Institution: Newcastle University

Unit of Assessment: UoA 14: Civil and Construction Engineering

Title of case study: Underpinning policy and practice for sustainable catchment management

1. Summary of the impact

Newcastle's research has shaped national policy and practice on the management of flooding and agricultural pollution, and international policy and practice in the developing world on managing forested catchments and sustainable water resources management. We show evidence that our research has:

- provided key evidence to inform five national policy and guidance documents on management of flooding and diffuse agricultural pollution, used by all relevant national bodies
- supported national guidance on natural flood management in catchments, reaching all 79 UK priority catchments and influencing funding for more than 40 farming grants to date
- provided exemplary demonstration sites, national guidance documents and tools for promotion of best practice to key stakeholders, reaching over 3000 interested people
- established a basin-scale approach to water resources modelling for nine Nile Basin countries
- influenced national water management policies in several Latin American countries.

2. Underpinning research

Over a period of 20 years Newcastle has developed a distinctive catchment systems approach attracting a continual stream of funding from a variety of sources, including RCUK, the Environment Agency and Defra totalling over £12 million, and providing the science base for the management of flooding, pollution, and water resources. We have pioneered methods for multi-scale monitoring and modelling, used these for quantitative assessment of full-scale interventions, and developed appropriate tools and frameworks to enable stakeholders and policy makers to engage with research outputs.

Process-based modelling underpinning decision-support systems (DSS) (up to 2000)

We developed innovative spatially distributed process (or physics) based modelling of the full water cycle for integrated land and water management, notably the SHETRAN model [**P1**], with new techniques for modelling of flow and transport of sediments and contaminants and for rigorous testing of their predictive capability [**P1**, **G1**]. We were early leaders in developing decision support tools (NELUP DSS) and their use to support decision making at the catchment scale [**P4**, **G2**].

Multi-scale monitoring, linking sources to downstream impacts (2000-2010)

As the lead organisation in a national study (CHASM) [**G3**], we developed and implemented a systematic approach to multi-scale monitoring which provided new understanding of how small-scale flow processes aggregate up to the larger scale [**P5**]. Defra commissioned Newcastle to lead a review of the causes of flooding from land management at the catchment scale [**G4**], and to develop a research plan to collect evidence of how upstream landscape interventions could potentially impact downstream flood risk at different scales.

Researching the impacts of full-scale land-use and soft engineering interventions (2005-2013)

We have used and further developed the multi-scale monitoring strategies and modelling tools to research the impacts of actual interventions in the landscape, including a comprehensive assessment of upland land use management on catchment scale flood generation [**P2**, **G5a,b**], multi-functional controls of agricultural land management on water and nutrient runoff at Nafferton Farm, Northumberland [**G6a**], and the first full-scale Natural Flood Management (NFM) soft engineering interventions that demonstrated measurable small catchment-scale impacts at Belford, Northumberland [**P6**, **G6b**]. Use of our catchment systems approach in subsequent studies [**G6c**] has provided new evidence of the scales at which pollution mitigation measures are detectable.

Research with stakeholders and policy-makers (1999-2013)

In the UK, we have shown that it is necessary to develop our multi-scale scientific approach in tandem to working with landowners at the farm scale to provide the solid evidence to underpin national policy, and to develop appropriate educational tools for wider dissemination to landowners [**G6d**]. Internationally, we developed methods of working with diverse stakeholders using hydroclimatic and socio-economic data and models to promote sustainable water resources management in shared Palestinian-Israeli aquifer systems [**G7a**], and further developed this

approach with stakeholders from nine Nile riparian countries to implement the first full Nile basin water resources model and pilot water resources studies based on consistent use of quality-assured data [**G7b**]. We have developed and applied innovative socio-technical approaches in several countries in Latin America in the Newcastle led EU funded EPIC- FORCE project [**P3**, **G8a**], integrating science, management and policy development for water resources management, and for management of forested catchments based on previous experiences in Costa Rica and India [**G8b**].

Key staff:

R1 J. Amezaga, RA/SRA/Senior Lecturer, 1999-present
R2 J.C. Bathurst, Lecturer/Reader, 1985-present
R3 I.R. Calder, Professor, 1998-2009
R4 J. Ewen, SRA/Lecturer/Senior Lecturer/Visiting Professor, 1988-present
R5 J. Jonczyk, RA, 2005-present
R6 P.E. O'Connell, Professor, 1985-present
R7 G. O'Donnell, RA/SRA, 1995-present
R8 G. Parkin, RA/SRA/Lecturer/Senior Lecturer, 1988-present
R9 P. Quinn, Lecturer/Senior Lecturer 1997-present
R10 M. Wilkinson, RA, 2002-2012

3. References to the research

[**P1**] *Ewen J., Parkin, G. and O'Connell, P.E. (2000). SHETRAN: distributed river basin flow and transport modeling system. ASCE J. Hydrologic Eng., 5, 250-258. *Reflected the state of the art in integrated water and pollution modelling (128 citations on Scopus - 14th October 2013)*

[**P2**] *O'Connell P.E., Ewen J., O'Donnell G.M. and Quinn PF. (2007). Is there a link between agricultural land-use management and flooding? Hydrology and Earth System Sciences 11(1), 96-107. *Summarised the key outputs of the Defra report [E2] (43 citations on Scopus - 14th October 2013)*

[**P3**] *Bathurst J.C., Amezaga J., Cisneros F., Gavino Novillo M., Iroume A., Lenzi M.A., Mintegui Aguirre J., Miranda M. and Urciuolo A. (2010). Forests and floods in Latin America: science, management, policy and the EPIC FORCE project. *Water International*, **35**(2), 114-131.
Best Paper Award (2010) from the International Water Resources Association

[**P4**] NELUP, Special Journal of Environmental Planning and Management Volume 38, Issue 1, February 1995. Example paper: R. Adams, S. M. Dunn , R. Lunn , R . Mackay and J. R . O ' Callaghan (1995). Assessing the Performance of the NELUP Hydrological Models for River Basin Planning, 53-76. http://www.tandfonline.com/doi/abs/10.1080/09640569513110

[**P5**] Mayes, W.M. Walsh, C.L. Bathurst, J.C. Kilsby, C.G. Quinn, P.F. Wilkinson, M.E. Daugherty, A.J. O'Connell P.E. (2006). Monitoring a flood event in a densely instrumented catchment, the Upper Eden, Cumbria, UK. Water and Environment Journal. 20(4), 217–226.

[**P6**] Wilkinson, M.E., Quinn, P.F. and Welton, P. (2010) Runoff management during the September 2008 floods in the Belford catchment, Northumberland. Journal of Flood Risk Management 3(4), 285-295.

* = the 3 references that best indicate the quality of the underpinning research

Grants

[**G1**] Simulating Radionuclide Transport From The Geosphere To The Biosphere (Nirex, £2M) 1993-2000 [R2,R4,R6,R8]

[**G2**] NERC-ESRC Land Use Project (NELUP) (NERC, £2M) up to 1995 [R2, R6]

[**G3**] Catchment Hydrology & Sustainable Management (CHASM) (NERC, £2M) 2000-2005 [R2,R6,R8,R9]

[**G4**] Review of impacts of rural land use and management on flood generation (FD2114) (Defra, £200K) 2002-2004 [R4,R6,R7,R9]

[**G5**] a) Flood Risk Management Research Consortium Phase 2 (EPSRC, £600K) (2007-12); b) The Upper Hodder Impact Study (EA, 200K) 2005-2010 [R4, R6, R7]

[**G6**] a) Nafferton Farm: Making Space for Water/Proactive (EA, £235K) 2005-8; b) Belford Catchment Flood Study, (EA Flood Levy, £150K) 2008-13; c) Demonstration Test Catchments (Defra, £550K) 2010 onwards; d) FARM Tool (EA, £30K) 2005-6 [R5,R9, R10]

[**G7**] a) SUSMAQ (DfID, £3.5M) 1999-2005; b) Nile Basin (UN, £150K) 2010-12 [R6,R7,R8]
[**G8**] a) EPIC FORCE (EC, £1.2M) 2007-10; b) Forest and Water (DfID, £2M) 2004-8 [R1,R2,R3]

4. Details of the impact

Newcastle research has shaped national policy and practice related to flooding and agricultural pollution, and international policy and practice in the developing world related to managing forested catchments and sustainable water resources management.

Impact on national policy (flooding and pollution management)

The Environment Agency's (EA) Research Scientist, EA Evidence Directorate stated [**E1**]:

> *"Over the past ten years, Newcastle has consistently provided high quality evidence and tools forming some of the key evidence used by the Environment Agency in this field."*

Newcastle University research has had a prominent impact on key national documents used by the water industry, regulators, and land managers:

1. The 2004 Newcastle-led Defra report FD2114, '*Review of impacts of rural land use and management on flood generation*' [**E2**,**P2**] provided the basis for building the research evidence supporting national policy, policy review and regulation documents [**E1,E3**,**E4**,**E6**].
2. The 2008 joint EA / Defra document '*The role of land use and land management in delivering flood risk management*' [**E3**] defined flood risk policy mechanisms based on evidence provided by the 2004 FD2114 report [**E2**].
3. The EA's 2010 policy review document "*Greater working with natural processes in flood and coastal erosion risk management"* [**E4**] recommends the uptake of the Natural Flood Management (NFM) approach pioneered by Newcastle, and directly cites our research [**P6**] and case studies [**E5**].
4. The EA's 2012 policy document addressing management of diffuse agricultural pollution *"Rural Sustainable Drainage Systems* (RSuDS)" [**E5**] advocates using our soft engineering approach, citing 5 examples from research at Nafferton.
5. The 2013 report '*A Review on Natural Flood Management (NFM)*' which is part of the Defra policy review "*The Economics of Climate Resilience (ECR) project"* [**E6**] advocates that: *"Construction of a NFM scheme can be much quicker than traditional approaches ...".*

National impact on practitioners (agriculture and water sectors)

The EA's Environment and Business Advisor to the agriculture sector (and project manager for the RSuDS report [**E5**] which has been distributed to all Natural England and Catchment Sensitive Farming advisors in the UK's 79 priority catchments) stated [**E5**]:

> "*The work at Belford was a pioneering initiative to address a water management issue within a catchment at low cost, involving stakeholders and demonstrating the solid evidence of its success. It is a fine example of research involving both policy, industry and science practitioners. … Many of the measures … are included in over 40 Catchment Sensitive Farming grants.*"

As a key example, although the cost of traditional flood defences (hard engineering) for the Belford village in Northumberland was estimated as £2.5M, Newcastle University's approach of installation of NFM features which has now successfully withstood a number of flood generating rainfall events cost under £250K [**E7**]. The EA Regional Flood Defence Manager states in an official video [**E7**], "*For communities such as Belford that cannot receive traditional defences, this sort of approach gives real solutions, real benefits, and at a fraction of the cost.*" A briefing paper on NFM from the Parliamentary Office of Science and Technology review for the Natural Environment White Paper [**E8**] stated: *" … evidence for the efficacy of this approach has been found."*

To support implementation of research findings in practice, the EA/Defra Making Space for Water report [**E3**] recommended "*Promotion of advice tools such as the FARM tool* …". Hence, Newcastle University constructed a web-based advisory toolkit 'FARM' (Floods and Agriculture Risk Matrix, http://research.ncl.ac.uk/thefarm/), which has had 3100 unique/first time visitors.

The Construction Industry (CIRIA) practice guide C719 '*Land use management effects on flood flows and sediments: - guidance on predictions*' [**E1**], a primary national resource for policy makers, farmers, landowners and land managers, governing bodies and consultants to support sustainable land use decisions, was co-authored by Newcastle staff [R4, R6 and R7] and uses concepts, images, and case studies from Newcastle University research studies [**P2**,**P6**,**G6d**]. A

key practical finding in C719 is that "*the effects of land use management on flooding are expected to diminish as the scale of the catchment increases*". This was proposed in [**G4]** and established in [**G5**].

International impact on water resources management

Newcastle's catchment systems approach has led to the development and use of integrated socio-technical frameworks for water and land management worldwide. Two examples are cited here.

The World Bank-funded *Nile Basin Initiative* (NBI) engaged Newcastle University to develop the first water resources model of the full Nile basin that uses consistent quality-assured shared data from the nine riparian countries as part of a Nile Basin Decision Support System (DSS), enabling a shared approach to catchment management. An independent international panel of experts stated:

> "*The Nile basin is one of the world's most complex and difficult to manage trans-boundary river systems … we concluded that the data management and modelling tools developed largely by Newcastle University had provided a key part of the NBI DSS, and recommended that they be used operationally by the NBI countries"* [**E9**].

Several countries in Latin America including Argentina, Ecuador, Chile and Costa Rica have used guidelines based on Newcastle University research. In Argentina, based on research in the EPIC-FORCE project [**P3**], the Director General of Water Resources, Government of Tierra del Fuego, and Member of the Federal Commission for Water Resources Management stated [**E10**]:

> "*… Newcastle University has had a direct influence in the definition of local and national policies for environmental protection against extreme events ....The problems and solutions identified during the project were included as priorities in the National Water Resources Plan*".

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

[**E1**] Testimonial: Research Scientist, EA Evidence Directorate, project manager for Upper Hodder Study, and major contributor to FRMRC2 report *Land use management effects on flood flows and sediments: - guidance on predictions* (2013). Ed. McIntyre and Thorne published by the Construction Industry (CIRIA).

[**E2**] *Review of impacts of rural land use and management on flood generation: Impact study report* (2004) O'Connell PE, Beven KJ, Carney JN, Clements RO, Ewen J, Fowler H, Harris GL, Hollis J, Morris J, O'Donnell GM, Packman JC, Parkin A, Quinn PF, Rose SC, Shepherd M, Tellier S. Defra R&D Technical Report FD2114.

[**E3**] *The role of land use and land management in delivering flood risk management* (2008). Making Space for Water Project (by Halcrow Group Limited).

[**E4**] *Greater working with natural processes in flood and coastal erosion risk management* (2012). A response to the Pitt Review Recommendation 27. Defra, Welsh Government, Environment Agency, Natural England, Countryside Council for Wales, Wildlife & Countryside Link, National Trust, The Wildlife Trusts, RSPB, and The River Restoration Centre.

[**E5**] Testimonial: EA, Env. & Business Section, project manager for *Rural Sustainable Drainage Systems (RSuDS) Report* (2012). Avery M, Macaulay Institute.

[**E6**] Economics of Climate Resilience ECR (Quote taken from page 21) *CA0401 - Natural Environment Theme: Natural Flood Management* (2013). Frontier Economics Ltd, London, Irbaris LLP and Ecofys.

[**E7**] Quote from EA Regional Flood and Coastal Defence Manager; EA video of the Belford project, quote taken from minutes 17-20. Relates to original cost from: *Belford prefeasibility study (2007)***.** Halcrow, Edinburgh.

[**E8**] Parliamentary Office of Science and Technology. - *POST Note on Natural Flood Management* (2011). Pescott O. and Wentworth J.

[**E9**] Testimonial: Independent international review panel for the Nile Basin Initiative Water Resources Planning and Management NBI-DSS Project "Data Processing and Quality Assurance, Pilot Application of the Nile Basin Decision Support System".

[**E10**] Testimonial: Director General of Water Resources of the Province of Tierra del Fuego, Member of the Federal Commission for Water Resources Management.