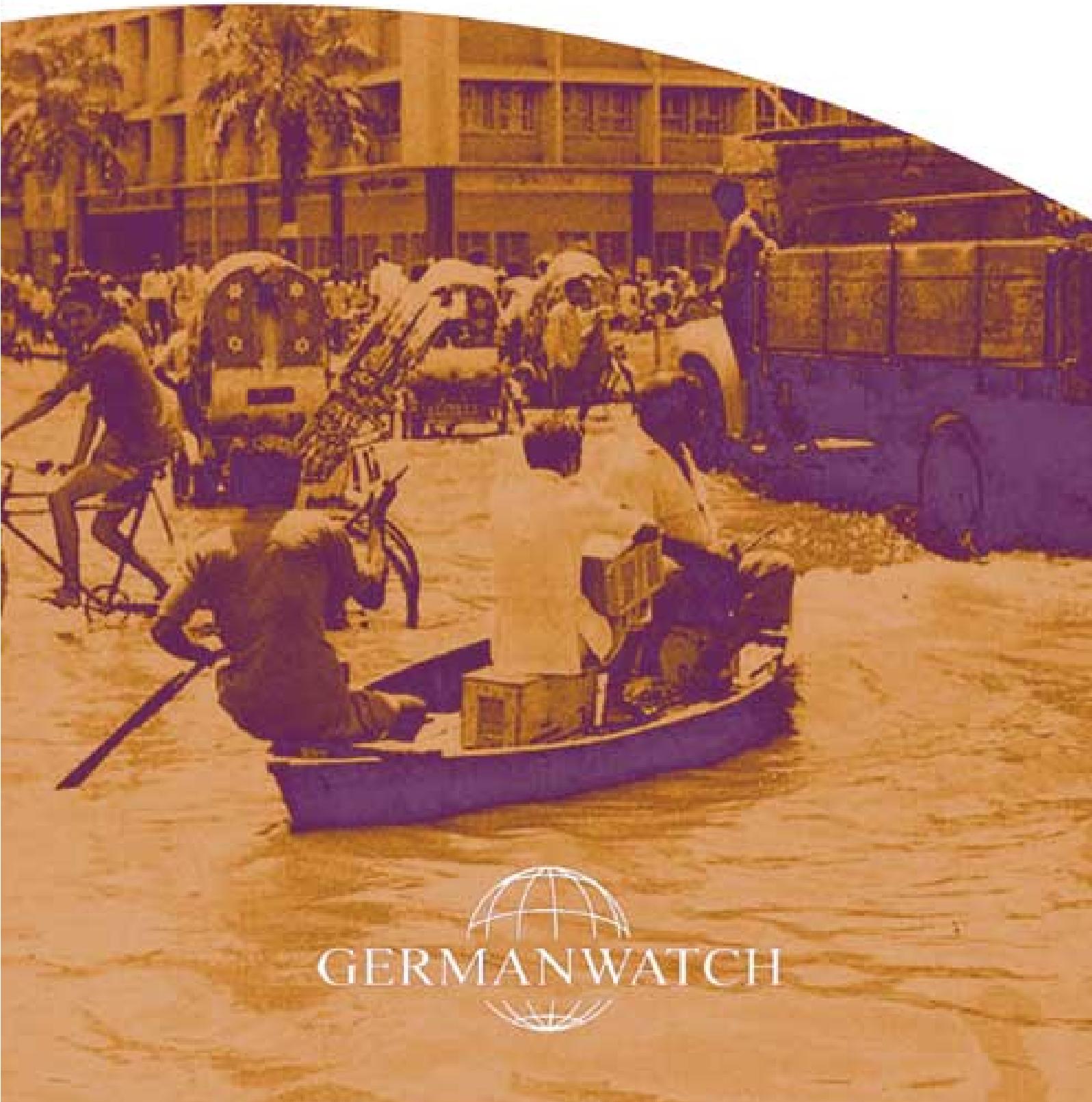


# SEA-LEVEL RISE IN BANGLADESH AND THE NETHERLANDS

ONE PHENOMENON,  
MANY CONSEQUENCES



# Sea-Level Rise in Bangladesh and the Netherlands One Phenomenon, Many Consequences

*Hot summers, floods, and winters without snow – during the last decade extreme weather events have given rise to worldwide concerns. One can hardly fail to notice that these extreme events indicate potential impacts of climate change in the future. Other consequences, however, which are at least as serious, emerge only gradually. One example are rising sea levels which threaten huge areas and coastal settlements and have serious effects particularly on people in developing countries.*

As it is a physical law that water will expand if heated, the seas react to climate change slowly but persistently. Even if the concentration of greenhouse gases in the atmosphere can be stabilised by 2100, sea levels will continue to rise for many centuries. The thawing of the Greenland ice sheet – which is likely to set in with an increase in temperature of more than 2°C – would continue for even thousands of years and cause sea levels to rise by about 5 metres.

During the 20th century, sea levels have already risen by 10-20 centimetres, on average. The Intergovernmental Panel on Climate Change (IPCC) projects that, by 2050, they will have risen at the same amount as a result of climate change (see also the info boxes on climate change and rising sea levels below). But how do global environmental changes, such as rising sea levels, affect humans and their environments in practice?

Regional consequences do not only depend on the environmental conditions in a specific region, but also on the economic and social situation as well as the available options to respond to the new challenges. This means that especially developing countries, which until now have hardly contributed to the anthropogenic climate change, will usually be the most affected by the consequences. A comparison between Bangladesh and the Netherlands, which are both seriously affected by rising sea levels, illustrates this fact.

## Info Box: Climate Change

The Intergovernmental Panel on Climate Change (IPCC\*), which is dealing with the causes and effects of climate change since 1988, stressed in its most recent report that

- ▶ The greatest part of the warming during the last 50 years results from the increase in concentrations of greenhouse gases in the atmosphere caused by human activities;
- ▶ Average temperatures at the Earth's surface have risen by 0.6 degrees Celsius (1.1 degrees F) since 1861; and
- ▶ During the 20th century sea levels already rose by 10-20 centimetres.

The warming expected by 2100 ranges from 1.4 to 5.8 degrees Celsius (2.5 to 10.4 degrees F) and sea levels are expected to rise by 11 to 88 centimetres on average compared to 1990 levels. Due to different scenarios for greenhouse gas emissions and the calculation formulas used, the range of forecast on global warming is rather wide. It lies in their nature that projections of future events hold uncertainties. However, control calculations have shown that computer models used for climate projections have underestimated rather than overestimated the rising of sea levels.

\*The Intergovernmental Panel on Climate Change was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). Every five years, it summarises the actual scientific status in a consensus report that has been discussed and adopted by hundreds of experts worldwide.

### Info Box: Sea-Level Rise

#### Why does climate change cause the sea levels to rise?

The main cause for rising sea levels is the expansion of water due to an increase in water temperature and is thus a mere physical phenomenon. Additional factors are the melting of mountain glaciers and the ice crust in Greenland, caused by an increase in temperature of the earth's atmosphere. Yet, an increase in rainfalls and the subsequently growing Antarctic ice cover can also cause the sea levels to fall. The influence of the Antarctic, however, is small in relation to other factors, resulting in an overall rise of the sea level.

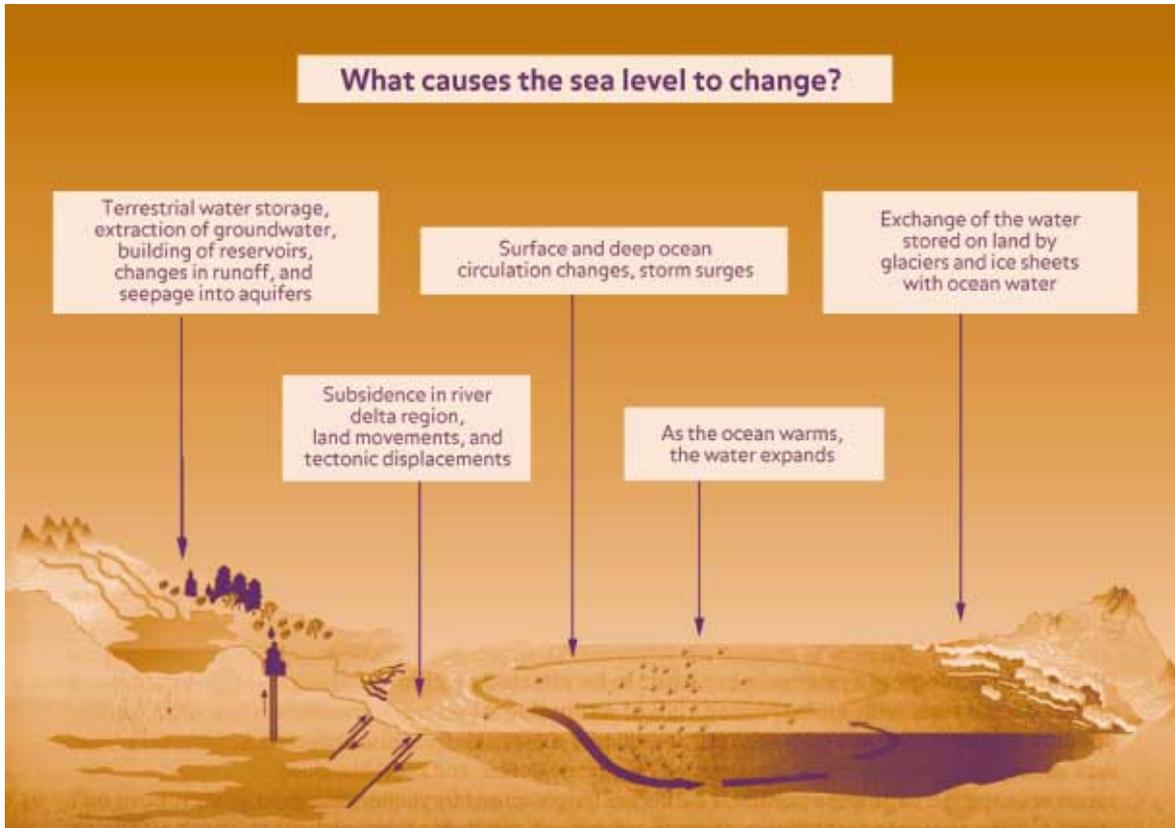
#### Regional differences

Sea levels do not rise identically in every geographical region. Therefore, in some regions sea levels are expected to rise slightly more than in others, as the increase in temperature

within the different (vertical) layers of water takes place in different stages. Independent of global warming, changes in regional sea levels can also result from continental drifts. For example, land in some river deltas subside by several millimetres per year because sediments collapse. In these cases, a rising sea level intensifies the existing regional effects. In other regions, a rise in sea level remains unnoticed because the land is rising to the same extent or even more than the sea level itself.

#### How can the sea level be measured?

In the past, the rise of sea level was measured solely by fixed measuring positions ashore. As measuring positions did and do not exist at every point along the coast, the web of data collected was rather wide-meshed. Since the 1980s, satellite technology has facilitated the collection of more comprehensive data.



The level of the sea at the shoreline is determined by many factors in the global environment that operate on a great range of time scales, from hours (tidal) to millions of years (ocean basin changes due to tectonics and sedimentation). On the time scale from decades to centuries, some of the largest influences on the average levels of the sea are linked to climate and climate change processes (IPCC 2001, Synthesis Report, p. 67).

## Consequences of Rising Sea Levels for the Netherlands

The Dutch have always fought against the power of the sea and have attempted to preserve existing and to reclaim more land areas. 500 B.C. the first coastal dykes were built and afterwards huge land reclamation projects took place, such as the drainage of the Haarlemer Meer. The completion of the final dyke at the Zuider Zee in 1932 turned the potentially dangerous bay into a tame freshwater lake where 1650 square kilometres of new land areas could

be reclaimed in the south, which is about 2.5 % of the Netherlands' total area.

But the Dutch history of dykes and land reclamation is not only a history of success: In 1953, a heavy storm forced a storm surge killing 1,800 people. After that incident, the implementation of flood abatement projects was realized. Almost 5 billion Euros were spent on the "Delta Plan" alone designed to protect the Southwest coast. The commission in charge of the project demanded to construct dykes so high that they could withstand a maximum flood occurring once in ten thousand years. At the Oosterschelde, a high-tech bridge was completed in 1986 that can quickly be turned into a dyke. If a heavy storm is approaching, shields with a weight of many tons come from the bridge down into the water in order to prevent flooding. The permanent weather monitoring via satellite technology guarantees sufficient warning time in advance. Inland dyke construction is also an important issue. Since the 11th century, dykes have been constructed along the rivers Rhine, Maas and Waal in order to protect the neighbouring regions.

Because of its low lying coasts, the Netherlands will be seriously affected by rising sea levels. Presently, about one quarter of the Netherlands' total territory lies below sea level. Without dykes, this part of the country would be permanently flooded and more than 60% of this area with its 10 millions inhabitants would

be threatened by storm surges. Due to the safeguard measures the area under risk could be reduced to less than 1% or 24,000 people, respectively.

In the past, the sea level in the Netherlands rose about 20 centimetres within 100 years, also caused by the subduction of the delta systems.<sup>1</sup> The rising sea level caused and causes local coastal erosion and sediment deposits in mudflats of the North Sea. Recent studies expect the sea level to rise by 20 to 110 centimetres by 2100, on average by 60 centimetres.<sup>2</sup> Thus, in the future, stronger dykes and broader dunes will be needed.

Without countermeasures, the threats of floods and groundwater salinisation are increasing and both can have negative effects on freshwater supply and agriculture. If the rate of sea level rise increases from 20 to 60 centimetres within 100 years, a doubling of the erosion in shallow coastal waters can be expected. In order to compensate for this erosion and to protect the current shoreline, three times the amount of sand compared to now must be washed ashore.

Currently, there is hardly any discussion about the rising sea level in the Netherlands. "The feeling of safety is so strong in the Netherlands that this seems to be no subject for discussion at all," said Frank van der Meulen, an expert working with the Coastal Zone Management Centre based in the Netherlands. "People regard it as natural that they are protected by dykes and other flood control measures."

Since long, several research institutions, however, such as the National Institute for Coastal and Marine Management (RIKZ) and the Coastal Zone Management Centre (CZMC), have analysed different reaction models taking account of social and overall economic development. The goal is to develop a holistic and proactive approach and to combine technical and

<sup>1</sup> Partly, this problem is "home-made": excessive constructions of dykes and drawing of groundwater caused related areas to sink.

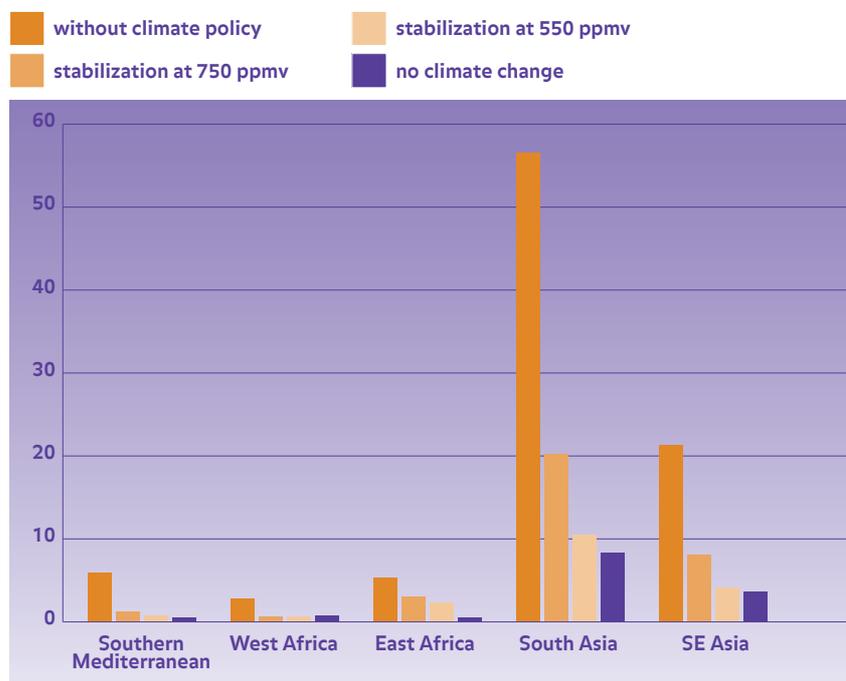
<sup>2</sup> Verbeek, Koos (2003): Climate Change in the Netherlands. <http://www.knmi.nl/voorst/nader/klim/klimaatrapportage2003/climatereport.html>

regional planning means. The organisational implementation of these measures is clearly regulated: water authorities, elected and financed by local inhabitants, are supported by the ministries of transport, infrastructure and water management.<sup>3</sup>

In view of that, the Dutch look beyond the borders of their country and seek to achieve an integrative coastal management in co-operation with other EU Member States. This includes, for instance, manipulation of sediment deposits in the North Sea. By widening river banks in the inland, larger retention areas and thus water storage capacities shall be created.

All in all, it can be concluded without any doubt that the Netherlands will experience potential impacts by rising sea levels, but the presently existing infrastructure provides already a high protection level and can be further enhanced in order to meet future demands. The Technical and financial capacities are available.

**Average number of people affected by flooding annually (millions per year) in five vulnerable regions of the world under three different emission scenarios**



Source: Nicholls. R.J., *The impacts of Sea-Level Rise. In Climate Change and its impacts, The Met Office Bracknell, UK, pp. 20-23, 1999.*

## Consequences of the Rising Sea Level for Bangladesh

Wide regions of Bangladesh, one of the heaviest populated regions on earth, are situated just above sea level and in the estuary of three large rivers – Brahmaputra, Ganges and Meghna. As in the case of the Netherlands, floods from the sea as well as from rivers bursting their banks threaten the country. Additionally, the situation in Bangladesh is intensified by tropical cyclones and monsoon rainfalls. Unlike the Netherlands, however, there exists hardly any protection such as modern dykes.

Therefore, disastrous floods took and continue to take place. Each time during the heavy river floods in 1992 and 1998 more than half of the national territory was flooded. In 1970 and 1991, tropical cyclones forced storm surges killing some hundred thousand people. The storm of 1970 forced a storm surge of 9 metres. Houses, crops and hundreds of thousands of livestock were swept away.

But according to Mr Rien van Zetten, who also works at the Coastal Zone Management Centre and who is regularly staying in Bangladesh,



the concept of floods is different than in the Netherlands: "Floods that occur practically every year cause the water levels to rise by 13 centimetres to 2 metres. Only if more than 50% of the country is flooded, a flood will be called 'heavy'."

<sup>3</sup> The storm flood of 1953 resulted in a significant concentration of and increase in governmental financing

## Threat to People's Existences

A further rise in sea level is a threat to the existence of many people in Bangladesh. Compared to the Netherlands, the relative sea level rises with double to quadruple speed: due to tectonic movements the ground level has been slightly falling down, thus an average relative rise in sea levels by 4-8 millimetres per year has taken place. This equals a rise by 8-16 centimetres within 20 years.

If the sea level rises by 45 centimetres, scientists expect a permanent loss of up to 15,600 square kilometres of land. If sea levels rise by one metre and no dyke enforcement measures are taken, 14,000 to 30,000 square kilometres will be permanently flooded, which means more than one fifth of Bangladesh will be under



water.<sup>4</sup> For comparison: the Free State of Thuringia covers an area of 16,000 square kilometres; the Netherlands cover an area of 41,000 square kilometres. Due to the high population density, the number of people affected will be extraordinarily high – 10 to 15 million people will lose their homes.

Additional to the permanent loss of land, an increase in floods is expected. Due to the rising sea level, large rivers could drain away slower from the delta systems. This feedback effect can cause penetration of heavier floods further inland. As sanitary conditions are insufficient, floods hold the threat of epidemics, such as

Cholera. Wet areas, habitat of mosquitoes, will expand, therefore the risk of malaria infections will increase.

Atiq Rahman und Mozaharul Alam, scientists at the Bangladesh Centre for Advanced Studies (BCAS), estimate that losses of immobile infrastructure due to floods will amount to more than US\$ 5 billions in 2010, if sea levels rise by 1 metre (by 2001). This equals 10% of the present GDP of Bangladesh.<sup>5</sup> If 10% of its GDP were bound, Bangladesh, already one of the poorest countries, would suffer enormous development problems. Economic centres, such as the main export port Chittagong, would be affected.

Moreover, indirect effects of the rising sea level will increase the salt content of soils. In view of Bangladesh's already problematic food situation, the expected decrease of rice production as well as several hundred tons of vegetables, lentils, onions and other crops could be disastrous.

Last but not least, valuable ecosystems would be lost. The Sundarbans, huge mangroves swamps along the coasts that are part of the United Nations world natural heritage, will be especially affected. They are the last retreat of the Bengal tiger. If the mangroves swamps disappear under water, the reserve of many hundreds of species, such as marine turtles, crocodiles and fresh water dolphins, would be destroyed. 2 million Bangladeshis live directly on honey, shells, crabs, fish and wood of the Sundarbans. Furthermore, the mangroves swamps serve as natural storm barriers. According to Muhammed Ali Ashraf, scientist at the Institute for Environment and Development Studies, "the entire population of Bangladesh depends on the Sundarbans as these last swamps protect us against many floods threatening our flood-ridden country."<sup>6</sup>

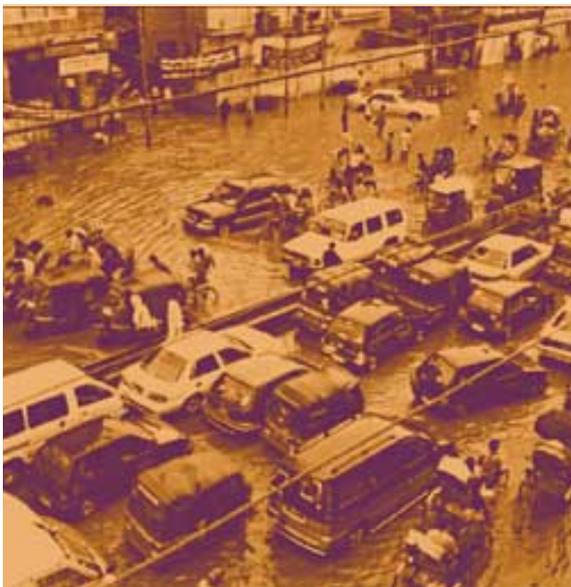
<sup>4</sup> Nicholls, R.J. (1995): Synthesis of vulnerability analysis studies, Proceedings of World Coast '93, Coastal Zone Management Centre, The Netherlands; Anwar, A. (2000/2001): Vulnerability of Bangladesh Coastal Region to climate change with adaptation options, SPARSSO.

<sup>5</sup> In comparison: 10% of the German GDP amount to US\$ 218 billions (1998).

<sup>6</sup> Action Alert (2000): Protect World's largest Mangrove Forest in Bangladesh. <http://forests.org/archive/asia/prworlla.htm>

## Limited Solutions

In view of the extreme population density it is impossible to retreat to higher situated areas. Bangladesh has the highest population density of the world, 1000 individuals per 1 square kilometre, which is four times more than in Germany. There are no free areas left in Bangladesh; its neighbour India is already very concerned about the past and present illegal immigration of Bangladeshi.



Even today, houses are very often built on walls of earth in order to ensure a minimum protection against floods. But, like already existing earth dykes, these walls of earth are threatened by erosion and are not as durable as European dykes.

The construction of big, modern dykes is problematic as well. If sea levels rise up to 1 metre, "normal" flood waves can be expected to increase from presently 7.4 metres to 9.1 metres.<sup>7</sup> This shows clearly that coastal dykes must be very high to really protect the inhabitants. The present lack of financial and technical capacities add to the existing problems, though Bangladesh intensified its efforts in co-operation with international donors. Even if a complete dyke construction could be financed, it would destroy valuable agricultural areas. Since 1989, this issue has aroused local protests against a World Bank project pushed forward by France, Japan and the USA that foresees to construct 8,000 kilometres of river dykes with costs amounting to US\$ 10 billions.

But with the help of international co-operation Bangladesh also achieved successes: in many directly affected coastal areas shelters on concrete pillars were built. "Usually, these shelters are built on 5 metre high pillars. Often, they are used as school houses and thus have a double function: to protect children and to improve education," said Mr van Zetten. Thus, the number of victims during the last storm flood in 1995 was significantly reduced. Also, the development of early warning systems helps to minimise the number of victims. However, these measures cannot prevent loss of crops, houses and other infrastructure.



A cyclone shelter in Bangladesh. Photo: Pitchford

All these facts show how disastrous the rising sea level can be for Bangladesh, despite the negligible contribution the country has made to climate change. Since its founding in 1972, Bangladesh's contribution to global emissions of the greenhouse gas carbon dioxide has been 0.06% only.

**Further information on consequences of climate change for developing countries is available at [www.climate-responsibility.org](http://www.climate-responsibility.org)**

<sup>7</sup> World Bank (2000), Bangladesh: Climate Change & Sustainable Development, p. 40. [http://wbi1018.worldbank.org/sar/sa.nsf/Attachments/ch2/\\$File/ch2.pdf](http://wbi1018.worldbank.org/sar/sa.nsf/Attachments/ch2/$File/ch2.pdf)

## What Germanwatch does

The non-profit organization Germanwatch has been working for a social and ecological shaping of globalization since 1991. Some of our main aims are:

- ▶ implementing climate protection with efficient and fair instruments and economic incentives
- ▶ fair opportunities for developing countries by reducing dumping and subsidies in agricultural trade; a fair world trade system
- ▶ ecological and social investment
- ▶ compliance with social and ecological standards by multinational corporations

By means of a dialogue with politics and business as well as by public relations work, Germanwatch promotes necessary changes in structures and strategies. The economical and ecological reorientation in the North is a pre-

condition for people in the South being able to lead a humane life and for all regions being able to develop sustainably.

You can also make a contribution to help achieve these goals. Become a member of Germanwatch or support our work with a donation!

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Further information can be found at [www.germanwatch.org](http://www.germanwatch.org)

A German version of this booklet can be downloaded at [www.klimausbadekampagne.de](http://www.klimausbadekampagne.de)

For further information see [www.climateresponsibility.org](http://www.climateresponsibility.org)

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