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ENVIRONMENTAL IMPACTS OF ENCLOSURE DAMS IN THE NETHERLANDS

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INTRODUCTION

A big storm surge in 1916 caused great damage and land losses in the areas around the Zuider Zee. As a result, the longest enclosure dam in the Netherlands, the one enclosing the former Zuider Zee, was built in 1932 (see Figure 1). An even more disastrous storm surge in 1953 was the catalyst for the building of the so-called Delta Works, which were finished in 1986 with the completion of the storm surge barrier of the Eastern Scheldt. During the building of the Delta Works, three other estuaries were cut off from the sea. This paper discusses the impacts of these enclosures.

THE IMPACTS OF THE ENCLOSURE OF THE FORMER ZUIDER ZEE

The enclosure of the former Zuider Zee caused a big change in the tidal and storm conditions in the Wadden Sea area. The tidal range increased by roughly 50% -- e.g., at Harlingen it increased from 1.25 to 1.80 m. In addition, the height of storm surges increased by roughly 20%. This meant that besides building the dam itself, all the dikes in the western part of the Wadden Sea needed raising.

Since the enclosure of the Zuider Zee, the morphological system required about 30 to 40 years to reach more or less a new equilibrium (Misdorp et al., 1989). After these 30 to 40 years, the changes have become smaller. To reach a real equilibrium will probably take more than 100 years. Near the dam, the currents decreased. But in other areas of the Wadden Sea, and especially in the tidal inlets between the islands, the currents and tidal volumes increased, causing an unbalance in the morphology of the area. The tidal gullies near the dam have been filled up by sediments, while the cross-sectional areas of the

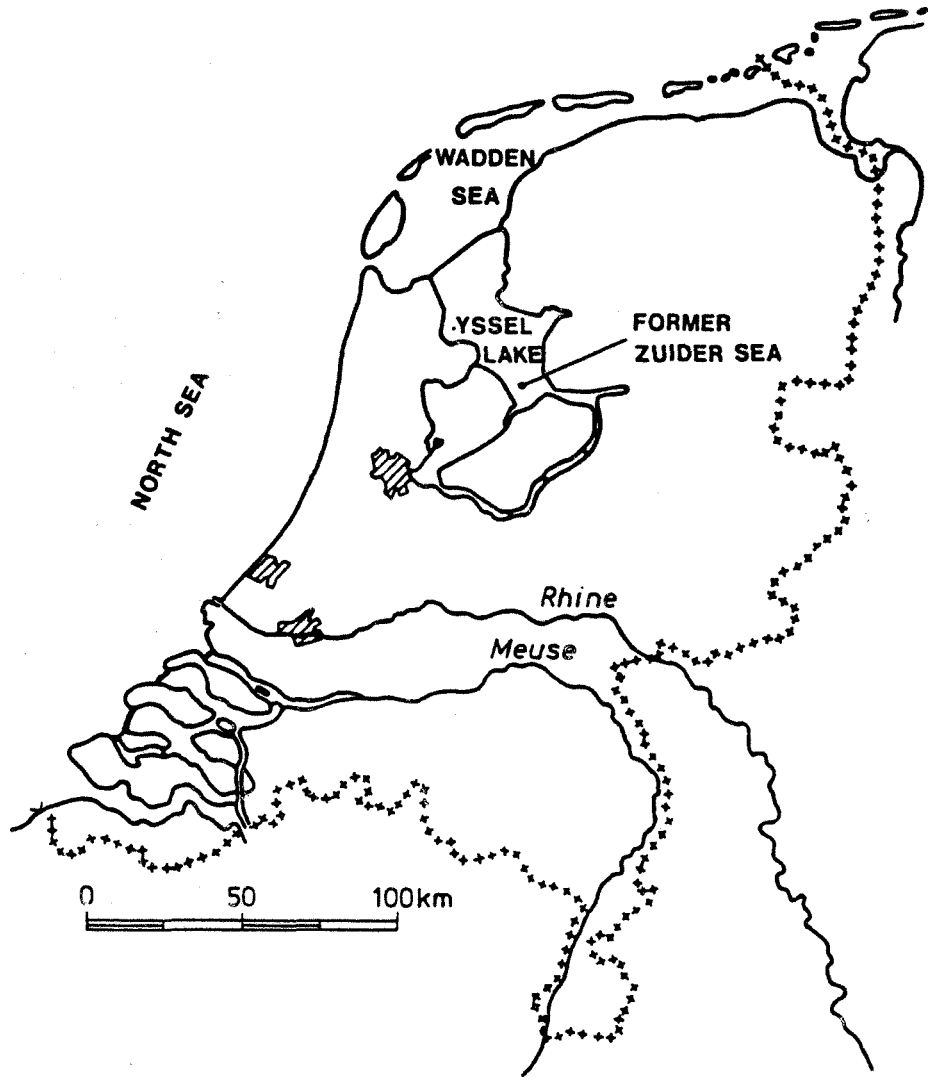

Figure 1. Map of the Netherlands showing the former Zuider Zee, now enclos and called the IJsel Lake.

tidal inlets have increased by about 15-20%. Due to this morphological chang the tidal system in its turn has been changing as well, causing an extra increa of the tidal range of about 5% over the last 50 years (Misdorp et al., 1989).

The enclosure and the increase in tidal range caused the loss of intertid and salt marsh area (about 1000 hectares of salt marsh were lost), which affect the ecology of the area. In the long run, a small increase of intertidal a marsh area may be expected (Dijkema, 1987). On the inside of the dam, t impacts were greatest: a large salt intertidal system changed into a freshwat lake. The largest negative impact was felt by the fishermen, who lost the fishing grounds.

THE IMPACT OF THE DELTA WORKS

The impacts on Zeeland due to the Delta Works will be discussed in relation to the water system going from north to south (see Figure 2). The impacts of the storm surge barrier on the Hollansche IJssel will not be discussed; they may be neglected. The Western Scheldt is not included because, owing to shipping to Antwerp, this estuary will remain open.

The Haringvliet

This water system has been enclosed with a huge sluice complex. During high discharges of the Rhine and Meuse Rivers, most of the water has to be discharged via the Haringvliet to the North Sea. The system changed from a brackish tidal estuary to a more or less stagnant freshwater lake. The present tidal range is less than 20 cm; greater water level variations are caused by high river discharges.

At present, an unforeseen impact has given cause for great concern. During the planning of the Delta Works, pollution was not yet of much concern. However, today, sediments of the Rhine, strongly polluted with heavy metals, largely settle on the bottom of the Haringvliet. Plans are being developed to clear these sediments at huge costs. However, this effort will be useful only if the river's future sediments become cleaner as well.

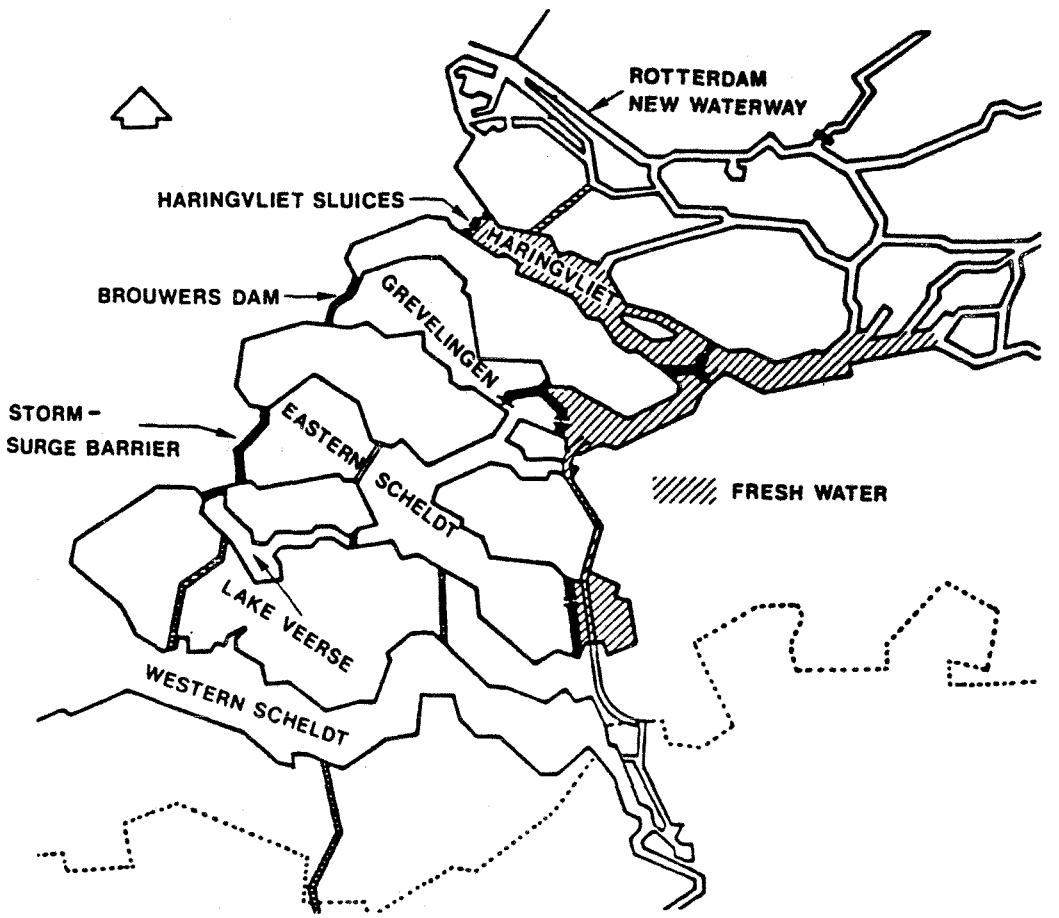

Figure 2. Map of the delta area of the Netherlands.

Environmental Implications

This unforeseen problem would not have occurred if the Haringvliet had remained open; the sediments would have been transported into the North Sea and would have settled in sedimentary areas. At present, officials are discussing reopening the sluices, and closing them only during a storm surge. Owing to these pollution problems, the impact of the enclosure on ecology is rather large, and the system was more valuable in an ecological sense in the past.

The Grevelingen

The Grevelingen Lake was planned to be a freshwater lake after enclosure to supply freshwater to the agricultural areas of the islands north and south of it. At the time the dam was completed (1972), the ecological value of such a freshwater lake as compared with that of a saltwater lake already was questioned, and the lake was temporarily left marine. Despite a heavy protest from the farmers, it was decided, many years later, to leave the lake marine.

In the beginning, seawater was let in and out only through sluices in the Brouwers Dam on the sea side of the lake. It appeared that this strategy caused stratification, accompanied by anoxia. This unforeseen problem was solved by making another sluice on the eastern end of the lake. Now seawater can be taken in from the Eastern Scheldt and can be discharged via the other sluices to the North Sea. With this strategy, stratification no longer occurs. Today, the lake has a very high ecological value due to the rarity of an unpolluted, clean, saltwater lake. The lake enjoys a great number of different species of birds, fish, plants, and especially seagrasses (Zostera). Even the economic value of the lake is important because of high production of oysters and mussels, which was not expected at all.

The Eastern Scheldt

In 1958, part of the plan for the Delta Works was to separate the Eastern Scheldt completely from the sea and to make a freshwater lake of it. After the closure of the Haringvliet and Grevelingen in 1972, the political pressure to preserve the Eastern Scheldt as a marine environment grew so strong that the Dutch government ordered a further study. The study advised against closing the Eastern Scheldt, and in 1976 the government decided to build a storm-surge barrier, which was completed in 1986. To preserve the valuable ecosystem and the oyster and mussel nurseries in the area and to reduce the length of sea dike by 150 km, the government decided to spend an additional 2 billion guilders (billion U.S. dollars) on the Delta Plan.

Still, the storm-surge barrier together with the necessary extra enclosure dams at the end of the estuary had some impacts on the environment. The tidal range in the estuary decreased by 10-15% (the average tidal range is about 3 m) The tidal volume decreased about 30%. Because of the extra enclosure dams and the decrease in tidal range, roughly 30% (6,400 hectares) of the intertidal areas and 65% (1,150 hectares) of the salt marsh areas were lost. Of the remaining intertidal areas (11,000 hectares), another 1,400 hectares will be lost in the next 30 years, as a result of the morphological changes caused by reduction of the tides (Kohsiek et al., 1987).

These losses of intertidal and salt marsh areas have destroyed a large feeding area for birds. Up until now, the numbers of birds have not decreased. Although the birds can move to another place like the Western Scheldt, they have to stay in the delta area. What will happen in the long run is not known. In contrast, the mussel nurseries were able to move to other areas and production remained the same. In fact, future production might even increase because of lower water velocities.

Lake Veerse

The first estuary to be enclosed was the smallest one (Lake Veerse in 1961). The plan was to make it a freshwater lake that would be flushed through with freshwater via a fresh Eastern Scheldt.

At present, with a saltwater regime in the Eastern Scheldt, the water in Lake Veerse is still brackish, with a rather low ecological value. As a water supply for agriculture, the salt concentration of the water is too high. At the moment, the possibility of making the lake saltwater again is being discussed. To get a healthy saltwater ecological system, the lake needs to be flushed with saltwater (a lesson learned from the Grevelingen lake). To make flushing possible, a sluice has to be built in the Veerse Dam. Up until now, this decision has not been made.

The Outer Delta Area

The impacts of the enclosures on the sea side of the delta are mainly morphological. Tidal ranges and storm surge levels increased only locally near the enclosures. Near the Eastern Scheldt storm surge barrier, the level of a design storm surge, with a return time of 4,000 years, is increased by about 40 cm. At greater distances (more than 30 km), changes are less than a few centimeters.

The morphological changes are quite noticeable, especially in front of the Grevelingen and Haringvliet, because of the changing tidal currents (Kohsiek, 1988). Along the shore, large sandbars developed, which started to migrate landward and to increase in height. After about 10 years, the height of the sandbars reached the intertidal zone, after which they stabilized at about -0.5 m below mean sea level.

The further development of this area into a more lagoon-like system has been predicted by some experts. We must wait and see whether this will be the case, and if so, how long it will take.

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