












Tyndall Partners

-  University of East Anglia
-  UMIST
-  University of Southampton
and Southampton Oceanography Centre
-  University of Cambridge
-  SPRU (Science and Technology Policy Research),
University of Sussex
-  ITS (Institute for Transport Studies),
University of Leeds
-  NERC Centre for Ecology and Hydrology
Bush & Wallingford
-  Cranfield University
-  Energy Research Unit (CLRC-RAL)

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Tyndall°Centre

for Climate Change Research



The Tyndall Centre Research Strategy

A Summary

Integrated research providing choices for the future

Partnership

The Tyndall Centre is a national consortium for trans-disciplinary climate change research, launched in November 2000. The University of East Anglia in Norwich (School of Environmental Sciences) leads a group of nine UK research institutions, with regional offices at the University of Southampton and the University of Manchester Institute of Science and Technology (UMIST). The full Tyndall Consortium includes the University of Cambridge, NERC's Centre for Ecology and Hydrology, the University of Sussex's Science and Technology Policy Research unit (SPRU), the University of Leeds' Institute for Transport Studies, Cranfield University's Complex Systems Management Centre and the Rutherford Appleton Laboratory's Energy Research Unit.

Approach

The climate change challenge goes beyond any individual academic area and the integration of knowledge is a key tenet to this Centre. Our new approach brings together climate scientists, economists, social scientists, and engineers. We have a partnership focus and an organisational network that mobilises and funds expertise in different centres.

Other distinct Tyndall characteristics include commitment to a wide engagement with stakeholders, an active role in education and opinion-shaping, and a Business Liaison Programme to work at the interface between UK business, Government and academia on issues related to climate change.

The Tyndall Centre is also a founding member of the European Climate Forum, launched in October 2001.

Research

Our research is organised into four specific Themes that collectively contribute to the most crucial aspects of the climate change issue and are individually managed by established scientists. A Theme contains a number of research projects, each of which comprises a lead investigator and multi-centre research team. Twenty research projects commenced in 2001 (£1.9m), with more than 40 scientists employed on Tyndall research at any one time. The second round of research projects (2002) is funded in excess of £2.6m, with approximately 30 percent of funds supporting expertise from outside the Consortium. A third funding round will follow.

The research results will contribute to the development of strategies for mitigation and adaptation, a concern at the core of the UK Government's Climate Change Programme and central to international efforts towards global climate change management.

The Tyndall Centre

Vision

To become an internationally recognised *source* of high quality and integrated climate change research, and to exert a seminal *influence* on the design and achievability of the long-term strategic objectives of UK and international climate policy.

Purpose

To *research*, *assess* and *communicate* from a distinct trans-disciplinary perspective, the options to mitigate, and the necessities to adapt to, climate change, and to integrate these into the global, UK and local contexts of sustainable development.

Medium-Term Objectives

- *Advancing the science of integration* . . . to develop, demonstrate and apply new methodologies for integrating climate change related knowledge
- *Developing responses* . . . to seek, evaluate and facilitate sustainable solutions that will minimise the adverse effects of climate change and stimulate policy for the transition to a more benign energy and mobility regime
- *Motivating society* . . . to promote informed and effective dialogue across society about its ability and willingness to choose our future climate

Pursuing these objectives will require the Centre to: i) engage widely with stakeholders in public and private sector organisations; ii) collaborate closely, and/or form strategic partnerships, with researchers outside the Centre in the UK, Europe and globally; and iii) listen carefully to the perceptions and aspirations of all peoples in relation to the challenges created by climate change.

The Tyndall Centre is jointly funded by the Natural Environment Research Council (NERC), the Engineering and Physical Sciences Research Council (EPSRC) and the Economic and Social Research Council (ESRC), with additional support from the Department of Trade and Industry (DTI). The Centre is committed to matching the core funds by seeking further sponsorship from stakeholders in business, NGO's and Government and through other Research Councils and EU Commission initiatives. Our work complements that sponsored by DEFRA at the Hadley Centre for Climate Prediction and Research (Met Office) and in the UK Climate Impacts Programme.

This document provides a summary of the Tyndall Centre Research Strategy. The Strategy is a result of a process of widespread consultation, discussion and deliberation, both within and outside the Tyndall Centre, conducted during 2001. The full document was drafted by the Directors Professor John Schellnhuber and Dr Mike Hulme at UEA and is available at: www.tyndall.ac.uk/research/strategy.shtml

The Research Challenge and the Tyndall Centre

Human-induced global climate change initially emerged as a challenge for the natural sciences. But the causes of climate change are profoundly rooted in social and economic behaviour and the consequences of climate change for society are global, pervasive, and potentially very serious. Scientific

uncertainties are great. Recognising these needs, the economic, social and engineering sciences have become increasingly engaged in the research effort. Climate change management strategies are needed, targeted both at mitigating climate change and at adapting to its impacts. These strategies

must embrace uncertainties in environmental science, new engineering technologies and societal aspirations, together with a full array of policy instruments. The integration of this multi-disciplinary science is the fundamental challenge of the Tyndall Centre.

Main Tasks and Research Themes

The Tyndall Centre has to demonstrate, by conducting integrated trans-disciplinary and frontier research, that it can deliver insights about potential responses to climate change that could not have been achieved by simply collating diverse research outputs from disciplinary research communities. Four major types of non-standard challenges for the Tyndall Centre have been identified:

* Trans-Disciplinary Research Projects

The Centre has to demonstrate, exemplarily, what object- and solution-oriented allocation of research funds can achieve, if critical resources are mobilised. The resulting projects will integrate the diversity of expertise across the Centre, and from other institutions, and therefore include, as a rule, engineers and social scientists in addition to environmental scientists.

* Innovative Agenda-Setting

Due to its unique remit and construction, the Centre is expected to act as a bridge connecting the respective territories of the wider climate change science community, the Research Councils, relevant operational and political institutions, and stakeholder organisations and groups. A major task within this context is to stimulate new trans-disciplinary research and integrated policy agendas in the national and international arenas.

* Strategic Assessments

The climate change literature is studded with fragments of scientific knowledge. Comprehensive surveys exploring, for instance, the climate vulnerability of an entire region or sector are extremely rare. What decision-makers request (and

genuinely need), are strategic investigations that provide panoramic, but state-of-the art, views of complex issues. The Tyndall Centre will aim to generate such solution-oriented assessments driven by trans-disciplinary insights.

* Advancing the Science of Integration

The Centre's reputation will ultimately depend on its lasting contributions to the advancement of science. The Centre must make a real difference through pioneering work concerning the synthesis and integration of fragmented scientific knowledge. This is not just an act of patching together elementary insights; it is – or must become – a scientific enterprise of its own, based on clear-cut principles and employing a generic spectrum of appropriate formal methodologies.

Research Architecture

The research field to be addressed by the Centre has been organised into four Themes:

- **Integrating Frameworks** . . . a *systems* approach
- **Decarbonising Modern Societies** . . . a *targets* approach
- **Adapting to Climate Change** . . . a *questions* approach
- **Sustaining the Coastal Zone** . . . a *place-based* approach

Each of the four Research Themes also has a trans-disciplinary Flagship Project for which a Tyndall Senior Research Fellow is employed. These Themes and Flagship Projects are described on the following pages.

Research Theme 1: Integrating Frameworks

Objective

To organise, synthesise and apply strategic knowledge needed for judicious climate change decision-making.

Research Foci

The most crucial challenge is the scientific integration of information concerning distinct disciplines, scales, purposes and actors involved in the causes, consequences and management of climate change. This entire field is about the construction of 3rd generation integrated assessment modelling (IAM) tools and their application as part of an interactive process that will allow credible state-of-the-art answers to pertinent questions raised by negotiators, policy-makers or stakeholders. The emerging research will include the following:

- **Modelling for integrated assessment:**

A simulation system is required that assembles and couples key factors involved in the climate change problem. The system needs to be well-structured for convenient operation, flexible for addressing diverse issues, and harmonised for balanced treatment of natural and socio-economic processes. Models (e.g. agricultural production, transport, economics and climate) and data sets have to be created, modified or accessed from other communities. Other exploratory methods will include risk analysis for low probability-high consequence events; damage functions for non-linear impacts; semi-quantitative modelling for nature-society interactions; and interactive visualisation exercises for stakeholder discourses.

- **Scenario construction:**

Robust scenarios representing socio-economic driving forces must be generated through the iteration of plausible initial assumptions using adequate climate-nature-society models covering all major feedbacks (e.g. the impact of energy policy on land use). Detailed scenarios may then be derived through appropriate up-or down-scaling procedures.

- **Uncertainty analysis:**

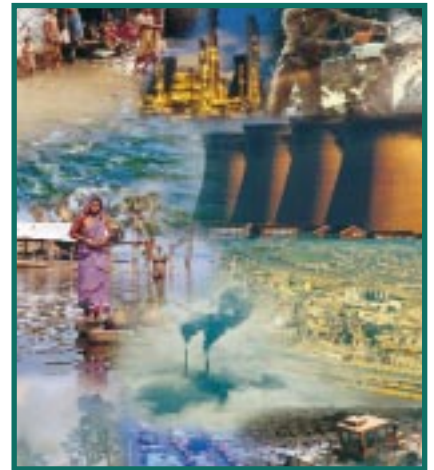
Well-defined procedures for analysing input uncertainties, error propagation dynamics, non-linear sensitivities, algorithmic instabilities, etc., for any given simulation machinery have to be designed, and applied as a matter of routine.

- **System interfaces:**

To facilitate widespread use of a model, interfaces must be developed, in co-operation with different end users, which reduce total simulation complexity to concise input-output schemes.

- **Organised stakeholder dialogue:**

Integrated assessment modelling needs continuing and organised interaction between scientists and stakeholders to identify relevant questions, and to check the usefulness of simulated answers to pertinent real-world decision-making processes. We define this as an Interactive Integrated Assessment Process (IIAP).



Flagship Project: A Modular Multi-Purpose Integrated Assessment System

This project will scope and demonstrate the viability of flexible modularity in integrated assessment modelling.

The construction of a modular prototype integrated assessment model, which will consist of a small number of linked modules, is the pragmatic first step. The project will draw upon the research foci above and also utilise models generated by the other Research Themes. It will aim to embrace scales from global to local at different and appropriate levels of complexity. The model will incorporate probabilistic treatment of uncertainties and feedback processes. Object-oriented software for connecting, processing and tuning the basic modules is required and will pave the way for incorporating additional modules from other institutions. This will require applications of recent and on-going developments in e-science.

Ultimately, the production of a full Modular Multi-Purpose Integrated Assessment System is required to match the complexity of the climate management challenge.

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Research Theme 2: Decarbonising Modern Societies

Objective

To undertake trans-disciplinary research and assessment of options for reducing carbon dioxide emissions in the UK.

Research Foci

The Theme requires exploration and integration of technical, managerial and behavioural strategies to decrease present carbon intensities. It is organised by scenario analysis that addresses short-, medium- and long-term pathways to decarbonisation, encompassing the key sectors of energy, transport and construction. Projects will combine engineering and social science approaches to explore the feasibility, effectiveness, efficiency and implications of various levels of decarbonisation, achieved in different ways. This longer-term analysis (e.g. using the Royal Commission on Environmental Pollution's target of a 60 per cent reduction in carbon emissions by 2050) will be complemented by an investigation of targets for the next several decades, taking the Energy Review of the Cabinet Office fully into account. Specific elements of this work include the following topics:



Flagship Project: Transition to a Decarbonised UK

Many of the opportunities for decarbonisation arise from new and renewable energy technologies and from carbon sequestration, as well as from national policy frameworks on energy efficiency, CHP, low-carbon RD&D schemes, transport, buildings and built environment etc. These can only sensibly be analysed from a UK-wide perspective. With major questions about energy policy and systems being asked at present it is a particularly opportune time for research on the prospects for decarbonisation in the context of energy security and competitiveness. We consider the transitional issues to be critical. It is relatively straightforward to develop speculative scenarios for 2050 based upon different trajectories. The more challenging task for research is how we can rigorously analyse the ways in which we move from the present energy system to different end-points. This project will develop new integrative methodologies for the analysis of necessary changes in technical, regulatory and socio-policy regimes.

• Carbon sequestration options:

There is a need for research into carbon sequestration which integrates large-scale technical and engineering analyses with economic appraisal, environmental assessment, policy sciences and social understanding of public perceptions. It is particularly important to understand better the implications of large investment in carbon sequestration relative to the economic and social performance of other carbon mitigation options.

• Carbon substitution options:

Assessment of the prospects for large-scale substitution of fossil fuels with zero- or low-carbon technologies (renewable sources, biomass, hydrogen and nuclear energy) also needs to analyse the engineering, economics and social acceptability surrounding their production and use.

• Implementing the efficiency revolution:

The technical opportunities for energy efficiency are well known, but the social and economic contexts of decisions that bear upon efficiency, are complex. The characteristics of technologies, organisations, economies and policy systems which permit efficiency gains require better comprehension through case-studies and theory.

• Impact of economic instruments and incentives:

The effectiveness, efficiency and equity of different economic instruments for achieving decarbonisation will be examined. This will employ theoretical modelling and empirically-based studies, making use of the emerging experience from the operation of the Climate Change Levy and carbon-trading schemes.

• Social organisation and design for decarbonisation:

What types of organisations and partnerships can best promote decarbonisation and what features of their design and *modus operandi* are most important? How can learning between organisations be promoted? How can an integrated assessment approach relate decarbonisation to the multiple elements that constitute a sustainable community or organisation?

• Pathways to clean development:

The global decarbonisation challenge is critically about what happens vis-à-vis carbon emissions in developing countries. The insights and approaches to decarbonisation developed in the industrialised world require re-investigation with respect to their applicability in a global development context.

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Research Theme 3: Adapting to Climate Change

Objective

To undertake trans-disciplinary research which enhances our understanding of climate change adaptation dynamics and options for managing change in natural and social systems.

Research Foci

The research strategy is to seek answers to the following seven questions:

- **Who adapts, to what do they adapt, and why should they adapt?**

Research will develop a conceptual framework for characterising the dimensions of climate change that challenge societies. This topic will explore how institutions identify sensitivities and prioritise them. It will define exposure to climate change by focussing on vulnerable sectors and resources, and on adaptation options at different scales of operation.

- **What influences the ability of institutions to adapt to climate change?**

This research will develop the concepts of resilience, vulnerability and adaptive capacity. It will include issues associated with the adoption of innovation, the importance of social organisation and the role of regulation in providing collective coping and insurance mechanisms.

- **Are there critical thresholds beyond which it is difficult to adapt?**

There are likely to be some important thresholds in climate impacts on natural and social systems which either trigger different types of adaptation or make adaptation impossible or impractical. This topic will explore thresholds at different scales and their interaction with adaptive capacity.

- **What are the justice and equity implications of adaptation?**

Adaptation strategies will have different impacts across society. Justice and human rights dimensions of impacts and adaptation are most important for highly sensitive and vulnerable parts of the world where climate change threatens life and livelihood.

- **What tools and scenario assessment methodologies does an institution seeking to adapt require?**

Adapting to an uncertain future poses challenges to institutions. Research will develop and apply scenarios, which take into account extreme weather and rapid climate change, and also develop decision-analysis tools.

- **How can the measurement of the economic costs and benefits of adaptation be improved?**

The costs and benefits of adaptation need to be considered in the light of persistent uncertainties concerning the future. Research advances will be sought in the area of the economics of adaptation, including transactions cost approaches and optimal timing of investment.

- **How can managed natural systems adapt to climate change?**

Adaptation by natural systems can be both reactive and planned. Insights will be developed from the ecological sciences on the role of adaptive management in enhancing resilience of ecosystems.



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Flagship Project: A Theory of Adaptive Capacity

This project will develop conceptual insights into adaptation drawing upon all the related research questions. It will synthesise research on economic and institutional issues associated with climate adaptation, and their relationship with changes in weather extremes and rapid climate change. It will develop and apply, for example, institutional economics approaches to both adaptation and governance in the context of climate change. The research will also explore the optimal timing of adaptation investment in the context of risks associated with irregular climate change. Challenges in this area include the analysis of the postponement of adaptation when it is effectively irreversible, the real value of capital over time, and the value of resilience and flexibility in adaptation investments.

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Research Theme 4: Sustaining the Coastal Zone

Objective

To understand and anticipate key processes and interactions in the coastal zone as the necessary basis for flexible adaptation to climate change and altering environmental conditions.

Research Foci

In considering the problem of integrative assessment at a specific geographic location the research strategy will address several topical areas:

- **National coastal vulnerability assessment:**

The sensitivity and adaptability of the most important economic sectors and environmental services along the British coastline will be explored, starting from well-chosen case studies. The differential vulnerability of coastal communities to sea-level rise will be evaluated with the ultimate aim of producing a national assessment.

- **Conservation strategies for coastal biodiversity:**

Coastal ecosystems and the biodiversity they support are threatened both by changing environmental conditions and by society's defence measures such as the erection of sea walls. Conservation strategies which employ environmental economics insights for institutional priority-setting have to be developed and tested. A particular focus is tropical small island states, where there is almost complete economic dependence on coastal natural resources, for subsistence, tourism and environmental services.

- **Soft and hard engineering options for coastline defence:**

For many coastal sites a well-managed retreat from rising sea levels and higher storm surges will be the best option, but many other sites need to be defended for social, economic and environmental reasons. It is of paramount importance to identify the right mix of protection measures that respect the ecological and physical integrity of the coastline. Relevant opportunities, provided by modern engineering analysis and design, will be explored for both on-shore and offshore defence.

- **Exploring new institutional approaches to coastal zone management:**

In view of multiple developmental and operational pressures on the coastal zone – in addition to climate change – radically new management strategies must be addressed. Redesigning the coast in the face of sea-level rise is potentially an enormous social experiment that requires novel methods for exploratory stakeholder involvement on the one hand, and the invention or transformation of relevant institutional frameworks for converting expressed interests into appropriate decisions on the other.



Flagship Project: An Integrated Regional Coastal Simulator

This flagship project involves the development of a coastal simulator, an analytical framework that allows the integration of climate change and sea-level rise scenarios with information on sediment transport, biodiversity, sea defence and socio-economic activities. The simulator is initially being developed for the East Anglian coastline and will allow exploration of the impact of sea-level rise and associated policy responses on the management of the coastal zone through interactive models. A hierarchy of investigation domains and approaches is being considered. While the East Anglian coastline may, in the first instance, be modelled at a relatively coarse scale of resolution, much higher spatio-temporal resolutions can be realised for selected sub-areas of the coast, such as individual estuaries. It is envisaged that the simulator will serve as a management system for engaging relevant decision-makers who, in turn, contribute to the improvement of the tool by using it. A particular emphasis will therefore be how the results of the integrative modelling can best be communicated to stakeholders.

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