



Climate Change Adaptation

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Editorial

Managing unavoidable social, economic and environmental impacts

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2007)¹ concluded that even the most stringent mitigation efforts cannot avoid further impacts of climate change in the next few decades. This inevitability of impacts makes investment in adaptation essential. Yet mitigation also remains crucial: to rely on adaptation alone would eventually lead to a level of climate change to which effective adaptation is no longer feasible. The cost of acting now to mitigate and adapt to climate change will be far less than the costs of delaying - see: 'Call for urgent action on climate change'.

In the past two decades more research has been carried out on mitigation than on adaptation. However, more effort is now being put into adaptation research, and this thematic issue presents a selection of recent highlights, including making the best use of green infrastructures, such as agricultural land. Current adaptation research includes analysis of:

- The feasibility, costs and effects of specific options within economic sectors and geographical regions. For example, research is helping decision-makers include the impacts of climate change into regional planning – see 'New tool helps evaluate regional plans for climate change adaptation'.
- The process by which people, organisations and society adapt. For example, the ability of farmers to adapt depends strongly on farm characteristics and socio-economic circumstances – see 'European farmers adapting to climate change'.
- The requirements on policy to identify and remove barriers to and otherwise support adaptation. For example, working together with farmers to link flood management with agricultural practice can increase the effectiveness of adaptation strategies – see 'Agricultural practice could help reduce flood risk'.
- The wider social and economic effects of investing in adaptation to climate change. For example, the wise use of limited water resources has wider benefits – see 'Increasing water supplies – reuse of treated wastewater'.
- Links between adaptation and other policy priorities, such as mitigation and development. For example, trees reduce heat stress during hotter summers while also capturing carbon dioxide – see 'Trees reduce city temperatures'.

The papers presented in this issue offer a mere snapshot of the rich research that has recently become available. They have been selected to demonstrate that adaptation to climate change will take place at a national, regional and local level. The EU can play a very important role in assisting these efforts. A comprehensive assessment of recent adaptation research, including limits to adaptation and links with mitigation, can be found in Chapters 17 and 18 of the Working Group II volume of the IPCC Fourth Assessment Report.

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¹ See: The IPCC Fourth Assessment report – Climate Change 2007 <http://www.ipcc.ch/ipccreports/ar4-wg2.htm>

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Call for urgent action on climate change

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Sustainable development and policy assessment

Urgent action to mitigate climate change makes economic sense, according to a new report which presents a response to critics of the *Stern Review*. The report also calls for a greater consideration of risk and ethical issues in economic climate change models, as well as political agreement on greenhouse gas (GHG) targets.

“The cost of having to cope with the effects of climate change is much higher than the cost of mitigating climate change.”

The landmark *Stern Review*¹ discussed the effects of climate change on the world economy. Some critics, particularly economists, argued that Stern had overestimated the present value of the costs of climate change and underestimated the costs associated with reducing emissions. Business stakeholders argued that the economic cost of Stern’s proposals would be severe.

The new report argues that the cost of having to cope with the effects of climate change is much higher than the cost of mitigating climate change. It argues that adaptation can play a significant role in controlling costs and capturing benefits if global temperature rises are limited to 1-2°C. However, under the business as usual model the authors argue that global temperatures could rise by as much as 5°C, which could cause abrupt and global changes, such as weakening the Atlantic thermohaline circulation and collapse of ice sheets leading to significant sea level rise, to which we could not easily adapt.

Furthermore, expecting future generations to cover the costs of adapting to these changes is unethical. Basing real world policy on formal economic models would be misleading and dangerous, the report argues. This economic view of the environment as an externality fails to take into account several key aspects of climate change. Namely that:

- Climate change is global in cause and consequence
- Its impacts are long-term and persistent
- There is risk and uncertainty surrounding the impacts
- There is a risk of major, irreversible change that will affect global growth and development

The *Stern Review* recommends that the GHG target range should span 450 to 550ppm (parts per million) CO₂e (a measure that combines the effect of all the GHGs), and that we should act now to avoid costly delays and more extreme measures in the future.

The costs of climate change for global trade in commodities as well as in terms of damage to human wellbeing, social instability and migration are great. For example, as global temperature rises by over 4°C, which studies predict is possible at 550 ppm CO₂e, entire regions are expected to see significant declines in crop yields, which may be as high as a third in Africa, and sea level rises are predicted to affect major cities, such as New York, Shanghai and London.

Strong and urgent action on GHG emissions is likely to help reduce the cost of new, low-emissions technologies more quickly, because these will then benefit from economies of scale. Political agreement on targets improves the credibility of climate change policy, leading to greater investment in low-emissions technologies².

¹ Stern, N. 2007. *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press.

² EU leaders have set three key targets to be met by 2020:

1. a 20 per cent reduction in energy consumption compared with projected trends
2. an increase to 20 per cent in the share of total energy consumption provided by renewable energy
3. an increase to 10 per cent in the share of petrol and diesel consumption from sustainably-produced biofuels.

These targets are now being discussed by the European Parliament and the Council of the EU. EU leaders have expressed their wish for agreement to be reached on the package before the end of 2008. See: http://ec.europa.eu/environment/climat/home_en.htm

Source: Dietz, S. and Stern, N. (2008). *Why Economic Analysis Supports Strong Action on Climate Change: A Response to the Stern Review’s Critics. Review of Environmental Economics and Policy*. Doi:10.1093/reep/ren001.



New tool helps evaluate regional plans for climate change adaptation

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Adapting to climate change requires policymakers to negotiate the complex web of effects it will have on the environment and human health. A new internet-based tool could help policymakers understand these effects and choose appropriate adaptive measures for their local and regional development plans.

“Adapting to climate change at local and regional levels will require policymakers to make decisions based on many different effects.”

Climate change will have major impacts on the environment and human health within the next few decades. Adapting to climate change at local and regional levels will require policymakers to make decisions based on many different effects. In order to make the most appropriate decisions, policymakers will need to understand how these effects are interrelated.

A new internet-based tool called an ‘adaptation scan’ is designed to help policymakers factor the effects of climate change into their decision-making plans. The scan includes local climate change scenarios and effects for specific areas and provides adaptive measures to deal with both positive and negative effects.

Developed in The Netherlands, the adaptation scan helps policymakers pinpoint risks and possibilities posed by climate change within their area. It consists of two linked databases – one containing effects and one containing measures. These effects and measures interact in complex ways. For instance, one direct effect of climate change could be higher water levels in canals as a result of increased rainfall during winter. One adaptive measure in this case could be precautionary draining to avoid flooding. Indirect effects arising from this might include restricted shipping, as a result of closed waterways.

In a pilot study, consultants evaluated a draft regional development plan put together by authorities in Groningen, in the north east of the Netherlands. They selected the 18 most relevant impacts of climate change on health and the environment in the area and used the scan to identify areas where adaptive measures were lacking and to make recommendations as necessary. Many of the measures already in place in Groningen were not suited to tackling the predicted effects, and the scan helped identify measures that had been proven elsewhere which could be added to the plan.

At present, the scan covers 22 physical changes, 250 effects and 100 adaptive measures of climate change and there are plans to extend its range even further. The researchers say that although the current scan is designed for The Netherlands, it could be used as a model for other EU countries. However, they stress that to ensure the best results, input is needed from people with local expertise. Although the scan can provide a framework for policy making, the adaptive measures should be considered in combination with careful research and cost-benefit analyses. The scan will be publically available in early 2009.

Source: Schneider, H.C., Bijl, K., Van Cranenburgh, S. *et al.* (2008). The Dutch Adaptation Scan for Local Authorities. ENS8/ECAC7 Abstracts. 5: EMS2008-A-00647.



European farmers – adapting to climate change

A changing climate will significantly affect the future of the agricultural sector in Europe. A new report shows that management practices are important factors in reducing the impacts of a changing climate.

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“Temperature has a significant influence on crop yields, but management and policy decisions can alter this impact.”

Researchers compared climate data with farm performance data¹ across the EU15, also taking into account policy, land use, size and intensity of farming, in order to investigate the effects of climate variability and change on agriculture at both regional and farm type levels. The study used temperature and precipitation (rainfall, snowfall) data as indicators of trends and variability in the climate and crop yields and farm income as indicators of farm performance.

Five crops, wheat, grain maize, barley, potato and sugar beet, were chosen because different crops are affected in different ways by the climate. Farm income reflects both the direct effects of climate on crop yields, as well as any changes made in adapting to a changing or variable climate. Results showed that:

- prevailing climatic conditions significantly influence farming, which suggests that regions with similar climates adapt in similar ways
- the influence of climate on the variability of crop yields and incomes is more significant at the regional level than farm type level; at farm type level, farm characteristics play a greater role
- temperature has a significant influence on the trends in crop yields across regions, but management and policy decisions can alter this impact
- individual changes in temperature have a bigger impact on crop yields than average temperatures over a period of time
- different precipitation patterns affect crop yield trends more than temperature variability does
- variation in crop yield, as a result of rising temperatures, does not necessarily cause variation in income
- Mediterranean regions are not necessarily more vulnerable than other regions. Income is higher and increasing faster in Mediterranean areas, even though crop yields are generally lower. This implies farmers are adapting to the variable conditions by, for example, reducing input costs, changing crop varieties, irrigating more crops and using more subsidies
- variable precipitation adversely affects wheat and barley yields, but not maize, sugar beet and potato yields as these are usually irrigated crops. Droughts are more likely across all regions of Europe unless water resources are adequately managed.

Researchers suggest that studies to assess the vulnerability of European agriculture to climate changes need to include those farm characteristics, policies and socio-economic circumstances that affect farm management decisions, because adaptive strategies can moderate the impacts of changing climatic conditions.

Source: Reidsma, P., Ewert, F., Lansink A. O., Leemans, R. (2008). Vulnerability and adaptation of European farmers: a multi-level analysis of yield and income responses to climate variability. *Regional Environmental Change*. DOI 10.1007/s10113-008-0059-3.

¹ Regional and farm type data were obtained from the Farm Accountancy Data Network (source: FADN-CCE-DG Agri and LEI) from 1990 to 2003.



Agricultural practice could help reduce flood risk

Coherent agri-environmental schemes could contribute to wider climate change adaptation objectives including safeguarding water quality, carbon storage, biodiversity and habitat conservation. New research suggests that integrating Sustainable Flood Management (SFM) principles into agricultural practice will require relatively few changes under the current legislative framework.

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“Agriculture is recognised as a significant factor in floods, but less often for its potential role in flood management.”

Climate change is expected to increase the intensity and frequency of rainfall, and hence flood risk, across much of Europe. Traditional flood management is dominated by hard-engineered flood defence structures, but the Water Framework¹ and Flood Directives² imply increasing use of SFM techniques. Using natural processes to reduce risk has also been specifically discussed in the recent EU adaptation green paper³, which outlined other ‘soft’ flood control measures.

The researchers gathered expert opinion on SFM and found that, at present, legislation and the distribution of responsibilities are uncoordinated. The analysis showed that past SFM schemes relied on the goodwill of landowners, who were under no legal obligation to consider downstream flooding. Experts expected that future agricultural and water policies would combine in order to meet SFM goals, but that contradictory urban planning and economic policies would remain obstacles to its implementation.

Agriculture is recognised as a significant factor in floods, but less often for its potential role in flood management. Therefore, education of farmers, advisors and service providers was highlighted as a vital component of SFM. Rural and urban land use policies should also avoid offering ‘perverse’ incentives for activities such as draining of wetlands or river straightening and confinement, which increase surface water run-off. A third major conclusion was that SFM demands a package of measures over entire catchments, rather than just isolated and local schemes.

The researchers suggested that subsidised water management under the reformed Common Agricultural Policy⁴ may be possible as another way of delivering economic, social and environmental improvements.

Source: W., Hill, G. and Shannon, P. (2008). Scoping the role of agriculture in sustainable flood management. *Land Use Policy*. 25(3): 351-360.

¹ http://ec.europa.eu/environment/water/water-framework/index_en.html

² http://ec.europa.eu/environment/water/flood_risk/index.htm

³ http://ec.europa.eu/environment/climat/adaptation/index_en.htm

⁴ http://ec.europa.eu/agriculture/index_en.htm



Increasing water supplies – reuse of treated wastewater

Reusing wastewater, particularly for agricultural purposes, plays an increasingly important part in water management, particularly in areas of low rainfall. A recent study of the Apulia region in southern Italy shows that wastewater can be used to meet agricultural water needs.

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“Changes in agricultural practices, an expanding economy and over-use of groundwater, combined with climatic conditions, have caused a scarcity of water in the Apulia region.”

The Apulian water agency (AQP) runs the largest aqueduct system in Europe, importing water from neighbouring regions and delivering over 300 million cubic metres of drinking water per year through a 19,635 km distribution network to over 4.5 million inhabitants. Demands on water resources are increasing in the region from both agriculture and tourism. Nearly 80 per cent of land in the Apulia region is used for agriculture, despite an average regional rainfall of around just 660 millimetres per year. Nearly a quarter of this land requires irrigation.

Changes in agricultural practices, an expanding economy and over-use of groundwater, combined with climatic conditions, have caused a scarcity of water in the region; researchers estimate that a further 700 million cubic metres of water is needed for agricultural purposes per year. Over-exploitation of the groundwater in the region, through the excessive drilling of wells, has enabled salt-water to encroach on the freshwater aquifers, especially along areas close to the coastline. Regional authorities plan to curtail borehole drilling and to reuse treated municipal wastewater for agricultural and industrial purposes and in the process, protect the aquifers as sources of good-quality drinking water.

Currently, the 215 treatment plants managed by the AQP have the capacity to process around 250 million cubic metres of treated wastewater per year. Not all these plants are appropriate for efficient wastewater recycling, as they do not have the appropriate technological features, size or connections to the distribution infrastructures, however, the regional plan has identified plants that are suitable. These plants are also close to agricultural areas. During the first stage of development, it is envisaged that approximately 50 per cent of the reclaimed volume of treated wastewater (92 million cubic metres per year) from these plants will be used.

Reusing wastewater has other benefits for the region, such as the need to halt the discharge of wastewater into subsoil which has been common practice in the Apulia region. The plan was developed to comply with European Union Directives on the treatment of urban wastewater (91/271/EEC)¹ and protection of water from agricultural sources, especially nitrate pollution (91/676/EEC)².

Researchers suggest that other European authorities, seeking to increase the supply of water through the reuse of municipal wastewater, could study the model adopted by the AGP authorities, as a viable strategy to combat increasingly scarce water resources.

Source: Lopez, A. and Vurro, M. (2008). Planning agricultural wastewater reuse in southern Italy: The case of Apulia Region. *Desalination*. 218: 164-169.

¹ See: http://ec.europa.eu/environment/water/water-urbanwaste/index_en.html
Urban Waste Water Directive

² See: http://ec.europa.eu/environment/water/water-nitrates/index_en.html
Implementation of nitrates Directive



Trees reduce city temperatures

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Environment and health, Urban environment

“As global temperatures rise in response to climate change, city planners will need to take into consideration the effects of surfaces on local temperature.”

In light of global climate change, temperature control should be an important consideration in the design of the urban environment as a public health measure. New research shows how different urban land cover types, such as concrete and grass, affect the air temperature in cities. The study could help planners reduce the effects of hot summers.

High temperatures in cities, during heat-waves, have been linked to increased mortality rates and exacerbation of health problems such as respiratory disease. With extremes of temperature projected to increase under a changing climate, ways of reducing temperature need to be identified. Changing the design of a city could be one way of achieving this.

Local climate in a city differs considerably from the climate of its surrounding environment. Even within a city itself, air temperature can vary quite dramatically depending on the type of ground cover and the time of day. These variations need to be characterised in order to understand the impact they have on air pollution and heat retention in urban environments and to inform decision making processes in urban planning.

Previous studies have shown that temperature can vary substantially across an urban environment. For example, a study in Gothenburg, Sweden¹, demonstrated that an area of parkland was, on average, 4°C cooler than the built-up city centre. However, both this and other existing studies into ‘heat islands’ were conducted during the winter. Now Chinese researchers working in Nanjing have published a detailed study of daily temperature variation in the city during the hot season. The research may be useful in helping planners to design or re-design urban environments.

The research takes into account differences in temperatures at two levels - differences between four sites within the city and, within these sites, variations between four different land cover types. The four types of land cover studied were urban wood, grass, water and bare concrete. The researchers carried out detailed statistical analyses comparing air temperatures, at around head-height, between the sites and between land cover types on twelve days between July and September.

Of the four land cover types, bare concrete generated the highest air temperature. This is because evaporative cooling does not occur on these surfaces. Areas covered in grass produced the next highest temperatures, followed by water and then woods or tree shade. At the peak of the day, between 12pm and 2pm, the average temperature difference between concrete and tree shade could vary by as much as 5.3°C. At night, concrete was much cooler than it was during the day, whereas areas covered by grass or trees maintained a more constant temperature.

The researchers say their study reinforces the importance of providing vegetation as shade to reduce air temperatures in urban areas, particularly in cities known for their hot climates. Temperatures in Nanjing, as in some southern regions of Europe, can reach 40°C during the summer months. As global temperatures rise in response to climate change, city planners will need to take into consideration the effects of surfaces on local temperature.

Source: Huang, L., Li, J., Zhao, D. and Zhu, J. (2008). A fieldwork study on the diurnal changes of urban microclimate in four types of ground cover and urban heat island of Nanjing, China. *Building and Environment*. 43: 7-17.

¹ Eliasson, I. (1996). Urban nocturnal temperatures, street geometry and land use. *Atmospheric Environment*. 30(3):379-392.



A selection of articles on Climate Change Adaptation from the *Science for Environment Policy* News Alert

An even wetter future? (9/10/08)

Scientists agree that climatic events such as storms and heavy rainfall could become more intense as the climate changes. New research suggests that global warming not only increases the likelihood of such events, but also leads to greater extremes in rainfall, making moves to tackle global warming and implement measures such as improved flood defences increasingly important.

Food safety in the face of climate change (24/7/08)

The potential impact of climate change on food safety is considered in a new report by The Food and Agriculture Organization of the United Nations (FAO). The report aims to raise awareness of the issue and to facilitate international cooperation in better understanding, developing and implementing strategies to address the changing food safety situation.

Planning for the inevitable: the impact of climate change on biodiversity (17/7/08)

Climate change is already having an impact on habitats and species in Europe, for example a decrease in plant species has been recorded in some areas. According to recent research, spatial planning is a key concept in making European ecosystems more resilient to climate change, as it takes into account all factors that affect a habitat, including economic development, transport, environmental protection, health and culture.

Predicting contamination of farmland after flooding (5/6/08)

Floods and the resulting damage to agricultural and urban environments are likely to increase as a result of climate change. Major floods in Europe, such as those affecting the Elbe River in Germany in August 2002, can result in contamination by heavy metals of flooded farmland. Taking zinc as an example, a new modelling approach showed that there was more than a one in three chance that contamination could exceed 500 mg zinc per kilo of sediment following future extreme events.

A model for health and climate change (22/5/08)

The impacts of climate change on human health are projected to be severe and widespread. A reliable model or software tool is needed to help quantify these impacts so that policies can be developed to mitigate against them. A recent report suggests that newly developed systems-based models need to be further expanded to allow greater quantification of climate-health relationships.

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