EDUCATION FOR SUSTAINABLE DEVELOPMENT

WORKSHEETS ON CLIMATE CHANGE

Sea level rise

Consequences for coastal and lowland areas: Bangladesh and the Netherlands

GERMANWATCH

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Consequences for coastal and lowland areas: Bangladesh and the Netherlands

As a consequence of the anthropogenic greenhouse effect the scientific community predicts an increase in average global temperature and resulting sea level rise. Heated water, however, expands only slowly because of the heat transfer from the atmosphere to the sea. For this reason, the sea responds to climate change like a slow-to-react monster – slow but persistent. In the 20th century the sea level already rose by an average of 12 to 22 cm. The Intergovernmental Panel on Climate Change (IPCC) concludes that, as a result of climate change, by 2100 the rise in sea levels could increase worldwide by up to almost 1 metre compared to the mean sea level in the years 1986–2005. Even if the concentration of greenhouse gases in the atmosphere was stabilised by 2100 to the 1990 level, the sea level would still continue to increase for centuries to come. Those states with extensive and low-lying coastal areas are particularly affected. This not only applies to a European industrialised country like the Netherlands, but also to a large number of developing countries, including the example given here of Bangladesh. The following aspects demonstrate the particular vulnerability of coastal zones:

- Coastal zones are about three times more densely populated than the global average. Around 23% of the world's population lives just approximately 100 km away from the coast and less than 100 m above sea level [1].
- These zones accommodate large and important ecosystems and natural habitats (coral reefs, mangrove forests, wetlands, dunes).
- In addition to the rise in sea level, further dangers must be taken into consideration on a regional level - not least because of the considerable human interventions in hydro, morpho and ecodynamic processes – which exacerbate the threat as a whole (changes in storm frequency, higher emergence of storms, storm surges, erosion, destruction of protective islands, salinization/ brackish drinking water wells, spits, reefs).

A comparison of the two countries, the Netherlands and Bangladesh, both of which are potentially very much jeopardised by sea level rise, clearly illustrates the likely impacts for humans and the environment, but also shows how different the capacities of individual countries are concerning their ability to adapt and to protect themselves from the consequences. Bangladesh, one of the poorest and at the same time most densely populated countries in the world, is also one of the countries which will be most affected by the expected sea level rise.

Flooding has already caused damage up to 100 km inland in the last decades. Many people are forced to live in flood-prone areas due to demographic pressure. If the sea level rises by 50 cm, it is anticipated that the number of people at risk will double. If the sea level rose by one meter, half of Bangladesh's rice fields would be flooded. Some scientists even believe that the sea level might rise by up to two meters by the end of the century, meaning we also should protect ourselves against such developments. The degree of the risk depends on the protective measures taken or on the financial, human and technical capacities to implement these measures. Bangladesh – unlike the Netherlands, a country also very much threatened by rising sea levels – does not have the necessary capacities for such measures. If the Netherlands had not implemented protective measures, about 3.7 million people – instead of 24,000 - would be exposed to the risk of flooding.

1 IPCC (2007): Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, p. 319.

Use in the classroom

With this teaching module, the school pupils are given the opportunity to compare and look at the effects of the phenomenon of climate change both in an industrialised and in a developing country. This teaching block can be introduced via a short film sequence or directly using the adjusted IPCC scenarios concerning the sea level rise by 2100 **(M 1)**. These sequences show that climate protection measures to reduce global emissions of greenhouse gases can still greatly reduce the extent of climate change and consequently also the rise in sea level. First of all, in an initial familiarisation phase, basic information is compiled about the rise in the sea level **(M 2–M 3).** Before the pupils go on to look at the different global impacts of the rising sea level in a team-based group exercise, they develop in **M 4** a methodological approach for detecting and assessing the potential risks facing coastal areas due to climate change. This phase is completed by a joint investigation of the possible ways in which the people affected might react. In addition to the small island states, undoubtedly the most threatened countries include the Netherlands and Bangladesh. In order to get a feeling for the risk situation facing the European industrialised country and the South Asian developing country, the pupils form a team to analyse the specific situations in Bangladesh and the Netherlands using their atlas and **M 5–M 10**. The group covering Bangladesh should be made up of more pupils because of the amount of material available. Building on the knowledge gained, the two countries are compared with each other in a final specialisation phase. **M 11** could be used as an introductory unit. The pupils should work out the different (financial) starting conditions and options available. Realistic examples of ways to adapt to the consequences of rise in the sea level can be taken as a basis **(M 5+6, M 12)**.

The work with these materials opens up a variety of methodological options. In addition to the group work in the individual learning phases, a role play between politicians from Bangladesh and an industrialised country (e. g. Germany) at an international climate conference provides for an interesting conclusion.

Further reading:

IPCC (2007): Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg2_report_impacts_adaptation_and_vulnerability.htm (Accessed 13.02.2014).

IPCC (2013): Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. http://www.climate2013.org/spm (Accessed 24.01.2014).

Sillitoe, P. and M. Alam (2012): „Why did the fish cross the road?“. In: Hornidge, A.K. und C. Antweiler (eds.) Environmental uncertainty and local knowledge – Southeast Asia as a laboratory of global ecological change.

The Guardian (2011): Bangladesh communities show how they adapt to climate change. http://www.theguardian.com/global-development/poverty-matters/2011/apr/05/bangladesh-communities-adapt-climate-change (Accessed 26.01.2014)

Winston, Y. et al. (2010): Climate Change, Risks and Food Security in Bangladesh. World Bank. http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2012/05/24/000426104_20120524164749/Rendered/PDF/690860ESW0P1050Climate0Change0Risks.pdf (Accessed 26.01.2014)

Germanwatch

Following the motto “Observing, Analysing, Acting”, Germanwatch has been actively promoting global equity and the preservation of livelihoods since 1991. In doing so, we focus on the politics and economics of the North and their worldwide consequences. The situation of marginalised people in the South is the starting point of our work. Together with our members and supporters as well as with other actors in civil society, we intend to represent a strong lobby for sustainable development.

We attempt to approach our goals by advocating for the prevention of dangerous climate change, food security, and compliance of companies with human rights.

Germanwatch is funded by membership fees, donations, grants from the “Stiftung Zukunftsfähigkeit” (Foundation for Sustainability) as well as grants from various other public and private donors.

You can also help achieve the goals of Germanwatch by becoming a member or by donating to:

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Within the series of *Worksheets on Climate Change* the following publications are available in English:

- Global climate change – General issues
- The melting glaciers – Glacial lake outburst floods in Nepal and Switzerland
- Sea level rise – Consequences for coastal and lowland areas: Bangladesh and the Netherlands
- Going under! The threat of rising sea levels for the small island nation of Tuvalu
- The threat to tropical rainforests and international climate protection
- Climate change and food security – Trends and key challenges
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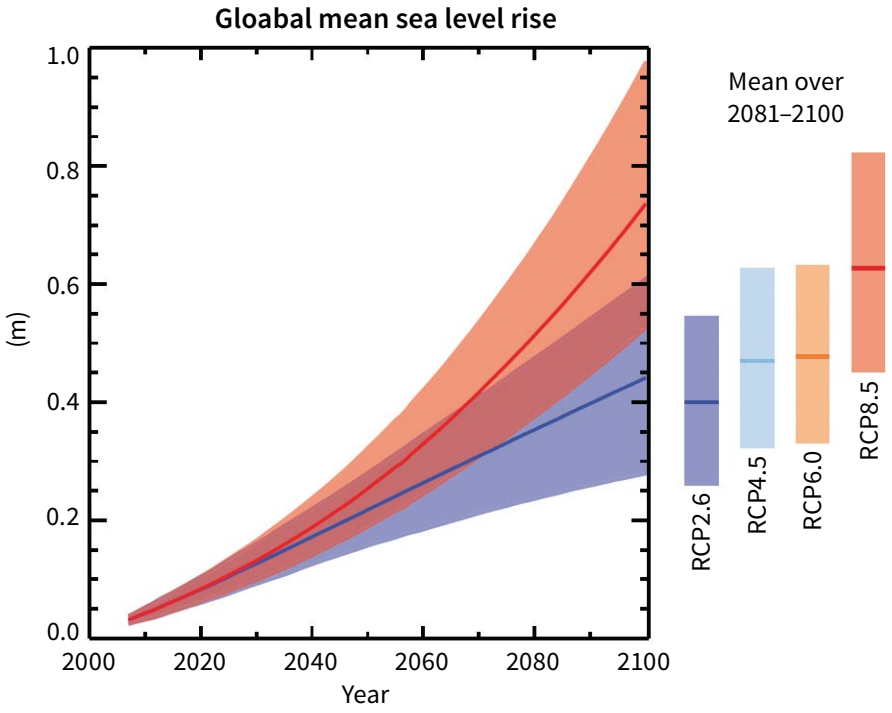
All worksheets are also available in German.

GERMANWATCH

Observing. Analysing. Acting.
For Global Equity and the Preservation of Livelihoods.

M 1

Projections of global mean sea level rise over the 21st century relative to 1986–2005



Projections of the sea level rise according to the four new scenarios of the IPCC. (RCP2.6 and RCP8.5 shown in the graph; RCP4.5 and RCP6.0 for comparison aside.)

The abbreviation RCP in the scenarios stands for "Representative Concentration Pathways". Each of them represents the time-dependent projections of different greenhouse gas concentrations and these are named after the radiative forcing value they have at the end of the observation period (measured in Watts per square meter [W/m^2]). A distinction is made between the four different pathways:

- one High, whose (anthropogenic) radiative forcing exceeds 8.5 W/m^2 in the year 2100 and which is still increasing even then;
- two Medium, whose radiative forcing lie at 6 and/or 4.5 W/m^2 in the year 2100; and
- one Low, whose radiative forcing reaches 3 W/m^2 clearly before the year 2100 and then decreases again.

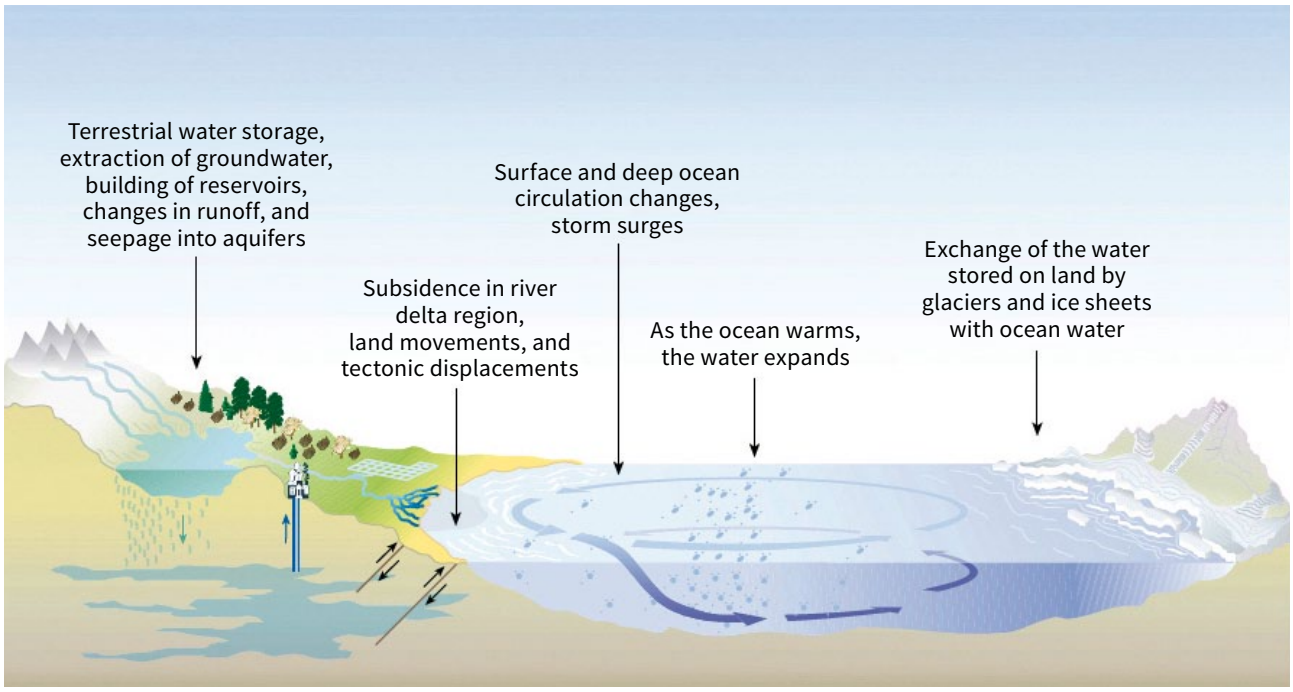
(Source: IPCC (2013): Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, p. 24. http://www.climate2013.org/spm, accessed 24.01.2014: Treber, M. (2008): Neue IPCC-Szenarien für den Fünften Sachstandsbericht. http://germanwatch.org/klima/mt08szen.pdf, accessed 27.01.2014.)

Like many other climate projections, statements relating to the rising sea level in the future are also subject to uncertainties since they are based on different scenarios. The emission scenarios shown above are only forecasts of possible future developments. Moreover, there is no conclusive scientific explanation concerning how the large ice sheets will behave in warmer temperatures.

M 2

What causes the sea level to change?

Variables influencing the sea level



(Source: IPCC (2001): Climate Change 2001 – Synthesis Report, p. 67. http://www.ipcc.ch/ipccreports/tar/vol4/english/pdf/q1to9.pdf, accessed 24.01.2014)

The sea level along coastlines is influenced by many global and local environmental factors. These factors are influenced on different time scales, from hours (tidal range) to millions of years (changes in the seabed by tectonics and sedimentation). If we take the time scale of decades to centuries, the greatest influences on the average sea level are connected, among other things, with climate and climate change processes.

The two main climate-related reasons for sea level rise, which measurements have placed at 19 cm since the beginning of the last century, are the thermal expansion of the water in the warming oceans and the additional water that flows into the oceans because of the melting ice from inland glaciers, on Greenland and in Antarctica.

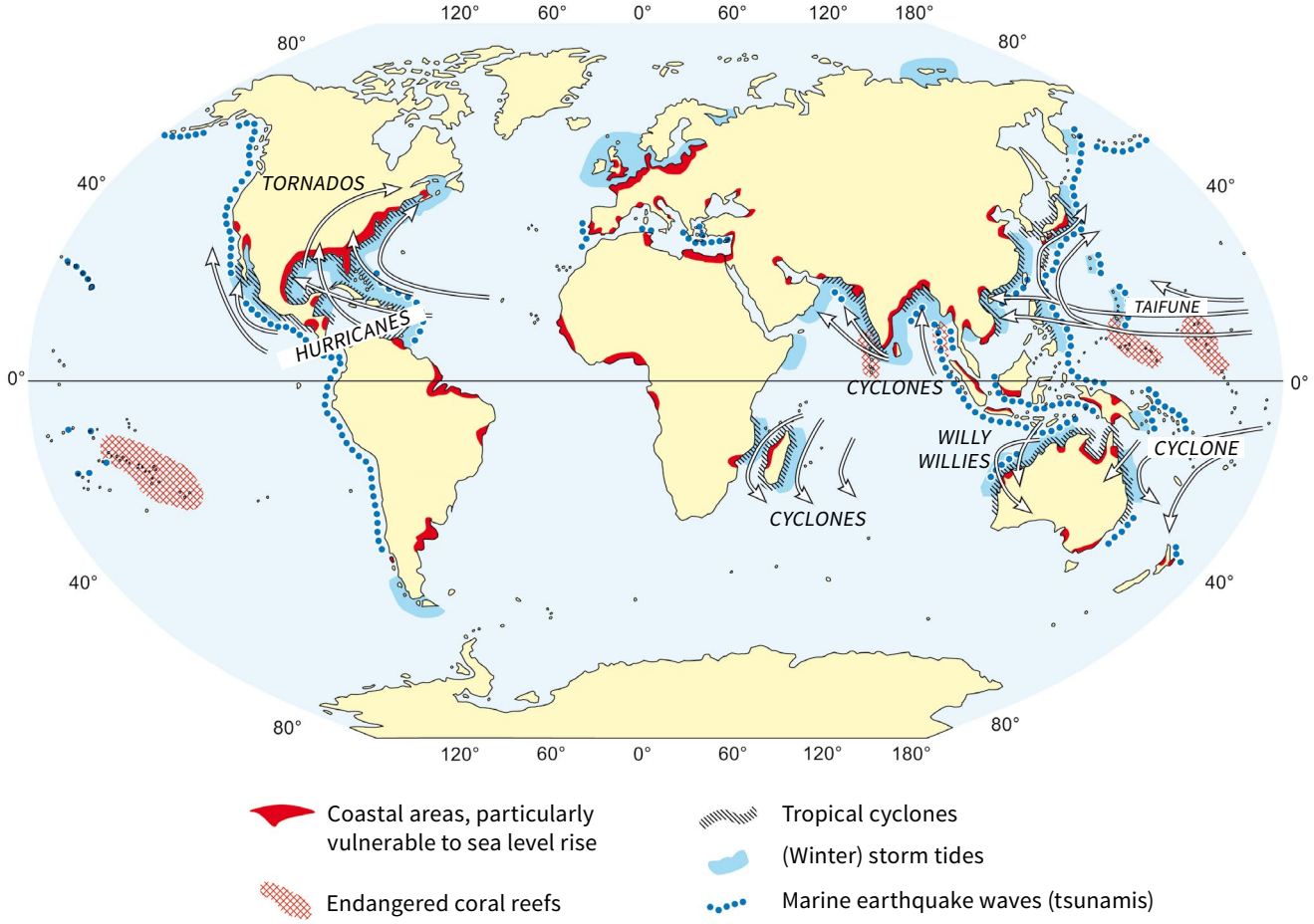
In 1986 Der Spiegel magazine headlined with “Ozone hole, poles melt, greenhouse effect. Researchers warn of a climate catastrophe” and painted a picture of an apocalyptic future. The title page shows Cologne Cathedral, one third of which is under water. For this to happen, the sea level would have to rise by about 60 m above the current level. But how high can the water really rise?

If all the ice on this planet melted, also including the large ice sheets in Antarctica and Greenland, a rise in the sea level of almost 70 m would be theoretically possible. But even if, for example, melting processes in Greenland are already happening today, and if these continued to intensify with an increase in global warming, there is no reason to fear that the ice will melt on this scale at the present time. It would take thousands of years for the large ice sheets to melt completely.

(For the cover picture of Der Spiegel see: http://www.spiegel.de/spiegel/print/index-1986-33.html, accessed 24.01.2014)

M 3 Coastal regions that are particularly affected by the rise in the sea level

Affected are low-lying coastal plains, coastal subsidence areas, delta areas, sandy beaches, barrier islands, coastal wetlands, estuaries, lagoons, mangrove areas and coral atolls. The areas in which the natural risks mapped below occur are particularly jeopardised.



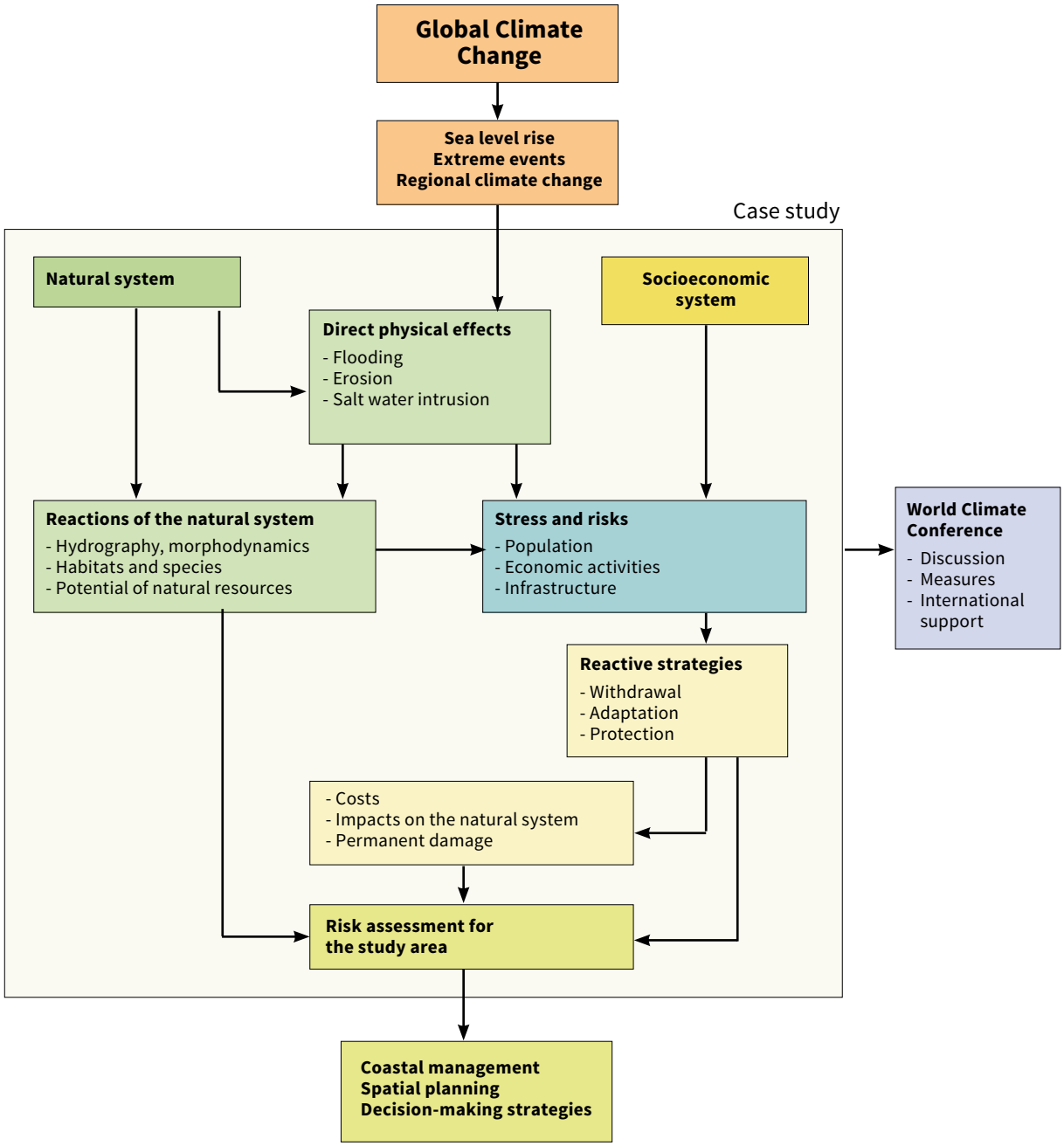
(Source: Kelletat, D. (1999): Physische Geographie der Meere und Küsten, Second edition, Stuttgart. fig. 45 and 143.)

EXERCISES

1. Describe the possible scenarios of sea level rise by the end of the century and the different factors that affect the sea level **(M 1 and M 2)**.
2. Demonstrate the relationship between climate change and sea level rise **(M 2)**.
3. Examine the different regional effects of climate-related changes in **M 3** (rise in sea level, increase in incidence of tropical cyclones, etc.) and explain them against the background of what you know about the most affected countries. Consult the maps in your Atlas which provide details about population distribution.

M 3

Methodological approach for identifying and evaluating the potential risks facing coastal areas from climate change



(Source: Sterr, H. and K. Schmidt (1995): Auswirkungen des Klimawandels auf den deutschen Küstenraum. In: Geographische Rundschau vol. 47(2). p. 106, according to: IPCC.)

EXERCISES

4. Explain the potential impacts of and challenges caused by a climate-change-induced sea level rise for people and the natural environment in coastal areas using the diagram in **M 4**.

M 5 The Netherlands – under water?

"The trauma of the Dutch dates back to the year 1953, the year of the most devastating storm surge in recent history. The water penetrated into the country's interior up to 80 kilometres from the coastline and 1,835 people lost their lives. Shortly afterwards, the dykes became a national obsession, and people began to relentlessly implement new defence mechanisms. They realised the "Deltawerken", a gigantic lock system that cost 13 billion euros and is designed to protect the commercial centre of Rotterdam. They built the dykes so high there that, statistically, they can break only once in 10,000 years. The whole country was equipped with more than fifty large dyke rings, with thousands of kilometres of first, second and third lines of defence. Twelve million cubic metres of sand are deposited along the coastline every year to protect the country. The powerful Rijkswaterstaat authority has a higher budget at its disposal than the defence ministry."

(Source: own translation of Die Zeit from 17.5.2007. http://www.zeit.de/2007/21/Bangladesch, accessed 24.01.2014.)

"In addition, the Dutch government has approved five billion euros by 2015 to protect the coasts from the effects of climate change. The aim is to reduce the statistical risk of a catastrophic flood from once every 10,000 years to almost zero. In addition, aquifers are to be protected against salination by fresh water buffers."

(Source: Die Welt from 13.10.2008. http://www.welt.de/wissenschaft/article2569770/Niederlande-wappnet-sich-gegen-gefraessige-See.html, accessed 24.01.2014.)

M 6 Reactions to rising water volumes in the Netherlands

Houseboats have a long tradition in the Netherlands. What is new is that some people are taking the plunge and moving into proper family houses on pontoons, even in waters that are exposed to the tides. The recent trend is not to work against the water, but to work with it. This means that dykes are no longer heightened at any price, but water is given more space. In addition to floating houses, floating car parks and greenhouses are also to be developed. Climate researchers believe that the Netherlands will likely develop into a hydro-metropolis by mid-century. It is, however, questionable how many Dutch people can afford such houses.

The most ambitious project will be started in Nimwegen, with the aim of protecting up to four million people from rising rivers. For this purpose, the Meuse river will have a large tributary added, meaning that around 200 families need to be relocated. This will, however, reduce the risk of flooding considerably.

(Sources: according to Tageblatt from 19.11.2012. http://www.tageblatt.lu/nachrichten/story/Nimwegen-baut-eine-Insel-30907379;
Spiegel Online Wissenschaft from 1.12.2011. http://www.spiegel.de/wissenschaft/technik/klimawandel-in-holland-wohnen-in-ebbe-und-flut-haeusern-a-800897.html;
and Klimawandel Global: http://www.klimawandel-global.de/klimaschutz/klimawandel-aqua-architektur; all accessed 24.01.2014.)

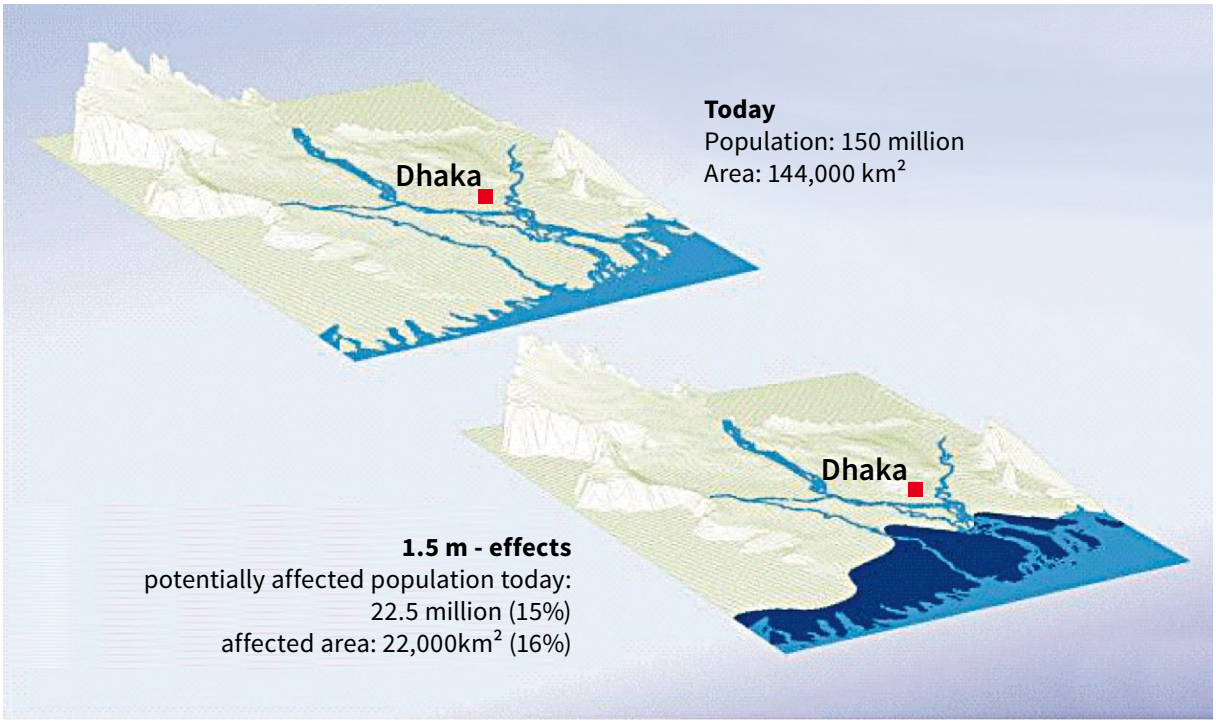
M 7 Bangladesh and the sea level rise

“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. […] 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. 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. Economic centres, such as the main export port Chittagong, would be affected. […] 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.”

(Source: Butzengeiger, S. and B. Horstmann (2004): Sea-level rise in Bangladesh and the Netherlands, one phenomenon, many consequences, Germanwatch, Bonn, p. 5f. http://germanwatch.org/download/klak/fb-ms-e.pdf, accessed 14.02.2014.)

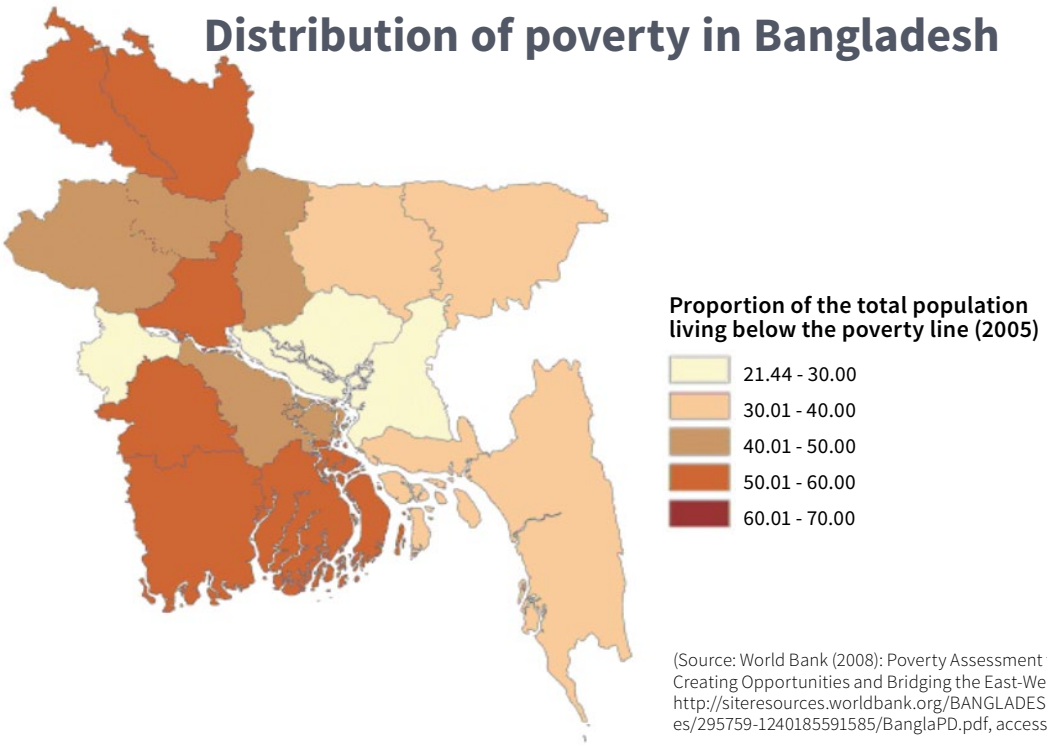
M 8 Possible impacts of sea level rise on Bangladesh



(Source: altered from UNEP/GRID-Arendal, www.grida.no)

M 9

Distribution of poverty in Bangladesh



(Source: World Bank (2008): Poverty Assessment for Bangladesh: Creating Opportunities and Bridging the East-West Divide, p. 54. http://siteresources.worldbank.org/BANGLADESHEXTN/Resources/295759-1240185591585/BanglaPD.pdf, accessed 24.01.2014.)

M 10

The situation in Bangladesh

In 2009, the raging cyclone "Aila" destroyed large parts of the rice harvest in Bangladesh. The soils were damaged by sea water, in some parts permanently, and more than 500,000 people were left homeless. Climate change leads to an increase in the number of cyclones, although the number of people killed in Bangladesh has actually decreased in recent years. This is mainly due to an early warning system and measures to educate children and young people in schools about this issue. That's why Bangladesh has slipped in the long-term Climate Risk Index for the years 1992–2011 from first to fourth place. The neighbouring country of Myanmar, for example, is affected more significantly by climate change. Nevertheless, the situation in Bangladesh is catastrophic. Food prices vary greatly and on average people have to spend 55% of their income on food. In addition, large parts of fertile alluvial soils are salinated and some villages are totally dependent on water supplies from outside. If this situation continues, a third of the total population might become refugees. But where should they go? India has erected a 4,000 km long fence and Myanmar intends to follow this example. In the face of this, one should keep in mind that CO_2 emissions per capita in the Netherlands is more than 25 times higher than the figures for Bangladesh.

M 11

International vulnerability comparison (vulnerability degree)

Indicators	Germany*	The Netherlands	Poland	Marshall Islands
Affected area	3.5%	>70%	0.7%	80%
Affected population	2.8%	67%	0.6%	100%
Affected overall amount/GDP	17.4%	69%	24%	324%
Annual coastal protection/GDP**	0.009%	0.05%	0.02%	7%

* Real scenario: based on an assumed rise in sea level that would see areas on the North Sea affected up to 5 m height line and on the Baltic Sea up to the 2.5 m height line; the corresponding effects for the other countries were calculated based on these assumptions;
** Coastal protection and adaptation costs per year

(Source: Behnen T. (2000): Der beschleunigte Meeresspiegelanstieg und seine sozio-ökonomischen Folgen – Hannoversche Geographische Arbeiten, Vol. 54, Münster.)

M 12 A solution for Bangladesh

The construction of modern coastal dykes in Bangladesh cannot be financed and therefore does not make sense, because dykes would have to be extremely high, which would not be feasible from a technical point of view. In addition, valuable agricultural land would be destroyed. Instead, the country has opted to adapt agriculture – one of its most important areas of action – to cope with the most severe impacts of climate change. Researchers and non-governmental organisations are currently developing Bangladesh to make it a centre for climate change adaptation. Experts from other countries come to Bangladesh and learn from the progress that can already be seen there. Many measures can be transferred well to other least developed countries (LDCs) since similar conditions prevail there. There are many adaptation measures being implemented at the local level, involving local people. With floating gardens, for example, it is possible to harvest even during times of flooding. For this reason, water hyacinths are composted on floating bamboo frames, on which food is grown. For cooking, portable loam ovens are mounted on rafts, so that food preparation is also possible during flooding. Moreover, some chicken farmers in Bangladesh have now switched to breeding ducks, as they are less affected by floodwaters. In addition, some houses and seed stores are positioned on loam platforms to protect them from the water. Farmed fish are prevented from escaping over the dams at high water using jute sticks. To reduce the number of victims in floods, children are taught to swim, which has not always happened up to now in Bangladesh. Some school children are even picked up by floating schools to attend classes. Rainwater is directed from the roofs of houses into large tanks so that it can be used during periods of drought. In addition, attempts are being made to grow salt-resistant plants so that agriculture can continue despite the increasing salinization of groundwater in the coastal areas. In individual cases, cyclone shelters are being built. In another project, Dutch engineers are helping to create a polder landscape, which is made possible through sediment input in river deltas.

On the whole, Bangladesh is still at the beginning of its implementation of adaptation measures to climate change. It is questionable whether these measures will be sufficient to protect the more than 150 million inhabitants. What is more, full-scale implementation requires a lot more financial resources than the country can contribute on its own. Measures implemented by the government usually help only the few better-off in the country. It is to be hoped that those affected can claim from those responsible for climate change to provide support for protective measures. Until then, however, there is still a long way to go.

TASKS

5. Evaluate Table **M 11**, taking into consideration further rising sea levels.

6. Discuss the objectives and the scope for action in Bangladesh as part of international climate policy **(M 10)**.

7. Create a cause-and-effect diagram for flood threat in Bangladesh, using the present materials and your Atlases **(M 7–M 10).** In this exercise, deal in particular with the affected areas listed in **M 8 and M 9**.

8. Do you think that it makes sense to compare the Delta region in the Netherlands with Bangladesh? Consider in particular also **M 5 and M 6**.

9. Explain the term “ecological survivability” of a country using all materials.

10. Finally, carry out a role play dealing with the subjects of emission reductions, adaptation measures to the negative effects of climate change as well as financing, in which you take on the role of politicians from Bangladesh and an industrialised country (e.g. Germany) at an international climate conference.