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| Institution: Middlesex University |
| Unit of Assessment: 17 Geography, Environmental Studies and Archaeology |
| Title of case study: Flood Damage Appraisal Research |
| <p>1. Summary of the impact</p> <p>Throughout the REF period our research - driven by risk assessment theory - has provided a continuously updated set of unique models, data and techniques for assessing the benefits of UK flood alleviation investment. These have been used to justify all flood alleviation investment for the whole of the UK for the whole of the REF period (c. £3bn), as well as for the previous 30 years. Our work has been central to all assessments by Defra and the Environment Agency (EA) of national flood risk (Foresight; NaFRA (England, Wales, and Scotland); LTIS) and all the Catchment Flood Management Plans for England and Wales. The research is also used in Scotland (by the Scottish Environmental Protection Agency, SEPA), by international and national insurers (e.g. through Risk Management Solutions Ltd), and in many other countries.</p> |
| <p>2. Underpinning research</p> <p>Since the creation of the Flood Hazard Research Centre (FHRC) in the early 1970s, underpinning research in the area of flood damage appraisal at Middlesex University has been characterised by a number of interconnected streams, which have continued across the current REF period:</p> <p>Risk assessment theory-driven econometric methods. We have pioneered work in this area to derive a unique suite of nationally applicable theory-informed empirical relationships between flood characteristics and economic damages that scale the extent of damage potential faced by those at risk of flooding. These characteristics include flood depth, duration and flood velocities. Behind this flood damage modelling lie more than 1 million data items (Penning-Rowse and Green 2000; Penning-Rowse and Pardoe 2012; Penning-Rowse <i>et al.</i>, 2013). This research was central to the UK Foresight's <i>Future Flooding Project</i> and its Supplement to the Pitt Report in 2008, for which we received a commendation from Sir David King (dated letter 2005). Research completed for the EA (2012-13) has explored important but poorly understood secondary indirect (off-floodplain) flood effects (<i>op.cit.</i> 2013) to gauge previously unquantified hazard impacts in economies and communities peripheral to flooding and floodplains.</p> <p>Modelling of flood deaths/injuries. For both the UK and Europe, models have been developed through: (1) an algorithm that relates flood deaths to the characteristics of floods and floodplains (<i>op.cit.</i> 2013); and (2) innovative assessments of the health effects of flooding, used in this REF period in the EA's nationally applied Multi Decision Support Framework (MDSF2), outlined in Tapsell <i>et al.</i> (2002).</p> <p>Non-structural flood risk management measures. Our studies here have focused upon flood warning systems; incident management; insurance and their benefits, counteracting previous over-emphasis on engineering 'solutions' for flood risk management (<i>op.cit.</i> 2012).</p> <p>Policy evaluations. Insights from our research have led to UK policy evaluations that examine the secondary effects of floods (<i>op.cit.</i> 2013) and hitherto ignored social justice considerations (Johnson <i>et al.</i> 2007) and counter-intuitive distributional consequences (<i>op.cit.</i> 2012).</p> <p>International research has built on our UK expertise, in both the risk assessment and policy evaluation areas. This has included more than two decades of research in Bangladesh on livelihoods and flooding, fisheries governance in flood risk areas, adaptation to climate change, stakeholder engagement and policy evolution (Sultana <i>et al.</i> 2008). We have contributed, with this, to the Foresight project on <i>Migration and Global Environmental Change</i>, and have been commended for this research by Sir John Beddington.</p> <p>In exploiting and applying our research findings we have worked closely with world-class consulting engineering companies (e.g. Ch2m Hill (Halcrows); Atkins; Jacobs; Black and Veatch; ARUP) to undertake real-world UK investment appraisals for the EA and its predecessors. These appraisals cover, in total, over 150 flood schemes including, within the REF period, the £200m</p> |

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Lower Thames appraisal, the £4bn Thames Estuary (TE2100) project on replacing the Thames Barrier, and the innovative Exeter scheme (2013) founded on local contributions. Our results have been used by numerous insurance-related companies (e.g. RMS; Willis; Aviva).

Our research has been continually supported by the University throughout its 35-year lifetime, including in this REF period, via the provision of both capital and revenue resources. We have also enhanced our research since 2008 within a number of major EU projects: FLOODsite (2004-2009, €493,078); ENSURE (2008-2011, €138,980); THESEUS (2009-2013, €376,000); CONHAZ (2010-2012, €112,417); FLOOD-CBA (2013-2014, € 95,000); STARFLOOD (2012-2016, €869,345); RISC-KIT (2013-2-16, €605,650) and WeSenseIt (2012-2016, €376,630). Contributions by FHRC to the RCUK-Flood Risk Management Research Consortium (2004-2012) brought in over £500K supporting research into flood risk communication (*N.B. figures represent total award to this UoA but award period straddles the REF period in some cases as indicated*).

This underpinning research has been recognized by wholesale support by official statements and awards, in the current REF period and before. These include:

- The Royal Geographical Society 2011 'Back Award' for 'An outstanding contribution to the development of national or international public policy';
- Commending MAFF/Defra/EA Forewords to our flood damage appraisal Manuals (2005; 2010; 2013: see section 5, below);
- Commendations on our research on risk assessment and its impact, from successive Government Chief Scientific Advisers: Sir David King (2005) and Sir John Beddington (letter of 25.10.2011: 'There is .. substantial interest in the report .. in no small part due to the quality of the input .. The work that your people put in was invaluable, for which again my thanks');
- An RCUK EUREKA report (2006) which cited our research on the long-term psychological impacts of floods as one of 100 discoveries and developments in 'UK universities that have changed the world';
- A Queen's Anniversary Prize (2000);
- An OBE to Professor Penning-Rowsell for 'Services to flood risk management' in 2006.

Staff team involved: Penning-Rowsell (Professor); Parker (Professor), Tapsell (Principal Lecturer); Sultana (SRF), Tunstall (SRF retired in 2011), Viavattene (RF/SRF); Johnson (SRF, left in 2011); Handmer (Professor now at RMIT, Australia); Green (Professor); Priest (SRF) and others.

3. References to the research

Johnson, C., Penning-Rowsell, E.C. and Parker, D.J. (2007) Natural and imposed injustices: the challenges in implementing 'fair' flood risk management policy in England. *Geographical Journal*, 173(4), 374-390. DOI: 10.1111/j.1475-4959.2007.00256.x

Penning-Rowsell, E.C. and Green, C.H. (2000) New insights into the appraisal of flood alleviation benefits: flood damage and flood loss information. *J. Institution of Water and Environmental Management*. 14(5), 347-353. DOI: 10.1111/j.1747-6593.2000.tb00272.x.

Penning-Rowsell, E.C. and Pardoe, J. (2012) Who benefits and who loses from flood risk reduction? *Environment and Planning C: Government and Policy*, 39, 448-66. DOI: 10.1068/c10208.

Penning-Rowsell, E.C., Priest, S., Parker, D., Morris, J., Tunstall, S. Viavattene, C., Chatterton, J.B., and Owen, D. (2013) *Flood and Coastal Erosion Risk Management: A Manual for Economic Appraisal*. London: Routledge.

Sultana, P, Johnson, C. and Thompson, P.M. (2008) The impact of major floods on flood risk policy evolution: Insights from Bangladesh. *International Journal of River Basin Management* 6, (4) 339-348. DOI: 10.1080/15715124.2008.9635361.

Tapsell, S. M., Penning-Rowsell, E. C., Tunstall, S. M. and Wilson, T. L. (2002) Vulnerability to flooding: health and social dimensions, Flood risk in a changing climate, *Philosophical Transactions of The Royal Society, Mathematical, Physical and Engineering Sciences* Vol 360, 1511-1525. DOI: 10.1098/rsta.2002.1013.

Impact case study (REF3b)

Research was funded by competitively won resources, usually benefiting from high calibre Advisory Committees (including HM Treasury; Defra; CLG; EA) and was rigorously peer reviewed.

4. Details of the impact

The unique nature and *rigour* of the underpinning research led directly to its widespread use and hence its impact. Without the research, since 1973 and continuing through this REF period, there would not have been the models, data, techniques or policy impact that we have achieved. Our 2005 'Multi-Coloured Manual', current throughout the 2008-13 REF period, has attracted over 38,000 UK Google citations. Our heavily used Manuals (Penning-Rowse *et al.* 2013) have been central to the process through which our research has led to this impact. They have been supported by peer-reviewed papers, and endorsed by successive government departments, with commendations by MAFF/Defra Chief Engineers and the Environment Agency (EA):

- 2013 (Jonathan Day, EA) *'This Manual represents the results of intensive high-quality researchrepresenting the continuing close collaboration between us'*.
- 2010 (Aidan Kerr, EA) *'The Handbook provides users with techniques that fully support (our) sustainable development principles'*.
- 2005 (Reg Purnell, Defra): *'The Manual is seen by Defra as ... (providing) a single appraisal compendium ... that supports (our policy) of sustainable development'*.
- 1992: (Reg Purnell, MAFF): *'This Manual fills a significant vacuum and ... will be an important guide to engineers and others...'*
- 1987 (Brian Trafford, MAFF) *'... the FHRC ... has been at the forefront in developing methods (of obtaining value for money for) flood protection projects ... I commend this work'*.
- 1977 (Gordon Cole, MAFF): *'It is a unique contribution to our knowledge'*.

These Manuals have been in constant and routine professional use throughout the REF period by the Environment Agency, consultancy firms and local authorities. Furthermore, the material within these Manuals has been communicated to professional practitioners in this field via repeated CPD courses run by the FHRC from 1978 to today. In the 2008 to 2013 period alone we have run 32 such courses for Environment Agency staff and others, training a total of 906 professionals.

The nature and extent of the impact

The *reach* of this research has been profound within the UK, with complementary international extensions (e.g. through the EU Floodsite and FLOOD-CBA projects, and the 'E-Learning Platform for Integrated Flood Management (IFM)'). As a result of our research, the flood risks experienced or faced by at-risk communities, businesses and farmers have been fully recognised, quantified, and all investment has then been prioritised on this basis. Hitherto, investment had generally followed those who 'shouted loudest', rather than rigorous research-driven prioritisation.

Our research has been used to implement **all** UK flood risk management/defence schemes implemented in the REF period (total spending amounts to over £3bn). The precursor research supported all comparable expenditure from 1977 to 2008 (a further £10-£12 billions at 2013 prices). See p. 30 in:

<http://archive.defra.gov.uk/environment/flooding/documents/policy/guidance/erosion-manage.pdf>,

Our research on human fatalities and health effects during floods has been instrumental in influencing Defra policy and EA practice through the quantitative incorporation of these variables into project appraisal techniques (e.g. see the EA's FCERM-AG, p. 205: <http://www.environment-agency.gov.uk/research/planning/116705.aspx>). Our data and techniques have been used in the National Assessment of Flood Risk (NAFRA), in the appraisal of flood options for London (TE2100), and in the influential 2004 Foresight report on Future Flooding, and its 2008 Supplement to the Pitt Report:

http://webarchive.nationalarchives.gov.uk/20100807034701/http://archive.cabinetoffice.gov.uk/pittreview/_media/assets/www.cabinetoffice.gov.uk/flooding_review/evidence/foresight_report%20pdf.pdf.

Our unique sets of models, data and techniques, and the Manuals/papers which explain their research origins, are 'industry standard' sources in flood risk management implementation in the

UK. Our results are also central to the long-term investment strategy (LTIS) of the Environment Agency, which sets the policy direction for investment in flood risk management for the future in this country. Corroborations and corroborators to all these impacts are listed in section 5.

The beneficiaries

The *significance* of this research is attested to by the number of those directly or indirectly affected. The direct beneficiaries in 2008-13 have been hundreds of communities across the UK who have gained from having investment in flood defence and flood risk management schemes to protect them from the floods from which they otherwise would have suffered.

The 2012/13 investment programme alone included 323 different schemes. These communities include 100,000s of people and the several millions in London protected by the FHRC research guided 'TE 2100' plan. Further beneficiaries include the owners of thousands of hectares of agricultural land and hundreds of thousands of businesses protected from flooding, including those in the cities of Lincoln, Manchester, Newcastle, Bradford, Leeds, Exeter, Glasgow, Belfast, as well as many other metropolitan areas.

Our work is always cited in MAFF/Defra/EA policy papers and by SEPA in Scotland (see source 3 below). Defra/MAFF officials have consistently confirmed, following their experience of successive Spending Reviews, that Treasury allocations to flood defence budgets would not have been as high as they have been, nor the value to the taxpayer as great, without the rigour of our research supporting the key investment decisions. Indeed the FHRC research guided *Foresight Future Flooding* work led to a £200m p.a. increase in capital spend within the 2008-13 REF period.

5. Sources to corroborate the impact

Key citations:

1. The Environment Agency's '*Flood and coastal erosion risk management appraisal guidance (FCERM-AG)*' (2010), pp. 5, 53, 205, 207, 218: <http://www.environment-agency.gov.uk/research/planning/116705.aspx>.
2. Department for Environment, Food and Rural Affairs (Defra) (2009) *Appraisal of flood and coastal erosion risk management: a Defra policy statement*, p. 31: <http://archive.defra.gov.uk/environment/flooding/documents/policy/guidance/erosion-manage.pdf>.
3. *Flood Risk Management (Scotland) Act 2009 (FRM Act) National Flood Risk Assessment – Methodology*, p. 11 ff. and *Guidance for local authorities. Chapter 5. p. 9, paragraph 5.9.* www.sepa.org.uk/flooding/flood_risk_management/national_flood_risk_assessment/doc.aspx?docid=7f3adc71-8c27-451a-b923-32933fd6e574&version=-1 and <http://www.scotland.gov.uk/Publications/2012/02/9806/9>
4. *Foresight Future Flooding* <http://www.bis.gov.uk/foresight/our-work/projects/published-projects/flood-and-coastal-defence/project-outputs/volume-1>, p. 351
5. *E-Learning Platform for Integrated Flood Management (IFM)* sponsored by the World Meteorological Organisation, the WWF, and the Geneva Zoë Environment Network <http://daad.wb.tu-harburg.de/?id=1372>

Contact details of end users (government; government agency; and private sector):

6. Head of Water and Floods Analysis, Department for Environment Food and Rural Affairs (Defra).
7. Head of Flood Risk Management, Environment Agency.
8. Head of Extreme Events and Health Protection, Public Health England.
9. Head, Regulatory Policy Committee Secretariat, Department of Business, Innovation and Skills.
10. Regional Director (Europe) for Flood Risk Management and Water, and member, Institution of Civil Engineers' Expert Water Panel, Halcrow Group Limited, a Ch2m Hill Company.