

# Adapting to a changing climate





## DHI

DHI is an independent, international consulting and research organisation. Our objectives are to advance technological development, governance and competence within the fields of water, environment and health. We offer a wide range of consulting and policy services as well as leading edge technologies. DHI works with governmental agencies and authorities, contractors, consulting companies and a wide range of industries. We are more than 800 employees working worldwide and on all continents.

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## Climate change will hit us first through water

There is now clear scientific evidence that global warming and climate change is real and that there is a global challenge to learn to cope with increasing temperatures and other effects of climate change. Water is in all aspects of climate change among the key areas to be impacted by climate change as illustrated below based on IPCC predictions.

### The future

**in Africa...** by 2020, between 75 and 250 million people are projected to be exposed to an increase of water stress due to climate change. In some countries, yields from rainfed agriculture could be reduced by up to 50% by 2020.

**in Asia...** glacier melt in the Himalayas is projected to increase flooding, rock avalanches from destabilised slopes and affect water resources within the next two to three decades. Freshwater availability



in large river basins is projected to decrease. Worldwide, some one billion people living in major snowmelt fed river basins may be affected.

**in Australia and New Zealand...** water security problems are projected to intensify by 2030 as a result of reduced precipitation and increased evaporation. Ongoing coastal development and population growth are projected to exacerbate risks from sea level rise and increases in the severity and frequency of storms and coastal flooding.

**in Europe...** negative impacts will include increased risk of inland flash floods, and more frequent coastal flooding and increased erosion. In Southern Europe, climate change is projected to worsen conditions in a region already vulnerable to climate variability, and to reduce water availability, hydropower potential, summer tourism and, in general, crop productivity. In Central and Eastern Europe, summer precipitation is projected to decrease causing higher water stress.

**in Latin America...** sea level rise is projected to cause increased risk of flooding in low lying areas. Changes in precipitation patterns and the disappearance of glaciers are expected to significantly affect water availability for human consumption, agriculture and energy generation.

**in North America...** warming in western mountains is projected to cause decreased snowpack, more winter flooding and reduced summer flows exacerbating competition for overallocated water resources.

**in small island states...** sea level rise is anticipated to cause increased risk of flooding in coastal and low lying areas.



## Adapting to the climate change



IPCC states that there are two responses to climate change, which must go hand in hand. The first response, mitigation, involves reduction of greenhouse gases to slow or stop the process of climate change. The second response, adaptation, is learning to cope with temperature increases and extreme events and higher sea levels associated with the temperature increases. This adaptation comprises a wide range of responses, eg highlighted in the roadmap agreed by the parties of the Climate Change Convention in Bali, December 2007: vulnerability assessments, financial needs assessments, prioritisation of actions, integration of adaptation actions into sectoral and national planning.

### Climate screening and proofing

The purpose of screening is to 'climate proof' the activities, which are implemented with Danish assistance, typically in the form of sector programmes.

A project in Uganda focused on the Danish support to the agricultural sector and to the water sector. DHI provided assistance on climate change aspects in relation to the water sector, especially on integrated water resources management. One concrete example of the output is a list of 15 recommended actions to be included in the detailed planning of the upcoming joint multidonor water sector programme.

### Adaptation - integration into national and sector plans

All countries, and especially the developing countries, will feel the consequences of climate change – and will need to identify appropriate measures to adapt to the expected change.

Many of these countries, which are expected to experience the most dramatic consequences of climate change, are also expected to be exposed to more severe and frequent natural disasters such as typhoons, floodings, droughts, etc.

Since the exact consequences of climate change are still uncertain, it is necessary to develop flexible and robust coping strategies – strategies which focus on enhancing community resilience in a broader sense, including resilience towards natural hazards.

### Disaster risk reduction

It is increasingly acknowledged that strategies to cope with climate change need to be linked to and integrated with strategies for disaster risk management. By reducing the vulnerability of people in disaster prone areas, it is most likely that they will also be better prepared for – or better adapted to – climate change impacts.

Vietnam is an example of a country going to implement this concept in its climate change adaptation strategy with Danish assistance. DHI supports Danida and the Vietnamese Government in developing this strategy.



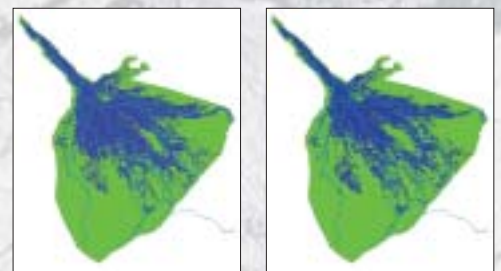
## Vulnerability assessment



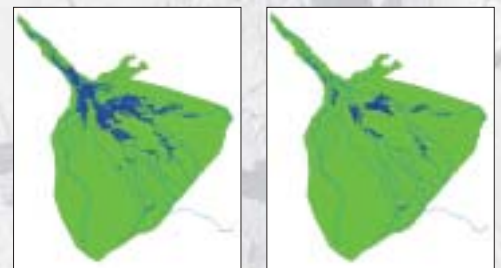
A study of the Okavango Delta system in Botswana reveals how significant the impact of climate may be. The system is the largest inland delta in the world and supports a pristine ecological system comprising densely vegetated swamps, riparian fringe vegetation, woodlands, grass land, savannah and barren land areas. The ecological diversity of the delta is a direct result of the abundance of surface water over a 4,000-15,000 km<sup>2</sup> area surrounded by the Kalahari Desert. Hydrological processes in the Delta are highly dynamic, complex and interrelated.

Results from several potential management scenarios indicate that increased crop irrigation in Namibia and Angola and projected climate change may have severe impacts. The study concludes that:

- The basin and delta are presently in a near natural state with minimal impact from land use changes and water abstractions from the delta and the upstream basin
- Proposed hydropower dams in Angola will not have a major impact on the delta with no net water consumption and small changes in releases during the dry period
- Upstream irrigation in Namibia, and especially Angola, will have a significant impact
- The permanently flooded delta areas may be reduced by 40% in dry years
- Projected climate change will have a severe impact and reduce both inflows and rainfall while increasing the rate of evapotranspiration
- In combination with upstream irrigation, the permanently flooded area may be reduced from about 2,770 km<sup>2</sup> to 145 km<sup>2</sup> only.



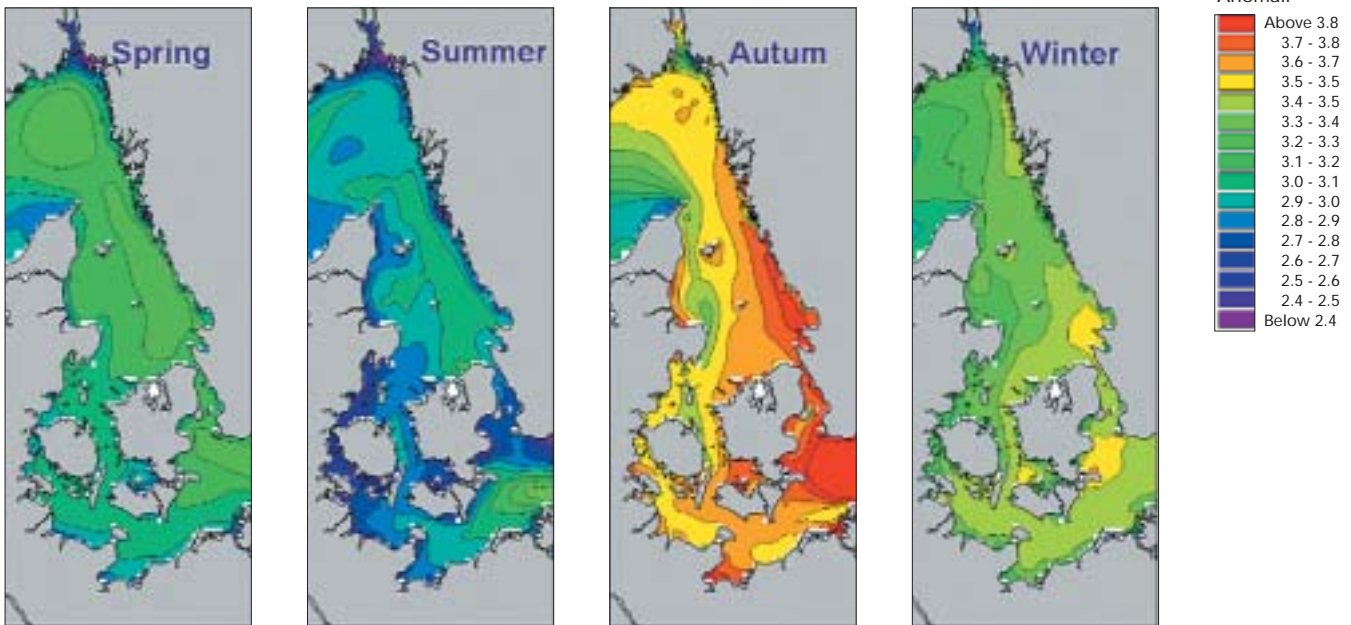
Upper envelope of flood extent for baseline (left – 10,400 km<sup>2</sup>) and combined scenario with climate change (right – 9,063 km<sup>2</sup>) for the dry period (1992 to 1997).



Lower envelope of flood extent for baseline (left – 2,770 km<sup>2</sup>) and combined scenario with climate change (right – 145 km<sup>2</sup>) for the dry period (1992 to 1997).



## Climate change impact assessment



Modelled effect on the sea temperature in year 2100.

DHI has been part of a major Danish research project concerned with the effects of increased precipitation, temperatures and more extreme weather incidents on the ecology of the aquatic system in and around Denmark.

In the coastal and marine environment the effects are:

- Increased biological activity in the coastal zone
- Changes in salinity
- Changes in the dynamics of salt wedges
- Changes in spring bloom
- More widespread areas and more severe incidences of oxygen depletion
- Major Baltic inflows will not be reduced

DHI applies MIKE SHE, MIKE 11 and EVA as modelling and postprocessing tools.





## Protecting infrastructures

It is in the interest of society to protect the population. It is also important to provide timely and cost-efficient protection of the infrastructure against flooding and the aquatic environment against polluted sewer overflows.

Climate change may alter the precipitation pattern significantly. It is foreseen that extreme rainfall events followed by floods will increase in many countries around the world – both in number and intensity.

### Urban infrastructure

DHI has participated in the development of guidelines, providing a consistent framework for the impact analysis of future climate changes.

The guidelines include methodologies for developing an appropriate and cost-efficient strategy for coping with climate change and its impact on sewer systems.

Vulnerable urban water infrastructures include:

- Stormwater drainage systems
- Combined sewer systems
- Embankments and dikes for flood protection

The guidelines contain:

- Three levels of analysis depending on the complexity of the sewer system
- A framework for analysing if, where and when the climate change statistically will violate today's standards. Will it be in 10, 25, 50 or 100 years? or is today's design climate proof?
- If today's design standards are violated, what is then the implication in terms of flooding and damage to society?



*Predicted flooding in a Danish city for a rainfall event with a 10-year return period – in the year 2100.*

### Ports

Ports and other vital facilities are other elements of the infrastructure, which will be affected by climate change and sea level rise. Higher sea level and storminess will probably decrease the effectiveness of breakwaters against wave forces, and wharves may have to be raised to avoid inundation. When such effects are anticipated, countermeasures can be implemented to maintain function and stability.

DHI has been involved in a number of worldwide ports and offshore projects where the impact of increasing sea levels has been considered using advanced numerical models and physical model tests.

The hydraulic model includes structure operation based on existing and potential future rule curves for all major structures. Exceedance statistics for flooding and water levels are derived from model results with alternative operation strategies and potential land use changes within the basin by year 2031. The results are used in evaluation and decision making in relation to structure operation strategies. DHI applies MIKE SHE, MIKE 11 and EVA as modelling and postprocessing tools.



*Verifying breakwater design with physical model tests.*

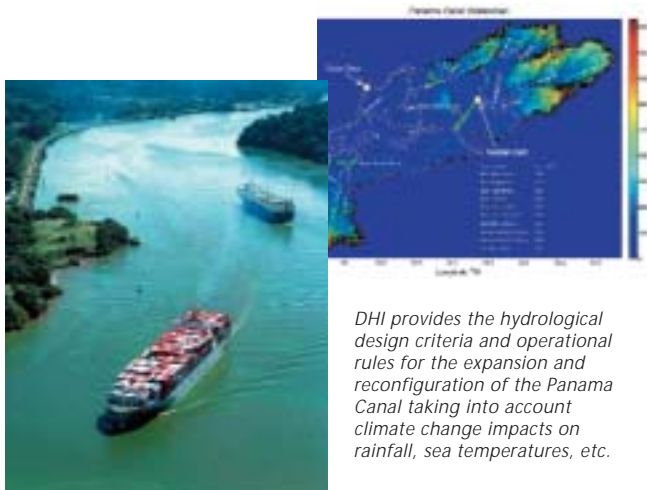


## Water transport

DHI provides the hydrological design criteria and operational rules for the expansion and reconfiguration of the Panama Canal taking into account climate change impact on rainfall, sea temperatures, etc. The canal will be expanded and reconfigured. New rules for lock, dam and spillway control, which will apply from 2010, are also being developed.

Due to decreasing water levels during drought periods, higher water levels should be maintained in the Gatun and Madden Dam to secure the operation of the locks. Higher water levels do, however, affect flood risk, hydropower production and the ability to meet water demands in the basin.

DHI has developed an integrated hydrological and hydraulic model of the Panama Canal basin, which is driven by inputs from projected rainfall. The hydraulic model includes structure operation based on existing and potential future rule curves for all major structures. Exceedance statistics for flooding and water levels are derived from model results with alternative operation strategies and potential land use changes within the basin by year 2031. The results are used for the evaluation and decision in relation to climate change.

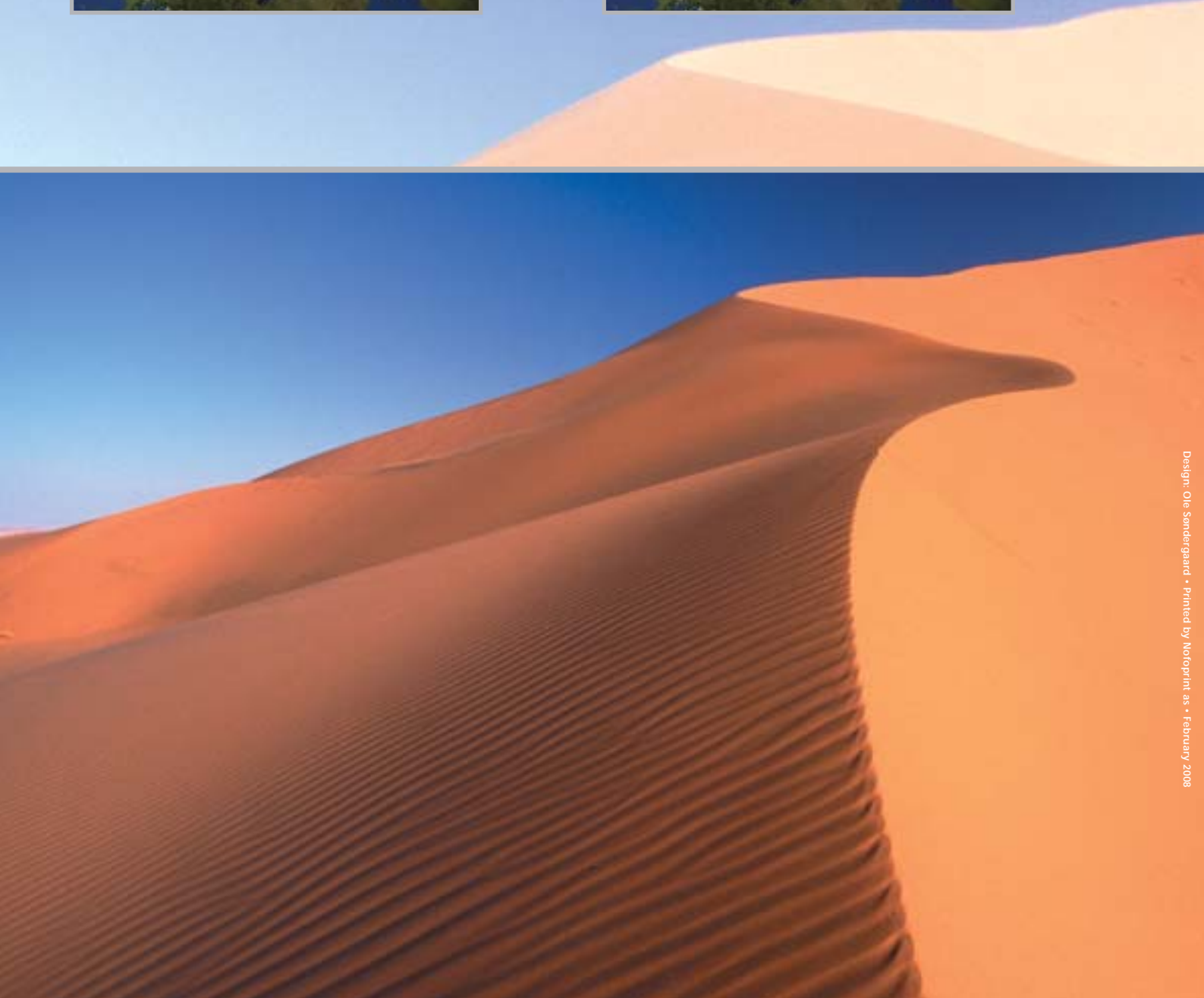


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