Institution: Loughborough University

Unit of Assessment: C17 Geography, Environmental Studies and Archaeology

Title of case study: Scientific advisory services for climate adaptation and development planning

1. Summary of the impact (indicative maximum 100 words)

Research by Professor Wilby since 1993 has led to the development of regional climate modelling techniques, climate risk assessment frameworks, and adaptation planning approaches for long-lived water and energy infrastructure. Benefits were delivered through public domain software, practitioner training, and technical advice to policy-makers. This case study provides examples of impact conveyed via these services to national and international agencies, non-governmental organisations and commercial partners who are formulating strategies to manage exposure of their portfolios to climate risks. The work helped build technical capacities in climate risk management and adaptation options appraisal, particularly in vulnerable parts of Asia and the Middle East.

2. Underpinning research (indicative maximum 500 words)

Freshwater management addresses three types of challenge: a region can have too much water, too little, or the available water may be too dirty to meet human needs. Under climate change there could be *even* more, *even* less, or *even* dirtier water. Although many water managers recognise that traditional planning methods no longer apply, there is less agreement about what practical steps can be taken to meet future water needs of society and the environment.

Professor Robert Wilby (left 1993 then re-appointed 2008-present) investigated potential impacts of climate change on water resources as a post-doctoral Research Fellow supported by the National Rivers Authority (NRA) at Loughborough University in 1993 [**G3.1**]. This early research and resulting clutch of papers laid the foundations for his statistical downscaling technique which derives scenarios for climate change risk assessment at river basin scales [**3.1, 3.2**]. His coupled climate-hydrological modelling framework was initially used to assess recovery times for acidified catchments [**3.1**] and then for low flow estimation under climate change [**3.3**].

Professor Wilby recognised that most downscaling tools were only accessible to specialists and research institutions, thereby limiting uptake of climate risk information by decision-makers (especially in developing regions). At this time Professor Wilby's downscaling software was available in Fortran code and early model testing was performed using UK meteorological data. Between 1993 and 2008 Professor Wilby continued to develop the downscaling algorithms during secondments to the National Center for Atmospheric Research in Boulder, Colorado and whilst employed by the Environment Agency. In 2001 the first public domain, Windows-compatible version of the tool – the Statistical DownScaling Model (SDSM) – was released in collaboration with Dr Christian Dawson (an employee of Loughborough University since 1999).

On returning to Loughborough University in 2008, Professor Wilby continued to research and write extensively about the 'smarter' use of climate risk information in adaptation planning [**3.4, 3.5, G3.2**]. He collaborated with the UK Government's Department for International Development (DFID) [**G3.3**] and the European Bank for Reconstruction and Development (EBRD) [**G3.4**] to assess ways of applying climate risk information and robust adaptation frameworks for water management in Central and Southern Asia. Meanwhile, SDSM continued to evolve to meet user needs. The latest version [January 2013] has features for quality controlling meteorological data, analysing extremes, and generating synthetic weather data.

Professor Wilby's research increasingly turned to the utility of climate change scenarios and adaptation strategies for the built environment and long-lived infrastructure (to manage long-term heatwave, air quality, drought, and flood risks) [**3.5, G3.5, G3.6**]. Professor Wilby also undertook research with industrial partners to appraise ways of incorporating flexibility of design and safety margins in water supply systems, hydropower infrastructure, and new nuclear build so that these assets can be adaptively managed throughout their long life cycles, despite deep uncertainty about future climate risks [**3.6, G3.7**].

3. References to the research (indicative maximum of six references)

Outputs based on research undertaken at Loughborough University with evidence of quality summarised [in brackets].

3.1. Wilby, R.L. 1993. The influence of variable weather patterns on river water quantity and quality regimes. *International Journal of Climatology,* **13**(4), 447-459. DOI: 10.1002/joc.3370130408 [International, peer reviewed journal, WoS cites = 23]

3.2. Wilby, R.L. 1994. Stochastic weather type simulation for regional climate change impact assessment. *Water Resources Research*, **30**(12), 3395-3403. DOI: 10.1029/94WR01840 [High impact, international, peer reviewed journal, WoS cites = 48]

3.3. Wilby, R.L., Greenfield, B. and Glenny, C. 1994. A coupled synoptic-hydrological model for climate change impact assessment. *Journal of Hydrology*, **153**(1-4), 265-290. DOI: 10.1016/0022-1694(94)90195-3 [High impact, international, peer reviewed journal, WoS cites = 63]

3.4. Wilby, R.L. and Dawson, C.W. 2013. The Statistical DownScaling Model (SDSM): Insights from one decade of application. *International Journal of Climatology*, **33**(7), 1707-1719 DOI: 10.1002/joc.3544. [International, peer reviewed journal, WoS cites = 1]

3.5. Brown, C. and Wilby, R.L. 2012. An alternate approach to assessing climate risks. *Eos*, **93**(41), 401-402. DOI: 10.1029/2012EO410001. [International, peer reviewed, cites = 7]

3.6. Wilby, R.L., Nicholls, R.J, Warren, R., Wheater, H.S., Clarke, D., and Dawson, R.J. 2011. Keeping nuclear and other coastal sites safe from climate change. *Proceedings of the Institution of Civil Engineers: Civil Engineering*, **164**(3), 129-136. DOI: 10.1680/cien.2011.164.3.129 [Peer reviewed, professional readership, WoS cites = 3]

Grants (£'s given are for the allocation to Loughborough University):

Code	*Dates*	*Title*	*Funder*	*Amount*
G3.1	01/92-12/93	*Modelling the relative impact of weather, land-use and groundwater abstraction on low flows (Co-I)*	NRA	£50,000
G3.2	09/09-10/12	*Water System Resilience (ARCC-Water) (Co-I)*	EPSRC	£71,712
G3.3	07/09-09/09	*Climate for Development in South Asia (PI)*	DFID	£35,415
G3.4	12/10-04/12	*Improving the climate resilience of Tajikistan's energy sector (PI)*	EBRD	£51,982
G3.5	10/10-09/13	*Towards adaptable and resilient urban environments for a changing climate (Co-I)*	British Council	£22,688
G3.6	10/11-09/16	*Adaptation and resilience of coastal energy production and supply (Co-I)*	EPSRC	£86,588
G3.7	09/08-	*British Energy Climate Change (BECC) Working Group (PI)*	EDF	£31,225

4. Details of the impact (indicative maximum 750 words)

Growth in demand for high-resolution climate change scenarios created opportunities for Professor Wilby to interact with the policy arena. The following examples illustrate how his research contributed to environmental sustainability and long-term security of public services (water and energy) through raised awareness of climate risks in the UK and beyond.

Application of SDSM in policy-making and provision of public services

SDSM is freely available to practitioners via a web-portal (http://www.sdsm.org.uk/). Up to September 2013 there were approximately 7000 registered downloads of the software from more than 100 countries. Over 1000 registrations originate from Africa, Asia, Central and South America, with strong recent growth in demand from China and Iran. Examples, of the impact and reach of this research in public policy-making and sustainable development are given below.

Interest in SDSM grew after referrals by the United Nations Framework Convention on Climate Change (UNFCCC) [**5.1**] and the United Nations Development Programme (UNDP) [**5.2**]. SDSM was also cited repeatedly in the Intergovernmental Panel on Climate Change (IPCC) Working Group I Fourth Assessment Report (AR4). Another important factor was the endorsement and web-delivery of the software via the Environment Canada sponsored Canadian Climate Change Scenarios Network portal [**5.3**]. By 2008, SDSM had even been cloned by the Global Environmental and Climate Change Centre in Quebec to automate some aspects of the software. Professor Wilby and Dr Dawson obtained sponsorship to undertake training (of groups of up to 30 practitioners) in the use of SDSM on behalf of Environment Canada [Toronto workshop, May 2010], Chinese Ministry of Agriculture [Xi'an workshop, October 2010], the British Council in Bangladesh [Dhaka workshop October 2011], and EPSRC [Tunis workshop, July 2012].

Meta-analysis of over 200 studies based on SDSM reveals that impact assessments for water resource and flood risk management account for nearly half of all outputs, with lower levels of activity in agriculture, the built environment, energy, human health, and tourism (see: **3.4** and http://co-public.lboro.ac.uk/cocwd/SDSM/Bibliography.pdf). The range of end-users and applications is very diverse. For example, SDSM was used to evaluate design standards for urban drainage infrastructure in Ontario, Canada. In 2008, SDSM was used to assess tidal surge risk within the Environment Agency Thames Estuary 2100 study. Alongside evidence provided by the Met Office, this work enabled planners to design a long-term strategy for adapting London's flood defences to rising sea levels [**5.4**]. Since 2008, SDSM was used in World Bank studies to evaluate regional climate changes and potential impacts on rural development in Djibouti, Jordan, Lebanon, Morocco, Syria, Tunisia and Yemen. This work was subsequently incorporated in a flagship report on *Adaptation to Climate Change in the Arab Countries* showcased at the UN Conference of Parties (COP17) in Durban [**5.5**].

Scientific advisory services to Government, industry and international donors

Thanks, in part, to the visibility of SDSM, Professor Wilby was asked to provide technical advice on climate scenarios and risk management by a range of communities. Since 2008 he has counselled the Adaptation Sub Committee (ASC) of the Committee on Climate Change; Department for Environment Food and Rural Affairs (Defra); DFID; EBRD; Environment Agency of England and Wales; European Commission; Tearfund; UK Collaborative on Development Sciences (UKCDS); UN Environment Programme; UN International Fund for Agricultural Development (IFAD); US Water Research Foundation; and the World Bank. Three examples of these scientific advisory services are given below.

First, Professor Wilby has sat on technical steering committees formed by UK Government. These

were: Defra's 2009 *UK Climate Change Projections (UKCP09)* to which he provided technical advice and a user perspective (to 2009) [**5.6**]; the High Performance Computing Subgroup for cross-department provision of climate science services to UK Government (in 2010); the Steering Committee of the Met Office Hadley Centre – DFID Climate Science Research Programme (CSRP) (2010-2012). His review in 2012 informed early thinking by the Committee on Climate Change on the shape of the next UK Climate Change Risk Assessment (CCRA) [**5.7**].

Second, since 2008 he has chaired the British Energy Climate Change (BECC) Working Group: an expert panel formed by EDF to provide technical advice on potential climate risks and their management over the 200-year life-cycle of proposed new nuclear build at Hinkley Point and Sizewell C [**5.8**]. The EDF-BECC partnership also acquired UK Research Council funding to investigate the resilience of coastal energy systems [**G3.6**]. In 2013 he reviewed scientific evidence behind credible maximum sea level change scenarios for the UK to inform the planning and design (flood risk assessment), and operational (safety case) of new nuclear build.

Third, in 2011/12 Professor Wilby advised the World Bank Independent Evaluation Group (IEG) on climate modelling as part of their corporate assessment of the utility of climate scenarios for adaptation project and lending decisions [**5.9**]. He developed a typology of adaptation practice then appraised their portfolio of water projects to determine how useful climate models had been for discriminating options. The World Bank accepted his principal recommendation that operational procedures for identifying and managing climate risks should be standardized across the Group. Guidance issued by the Organisation for Economic Co-operation and Development (OECD) at the 2013 World Water Week also drew heavily on his risk-based approach [**3.5**] as "a promising way forward" for adapting to climate change in ways that promote water security [**5.10**].

5. Sources to corroborate the impact (indicative maximum of 10 references)

The following sources of corroboration can be made available at request:

5.1. SDSM is endorsed by the United Nations Framework Convention on Climate Change: http://unfccc.int/adaptation/nairobi_work_programme/knowledge_resources_and_publications/items/5487.php

5.2. United Nations Development Programme, (2010) *Designing Climate Change Adaptation Initiatives: A UNDP Toolkit for Practitioners* - SDSM is listed as a 'key tool': http://www.undp.org/content/undp/en/home/librarypage/environment-energy/low_emission_climateresilientdevelopment/designing-adaptation-initiatives-toolkit/

5.3. SDSM was sponsored and distributed by Environment Canada via the Canadian Climate Change Scenarios Network: http://www.cccsn.ec.gc.ca/index.php?page=dst-sdi

5.4. Thames Estuary 2100 Technical Lead, Environment Agency: See: corroborating letter.

5.5. World Bank Flagship report, (2012), *Adaptation to a Changing Climate in the Arab Countries* http://elibrary.worldbank.org/content/book/9780821394588

5.6. *UK Climate Change Projections (UKCP09)* http://ukclimateprojections.defra.gov.uk/21691

5.7. Adaptation Sub-Committee, (2012: 82), *Climate Change – Is the UK Preparing for Flooding and Water Scarcity?* http://www.theccc.org.uk/publication/climate-change-is-the-uk-preparing-for-flooding-and-water-scarcity-3rd-progress-report-2012/; Adaptation Sub-Committee Minutes 26 April 2012 http://archive.theccc.org.uk/aws/260412%20Minutes.pdf

5.8. Environment Manager (Marine), New Nuclear Build, EDF: See corroborating letter.

5.9. World Bank Independent Evaluation Group (2012) *Adapting to Climate Change: Assessing World Bank Group Experience*: http://ieg.worldbankgroup.org/Data/reports/cc3_full_eval_0.pdf

5.10. OECD (2013: 19) *Water and climate change adaptation: Policies to navigate unchartered waters*. http://webexchanges.oecdcode.org/orL3A3OG/9713091e.pdf