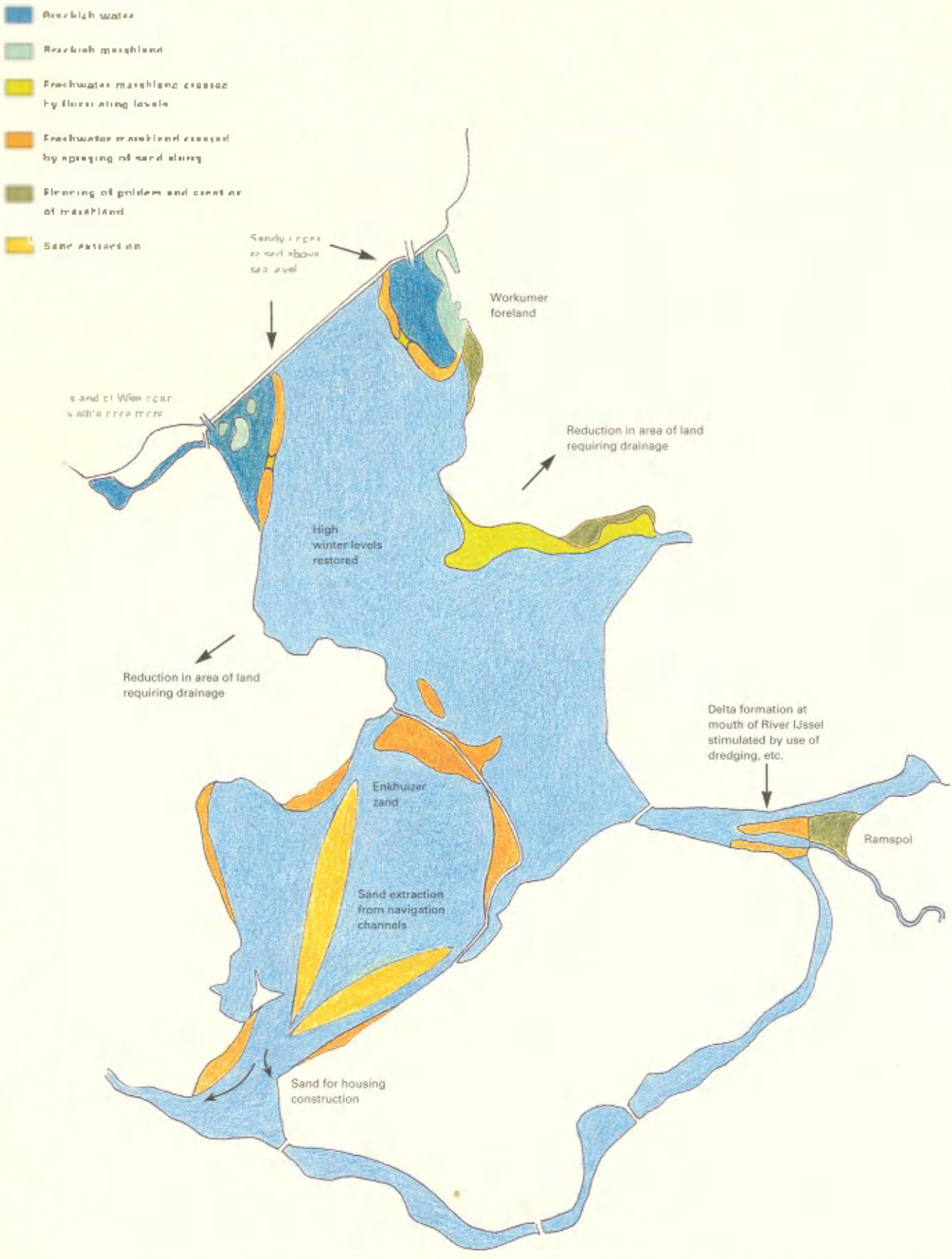


Fig. 3. Growing with the sea in the IJssel region

IJsselmeer and Markermeer

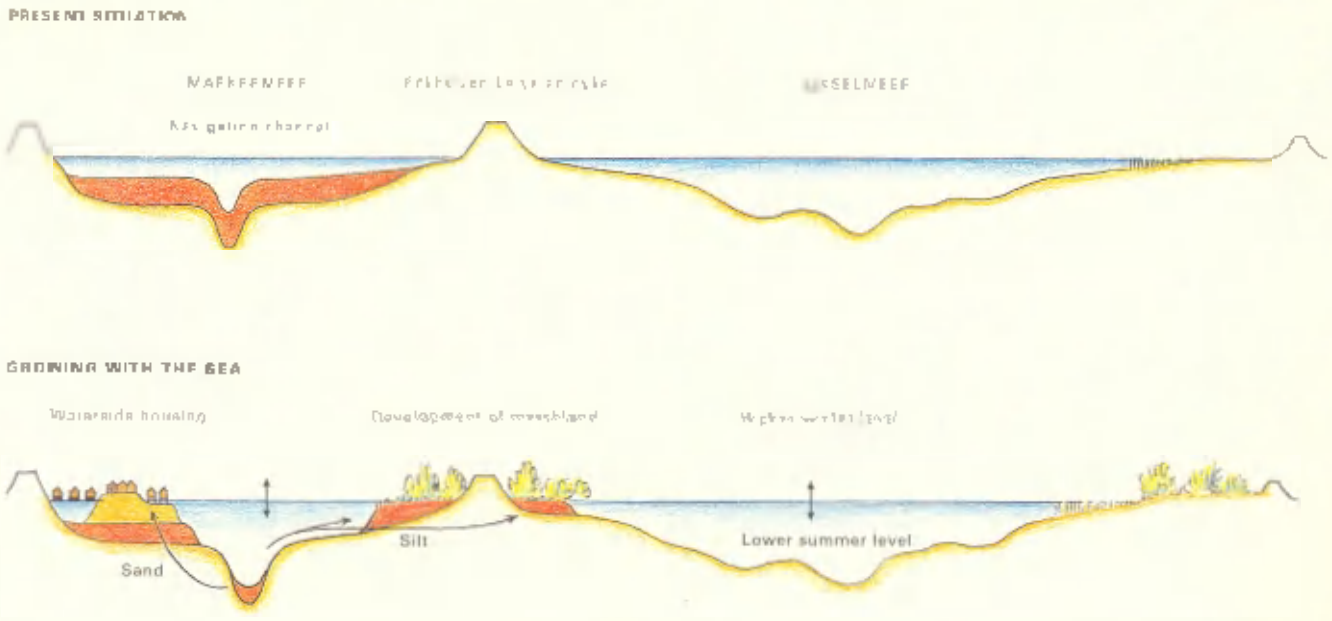


Fig. 8 Growing with the sea in the IJssel Delta (cross section)

A more natural water level in the IJsselmeer

spill-overs (see chapter 9). The dependence of the peat bogs on the IJsselmeer can be greatly diminished by reducing the area of land requiring drainage, by reducing (or tolerating) saltwater seepage, and by conserving autochthonous water.

The IJsselmeer - one of the very few large freshwater lakes at this latitude which has a plentiful food supply and rarely freezes over - is an important feeding-place and sanctuary for many species of European aquatic birds. In summer, however, birds able to take advantage of the abundant food supply cannot find enough places to breed. The development of new marshland and woodland could greatly increase the natural efficiency of the lagoon system.

This can be achieved in various ways and at various locations (see map on page 26):

- By creating marshland in uninhabited, extensively exploited summer polders along the IJsselmeer coast of Friesland.
- By stimulating natural delta formation at the mouth of the River IJssel, in combination with flooding of summer polders and controlled dredging (more than 5000 hectares in total). A large, water-storing nature area in this area could help to buffer high water levels in the River IJssel (which would be unable to drain away as quickly if the level of the IJsselmeer were higher in winter).
- By combining sand extraction and housing construction in the Markermeer and IJmeer area with the creation of new marshland (see box about sand extraction on page 28).
- By using sand to raise various natural ridges in the Northern IJsselmeer and so create sheltered areas around the Kornwerderzand and Den Oever locks with ample scope for the development of marshland. Appropriate lock management could be used to create thousands of hectares of brackish marsh and and open water in this area.

Behind high natural ridges new brackish marshlands are created

The Oostvaardersplassen lakes are above all evidence of the ecological potential of the IJsselmeer. The thousands of aquatic birds which come to feed on the IJsselmeer can find suitable breeding or resting places in the wood and reedy marshland of the Oostvaardersplassen. However, such places are still lacking elsewhere in the IJsselmeer area.

Sand extraction and development of nature areas

Sand extraction from deep channels may stimulate the further development of the freshwater ecosystem by increasing the clarity of the water and improving the quality of the hard substrate. The positive effects of this would be most evident in the Markermeer, which at present is a fairly homogeneous, turbid lake, in contrast to the IJsselmeer, whose bottom is more varied and whose water is clearer. Concentrating sand extraction in the Markermeer would have the following advantages:

- silt which is now constantly stirred up by the wind would sink into the deeper troughs, making the water at the surface of the lake clearer. This would improve conditions for the growth of shoreline and aquatic plants which would in turn help to purify the water;
- residual material from above the extracted sand, mixed with sand, could be used to create islands and shoals and to raise the shallows around the periphery of the lake. This would create not only a large new nature area but also attractive routes for recreational boating;
- [illegible] much of the bed would [illegible] the hard substrate and become suitable once more for mussels, etc.;
- the central location of the Markermeer would make it relatively easy to find customers for the extracted sand.

This final measure would also restore the freshwater/saltwater gradient (which is so essential to natural systems) in part of the IJsselmeer. However, the brackish area would need to be hydrologically well isolated from the freshwater of the lake.

The creation of new marshland and marshy woodland (intersected by channels) around the periphery would make the IJsselmeer and Markermeer more attractive areas for water sports. The number of attractive routes and mooring-places for small boats would be greatly increased, while large yachts would still have access to the open water.

9 Peat bogs and reclaimed land

Although the resilience of the Dutch coast can to some extent be increased by measures on the seaward side, really effective results can only be achieved by appropriate planning measures in the low-lying parts of the Netherlands. This is why peat bogs, polders and marine clay areas are also discussed in this booklet.

Our present approach to drainage has resulted in a downward spiral. The land is continuing to subside, by as much as 40-50 cm a century in some peat bog areas. Saltwater is seeping inland must be flushed out with large quantities of freshwater, which cannot then be used for other purposes. In the long term, with the prospect of rising sea levels, this is a time bomb which could wreck the Netherlands' water management strategy (in terms of both quality and quantity). Spill-over embankments in subsiding peat bog areas are under increasing pressure. Since the population of the areas below sea level is still rising, this is an ever more serious hazard.

Clearly, then, the spiralling process of drainage and subsidence must be reversed in these areas, and the sooner the better. Saturation with autochthonous water can actually stimulate the growth of peat bog areas (by as much as 5 mm a year, thanks to the availability of nutrients). At the same time, pressure will be created to counteract saltwater seepage and so reduce the amount of freshwater needed to flush it out. Water quality in the area will be further improved as a result.

This new strategy requires a different planning approach, based on concentration of capital-intensive functions (urban development, business sites, glasshouses and expensive infrastructure), while the number of hectares devoted to agriculture will be reduced in the remainder of the area to make way for more water-oriented functions. Spill-over embankments will provided in order to protect urban areas and infrastructure, or will become unnecessary as spill-overs are expanded.

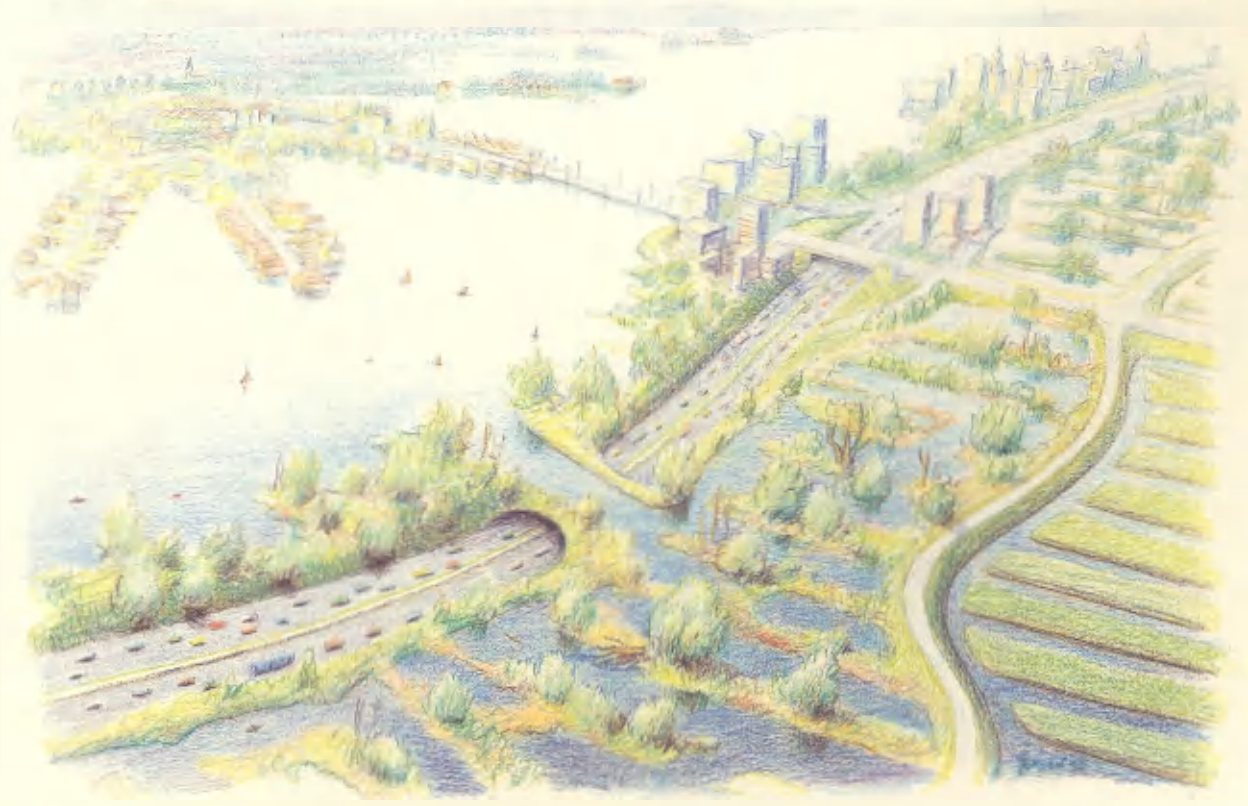


Fig. 9 Land of the clay marsh and - Picture of the future

Peat bogs

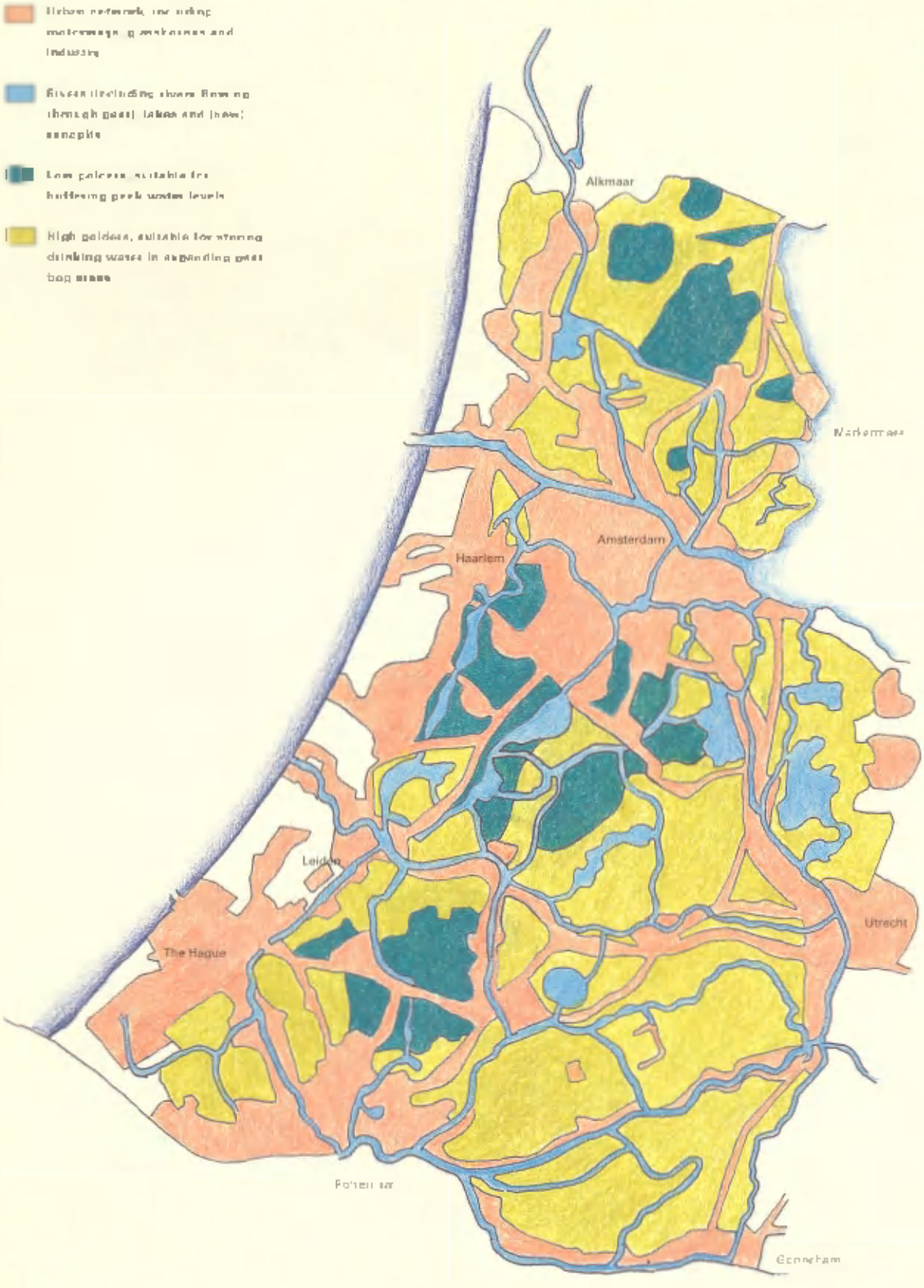
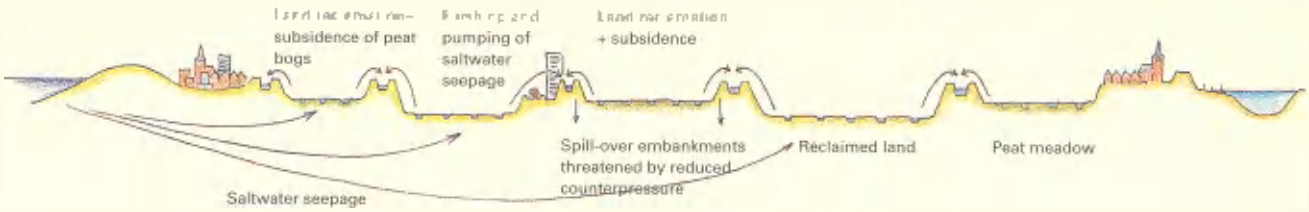


Fig. 10 Possibilities for water buffering in the peat bog areas of North and South Holland

Peat bogs and reclaimed land

PRESENT SITUATION



GROWING WITH THE SEA

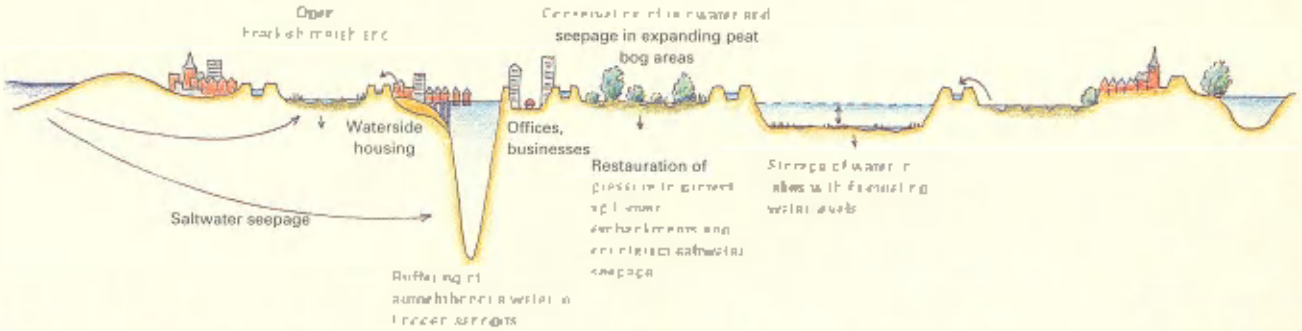


Fig. 11: Growing with the sea in peat bogs (cross section).

In the latter case, a distinction can be made between peat meadows and reclaimed land, the main differences being in the dynamics and quality of the water buffers (see map on page 30).

Peat bogs:

- conservation of clean autochthonous water in expanding peat bog areas;
- limited, gradual fluctuations (of several decimetres) in shallow water;
- nature-oriented recreation in large expanses of marshland, carrs and quaking bog areas;
- excess rainwater and seepage used for drinking-water supply (once nature areas have become saturated).

Reclaimed land:

- buffering of rainwater (particularly from urban areas) in relatively deep, dynamic lakes whose levels can fluctuate by up to several metres;
- absorption of peak river flows (which are expected to increase) which coincide with north-westerly gales from the sea. In view of its origin, this water will be eutrophic and slightly polluted;
- water supply for remaining agricultural uses during dry periods;
- pressure to counteract subsidence of higher peat bog areas;
- scope for intensive recreation and waterside housing at the boundary with urban areas;
- the new lakes and marshes will help to ensure natural

In areas such as this, water conservation will create fertile lakes and marshes where the Bittern can thrive.

Freshwater management

Economical use of freshwater is increasingly important. If the current rise in per capita water consumption continues and the Netherlands reaches a level similar to that of countries such as Sweden and the USA (500 litres per person per day, as against 150 now), the total quantity of water required in the Netherlands will rise from 1.3 to 5 billion m³ a year.

Supplying such amounts raises problems of both quantity and quality.

As regards quantity, there are few countries in the world with so little freshwater per head of population as the Netherlands, which remains largely dependent on other countries upstream. Much of the available freshwater must be used to counteract salinity in coastal areas, mainly for the benefit of agriculture. Agriculture also makes qualitative demands on this scarce freshwater supply. As fertilisers and pesticides leach into the water, increasing sums have to be spent on making it fit for human consumption.

More economical use of scarce freshwater supplies in coastal areas can be achieved by taking the following specific measures:

- longer storage of rainwater and upwelling groundwater, preferably in nature areas;
- reduction of the amount of agricultural land in areas subject to saltwater seepage, creation of counterpressure by reflooding previously drained land and expansion of spill-overs;
- as far as possible, natural purification of surface waters, for example by creating broad belts of shoreline vegetation;
- increasing freshwater supplies in the dunes by increasing the surface area and reducing the area covered by conifers;
- reduction of saltwater seepage and creation of rain-fed/brackish marshland;
- through storage of excess rainwater and controlled extraction of seepage water. 1000 hectares of new marshland and lakes could supply around 2 million m³ of water a year. Some 25% of the Netherlands' drinking water requirements could therefore be met by creating 100,000 hectares of new marshland and lakes.

Economical use of freshwater is increasingly important

Through subsidence of peat bogs and rising sea levels, large areas of the Netherlands have already sunk by more than 6 metres in relation to sea level.

purification of water from urban and agricultural areas and rivers;

- lakes which dry out during the year can be a favourable environment for migrating waders and other aquatic birds in spring and autumn.

Near some urban areas, expansion of spill-overs can be combinated with sand extraction. Additional advantages of this approach are that the distances over which the sand has to be transported (and the resulting environmental impact) are relatively small, and that water sport areas established near towns and cities (so reducing the need for mobility) can serve as buffers for more vulnerable nature areas in the immediate vicinity.

Using freshwater to reflood land which has hitherto been pumped dry will not only be beneficial from the point of view of flood protection, nature conservation and recreation in coastal areas, but will also add to the drinking-water supply (see box on this page).

Furthermore, saltwater seepage will no longer need to be flushed out in such areas, and this will help to conserve scarce freshwater supplies.

In areas where there is considerable saltwater seepage, an alternative solution is to take direct advantage of it. For example, brackish marshland is an ideal environment for certain types of flora and fauna which have died out practically all over Europe. At the same time, reflooding polders with saltwater seepage will create pressure to counteract further inflow of saltwater and so reduce the need for flushing with freshwater over a larger area.

As a rule, reducing the areas of land requiring drainage will mean that less water has to be discharged into large bodies of water such as the IJsselmeer, which can therefore revert to a more natural water level. This will create better conditions for the development of aquatic and shoreline plants.

The links between Amsterdam and the surrounding water and have largely been destroyed. These links can be restored by creating new aquatic nature areas which will link up with the city's river and canal system and also serve as saltwater and drinking water buffers.

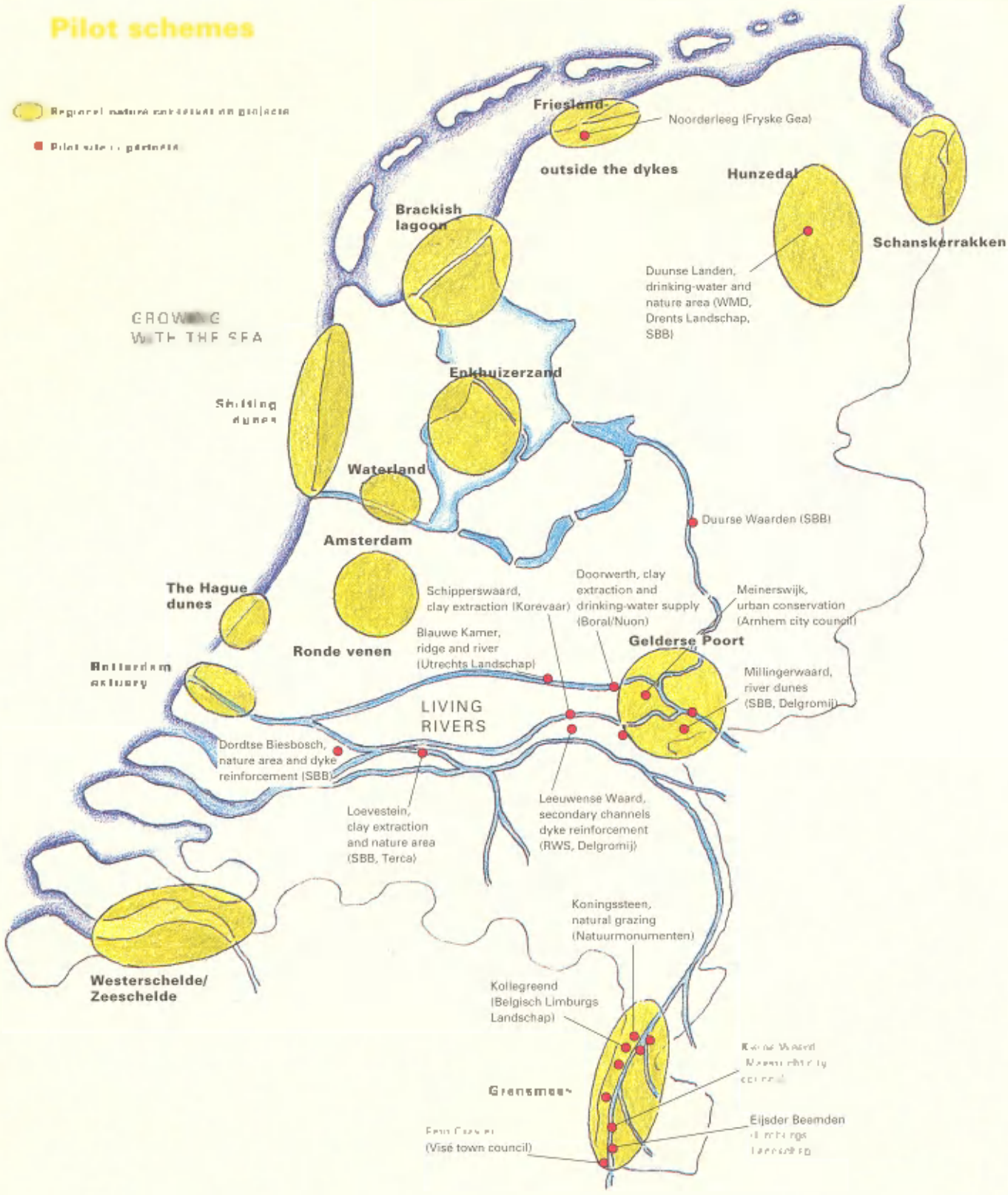


Fig. 12 Pilot projects and pilot sites. Extending the Living Rivers programme to the coastal area

10 Pilot schemes

Detailed plans

Over the next few years, the World Wide Fund for Nature will work out more detailed plans in partnership with the government, business, and private conservation groups.

Such plans may include:

- Conversion of a disused North Sea oil rig into an international visitors' centre, to encourage commitment to the sea among people in nearby countries.
- Expansion of floodplains along the Westerschelde and Zeeuwsch-Vlaanderen.
- Development of dunes and indented coastline in North and South Holland.
- Schanskorfrakken, a brackish tidal area adjoining the River Dollard.
- Enkhuizerzand, an example of new marshland in the IJsselmeer area.
- A housing project (to be identified later) with a 'mark'-type financing system.
- Water buffers in expanding peat bogs and brackish marshland.
- The Amstelmeer brackish lagoon (near the IJsselmeer Dam).

Pilot projects

As well as plans, practical examples will also be required. Encouraged by the success of the 'Living Rivers' project, the WNF therefore intends to support or set up, in various parts of the Netherlands, pilot projects which will demonstrate what 'growing with the sea' can actually mean.

Nature in the urban environment

The variety of the Dutch coastline is reflected in the totally different characters of the three main cities: Amsterdam, a city built on water, The Hague sheltering behind the dunes, and Rotterdam at the estuaries of the Rhine and Meuse. Certain pilot projects could usefully be set up near these cities, on the basis of their specific characteristics. This would enable a relatively large proportion of the general public to become more directly involved in subsequent stages of the planning process.

New nature areas will encourage the sea eagle to nest in the Netherlands.

Colophon

'Growing with the Sea' is an exploratory study on the future of the Dutch coastline. This booklet is a summary of a main design report produced by Stroming BV and the IVM Institute for Environmental Issues, Free University of Amsterdam on behalf of the World Wide Fund for Nature (Netherlands) in Zeist and the National Coastal and Marine Institute (Ministry of Transport and Public Works) in The Hague.

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