Institution: University of East Anglia

Unit of Assessment: 7 – Earth Systems and Environmental Sciences

Title of case study:

Guiding Sustainable Adaptations to the Impacts of Climate Change

1. Summary of the impact

The United Kingdom is today better adapted to climate risks as a result of a sustained programme of research completed by the School into the impacts of climate change on ecological, social and infrastructural systems. This work has had significant and continuing impact on the design and implementation of UK (and international) climate adaptation strategies and policies, especially with regard to flooding, the built environment and water and coastal management. Decision-support tools (such as climate scenarios and options appraisal) and direct policy advice produced by the School have been used by numerous public and private sector organisations to inform and guide their adaptation strategies and investments.

2. Underpinning research

Since 1980, the School of Environmental Science's Climatic Research Unit (CRU) has undertaken ground-breaking work on the development of scenarios of regional climate change. During the 1980s, CRU was one of the few groups in the world using global climate model simulations to guide climate scenario construction. This research later exploited new regional climate models and developed statistical downscaling techniques to provide scenario information at the finer spatial scales requested by decision-makers. Sustained work by scientists in the School – **Jones** (in post since 1976), **Wigley** (1978-2010), **Goodess** (since 1982) and **Hulme** (1988-2013) – developed a range of climate scenario methods and techniques, e.g. multi-model scenario composites, regional pattern-scaling, climate scenario generators and statistical weather generators [1]. This work has resulted in national, regional and global climate scenarios constructed for UK and European governments and for UN organisations. Building on this scenario work and continuing today, work by **Goodess, Hulme, Jones, Warren** (since 2002)**, Watkinson** (since 1976) has simulated the physical and social impacts of climate change and extreme weather at global, European [2] and UK scales and for a wide range of sectors (water, agriculture, flooding, built environments [3], human migration, coastal processes, biodiversity and human health). Risk-response metrics in a number of these sectors have been developed [4], suitable for a wide range of policy applications.

The winning by the School in 2000 of the joint Research Council contract to establish the Tyndall Centre (£19m core funding, 2000-2009, plus over £10m funding in levered contracts) enabled one of the world's earliest coherent research programmes on climate change adaptation to be established. This Tyndall Centre programme was led by School researchers (**Adger** 1992-2012; **O'Riordan** since 1971, now Emeritus; **Hulme**) and has produced over 200 peer-reviewed publications and more than ten books with leading publishers; the current Director is Corrine **LeQuerre** (since 2005). The group pioneered the development of metrics for vulnerability, adaptive capacity, resilience and equity which have been applied to the design and evaluation of adaptation planning and decision-making in the UK and globally. This work has also stimulated new thinking around the principles of fair and resilent adaptation [5], with particular applications to policies dealing with coastal retreat and the rights of indigenous peoples. The School's adaptation programme also published research exploring the meaning of *'dangerous climate change'* – a central concept in international climate change negotiations – and on establishing where limits to adaptation to climate change may reside [6], be they in the policy system, in wider society or in human cognition.

The quality of our pre-eminent work on climate scenarios was evidenced through CRU being contracted to host the IPCC's scenario data centre from 1997 to 2002. The world-leading research in these areas is also evidenced through: a) **Hulme** being appointed to co-convene the climate scenarios chapter in the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC); b) **Adger** to co-convene the adaptation chapter in the Fourth Report; c) **Adger** to

co-convene the human security chapter and **Warren** the emergent risks and key vulnerabilities chapter in the Fifth Report; and d) **Warren** being appointed as co-Chair elect of the new IPCC Task Group on Data and Scenarios Support for Impact and Climate Analysis.

3. References to the research

(UEA authors in bold) {citations in Scopus unless otherwise stated}

[1] **Hulme, M.**, **Raper, S. C. B.** and **Wigley, T. M. L.** (1995) An integrated framework to address climate change (ESCAPE) and further developments of the global and regional climate modules (MAGICC) *Energy Policy* **23** 347-355 doi: 10.1016/0301-4215(95)90159-5 {51}

[2] **Hulme, M., Barrow, E. M.**, Arnell, N. *et al.* (1999) Relative impacts of human-induced climate change and natural climate variability. *Nature* **397** 688-691 doi: 10.1038/17789 {121}

[3] **Goodess, C.M.,** Hall, J., Best, M., Betts, R., Cabantous, L., **Jones, P.D.,** Kilsby, C.G., Pearman, A. and **Wallace, C.J**. (2007) Climate scenarios and decision making under uncertainty. *Built Environment* **33** 10-30 doi: 10.2148/benv.33.1.10 {11}

[4] **Warren, R.**, **Price, J.,** Fischlin, A., de la nava Santos, S. & Midgley, G. (2011) Increasing impacts of climate change upon ecosystems with increasing global mean temperature rise. *Climatic Change* **106** 141-177 doi: 10.1007/s10584-010-9923-5 {9}

[5] **Adger, W. N., Paavola, J.,** Huq, S., and Mace, M. J. (eds) (2006) *Fairness in Adaptation to Climate Change*. MIT Press: Cambridge 317pp. ISBN: 978-0-262-51193-3 {230 Google Scholar}

[6] **Adger, W.N., Dessai, S**., **Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D., Otto-Naess, L., Wolf, J.** and **Wreford, A**. (2009) Are there social limits to adaptation to climate change? *Climatic Change* **93** 335-354 doi: 10.1007/s10584-008-9520-z, {200}

4. Details of the impact

UK adaptation policy and regulatory development has been influenced through the codified knowledge of possible future climate impacts and adaptation options developed in the School. Hansard cites links to our work in three White Papers between 2001 and 2005 and three policy briefings from the Parliamentary Office for Science and Technology, one of which was authored by a School secondee to Parliament, have relied heavily upon this work [7]. These findings have been presented through personal briefings to successive Secretaries of State for the Environment (Beckett, 2001-05; Miliband, 2005-07; Benn, 2007-10); to parliamentary select committee inquiries (International Development; Science and Technology; Energy and Climate Change; Environment Audit [e.g.8]); and to devolved administrations in Belfast, Cardiff and Edinburgh. **Liss** (since 1971) served on the UK's Royal Commission on Environment and Pollution for their 2010 report on *Adapting Institutions to Climate Change*. **Warren** led Workstream 1 of the AVOID programme funded by the Department of Energy & Climate Change during 2009-2013 to inform UK's mitigation and adaptation strategies. **Watkinson** was seconded to lead *Living With Environmental Change* from 2008-2013.

The School provided a team (led by **Hulme**) which designed and delivered the UKCIP02 climate scenarios for Defra [9]. The UKCIP02 scenarios have been cited over 1,100 times (half of which are in the period 2008-2013) in academic, policy and applied studies and used by large numbers of public and private sector organisations in their strategic planning and decision-making in the period from 2002-2010. One specific example of their impact concerns the UK Government's 2004 Foresight report on future flood risk [10]. **Watkinson** was one of the six lead authors of this peer-reviewed study, and **Jordan** (since 1992) a contributing author, which drew specifically on the UKCIP02 climate scenarios. The report was commissioned by the DTI and received by Defra and constituted the primary evidence base for the subsequent policy document *Making Space for Water;* in turn it directly informed a multi-million pound uplift in the flood risk management budget announced by Defra in 2006. The national benefits of this work and policy advice, through improved flood defence, continue to be realised throughout the period to 2013 – and beyond. The innovative methodology developed for this purpose [10] has also informed flood risk management in other parts of the world (China and the USA). The UKCIP02 scenarios also guided the

development of the new 2009 national building design data for the *Chartered Institute of Building Service Engineers* and improved the resilience of new buildings to future weather extremes [11].

The School's underpinning research also made substantial contributions to the most recent update of these scenarios: the 2009 UK Climate Projections (UKCP09). Their development was led by the Hadley Centre who refined the UKCIP02 scenarios through adding detailed probabilistic assessments of uncertainty and extreme weather outcomes. **Goodess'** work [3] provided justification for this approach and she also served as a member of the UKCP09 science steering committee and as an international reviewer for Defra. **Jones**, together with the University of Newcastle, developed the UKCP09 weather generator (WGen) which allows public and private sector users to generate scenarios of local extreme weather events. The UKCP09 scenarios formed the basis of the 2012 *National Climate Change Risk Assessment* [12] and have been used by over 100 public and private sector organisations for developing their adaptation strategies, e.g. Network Rail; the Lighthouse Authority; Severn Trent Water; Anglian Water [12]. Some of the development work of WGen was undertaken for the Environment Agency which now uses the derived 'EarWig' tool on an operational basis [13]. Further applications of WGen are focused on urban planning and adaptation decision-making by regional policymakers such as the Greater London Authority and third sector bodies such as the Commission for Architecture and the Built Environment and the Town and Country Planning Association. Through a series of EU FP6 and 7 funded projects, the School's work on climate scenarios, impacts and adaptation assessments has informed the EU's 2009 *White Paper on Adapting to Climate Change: Towards a European Framework for Action* [14].

The School's work on adaptation has influenced the large-scale disbursement of funds to developing countries to adapt to the impacts of climate change. It has informed the 2010 World Development Report of the World Bank (**Adger** scientific advisor, 2008-2010) and contributed to UNDP's Adaptation Policy Frameworks and FAO's 2009 assessment of adaptation for fisheries as part of World Food Summit [15]. On the basis of research in the School on climate change and migration funded by the MacArthur Foundation, **Adger** served as a member of the Lead Expert Group for Government Office Science Foresight 2011 report on migration and global environmental change [16], for which **Goodess** (extreme events) and **Jordan** (adaptation policy coordination) produced expert review papers and **Watkinson** was on steering group. The expertise of the Tyndall Centre on sustainable adaptation and the impacts of climate change are being adopted in China through the establishment of a Tyndall Centre in Fudan University, funded by the Chinese government with a 15-year commitment and £2 million budget for phase I (2013-2014).

5. Sources to corroborate the impact

[7] POST Notes 232 (2004), 342 (2009) and 373 (2011)
Archived at: http://www.parliament.uk/mps-lords-and-offices/offices/bicameral/post/publications/postnotes/
These Notes dealt with adaptation in the UK and developing countries to urban flooding, health impacts and coastal management.

[8] House of Commons (2010) *Environmental Audit Committee Minutes*
Archived at: http://www.parliament.uk/documents/documents/upload/eacfm0910web10.pdf
Showing that on 19/1/10 Adger and Rayner from Tyndall Centre presented oral evidence on the topic of Adapting to Climate Change.

[9] *Climate Change Scenarios for the UK: the UKCIP02 Briefing Summary* (2002)

[10] Office of Science and Technology (2004) *Foresight Project: Flood and Coastal Defence*
The science underpinning the report is published as *Future flooding and coastal erosion risks* (2007) ISBN: 978-0-7277-3499-5
This policy-relevant report was highlighted in the 2012 Academy of Social Sciences publication "*Sustainability,the environment and climate change*" that contained a series of case studies with high impact.

[11] Chartered Institute of Building Engineers (2009) *TM48: The Use of Climate Change Scenarios for Building Simulation: the CIBSE Future Weather Years* ISBN-10: 1906846014
Includes the testimonial from Dr Hywel Davies (Technical Director, CIBSE):

"*The publication of the TM48 and the future weather files, derived from the UKCP02 scenarios, has enabled building design professionals in the UK to assess building performance under future climate scenarios and increase the resilience of their design solutions. The resource has seen steady increase in their uptake since its launch by both industry and policy which has led CIBSE to further revise and expand its guidance and resources relevant to the adaptation of buildings to the impacts of climate change.*"

[12] Defra (2012) *The UK climate change risk assessment Government report*
For evidence of organisational use see:
a) Defra (2011) *Adapting to Climate Change: helping key sectors to adapt to climate change*
b) Defra (2013) *The National Adaptation Programme: Making the country resilient to a changing climate*, p36:
"Severn Trent and Anglian Water are using the UKCP09 Weather Generator tool with Anglian Water also using the UKCP09 Threshold Detector tool to assess climate change risks"
c) Tang,S. and Dessai,S. (2012) *Usable science? The UK Climate Projections 2009 and decision support for adaptation planning*
Weather, Climate & Society **4**, 300-313, doi:10.1175/WCAS-D-12-00028.1

[13] North East Climate Change Adaptation Study
See statement on p.2:
"The Environment Agency Rainfall and Weather Impacts Generator (EARWIG) was developed for the EA by Newcastle University and the University of East Anglia"

The organisations now using the UKCP09 Weather Generator Tool (Wgen) can be found at: http://ukclimateprojections.defra.gov.uk/23081

[14] EU Commision (2009) Underlying impact assessment report accompanying the 2009 EU White Paper *Adapting to climate change: Towards a European framework for action*
See: page 45: The ADAM project (led by **Hulme**) and the ENSEMBLES and PESETA projects (to which the School made substantial contributions) are identified as providing major inputs to the assessment.

[15] **Brooks** and **Adger** *Assessing and enhancing adaptive capacity*, Chapter 7 (pages 165-181) In: Lim, B., Spanger-Siegfried, E., Burton, I., Malone, E. and Huq, S. (eds) *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures* (2005) Cambridge University Press ISBN: 052161760X

Also: Daw, **Adger,** Brown, and Badjeck *Climate change and capture fisheries*, pp. 107-153 In: K. Cochrane, C. De Young, D. Soto and T. Bahri (eds). C*limate Change Implications for Fisheries and Aquaculture. Overview of Current Scientific Knowledge* (2008) FAO Fisheries and Aquaculture Technical Paper No. 530 ISBN: 9789251063477

[16] BIS (2011) *Foresight Project: Migration and Global Environmental Change: Future Challenges and opportunities*

See also: **Jordan** (2011) *Policy Development Review PD 18: The European Union: coordinating environment and migration policies?* Which was commissioned as part of the *Foresight Project: Migration and Global Environmental Change*

The one year review into the impact of the *Migration and Global Environmental Change* report on government and others can be found at:
http://www.bis.gov.uk/assets/foresight/docs/migration/12-1265-migration-one-year-review.pdf