

Tyndall°Centre
for Climate Change Research

the effect²⁰⁰⁴

Highlighting research and communication at the UK's Tyndall Centre



Modelling long-term economics of global technical change

New indicators of vulnerable countries

Reducing flood risks and strengthening coastal defences

Global engineering evaluated



Climate change and aviation

Stormy times for winter coastlines

Plugging renewables into the grid

www.tyndall.ac.uk



Professor John Tyndall, after whom this Centre is named, was a Victorian physicist and populariser of science who explained the greenhouse effect and why the sky is blue – called the Tyndall Effect.

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Future climate starts today

Founded in 2000, we integrate traditionally separate disciplines into a single body that is the nation's academic expertise for responding to global climate change. We bring together climatologists, social scientists, economists, policy analysts, engineers and environmental scientists to develop sustainable responses to climate change.

We assess and communicate the options to reduce greenhouse gas

pollution, the necessity to adapt to the impacts of climate change, and aim to integrate this knowledge into global and local decision-making.

Named after John Tyndall, the discoverer of the greenhouse effect and successor of Michael Faraday as Director of the Royal Institution of Great Britain, the Tyndall Centre aims to be academically strong, socially relevant, and an outstanding science communicator.

We are always very pleased to respond to suggestions for initiatives the Tyndall Centre should take; please contact Asher Minns (the Communication Manager) with your ideas.

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The year in review

The third and final round of research projects was announced by the Tyndall Centre last autumn. These projects built on our pioneering work in energy-economic modelling, adaptation in the water sector and decision-support tools for coastal zone management, but also opened up new work on flooding and public health, linking air quality and climate change mitigation, and on perceptions of dangerous climate change.

Examples of this and other Tyndall front-line research are reported in this (third) issue of *the effect*. The Centre also functions as an interdisciplinary think-tank promoting dialogue across society and setting new research and policy agendas. Examples of such activity within the last year include a symposium on biofuels convened on behalf of the European Climate Forum; a symposium evaluating macro-engineering solutions to climate change jointly organised with the Cambridge-MIT Institute; and a side-event at COP9 in Milan for new ideas on the economic dynamics of technological change. Our work on Domestic

“no comparable programme in its initial years has come further, faster or produced more exciting results than the Tyndall Centre”

Research Councils’ Review of the Tyndall Centre, April 2004

Tradeable Quotas (DTQs) has led to a 10 minute rule Bill being debated in Parliament, while Tyndall also played a pivotal role in the Flood and Coastal Defence Foresight Report for the Office of Science and Technology.

We continue to work in partnership with a diverse range of external organisations who are stakeholders in the management of climate change - including inter alia the Cayman Islands Government, Oxfam International, UK Water Industry Research, the finance sector’s Carbon Disclosure Project, DEFRA, the DTI, the Environment

Agencies, English Nature and the Northwest Development Agency.

These three core attributes of the Tyndall Centre – scientific excellence, high-level convening power, and stakeholder engagement – will remain central to our on-going mission as later this year we prepare a new business plan for the period 2005-2010 for our funding research councils. We have a sound foundation to build upon. Our recent review by the Research Councils’ said “no comparable programme in its initial years has come further, faster or produced more exciting results than the Tyndall Centre”.

With climate change remaining close to the top of national and international public policy concerns into 2005 and beyond, the Tyndall Centre faces no shortage of challenges to which it must bring its unique combination of policy-oriented inter-disciplinary research skills.

Professor Mike Hulme
Executive Director
August 2004



Modelling the long-term economics of global technology



The Tyndall Centre has put itself at the forefront of long term economic modelling by developing a pilot model fundamental to evaluating climate change policy. The model incorporates developments in information technology, bio-technology and nano-technology, and incorporates switching of energy from fossil fuels to renewable sources.

change policy. They introduced their new ideas to the Kyoto policy-making community at the Milan meeting in 2003 of the UN Climate Change Convention.

The Tyndall Centre has put itself at the forefront of long term economic modelling by developing a pilot global model fundamental to evaluating climate change policy. This new economics shows that early investment in sustainability makes a lot of sense.

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“It emerged from the seminar that a new economic view of climate change economics is resulting in a radically different policy message,” said Alex

The challenge now is to develop effective technology policy for the UK’s climate change effort, and to spread this

“a new view of climate change economics is resulting in a radically different policy message”

It also applies the theory of Kondratiev Waves to environmental technology, which explain the dynamics of long-term technological revolutions.

Haxeltine from Tyndall HQ. “The old argument is that society needs to wait until technology becomes cheaper before we embark on major efforts to reduce greenhouse gases. The new message is that appropriate policy can make the critical technology cheaper, sooner.”

more sophisticated understanding into wider international policy.”

This new approach to the economics of climate change has enabled the Tyndall Centre, in partnership with the Potsdam Climate Institute and Professor Michael Grubb of Imperial College and the Carbon Trust, to found a new international initiative for comparative modelling of the economics of climate

“Early action then makes a lot of sense. Initially high costs will help the innovation that brings down the eventual cost per tonne of reducing carbon dioxide.

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*Please see Tyndall Technical Paper 3 and Tyndall Working Paper 15
www.tyndall.ac.uk*

Reducing flood risks and strengthening coastal defence

The Tyndall Centre helped join climate change, social science, economics and engineering for the most wide-ranging analysis of future flood risk ever made for the UK. Launched in April by the Government's Chief Scientist, Sir David King, the Foresight report on future flooding outlines the possible risks for the UK from flooding and coastal erosion and highlights the decisions that need to be made to protect people, homes, businesses and the environment 30-100 years ahead.

Professor Andrew Watkinson of the Tyndall Centre and the University of East Anglia was lead author of several chapters for the report. "We brought a holistic interdisciplinary analysis of

climate change and flooding by integrating the engineering focus of flood defence with environmental and social aspects. We also became increasingly involved in the distillation and communication of the report's results."

The report is a national overview but its recommendations are particularly applicable to the east coast of England where Tyndall research is developing the coastal regional simulator to understand the complexity of changing coastal environments.

"We currently have a very wide range of approaches for managing flood risk but we need a longer-term vision that is



Professor Andrew Watkinson, manager of Tyndall's coastal zone research, led several chapters of the Foresight report on future flooding and coastal defence.

© M. Robinson

sustainable in the future for both local communities and the UK as a whole," said Professor Watkinson.

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New indicators of vulnerable countries

The first empirically-derived global index for identifying the countries most vulnerable to climate hazards has been developed by Nick Brooks and Neil Adger at Tyndall HQ and UEA. The index is constructed from key indicators that are strongly associated with deaths from climate-related disasters at the national level. They found the main indicators to be access to sanitation, literacy, maternal mortality, calorie consumption, civil and political rights, the effectiveness of government and life expectancy.

Gross domestic product (GDP) is not significantly associated with death from climate hazards, suggesting that GDP is not a particularly useful indicator of vulnerability. "National level indicators, and especially GDP, are not very good at capturing variations and inequalities within countries," says Nick.

During the 1990s, 28 of the 35 most vulnerable countries were in sub-Saharan Africa. The two highest-scoring non-African countries were Afghanistan and Iraq.

Small island states did not score as highly as might be expected. "The indicators were derived from a global

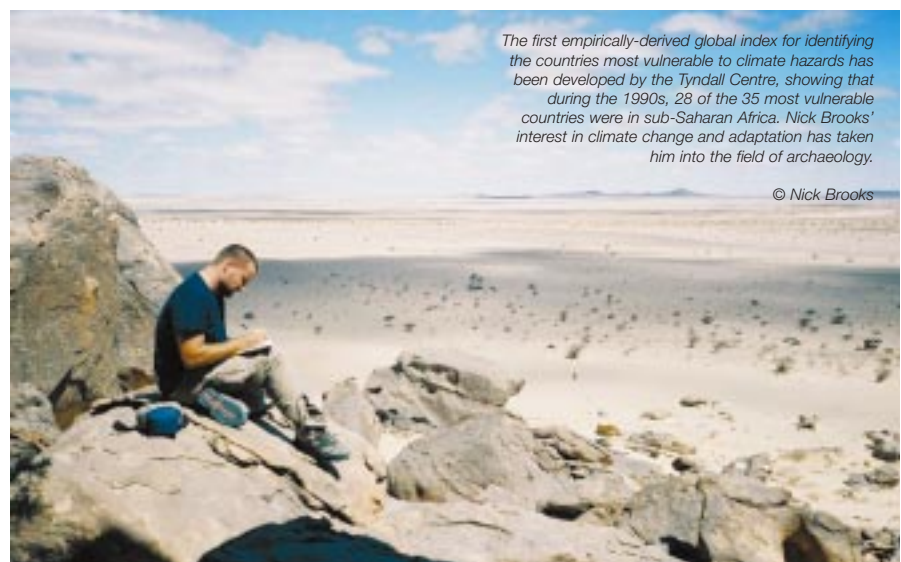
analysis, and the very specific factors that make small island states vulnerable are likely to have been swamped by the data relating to more countries. This analysis should be seen as a first step in identifying broad patterns of vulnerability, not the final word on the matter," says Nick.

Nick's interest in climate change and adaptation has also taken him into the field of archaeology, where he researches how past societies

responded to abrupt climate change. "If we want to look at case studies in order to understand processes of adaptation, the archaeological record is full of them," he says.

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Please see Tyndall Technical Report 7 and Tyndall Working Paper 38
www.tyndall.ac.uk



The first empirically-derived global index for identifying the countries most vulnerable to climate hazards has been developed by the Tyndall Centre, showing that during the 1990s, 28 of the 35 most vulnerable countries were in sub-Saharan Africa. Nick Brooks' interest in climate change and adaptation has taken him into the field of archaeology.

© Nick Brooks

Global engineering solutions evaluated

Big ideas for reducing the impacts of climate change were evaluated by an international line-up of leading scientists from the US, mainland Europe and the UK in January 2004 at a symposium in Cambridge. The scientists evaluated which large-scale bio-engineering, geo-engineering and chemical engineering ideas to combat global warming are worthy of further investigation. The

symposium, called macro-engineering options for climate change management and mitigation, was hosted by the Tyndall Centre and the Cambridge-MIT Institute.

"We urgently need to explore the feasibility of imaginative new ideas for reducing global warming in the future if we are to avoid dangerous climate change, either by slashing carbon dioxide emissions, or by counteracting its effects," said Professor John Shepherd, Director of Tyndall South who organised the meeting.

Proposed options for reducing carbon dioxide pollution currently include underground burying of liquefied carbon dioxide; disposal in the sea; fertilising its absorption by marine algae; reflecting the sun's rays in the atmosphere; and stabilizing sea-level rise.

The macro-engineering ideas were evaluated against a strict set of criteria, including effectiveness, environmental impacts, cost, public acceptability and reversibility. All of these options go beyond the conventional approaches of improving energy efficiency and reducing carbon dioxide pollution. A summary of the expert recommendations is at the web address below.

"Most of these macro-engineering options are not yet in the mainstream for climate policy, but the mere fact that they have been suggested places an obligation on scientists from many disciplines to explore their feasibility and evaluate their consequences and wider implications if and when they are needed," comments John Shepherd.

Further information:
www.tyndall.ac.uk/events/past_events/cmi.shtml

Reducing the health risks of flooding



Representatives of aid and health organisations, policy people and academics were brought together by Tyndall to assess how vulnerable people and health care systems can respond to risks from flooding.

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The Tyndall Centre and the Overseas Development Group at the University of East Anglia convened an international conference in July to assess how vulnerable populations and health care systems can respond and adapt to the health risks from flooding. The health implications of flooding are likely to be worsened by predictions of climate change.

"My aim with this conference is to bring together the international research community to understand how we can better adapt to the health risks of flooding," said Roger Few. "Developing countries are at particular risk because flooding brings increased risk of disease through the spread of waste and the collection of persistent low-lying water creating habitats for mosquitoes and other disease carriers."

In July, areas in north-east India, Nepal and Bangladesh were reported as being under water in the worst monsoons for a decade, affecting over 10 million people. "Floods may also increase respiratory infections, skin infections and diarrhoeal diseases. Risk of infection is greatly worsened by blockages to


drainage channels and sanitation systems," says Roger.

"But it is important not to overlook that flooding also brings threats to health in industrialized countries too. As well as drowning and injuries in violent flood events, there is growing evidence that the loss, damage and disruption brought by floods can lead to increased levels of stress and mental health problems."

Participants at the conference included researchers, as well as representatives of the World Health Organisation, the Red Cross and Save the Children Alliance of Vietnam.

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From research paper to rule Bill



A ten minute Parliamentary rule Bill based upon Tyndall research was presented to the House of Commons calling for the establishment of Domestic Tradable Quotas, a novel scheme for reducing emissions from energy use.

A ten minute rule Bill based upon Tyndall research was presented to the House of Commons in July. The Bill, proposed by Colin Challen, Labour MP for Morley and Rothwell, called for the establishment of a Domestic Tradable Quotas (DTQs) scheme in the UK.

“DTQs are a trading scheme for reducing emissions from energy use. Under the scheme, government sets an annual “carbon budget” – the maximum emissions from energy use – and this is ratcheted down year on year,” explains Richard Starkey at Tyndall North. Each budget is divided into “carbon units” which go to adult individuals and

organizations. Adults get their units free and on an equal per capita basis giving DTQs a strong component of fairness.

Under the scheme, every adult is issued with a smart card that allows them to surrender carbon units whenever they buy fuel or pay an energy bill. At the start of the scheme, 60% of adults would have surplus units which they could sell to high emitters.

The journey from Tyndall Briefing Note to Parliamentary Bill began when Tyndall's research was picked-up by BBC Radio 4's Today Programme. Colin Challen MP heard the feature on DTQs and arranged

for researchers Kevin Anderson and Richard Starkey to present their ideas to the House of Commons' Environmental Audit Committee, and to Environment Minister Elliot Morley.

The Bill will never become law, but it has provided a unique opportunity for dialogue with politicians about the practical challenges of achieving the UK's emissions reduction targets.

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Most UK buildings will need replacement or refurbishment to remain comfortable during future summers conclude researchers from Tyndall North. They have developed data from climate change models for analysing the future performance of buildings.

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Please see Tyndall Technical Report 14
www.tyndall.ac.uk

The climate change context of aviation expansion



Ninety percent of the UK's carbon dioxide pollution by 2050 could be due to aviation with the airport expansion recommended in the Aviation White Paper.

"Not only does the expansion leave hundreds of thousands of people exposed to noise levels above annoyance thresholds and permit substantial land-take in agricultural parts of the south east, but it also allows aviation carbon emissions to climb year on year to a level that cannot be reconciled with the long-term Energy White Paper target" says Paul.

"Climate change objectives are too important to have been subordinated to the perceived social and economic benefits of aviation expansion, the evidence for which is mixed," he comments. "The rest of UK business is expected to constrain their emissions towards achieving the reduction targets."

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Please see Tyndall Briefing Note 10
www.tyndall.ac.uk

Paul Upham is co-editor of the book *Towards Sustainable Aviation*, published by Earthscan.

The UK Government's Aviation White Paper, released in December 2003, gave an unduly low priority to environmental impacts of aviation and is in direct conflict with the carbon dioxide targets of the Energy White Paper, say Paul Upham and Alice Bows of Tyndall North at UMIST in Manchester. Their analysis shows that by 2020, with the recommended expansion in aviation, over a quarter of the UK's carbon dioxide emissions could be due to

aviation alone. Ten months previously the Energy White Paper UK endorsed an emissions reduction of 60% by 2050.

Using the Government's own figures, they demonstrate that projected UK aviation could contribute some 26% of domestic carbon dioxide emissions in 2020 and 57% in 2030, which is 92% of the UK's 2050 domestic carbon dioxide target.

Greenhouse gases and the east of England

Collaboration between the Tyndall Centre and east of England policymakers is producing scenarios for reducing the region's greenhouse gas pollution and adapting sustainably to climate change. They show how sectors important to regional policy might look in 2050 after emissions reductions close to 60% have been achieved. The scenarios incorporate economic activity, societal values, energy supply and demand, and the type and strength of regional government.

"Starting with the question 'what will a 60% emissions reduction at the UK scale mean for the region?' we have had senior figures from the region provide input to and critique our scenarios," said John Turnpenny from Tyndall HQ. The scenarios show that a

large reversal in current trends is needed if reduction targets are to be met, including more fundamental changes in policy and societal attitudes.

The scenarios are based upon four storylines: (i) 'Local and Green', where sustainable lifestyles reduce energy demand; (ii) market-driven movement to low-carbon energy supply; (iii) reductions achieved through government regulation; and (iv) 'more of the same' where current trends and strategies continue. 'More of the same' delivers an emission reduction of only 20 - 30% by 2050.

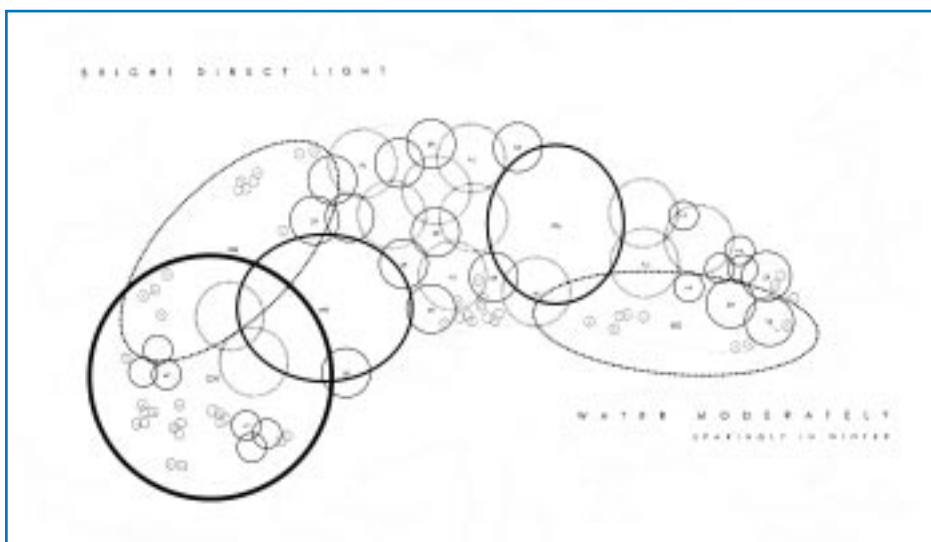
The first major part of the study involved creating a baseline on which to build the scenarios. Sebastian Carney from Tyndall North has built an inventory that shows where the region's greenhouse gases come from. In the East, the main polluters are domestic housing (25% of the total), transport (29%) and commerce and industry (23%). Called GRIP, Sebastian's inventory was first built for the north-west of England as the focus of his PhD research. GRIP and the regional scenario work are now ready to be applied to other regions of the UK.

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Please see Tyndall Working Papers 31 and 54 www.tyndall.ac.uk

Collaboration between the Tyndall Centre and east of England policymakers is showing how the region's social and economic sectors might look in 2050 after emissions reductions have been achieved.

© Andy Hilton/E.ON-UK



The Tate Britain Art Gallery exhibited Janice Kerbel's Tyndall-inspired drawings, called *Home Climate Gardens*, during its summer 2004 exhibition.

www.tate.org.uk/britain/exhibitions/artofthegarden/

© Janice Kerbel

Learning lessons in adapting to climate change



PhD researcher Marisa Goulden recently returned from six-months of fieldwork in Uganda, studying adaptation to past and current climate change at Lakes Koyoga and Wamala.

© Marisa Goulden

“Ugandan fishing villages should offer an insight into how communities adapt to climate change,” says Marisa Goulden, a PhD researcher at the Tyndall Centre and UEA, who returned from an initial six-month field season in April 2004. Marisa is investigating what aspects of life in lake-side communities help people cope with climate-related problems.

“My research seeks to better understand how people cope and adapt to past climate-driven fluctuations in tropical lakes and wetlands. In these communities, flooding and drought cause negative impacts as well as providing new opportunities, such as the exposure of fertile land when lake levels drop.”

Marisa’s research focuses upon the experiences of fishing communities on the shores of Uganda’s Lake Kyoga and Lake Wamala. 22% of Uganda’s land

area is open water or wetland, and 80% of its population live in rural areas dependent upon natural resources.

Marisa’s research techniques involve an interdisciplinary combination of quantitative and qualitative social science methods, including group meetings, questionnaires and in-depth interviewing. She is analysing her first set of data to compare the different ways that households cope with climate change and how this affects their resilience to climate change.

“My hope is for my research to contribute to a qualitative assessment of the possible impacts of future climate change in the light of people’s likely adaptation responses,” says Marisa.

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The UK’s electricity network can support the increased renewable energy required to meet the Government’s 2010 targets says an assessment of the existing technical, economic and regulatory conditions.

© Asher Minns/Tyndall Centre

The UK’s electricity network can support the increased renewable energy required to meet the Government’s 2010 targets, says an assessment of the technical, economic and regulatory conditions that are needed. Led by Professor Nick Jenkins at Tyndall North, the research also showed that the electricity network can accommodate the Government’s

target of 10 Giga watts of electricity from Combined Heat and Power Generators.

The project identified the likely geographical spread of the renewable generation and combined heat and power plants needed to meet the Government targets. Power losses in the transmission grid will decrease as additional generation is introduced into the South of England. The research also highlights the fact that faults in the network will potentially cause supply instability from wind power, and that

modifications to the generators will be needed.

“We also show that wind turbines that operate at variable speed can maintain their stability for longer, provided attention is paid to this issue in their design and construction,” said Professor Jenkins.

The research is a collaboration of UMIST at Manchester, the Science and Policy Research Unit at Sussex University and Warwick University’s Business School. Regular meetings were held throughout the project with the electricity companies and government energy organisations.

Their exploration of longer-term economics showed that current UK regulation does not create incentives for companies to connect wind turbines and CHP, although this matter is now being addressed by the energy-industry regulator OFGEM. The economics of investing in micro-energy at the very local scale also shows a long period before pay-back.

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Please see *Technical Report 13*
www.tyndall.ac.uk

Carbon underground

Face-to-face surveys with 200 people have revealed public concern about the idea of burying carbon dioxide deep offshore to prevent it from adding the nation's greenhouse gas pollution. Burying of carbon receives less support than an increase in renewable energy and energy efficiency, but more support than higher energy bills and nuclear power.

Geological carbon sequestration captures carbon dioxide from power stations and pumps it deep underground, most commonly into the same rocks that contain oil and gas fields. The technique is increasingly discussed in Europe and the US as a means for reducing pollution from power stations.

Two case studies evaluating the options for implementing geological sequestration

are underway – one in the East Midlands and the southern North Sea, and the other in Northwest England and the southern Irish Sea. A legal analysis has analysed key international and European legislation that is relevant to the implementation of geological sequestration, identifying the conditions under which it could take place.

The work is part of a wider integrated assessment involving Tyndall researchers at Tyndall North, the British Geological Survey, University College London and Tyndall South. Led by Simon Shackley at Tyndall North, they are considering the whole process of carbon storage from its capture at power stations, through transportation, to its potential storage sites. The evaluation encompasses technical, economic,



Tyndall researchers are evaluating the technical, economic, environmental and socio-political aspects of burying carbon dioxide beneath the sea floor.

environmental and socio-political aspects.

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Please see Tyndall Working Papers 44 and 45 www.tyndall.ac.uk

CDM has a small 'd' says forestry research

Well-off farmers who own tracts of land and communities that are well-organised are the most likely to benefit from forestry projects implemented through the Clean Development Mechanism, but they are likely to be poorly informed and receive only a small increase in income says a recently completed evaluation of forestry projects in Mexico and Belize.

The Clean Development Mechanism (CDM) is one of the key international initiatives to encourage the participation of developing countries in engaging with the aims of the Kyoto Protocol. It aims to bring benefits for greenhouse gas reduction and social and economic development. One of the most controversial areas is the use of forests where farmers are paid to plant and manage reforestation to sequester carbon dioxide from the atmosphere.



The focus of reforestation projects designed both to sequester carbon and promote social and economic wellbeing in developing countries has shifted solely to the market value of carbon says an evaluation of case-studies in Mexico and Belize.

© Esteve Corbera

"The focus of the projects has shifted over time from a broader engagement with social and economic development to a focus on the carbon value," says Professor Kate Brown of UEA's School of Development Studies and the Tyndall Centre. "Project managers are constrained by the market-structure behind these projects."

The research has developed criteria for evaluating CDM forestry projects and explored the interests of local and

international stakeholders. "A recommendation is that those who promote these projects as a development and conservation strategy to help the poor should be more aware of the social, economic and political dynamics and constraints in rural communities, and more realistic about what projects can and cannot achieve," says Esteve Corbera who is developing his PhD from the Mexico study.

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Please see Tyndall Technical Report 16 www.tyndall.ac.uk

Up to a third of Bonaire's white sand beaches could be lost through coastal squeeze under a predicted sea level rise of half a metre, according to a Tyndall study of sea level rise, coastal biodiversity and economic activity in Caribbean island states.

© Marianne Fish



Climate change squeezes Caribbean beaches

Climate change will have a range of environmental and economic impacts on Caribbean islands, says a Tyndall evaluation of the links between sea level rise, coastal biodiversity and economic activity. Low-lying Caribbean islands are protected from the open sea by coral reefs and mangroves which provide essential income as fisheries and tourist attractions. They are vulnerable to the impacts of climate change through sea level rise and hurricanes.

Work by PhD researcher Marianne Fish at UEA has shown that up to a third of beaches on the island of Bonaire could be lost by coastal squeeze through a predicted rise in sea level of half a metre, reducing the nesting habitat of protected sea turtles and making beach-side developments vulnerable. The project developed a range of methods for quantifying the impacts of climate change on biodiversity, including Geographic Information Systems (GIS), a database of mangrove biology and a database of 263 separate coral reef surveys. The

research is led by Jennifer Gill, Isabelle Côté and Professor Andrew Watkinson.

Analysis of the reef database by Toby Gardner and colleagues has revealed that coral cover across the region has declined by 80 percent in just the past 30 years. This dramatic degradation of a habitat that is critical for both

reserves in protecting coral reefs and their associated biodiversity. A study of the impacts of ecotourism on reef biodiversity is also planned.

Caribbean economies are strongly dependent on biodiversity and the associated tourism. The work also included a study of holidaymakers' willingness to pay for the protection of the islands' coastal habitats. Tourists were less likely to choose islands where beaches and coral reefs have degraded, although the relative importance varied between islands.

Further evaluation will explore the ability of the islands' biodiversity to adapt to climate change, and the implications to the islands' economies.

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Please see Tyndall Technical Report 9 www.tyndall.ac.uk



© Karen Cheney

biodiversity and local livelihoods was reported in May 2003 in the international journal *Science*. Further analysis of the unique database is underway including the role of hurricanes in coral reef declines and the value of marine

Health and climate change direct to Government

Dr Franziska Matthies is the first holder of a unique Tyndall Fellowship scheme that began in 2004 to bring climate change research to the attention of UK Parliamentarians. Franziska is researching and writing a Briefing Note on the likely impacts of climate change on health in the UK for the Parliamentary Office of Science and Technology (POST). The aim of POST is to provide independent evidence about science and technology to MPs, Peers and Civil Servants.

"It is a great opportunity for me to promote dialogue between scientists and the key players in UK climate change and health policy," said Franziska. Her Briefing Note is exploring the health implications of climate-related effects, including contaminated water through flooding, increases in vector-



Franziska Matthies is the first holder of a Tyndall-POST Fellowship for Tyndall researchers to write Parliamentary Briefing Note's on climate change topics.

© Franziska Matthies

borne diseases, heat stress and heat stroke, and the direct impacts of windstorms. Other climate-related health impacts might include increased air pollution and exposure to UV radiation.

Franziska also co-researches a Tyndall project on health hazards and climate change flood risk with Dr Roger Few of UEA's Overseas Development Group. Originally a biologist with a PhD in epidemiology from Basel University, Franziska has an additional role with Professor John Schellnhuber in providing the German Government with advice on environmental policy.

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Seeing the future for hydrogen power

A set of energy scenarios has been developed by the Tyndall Centre that explores possible pathways for achieving a UK economy that is powered by hydrogen instead of fossil fuels. The scenarios for 2050 range from a World Markets future where free-market forces fail to drive uptake, to a Global Sustainability scenario where hydrogen has become central to the UK's energy system through concerted policy action driving its development and uptake.

The scenarios, developed by teams at the CCLRC Rutherford Appleton Laboratory, the Science Policy Research Unit at the University of Sussex and the Institute for Transport Studies in Leeds, differentiate between the energy demands of transport, domestic, industry and service sectors and establish the likely contribution of hydrogen. The Global Sustainability scenario envisages that hydrogen supplies up to 30% of energy needs by 2050, including 90% of transport.

"The UK Government's target of 60% carbon dioxide emissions reductions by 2050 is unlikely to be achieved without substantial changes in the transport

sector," says Dr Geoff Dutton, who leads the research. "A shift to hydrogen as the fuel for transport could make the difference, but only in a world where environmental values are considered foremost in the production of hydrogen. If hydrogen is to be considered a sustainable fuel, its production, storage and distribution must all be considered."

The scenarios suggest that major new processes, or massive expansion of renewable or nuclear energy, is needed

to power the production of hydrogen fuel. They show that producing hydrogen from fossil fuels would not reduce carbon dioxide emissions, unless accompanied by large scale carbon dioxide sequestration.

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Please see Tyndall Working Papers 46 and 50 www.tyndall.ac.uk



A set of energy scenarios has been developed by the Tyndall Centre that explores possible pathways for achieving a UK economy powered by hydrogen instead of fossil fuels, particularly transport.

© Hartmut Schwarzbach/Still Pictures

Climate lessons learned for the Cayman Islands' Government

Emma Tompkins of the Tyndall Centre and Lisa-Ann Hurlston of the Cayman Islands' Department of Environment have published a report to help the The Caymans Islands' Government achieve further effectiveness in planning its responses to tropical cyclones. The islands offer a rare case-study of adapting to a climatic hazard because the government has actively enhanced its capacity to respond to hurricanes in the past 15 years. On average, a tropical cyclone passes within 155 miles of the Cayman Islands every year.

"Their decision to adapt to storm risk was influenced by direct exposure to storms, their experiences and their attitude to risk. The challenge is to learn how to transfer these lessons on adaptation to past hazards for adapting to future climate change" said Emma, who will be publishing a handbook on preparing for and adapting to climate change in the Caribbean with CPACC (Caribbean Planning for Adaptation to Global Climate Change).

"Their decision to adapt to storm risk was influenced by direct exposure to storms, their experiences and their attitude to risk"

To inform their research they interviewed key people in the Government agencies that provide essential services to identify what has enabled and constrained adaptation to hurricane threat. Emma and Lisa-Ann are about to publish an analysis of government adaptations, which will be followed by a report to the private sector. This will be followed by psycho-social analysis of individuals' behavioural changes

"We are interested in mapping-out the connections between government, the business sector and wider society. We are looking at which parts of society drive adaptation in other parts of society," said Emma who is one of the

managers of Tyndall's adaptation research.

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Please see Tyndall Working Paper 35
www.tyndall.ac.uk



Tyndall is working with the Cayman Islands' government and business to better understand adaptation to hurricanes. The islands offer a rare case-study of adapting to a climatic hazard because the government has actively enhanced its capacity to respond to hurricanes in the past 15 years.





Do biofuels have potential for climate protection?

The Tyndall Centre brought together leading people from industry, business, policy and academia on behalf of the European Climate Forum to explore the potential for climate protection of biofuels.

The Tyndall Centre and the European Climate Forum brought together leaders from industry, business, policy and academia to explore the development of biofuels as part of Europe's strategy for fuel security and reducing carbon dioxide pollution from transport. The European Biofuels Directive is to be incorporated into national law by December 2004 and the conference in autumn 2003 provided a timely opportunity to consider its technical, economic, land-use and policy implications.

Delegates discussed the economic questions central to the development of biofuels. Should less efficient options should be pursued now, or should industry wait for advanced bio-fuels – new innovations such as cellulose

ethanol from waste straw? Furthermore, will the development of a hydrogen economy in Europe make bio-gas only a short-term prospect?

The delegates agreed that in the short-term to 2010, conventional biodiesel and bioethanol fuel from oil and sugar or starch-rich crops are the most feasible options for transport. However, they only offer some 50% savings in greenhouse gases over fossil fuels at two to three times the cost.

Plant breeders believe that the crops can be designed to become more efficient, but agriculturalists say that there will be the same pressures to produce high yields, which concerns ecologists.

The conference concluded that biofuels must be integrated with policy measures in trade, agriculture, rural development, the environment, and with the climate debate, and must be evaluated as part of the energy system and the biological economy as a whole to ensure resource management and optimum climate change mitigation. Many delegates agreed that bio-energy should be part of an innovative bio-materials industry, thereby utilising its waste products.

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The full summary report is available at www.european-climate-forum.net/events.html

A detailed study to establish targets for reducing carbon dioxide emissions from transport and explore ways of reaching them has been produced by Tyndall Researchers at the Institute for Transport Studies at the University of Leeds.

UK transport is responsible for around 26% of the nation's carbon dioxide pollution and emissions are projected to increase. The research looks at reducing transport emissions by 60% and 80% by 2050. For personal transport such as cars, buses and trains, the reductions needed to meet these targets are 43% and 82% compared with current emissions of 27 million tonnes of carbon per year.

The research considered ways for the reductions to be met in personal transport, and shows that the reductions cannot be met without a combination of both technological advance and behavioural change.

Asked about the likelihood of achieving a 60% emissions cut in transport, Abigail Bristow, the project leader

Lower carbon transport needs more than technology



Both technological and behavioural shifts are needed in transport to achieve a 60% cut in carbon dioxide emissions show scenarios developed by Tyndall researchers at the Institute for Transport Studies at the University of Leeds.

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replied, "a step change in technology would be required to drive this reduction, largely in hydrogen fuel cells, but this technology is uncertain at present." The researchers interviewed households to explore the effectiveness and acceptability of measures to encourage low carbon transport. Householders could envisage only a 10% reduction in car use – showing the difficulty of making significant changes within current constraints.

"Millions of individuals make transport decisions every day and moves to facilitate change must happen sooner rather than later, alongside pricing and regulation measures to induce behavioural change" said Abigail.

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Please see Tyndall Technical Report 15 and Tyndall Working Papers 33, 19 and 36 www.tyndall.ac.uk

Stormy times for winter coastlines



Researchers at Tyndall South have devised a new methodology for producing local scenarios of climate change, sea level and wave heights as part of its large-scale assessment of the vulnerability of the UK coast to climate change. Its application has suggested that increases in storminess will disrupt the ferry services that are critical to Scottish island communities.

Global warming could lead to an increase in the storminess that disrupts the ferry services that are critical to Scottish island communities, says Tyndall research that has assessed changes in wave height with fluctuations in winter weather patterns.

The North Atlantic Oscillation (NAO) is one of the oldest recognised weather patterns and it determines whether winters in Northern Europe will be wet and warm, or cold and dry. Its influence on winter weather has increased in recent decades, although it is not clear whether this is specifically linked with global warming.

Tyndall researcher John Coll at the Environmental Research Institute of the University of the Highlands and Islands said "the lifeline ferry services to the islands are already heavily subsidised - one possibility might be the need for bigger and more expensive boats."

The findings result from the application of a new methodology for local scenarios of climate change, sea level and wave heights, analysed along with data on weather-related disruptions of ferry crossings. The methodology has been developed by Mikis Tsimplis and

David Woolf from Southampton Oceanography Centre as a component part of a large-scale Tyndall assessment of the vulnerability of the UK coast to climate change.

"Moving away from regional case-studies, the overall influence of the NAO's impact on sea levels around the UK coast is likely to be small. Nevertheless, wave heights at the North East Atlantic will continue to increase further," says Mikis. His recently completed research shows that sea level, wave heights and extreme surges along the north European coast are

positively correlated with the winter behaviour of the NAO; and southern Europe's coastal weather is negatively correlated with the NAO. The UK is located between these positive and negative influences and so the overall impact is smaller than for other European coastlines.

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*Please see Tyndall Technical Report 10
www.tyndall.ac.uk*



Tyndall researchers led by Professor Nigel Arnell at Tyndall South are assessing the impacts of changing weather extremes on water supply and flood control at the local scale to develop a model that provides information about the costs of water supply and flood protection services.



A new fast and efficient climate model is successfully reproducing the pre-industrial state of the earth which is the starting point for running experiments with additional carbon dioxide

Thousands of years of simulations are performed in a few minutes by a new earth system model that has been built to explore manmade carbon emissions over the next millennium. It simulates the global interactions between the atmosphere, ocean, freshwater, ice and land surfaces associated with climate change, including the carbon cycle.

Delivering a fast and efficient climate model

It shows that millennial time-scales are needed for the slower parts of the earth system, such as the thermohaline circulation, to return to a steady state after disruption through global warming. The new model runs efficiently on desktop computers enabling rapid investigation of climate change questions at low resolution.

"Our model now successfully reproduces the pre-industrial state of the earth which is the starting point for running experiments with additional carbon dioxide," said Professor John Shepherd, the Director of Tyndall Centre South. "The land model is giving good results, broadly reproducing the carbon cycling of major vegetated areas such as the Amazon rain forest and the northern boreal forests. It also accurately

reproduces arid regions such as the Sahara and Kalahari deserts."

It was developed in association with GENIE, the Natural Environment Research Council's e-science project for integrated earth system modelling.

The key technical aim of the work is to better understand uncertainty in the model itself, in the data and in the assumptions made by the modeller. It is a major component in achieving one of the Tyndall Centre's flagship objectives of devising a computer network that connects environmental, economic and social data to model the complexities of climate change policies.

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Where next for climate change research?

Asher Minns asked Professor John Schellnhuber for his personal opinion of the critical questions in climate change research.

"The main research challenges for the next five years range between hard science and social responses. Four critical issues come to my mind. First, there is no doubt that we are transforming the physiology and metabolism of the planet and we need to identify the earth-system's tipping points, the thresholds that we choose to cross at our peril. We do not have a century to think about this. Then we will know how aggressively to mitigate greenhouse gas pollution."

"Second, what are the benefits of avoiding the concomitant damages of climate change? We are calculating quite well the costs of mitigation, but what do we save? This isn't a measure done only in dollars; the evaluation needs to be multi-dimensional and include avoided casualties."

"Third, we also need to know what resources need allocating where. This

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"What are the benefits of avoiding the damages of climate change? We are calculating quite well the costs of mitigation, but what do we save?"

requires an understanding of the dynamics of innovation for mitigating climate change. And how do we induce these technological and social innovations? What are the necessary financial instruments? Fourth, who pays? Should the West choose to fund

developing countries to leap-frog pollution and go straight to clean energy?

"None of these questions are answerable in isolation. One of the unique aspects of the Tyndall Centre is that it tackles these four policy questions in parallel and brings these aspects together."

And what would you like to be asked by interviewers?

"I'm forever asked about the importance of the US to global warming, but so rarely about the actual science of this planet. I want to explain the interesting science to help the public engage with science. I also never get asked about the ethical issues of justice and liability for global warming – so few people want to go near it. This is the NIMBY morality, where the polluter-pays principle so obviously shall not apply in our own back yards."

Working Papers

Tyndall Working Papers (TWP) are for the early availability of results from Tyndall Centre research projects. The Series presents mature results that have been peer reviewed by Tyndall colleagues. They are downloadable at www.tyndall.ac.uk

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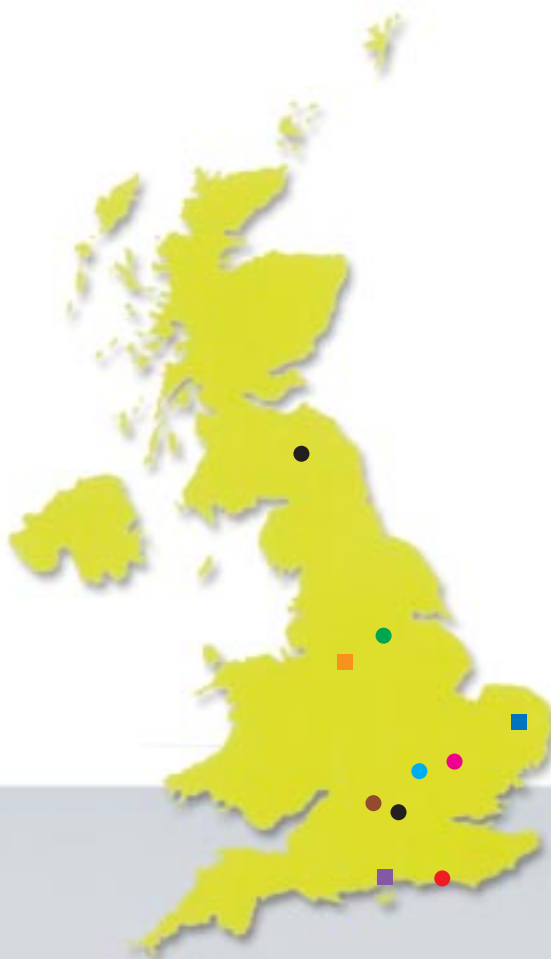
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A range of further information, including contact details for project leaders and other staff, fact sheets about the Tyndall Centre's research, the Tyndall Centre's Research Strategy, and a quarterly electronic newsletter, is available at our website.

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