COMMENTARY

Climate proofing the Netherlands

Regional climate change should not be seen only as a threat; changes to weather patterns could generate opportunities for large-scale innovations, especially for the agricultural sector, say **Pavel Kabat** and colleagues.

Since Noah's flood, people in regions all over the world have learnt, mostly by trial and error, to cope with extreme-climate events. Based on limited climatic and hydrological data on past events, countries have developed infrastructure and legislation to protect people from floods and droughts. Protective measures differ widely between regions, countries and continents — as do the risks. In economically important and densely populated parts of the Netherlands the standards of flood defence are the highest in the world; dykes protect delta regions from a flood event expected to occur once every 10,000 years.

But global climate change caused by greenhouse-gas emissions means that key climate and hydrological variables will change. We can no longer assume that the future climate can be predicted on the basis of past patterns[1]. Climate change and sea-level rise present major challenges to each of the world's delta regions, which together harbour about 70% of the world's population and economic resources. We think the international science and policy communities should develop plans for achieving future sustainability in these vital areas of our planet, using a 'climate proofing' approach.

Climate proofing does not mean reducing climate-based risks to zero — an unrealistic goal for any country. The idea is to use hard infrastructure to reduce risks to a quantified level, accepted by the society or economy. This risk can be further combated by 'softer' measures, such as insurance schemes or, as a last resort, evacuation plans. Such climate proofing should be driven by opportunities for technological, institutional and societal innovations, rather than purely by fear of the negative effects of climate change.

Too little too late

The high impacts of the recent US hurricanes (economic losses associated with Hurricane Katrina were in excess of $125 billion[2]), exposed the consequences of not taking enough precautionary measures to address low-probability but high-magnitude climate events. Most levees in New Orleans, breached by storm waters following hurricane Katrina, were built to deal with floods that occur once every 30 years. Since Hurricane Katrina hit New Orleans last summer, many have advocated increasing levee protections for New Orleans and even for the entire Louisiana coast. However, a broader climate-proofing approach may be a better long-term solution than simply reinforcing and raising the levees.

Globally, evidence is mounting for more frequent and intense climate extremes in the future, as a consequence of anthropogenic climate change[3,4]. But these predictions, and those for specific regional impacts, remain uncertain, and deciding on the right strategy to prepare for these events is not an easy task. In the Netherlands, the government is already investing in climate proofing. In addition to the ongoing Climate Changes Spatial Planning Research programme (KvR) scheduled for 2005–2009, which is costing €100 million (US $118 million), the government will soon launch a new initiative called ARK (Adaptation Programme for Spatial Planning and Climate). ARK will be several times larger than KvR, in both size and scope. It will develop, through partnership between policy makers, researchers and other stakeholders, a comprehensive agenda that deals with climate change across several sectors of the society and economy.

Lost at sea

In the Netherlands, many key decisions about future developments are being taken now, and incorporating climate-change risks and opportunities into these decisions, as was recently called for by the senate of the Dutch parliament, is essential. For the Dutch government, climate change is accepted as an issue to address in many sectors and policies. But why is it politically acceptable to spend millions of euros on climate proofing in the Netherlands, but not in most other countries?

Sixty percent of the Netherlands territory is located below sea level and 70% of the gross national product is earned in these flood-prone areas. So it is quite likely that the Netherlands will be confronted with several effects of climate change, including increased risk of flooding and more frequent summer droughts. The predictions for the Netherlands' climate in 2100 shown in the table[5] cover the

Vision of the future: a hydrometropole

Today the Netherlands is divided into several dyke-protected regions which have different flooding risks. A future floating city, or hydrometropole, could be further divided so that different risk thresholds are matched to suitable property insurance levels. Finding extra land to store surplus floodwater will require creative solutions.

For example, greenhouse horticulture businesses place a high demand on water for irrigating their crops, and are sensitive to both wet and dry climate extremes. Greenhouses and their water reservoirs also cover large surface areas. So integrating water reservoirs into the foundations of greenhouses could both save space and serve as emergency floodwater storage[9]. These ideas are already moving from research ideas to pilot projects in the Dutch city of Naaldwijk (see above).

range of known modelling and emission uncertainties. For most sectors of the Dutch economy and society, even the low to medium climate-change impacts would have serious consequences, such as a significant rise in sea level[6].

The Netherlands faces several climate-change tests. The first relates to how we cope with increased risk of flooding in regions that are already vulnerable. The second relates to the amount of time we have to adapt to climate change; when does acting later become too late? In our view, developing a climate-proofing strategy now is likely to be more cost effective than taking drastic actions later. The third challenge applies to the way different strategies are being discussed, worked out and eventually implemented and governed. Climate problems call for true integration across scientific disciplines, economic sectors and stakeholder groups. But they also call for a participatory approach in which strategies are discussed at all administrative levels, individual citizens included.

Water people

Public debate about how to cope with future floods, should climate change lead to a greater risk of flooding, was accelerated by two events in the 1990s. Because the Netherlands is situated on the delta of three major European rivers (the Rhine, the Meuse, and the Scheldt), it is especially vulnerable to increased peak discharges. In the winters of 1993 and 1995, extreme discharge nearly overtopped the river dykes, and 250,000 people were evacuated as a precautionary measure.

During the past 50 years, the Netherlands has adopted highly visible policies and measures for water management. After major sea floods in 1953, with economic losses estimated at €1 billion and 2,000 lives lost, the Delta plan was designed. This is a comprehensive system of protective dykes and surge barriers. So far, the Netherlands has invested €13 billion in the Delta plan. Between 1986 and 2005, the main storm surge barrier of the Delta plan has had to be closed more than 20 times because of the threat of flooding.

However, public debate after the 1993 and 1995 floods focused on the potentially negative consequences to the landscape of further raising the dykes. A new 'living with water' strategy was developed[7], which argues that extreme-climate events should be accommodated rather than fought with heavy infrastructure. The idea is that instead of always reinforcing and heightening the dykes along rivers, occasional flooding will be accommodated and carefully managed in specific designated areas. This new approach, designed to deal with the medium-impact regional predictions for the Netherlands (see Table), was adopted by the Dutch government as national policy in 2000.

Regional climate predictions for the Netherlands for 2100

Climate variable	Low-impact predictions	Mid-impact predictions	High-impact predictions
Temperature	+1°C	+2 °C	+4 to 6 °C
Average summer precipitation	+1 %	+2 %	+4 %
Average winter precipitation	+6 %	+12 %	+25 %
Sea-level rise	+20 cm	+ 60 cm	+110 cm

The Netherlands is also starting to build up resilience to other climate changes, such as increased frequency of summer droughts. The summer of 2003 was the hottest in Europe in more than 500 years. In the Netherlands, the heat wave was linked to an estimated 500 deaths, of mostly elderly people, which compared to 27,000 for Europe as a whole. According to some modelling studies[4], the 2003 summer conditions could become a close-to-normal summer by about 2050. This will have major implications for many sectors of the Dutch economy and society.

For example, the extremely low freshwater discharge by the river Rhine in 2003 resulted in groundwater seepage of seawater to the low-lying delta, which in turn threatened large areas of Dutch agri- and horticulture. New canals for bringing freshwater to the region, and additional summer storage facilities, are now under study. The low 2003 water levels, and high surface-water temperatures, also caused serious shortages of cooling water for the Dutch energy sector, with consequences for industrial productivity.

Paid to protect

What opportunities for climate proofing exist in the agriculture sector? Current changes to the rural policies of the European Union (EU) could be exploited by Dutch farmers wanting to prepare for future climate change. In June 2005, the EU agreed to support the European Agricultural Fund for Rural Development (2007–2013). This will help reform the Common Agricultural Policy and support rural development. For many Dutch farmers, this could allow them to diversify their activities and move away from traditional agriculture, such as dairy farming on low-lying peatland.

"Developing a climate-proofing strategy now is likely to be more cost effective than taking drastic actions later."

One possibility is to compensate farmers for lost income. We propose awarding those farmers achieving lower greenhouse-gas emissions or who use their land as water-storage facilities to combat summer dry spells and winter river discharges. The Dutch dairy farm is currently a significant source of carbon emissions (up to ten carbon dioxide equivalents[8] per hectare per year). These emission rates could be reduced considerably, and such farms even become a net carbon sink (of up to eight carbon dioxide equivalents[8] per hectare per year), if the farmland is transformed to a more natural state[7].

Farming income could be substituted by carbon credits for reduced emissions. The current emissions trading price under the Kyoto protocol is €23 per ton of carbon dioxide. Assuming that future emissions trading would cover all greenhouse gases and all sectors, which it does not do now, the farmer could generate an income of €414 per hectare per year. For comparison, an average Dutch dairy farm today generates an income of some €670 per hectare per year, one-third of which is subsidized by the EU.

The Netherlands faces higher sea levels and more extreme hydro-climatic events in the future. We think two basic approaches to climate proofing could help combat these threats. In one, urban and industrial activities, including infrastructure, move from below sea level to higher and drier lands, as found in the eastern Netherlands. The second approach involves the creation of a large 'hydrometropole', a world in which we have learned how to live with — and make a living from — water (see 'Climate proofing the hydrometropole'). This would be a major urban, industrial and rural area with more than 15 million people living and working in a world partly floating on and surrounded by water. Given the history of the Netherlands and the spirit of its people, this second vision seems more appropriate and attractive, but only time — and vigorous public debate — will tell what approach is favoured. ■

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