

Institution: Middlesex University		
Unit of Assessment: 14 – Geography and Environmental Studies		
Title of case study: Reducing the impact of flooding on society: risk assessment methodologies and data for flood risk management and investment		
Period when the underpinning research was undertaken: 2000 to 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Edmund Penning-RowSELL Sally Priest	Head of FHRC/ Pro Vice-Chancellor (Research) Senior Research Fellow & Associate Professor/ Head of FHRC	1997 to 2021 2007 to Ongoing
Christophe Viavattene Sue Tapsell Dennis Parker	Senior Research Fellow Principal Lecturer/Head of FHRC Dean of the Business School/Professor	2007 to Ongoing 1990 to 2016 2000 to 2013
Damon Owen Sylvia Tunstall	Research Assistant Senior Lecturer	2012 to 2016 1997 to 2013
Period when the claimed impact occurred: 2014-2020		
Is this case study continued from a case study submitted in 2014? No		
1. Summary of the impact		
<p>For over 30 years pioneering research on flood loss assessment methodologies has been undertaken at the Flood Hazard Research Centre (FHRC). From 2013, our research and outputs have been made available directly to licensed users via a bespoke website (www.mcm-online.co.uk). These flood impact methodologies, models, data and tools, developed from the research, are considered industry best practice, delivering the following impacts:</p> <ul style="list-style-type: none"> • Flood risk policy making, strategy and investment. FHRC research, approved by HM Treasury, has facilitated all central government investment in flood risk management interventions between 2014 and 2000. • Societal Impact - through avoiding flood risk damages. Based on FHRC research, over 720 flood risk management schemes, have been implemented between 2015 and 2020, delivering widespread social and health, as well as economic, benefits. • Flood risk practice: The Multi-Coloured Manual online dataset has been formally recognised for use across countries. In addition, hundreds of professionals from 146 organisations have used these methodologies and data. 		
2. Underpinning research		
<p>Flooding causes significant social and economic losses, with 5.2 million properties in England alone at some degree of flood risk. Estimations of the flood risk and its impacts, as well as the benefits realised interventions are required to justify investment in flood risk management. Pioneering research on flood loss assessment methodologies has been undertaken by staff at the Flood Hazard Research Centre (FHRC) since its inception in 1970 and research in this area since 2000 has continued to have a significant impact on communities liable to flooding. A body of research has been undertaken between 2000-2020 in a number of interconnected areas.</p>		
<p>Flood loss assessment methodologies: Our research has concentrated on developing and testing econometric theory-informed methodologies for flood risk assessment. Empirical relationships relating flood characteristics (e.g. depth, velocity, duration) to their potential impacts (e.g. damages to building structure, damages to stock, evacuation costs) have been derived and modelled [R1, R2] to permit detailed assessment of a wide range of potential losses; including to properties, people and livelihoods. Undertaking research to extend the scope of flood losses and developing comprehensive approaches (and tools for their application) for their</p>		

consideration permits the assessment of flood impacts on a more comparative basis, allows for both a more complete, a more balanced, and potentially equitable, flood loss assessment. Innovative approaches and novel evidence have been developed to extend loss assessments to consider damages which have traditionally not been quantified (e.g. indirect damages, business interruption, wider health impacts [R1; R3; R4]) as well as the potential impacts of mitigation approaches on economic and other losses (e.g. flood warnings [R1; R4], insurance uptake and benefits [R3, R5]). This represents a significant development in flood risk quantification, enabling a comparative and nationally-consistent approach to optimising flood risk management which can be used operationally. It affords a more comprehensive quantification of a range of flood risk losses and also the benefits of different types of flood management approaches.

Our research innovations have also included the development of metrics for calculating financial losses [R1]. These enable local flood losses to be estimated and quantified and widens the potential for local flood risk investment contributions (see Section 4). Our research, applied in both the UK and European coastal context [R3], has focused on developing novel high-level flood risk assessment approaches at a regional scale which enable coastal managers to identify and prioritise risk areas. This approach applies a threshold-based approach to both flood hazard and the vulnerability of exposed assets and also to the application of INDRA (INtegrated DisRuption Assessment model), which includes eight indicators of direct and indirect impacts (including network transport and utility service disruptions, household displacement, regional business disruption), subsequently integrated into our standard methods for assessing risk.

Assessing the impact of flooding on people: Drawing on empirical data, we have developed algorithmic methods which link flood and floodplain characteristics to the potential for fatalities and injuries [R1, R3]. Longstanding research by FHRC staff into the health impacts of flooding [R2] (a UK Universities EUREKA report (2006) cited our work as one of 100 discoveries and developments in 'UK universities that have changed the world'), have been used in appraisal methodologies to qualify mental health impacts economically since 2004. Data and methods in this area have been further developed and endorsed in national appraisal guidance, impacting flood risk management investment decisions, further re-balancing the consideration of the impacts on people and property.

Policy and decision-making evaluations: FHRC researchers have investigated the potential distributional consequences of flood risk decision-making and investment, with a particular focus on the socially disadvantaged and the critical role of insurance to UK flood risk management [R5]. Research undertaken by Penning-Rowse [R6] has highlighted an overestimation of flood risk in England. The comprehensive and in-depth analysis of expected annual average damage (the figure which is the basis of national flood risk investment levels) has informed policy of the implications of investment decisions as well as conducting a critical uncertainty and sensitivity analysis of national approaches to risk assessment.

Collaboration and research exploitation: Research has often been undertaken collaboratively; with academics, policy-makers and flood risk management professionals. Many consultant engineers (e.g. Arup, Capita, Jacobs, JBA Consulting, RMS) and insurers (e.g. Flood Re) apply and exploit our methodologies and findings, building our research and data directly into their internal flood risk assessment processes. Research for flood loss assessment has been supported by a number of competitively awarded projects between August 2013 and July 2020 including; €3.1 million from six EU framework/H2020 projects between 2004 and 2019 (FLOODsite, ENSURE, CONHAZ, RISC-KIT, WeSenseIt, STAR-FLOOD, SYSTEM-RISK). Additionally, funding between 2009 and 2020 totalling €880k for five projects (THESEUS, FLOOD-CBA, FLOOD-CBA2, ECOSHAZ & FLORIS) was received from EU DG-ECHO (*European Civil Protection and Humanitarian Aid Operations*) for collaborative research, knowledge exchange and training end users. These centred on training partners and end-users from 10 European countries directly implementing loss assessment approaches. Impact has therefore been generated during the projects as local policymakers are trained and provided with data to improve flood investment decision-making. In 2019, the THESEUS project received one

of the inaugural H2020 impact awards for its transfer of best practices and knowledge to stakeholders in other countries.

3. References to the research

R1. 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. Associated online methods and datasets <https://www.mcm-online.co.uk/>.

R2. Tapsell, S., Penning-Rowsell, E.C., Tunstall, S. M. & Wilson, T. L. (2002) Vulnerability to flooding: health and social dimensions, Flood risk in a changing climate, Philosophical Trans. of The Royal Society, Mathematical, Physical and Engineering Sciences, 360, pp. 1511-25.

R3. Viavattene, C., Jiminez, J., Ferreira, O., Priest, S.J., Owen, D. & McCall, R. (2018) Selecting coastal hotspots to storm impacts at the regional scale: a Coastal Risk Assessment Framework. Coastal Engineering, 134 (April). pp. 33-47.

R4. Priest, S.J., Parker, D.J. & Tapsell, S.M. (2011) Modelling the potential damage-reducing benefits of flood warnings using European cases. Environmental Hazards, 10 (2). pp. 101-120.

R5. Penning-Rowsell, E.C. and Priest, S.J. (2015) Sharing the burden of adapting to increasing flood risk: who pays for flood insurance and flood risk management investment in the United Kingdom. Mitigation and Adaptation Strategies for Global Change, 20 (6). pp. 991-1009

R6. Penning-Rowsell, E.C. (2014) A realistic assessment of fluvial and coastal flood risk in England and Wales. Transactions of the Institute of British Geographers 40 (1). pp44-61.

4. Details of the impact

Research conducted by FHRC into flood assessment methodologies and data has significantly contributed to flood benefit appraisal guidance and data, both in the UK and beyond. The methodologies, models and data underpinned by our research have been wholly integrated within flood risk investment decision-making in the UK. From 2013, our research and outputs have been integrated and made available directly to licensed professional flood risk management users (e.g. national and local government, consultants) via a bespoke website (www.mcm-online.co.uk) where the data are housed and methodological guidance provided via an eHandbook. These flood impact methodologies, models, data and tools, are considered **industry best practice** and provide the basis for all economic assessments of UK flood losses [F, G, I]. The research fundamentally impacts flood risk management implementation at both strategic and operational levels and its impact should not be underestimated:

“Defra’s £2.5bn. investment in flood defences in the current capital programme (2015-2021) and £5.2bn. in the next programme (2021-2027) have been or will be appraised following the guidance and analysis you developed. The latter programme is expected to deliver £30bn. of benefits in the next 50 years, mostly in the form of flood damages avoided but also in environmental benefits, better mental health and other societal benefits which will improve quality of live and protect lives and livelihoods across England. All these would have not been possible without your work on flood risk providing a better understanding and underpinning the analysis.” [Defra Flood Economist, G]

Impact on policy making, flood risk strategy and flood risk investment

Our research is frequently used in policy documentation highlighting its significance and its influence on the work on Defra, Environment Agency, SEPA and NRW [e.g. A; D; E]. The thorough, rigorous and comprehensive methodologies produced from the research, and approved by HM Treasury, has facilitated **all** central government investment in flood risk management interventions between 2014 and 2000. This is evidenced through the requirement in the national appraisal guidance of England [D], Scotland [E] and Wales to utilise methods and data from the MCM when presenting the cost-benefits of interventions and creating a business case [e.g. D, E]. Operationally, in flood risk investment terms, in England alone, in the financial years 2013/14 to 2018/19, this equates to GBP4.78billion (in real terms to 18/19 values) of UK Government capital investment being allocated using our methodologies and data. Furthermore,

research to enable the consideration of local financial, as well as economic, damages into appraisal methodologies has also facilitated the implementation and application of Defra's *Partnership Funding* approach; thereby enabling additional local benefits to be realised. Our approaches, therefore, helped to realise an additional c. GBP763million in local investment contributions for flood risk management to 2020/21.

Strategically, the research has been used to guide flood risk management developments. Our data underpins the economic analysis within the previous and current National Flood Risk Assessments of England (NaFRA) (including the recent *State of the Nation* update [A]), and Scotland, the English Long Term Flood Investment Scenarios (LTIS) [B] as well as consideration of flooding in the Climate Change Risk Assessment [C]. These high-level assessments are fundamental to understanding the distribution of flood risk and are used by governments to prioritise, develop its policy and guidance [G]. Indeed, based on the revised LTIS damage forecasting (underpinned by our data) the English budget for flood risk management over the next 6 year period (2021-2027) has been doubled to GBP5.2billion [G].

Since 2013, the research and the MCM data and methods are being increasingly used internationally and *"its impact has reached beyond our borders and our expertise is often sought by policy makers and flood risk managers from other countries"* [G]. We have international license holders who utilise our data from countries including, France, Germany, Canada, Ireland, Italy and Malaysia; as well as many engineering companies which work internationally. In particular, FHRC data and techniques have been, and continue to be, used in a national study of Romanian flood risk aimed at meeting the stringent and mandatory obligations of the European Floods Directive [J]. These have been used to improve flood risk assessment and 'screen in' areas so as to prioritise flood risk investment across Romania and develop a programme of investment requests to the European Community's Cohesion Funds [J].

Societal and economic impacts through avoiding flood risk damages

At-risk communities are the key beneficiaries of our research through its use to prioritise investment in flood and coastal erosion risk management and the implementation of flood risk management measures to reduce the impacts of flooding [H, F]. Over 720 schemes have been implemented between 2015 and 2020 in England alone; thereby directly positively impacting the flood outcomes of all those communities benefitting. *"By providing better protection for 242,000 homes, EA's investment programme has delivered valuable benefits for people, with flood risk being substantially lower for many thousands of homes in England"* National Audit Office Report (2020; p4) and facilitating the assessment of high benefit-cost ratios of 8:1. This equates to an estimated avoidance of GBP29.4billion of expected household damages, from capital investment in flood protection between 2015 and 2021, and c. 700,000 people benefitting from a reduction in their flood risk. In Wales, over 45,000 properties and in Scotland 10,000 properties benefit in the period 2016 and 2021 from flood defence investment, facilitated by our methods and data.

Importantly, this has widespread social and health implications as well as economic benefits. Beneficiaries of flood risk investment are not only those households which may flood directly, it is estimated that for every household directly flooded, an additional 16 people suffer knock-on effects from the losses of utility services (EA, 2019); so flood risk management investment has the potential to impact society much more widely. The Hull Flood Frontage defences and Oxford flood risk management schemes are just two examples of major interventions which have been evaluated and business cases developed using our research outputs and data. These two large schemes alone provide increased protection to a total of 123,000 properties and mean that an estimated 250,000 people, therefore, avoid the social and health impacts of flooding.

The impact not only relates to newly constructed flood alleviation schemes. Existing flood risk defences will continue to provide benefits (through damages avoided) throughout their lifetime. As is widely acknowledged, every single one of the millions of UK families, households, businesses and communities that has had their risk of flooding reduced via thousands of investment schemes has benefited from the availability of our rigorous and theory-informed research (both within 2014-20 and indeed since 1977) [F, G]. For river flooding in England it is

estimated that every year, on average, losses of GBP1.1 billion are avoided by existing defences equating to a 63% reduction of inland flood losses (RMS, 2019). As an example, the Winter 2019/20 floods caused c. GBP333 million in economic damages and inundated 4,600 properties. However, the economic damages avoided due to existing flood protection were estimated to be at least 14 times greater at GBP4.6 billion with the avoidance of flooding to 127,000 properties.

In the Romanian context, a total of 12 major World Bank managed projects are being implemented, covering all flood affected areas in Romania, including along the Danube, locations where the consequences of flooding are high. Annually, the Romanian GDP is estimated to be affected by 4.6% as a result of flood damages, annually affects 300,000 people and there have been 237 fatalities from over 400 floods between 1960-2000. Our research and data are therefore helping to reduce current and future impacts; which are increasing under climate change and due to the deterioration of Communist-era flood defences.

Impacts on flood risk practice: Training, data and tools for operationalising flood benefit appraisal

The significance of our research and data is demonstrated by its wide and routine use by flood risk management professionals [I] and policymakers [F, G, J]. 146 organisations (including international and UK government departments, local authorities, consultancies, water companies, NGOs, banks etc.) have used our loss assessment methodologies and data between 2014 and 2020 and we have run a total of 28 courses for EA, SEPA, Local Authority flood risk managers as well as others, training a total of 499 flood risk professionals in our approaches to flood loss assessment. These professionals are those tasked with undertaking or assessing business cases for flood risk interventions. Alongside the MCM data and methods the *MCM online calculator tool* was developed to directly integrate research outputs into decision-making. This spreadsheet-based tool allows an inexpensive screening approach and is now well-used by flood risk professionals undertaking high-level benefit appraisal. In 2018, the Environment Agency, the organisation in England tasked with strategic overview managing flooding, formally recognised its value by endorsing its use among their staff, as well as incorporating it into their in-house online training [F]. In addition, we have collaborated with Jacobs on their commercial *Flood Modeller Damage Calculator tool* which assists end users to undertake flood loss assessments.

5. Sources to corroborate the impact

Policy documents and guidance

- A. *Environment Agency (2018) NaFRA - State of the Nation - technical briefing – p2-3.* Highlights how our research and MCM data has been used to quantify flood risk extent.
- B. *Environment Agency (2014) [Flood and coastal erosion risk management: Long-term investment scenarios \(LTIS\) 2014](#), e.g. p 52 - Risk baseline: An example of where the data has been used strategically.*
- C. *Committee on Climate Change (2017) UK [Climate Change Risk Assessment 2017](#) - see p24 and appendix F as examples of how the data was used to inform the UK CCRA.*
- D. *Environment Agency (2010) '[Flood and coastal erosion risk management appraisal guidance \(FCERM-AG\)](#)', Environment Agency: London. (e.g. see p5, p53, p205, p207, p218 amongst others). Guides those appraising flood risk to use MCM approaches and used throughout 2014-2020 and used operationally to guide selection of options.*
- E. *Scottish Environmental Protection Agency (2016) [Flood Risk Management \(Scotland\) Act 2009 Options appraisal for flood risk management: Guidance to support SEPA and the responsible Authorities](#), SEPA: Edinburgh. See p7 and 28 amongst others to how the MCM is referenced a key source to underpin project appraisal in Scotland.*

Testimonials

- F. Environment Agency (Flood Investment Expert)
- G. Department of Environment Food and Rural Affairs (Flood Economist)
- H. National Flood Forum letter of support (Chief Executive)
- I. Managing Director, JBA Trust Consultancy company (Managing Director)
- J. Director, Romanian National Water Administration (General Director)