iCASP

Integrated Catchment Solutions Programme

Summary of Research

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NERC SCIENCE OF THE ENVIRONMENT

This document contains an overview of the research funded by the Natural Environment Research Council (NERC) available to the Yorkshire Integrated Catchment Solution Programme (iCASP) from our partner universities (Universities of Leeds, Sheffield and York).

The research is split into the broad interlinked themes of: Flood Forecasting and Climate Resilience; Drought and Flood Mitigation; Water Quality; Peatland Ecohydrology; and Sustainable Agriculture.

The purpose of this document is to provide a high level summary of the research which iCASP projects can draw on. It is not an exhaustive list and is only meant as a guide to inform iCASP partners.

Please note this is a working document and will be updated throughout the time of iCASP.

Contents

1. Flood Forecasting and Climate Resilience

Key Contacts: Prof. Alan Blyth (alan.blyth@ncas.ac.uk) and Prof. Piers Forster (p.m.forster@leeds.ac.uk)

The climate research base at the iCASP universities includes the Priestley International Centre for Climate, encompassing 160 experts working on climate related research with an active grant portfolio of £70 million. The iCASP universities contributed 5 lead authors and 11 contributing authors on the most recent Intergovernmental Panel for Climate Change (IPCC) assessment report. The National Centre for Atmospheric Science (NCAS) hosts world leading scientists in convective rainfall, working to determine phenomena responsible for flash flooding.

1.1 Weather and climate forecasting and projections

Research has improved the accuracy of short-time scale models that forecast heavy convective rainfall by providing a better representation of the physical processes in the models; including rainfall intensity variation between different storms (with the Met Office). This has included working with the Scottish Environment Protection Agency and Met Office to review the UK's weather radar network and its suitability for flood warning provision, and to make recommendations for future improvements (including new and temporary installations to help increase the probability of detection of intense rainfall by radar). Research has been undertaken to inform climate change projections using changes in global atmospheric circulation; in particular convective precipitation and surface winds. There is now a better understanding of possible future changes in storm tracks and storminess to inform high resolution convective modelling – particularly important for understanding high intensity flooding events during UK winters and how they may change.

There is a strong body of research informing and helping to apply the most comprehensive climate projections ever produced: UK Climate Projections (UKCP). The latest projections (UKCP18 – to be released in 2018) are informed by studies of the impacts of land cover on rainfall. World-leading techniques for how to estimate uncertainty and identify its sources have also been developed. Expertise exists across the iCASP universities and NCAS on identifying user requirements for climate and climate impact information, and how this information can be used to carry out risk assessments for particular sectors, e.g. agriculture (**Sustainable Agriculture**), business supply chains, nuclear infrastructure and urban planning, and for developing adaptation strategies, e.g. for Anglian Water, Southern Water and South West Water.

Tools/Models/Datasets that could be used in iCASP projects:

- Datasets on the temporal evolution of convective storms (and an estimation of rainfall rate near the surface every 5 minutes) have been produced for different parts of the UK. Models (e.g. Met Office Unified Model, and Weather Research and Forecasting model) have been used to produce such datasets at 1.5 km resolution.
- Such data has been incorporated into the UK convective-scale ensemble model MOGREPS (Met Office Global and Regional Ensemble Prediction System)-UK which provides statistical information useful for calculating uncertainty and can be used for estimating future risk.
- Weather climate change Impact Study at Extreme Resolution (WISER) project: Hourly precipitation data for 3km resolution produced by a numerical weather forecast model for 2031-2036 for the whole of Western Europe. This surface data includes temperature, relative humidity, wind speed, pressure, precipitation and long-wave fluxes.
- UK Climate Model analyses and forecasts have been produced with a spatial resolution of 4km (much higher than the 200km typical resolution of most climate models).

- Research and analysis of how vegetation (e.g. upland restoration of peat bogs with tree planting, **Peatland Ecohydrology**) affects rainfall by altering cloud formations.
- Climate narratives - descriptions of plausible future regional climate – could be developed for Yorkshire

Potential applications:
This research-base is important for forecasting the location, timing and intensity of rainfall and for informing planning and mitigation of future flood and drought risk in Yorkshire **(Drought and Flood Mitigation).** The output of the models can be fed into hydrological models to improve flood and drought forecasting, including pluvial flood warning, and potentially allow real-time control of sewerage systems **(Water Quality)**. Flood risk maps to inform Local Planning Authority Local Plans, and catchment solutions options maps to inform flood risk mitigation option site selection, could be developed. In addition, more accurate understanding of extreme rainfall events will be helpful in analysing the local effectiveness of Sustainable Urban Drainage Schemes, Natural Flood Management, and other such potential solutions in the context of climate change. Simulations of past extreme weather events such as the rainfall that led to the winter 2015/16 floods in Yorkshire could help further development of flood warning and response systems.

The research outlined above could be applied to analysing the resilience of infrastructure in Yorkshire (such as dams) to extreme rainfall events, and thereby informing business cases. For example, researchers have conducted modelling studies of the Boltby incident (June 2005) in which the dam almost over-topped, and of the spillway failure of the Ulley Dam near Rotherham (June 2007).

List of academics working this area:
Lindsay Bennett (NCAS); Cathryn Birch (UoL); Alan Blyth (NCAS); Ralph Burton (NCAS); Andrew Challinor (UoL); Suraje Dessai (UoL); David Dufton (NCAS); Alan Gadian (NCAS); Andy Gouldson (UoL); Piers Forster (UoL); Lindsay Lee (UoL); John Marsham (NCAS); Amanda Maycock (UoL); Ryan Neely (NCAS); Alice Owen (UoL); Doug Parker (UoL) and; Dominick Spracklen (UoL).

1.2 Understanding flood dynamics through hydrological modelling

Please note this section is currently in development.

Global flood forecasting models have been assessed with regards to Africa, due to improvements in numerical algorithms, global datasets, computing power, and coupled modelling frameworks. Work has been undertaken in applying high resolution convective modelling to understand the drivers of convection and high impact weather on a range of timescales, which can be used to improve flood forecasting. One example of this is the application of sub-kilometer model rainfall forecasts, which has been applied to Yate, South Gloucestershire. The uesefulness and credibility of global fluvial flood risk analysis has been researched.

Tools/Models/Datasets that could be used in iCASP projects:

- Datasets on the temporal evolution of convective storms (and an estimation of rainfall rate near the surface every 5 minutes) have been produced for different parts of the UK. These data can be incorporated into hydrological models such as JFlow.

Potential applications:
High resolution rainfall data can be applied to sub-kilometre models to simulate flood risk areas and this could contribute to the business case for different interventions to reduce flood risk.

List of academics working this area:
Cathryn Birch (UoL) and; Mark Trigg (UoL)

1.3 Communicating climate information to different organisations and members of the public

Insights from the environmental, social and behavioural sciences have helped to identify effective ways of communicating climate and weather information to different audiences and to develop recommendations for communicating uncertainty in seasonal forecasts to European decision makers in climate sensitive sectors (e.g., farming). In the UK, tests of different ways of visualising multi-decadal climate change projections have been carried out and work with emergency planners to better understand public responses to severe weather warnings. Ongoing work on perceptions of climate change and its impacts has attracted national media attention and substantially contributed to an understanding of how the UK public link climate change to extreme weather events and flooding.

Tools/Models/Datasets that could be used in iCASP projects:

- Meta analysis of reports, media articles and social media to understand how the wider public receive and digest climate infomation

Potential applications:
Combined with the above two work areas, this type of work could be used to analyse the use of flood-related information during extreme events from flood warnings to response. This could inform the way flood risk and response information is provided by those iCASP Springboard Partners with responsibility for providing such information to different audiences, including the general public, e.g. Met Office (including through the National Natural Hazards Partnership), councils as Lead Local Flood Authorities, and the Environment Agency in its development of frameworks to support local delivery of flood risk mitigation and response.

List of academics working this area:
Wandi Bruine de Bruin (UoL); Suraje Dessai (UoL) and; Andrea Taylor (UoL).

2. Drought and Flood Mitigation

Key contact: Prof. Colin Brown (colin.brown@york.ac.uk)

The Universities of Leeds, Sheffield and York house world-leading teams undertaking fundamental research on flood and drought mitigation in a changing climate, including the impacts of mitigation on geomorphology, sediment transport and ecology. In particular, the iCASP universities are completing research on sustainable urban drainage and natural flood management, which are increasingly being used to reduce flood risk. This expertise provides opportunities to co-develop iCASP projects related to the following areas.

2.1 Opportunities mapping for integrated catchment solutions

Opportunities mapping is enabled by a suite of research projects that have yielded novel mapping and modelling tools to determine suitable catchment locations for interventions such as Natural Flood Management and ways to measure their impacts. These have looked at: vegetation cover and upland river flow/flood flows, agricultural interventions and downstream flood, rewilding, erosion, carbon storage, suitable locations for woodlands, and water quality control. Enabling technologies include hydrological modelling (TOPMODEL, SWAT), hydraulic modelling (LISFLOOD-FP; MIKE II), analysis of low flow hydrological regimes, and integration of earth observation into spatial planning. The Water Friendly Farming platform (**Water Quality**) provides a testbed for large catchment-scale intervention experiments and the co-benefits of integrated solutions.

Tools/Models/Datasets that could be used in iCASP projects:

- PESERA is an erosion model which is disaggregated into components that depend on climate, vegetation, soil factors and topography. The model estimates long-term erosion rates within a catchment and can investigate land management options to maximize water availability under low flow conditions and different climate scenarios. It can also be used to model water quality and vegetation biomass.
- Multi Criteria Evaluation using GIS has been applied to assess the quality / character of wild areas, including in the Nidderdale Area of Outstanding Natural Beauty (AONB) and North Pennine AONB. Wildness maps can be used to assess the impact of human intervention on flow within a drainage basin, as well as assessing the impacts of rewilding on catchment dynamics e.g., suspended sediment within reservoirs.
- SPIDER is a hydrological model for application in small catchments with subsurface drains. It has been applied to identify the optimum location for and design of temporary water storage capacity in agricultural catchments.
- Spatially distributed TOPMODEL is a new model that can be used to test how different surface cover types (e.g. rough vegetation versus bare ground) have different impacts on the flood peak depending on the location of the changes on surface cover. It can operate on small (hillslope or 1 km^2) to large (1000s km^2) scales. So far it has been used with moorland applications, but with additional data could be applied further down the catchment system. It allows users to test different spatial configurations to see where effects on flood mitigation might be greatest.

Potential applications:

Aligning tools to produce opportunities maps showing overlapping benefits for targeted interventions; running scenario interventions in target catchments; co-design of catchment-based flood hazard reduction schemes; and water quality schemes **(Water Quality)** integrated with habitat and carbon sequestration solutions **(Peatland Ecohydrology)**.

List of academics working on this work area:
Tim Allott (UoM); Colin Brown (UoY); Alistair Boxall (UoY); Steve Carver (UoL); Pippa Chapman (UoL); Andreas Heinemeyer (UoY); Joseph Holden (UoL), Brian Irvine (UoL); Mike Kirkby (UoL); Martin Tillotson (UoL); Fred Worrall (UoD) and; Guy Ziv (UoL).

2.2 Urban green infrastructure / Sustainable Urban Drainage (SuDs)

Sustainable urban planning requires expertise on water-sensitive urban design (**Water Quality**) blue-green approaches to flood risk management and infrastructure resilience (**Climate Resilience**). Experimental studies have developed models on flow exchange between traditional urban drainage systems and surcharging manholes to identify flood risk. Specific strength in strategic SuDS retrofitting is complemented by experimental studies into the hydrological performance (**Flood Forecasting and Climate Reslience**) and contaminant removal mechanisms (**Water Quality**) in green infrastructures including wet ponds, green roofs, and biofiltration systems.

Tools/Models/Datasets that could be used in iCASP projects:

- Numerical models on flow exchange between traditional urban drainage systems, surcharging manholes and flood risk;
- Datasets on vegetation contribution to hydrological performance and pollutant removal;
- Models providing long-term simulation of green infrastructure performance;
- Urban pluvial flood risk models;
- Physical model of an urban drainage system and urban floodplain linked via a scaled (1:6) manhole that is used to investigate interactions between drainage systems and surface flows in urban flood conditions (https://www.sheffield.ac.uk/floodinteract).

Potential applications:
Combining engineered and natural solutions for urban flood risk; strategic retrofitting of SUDS (**Water Quality; Section 3.8**); and delivery of flood resilience (**Flood forecasting**) and water quality (**Water Quality**) co-benefits to address flooding and pollution control.

List of academics working on this work area:
Richard Ashley (UoS); Christian Berretta (UoL) and; Virginia Stovin (UoS).

2.3 Upscaling and integration into risk analysis

Effective planning requires that the science base is delivered in the format and at the scale required by decision-makers and other stakeholders. Previous and ongoing NERC research provides the tools to make this translation in the context of strengths and limitations in current knowledge and any constraints in data availability. This work has delivered methodologies for upscaling hydrological process-based understanding to large catchments; expressing uncertainties for example in radar-rainfall at local scales (**Flood Forecasting**), in changes to surface water connectivity across events, or in long-term hydro-climatic extremes; classifications for transfer of solutions between catchments and methodologies to link upstream management interventions to downstream flood risk decision frameworks and economic impacts.

Tools/Models/Datasets that could be used in iCASP projects:

- Linked hydrological (e.g. SWAT) and hydraulic (e.g. MIKE II, ISIS, LISFLOOD) models to quantify changes in flood risk across contrasting storm events (intensity profile, spatial distribution of rainfall etc) and in response to upstream interventions.
- Catchment similarity concepts to support knowledge-transfer between catchments.

Potential applications:
Modifying/translating risk-analysis models for practical use across the region; linking research models into flood risk planning toolkits; assessing economic payback and incentivisation mechanisms for packages of interventions

List of academics working on this work area:
Colin Brown (UoY); Joseph Holden (UoL); Mike Kirkby (UoL); Julia Martin-Ortega (UoL); and Mark Trigg (UoL).

2.4 Natural Flood Management (NFM)

NFM has been linked to storm tracking within Coverdale to understand where NFM should be located within a catchment and the impacts of rainfall on NFM (Flood Forecasting and Climate Resilience, Section 1.1). There is available expertise in assessing the impacts of NFM on delivering a variety of ecosystem services and on payment for ecosystems services which could be applied to NFM. The economic feasibility of ecosystem-based solutions for flood risk management in the Aire catchment has also been examined using cost-benefit analysis.

Specific NFM measures that have been investigated include:
1) Instream wood: The impact of instream wood on ecology (fish, invertebrates and vegetation); water quality including biogeochemical cycling and nutrient uptake and upland river hydro-morphological (physical characteristics of a water body) response (Water Quality, Section 3.2);
2) Sediment: The impact of NFM on sediment interactions within the River Aire, Yorkshire using modelling;
3) Re-meandering: by locating abandoned meanders (and storage potential) due to channelisation and potential sites for meander restoration within the River Ure catchment, Yorkshire;
4) Tree planting: by investigating the change in surface roughness;
5) As part of a programme on Water Friendly Farming, the efficacy of catchment-scale interventions including buffer strips, constructed wetlands, changes in tillage practice and other modified soil management, tree planting, offline storage, and permeable dams has been quantified to incorporate into flood risk and dredging strategies;
6) SuDS/urban green infrastructure (see work area 2.2 above);
7) Peatland management by monitoring peatland hydrology and water quality from plot to catchment scale in relation to climate and management, and supporting active blanket bog vegetation (see Section 3.9).

Tools/Models/Datasets that could be used in iCASP projects:

- Spatially distributed TOPMODEL can be applied to any catchment using a digital elevation model (DEM). The model can investigate the impact of surface roughness on flow duration and opportunity mapping for different NFM types (see also 2.1 above).
- GIS analysis and Google Earth, which can be used to assess the locations of paleo-channels and examples of where re-meandering could be put in place.
- Flow data (ongoing) – River Cover/ Ure and Aire; the data set spans from 2015 and can be used as a baseline to understand impacts of NFM. Data has been collected since 2008 on several Yorkshire peat uplands including discharge in response to peatland restoration. Baselining data is available for the Upper Wharfedale from 2002-2005 which could be used for baselining.
- Pre- and post-works data (from 2010-present) on flow, sediment, nutrient and pesticides levels, as well as biodiversity from catchment-scale intervention experiments in lowland agricultural landscapes in Leicestershire; includes buffer strips, constructed wetlands, changes in tillage

practice and other modified soil management, tree planting, offline storage, and permeable dams.

Potential applications:
This research base can help provide an evidence base to inform business cases within flood alleviation schemes (including costs and optimal locations of installing monitoring within the catchment/sub-catchment) as well as communicating NFM in different terms to suit specific audiences (e.g., the public, insurance industry). It can also support the production of regionally specific NFM opportunity maps (including various types of NFM; Section 2.1), as well as testing the effectiveness of NFM within and across catchments in the context of climate change. We could assess payment for ecosystem services as a sustainable financing mechanism for NFM.

The research base can help inform government supported NFM pilot measures across Yorkshire (and nationally), particularly in how to monitor effectiveness across the multiple benefits that NFM can provide (to flood risk, drought risk, water quality, soil erosion, carbon sequestration, biodiversity conservation, and tourism).

List of academics working on this work area:
Colin Brown (UoY); Lee Brown (UoL); Jonathan Carrivick (UoL); Richard Grayson (UoL); Andreas Heinemeyer (UoY); Mike Kirkby (UoL); Megan Klaar (UoL); Lorraine Maltby (UoS); Ryan Neely (UoL); Andy Sleigh (UoL); Mark Smith (UoL); Jouni Paavola (UoL); Piran White (UoY) and; Guy Ziv (UoL).

2.5 Multi-objective decision frameworks

We have developed models and case studies for multi-objective decision frameworks including multi-hazard interaction analysis, water management across the continuum from over-supply to under-supply, applications of engineering systems to allow decision-makers to interact with evidence underpinning model predictions, and participatory, narrative and online approaches to multi-stakeholder decisions for flood and drought risk mitigation. These are framed within regional case studies including drought risk for the Don, and flood risk for the York City Environment Observatory.

Tools/Models/Datasets that could be used in iCASP projects:
- Goal-structured notation is a methodology taken from engineering applications to allow decision-makers to understand and interact with the evidence base underpinning specific decisions; the approach has been incorporated into software for Natural England to underpin ecosystem-service delivery.

Potential applications:
Delivering effective engagement of public and multiple stakeholders in decision-making; providing frameworks for quantifying tradeoffs and making optimised decisions in the face of multiple (and often competing) objectives.

List of academics working on this work area:
Steve Carver (UoL); Steve Cinderby (UoY); Barbara Evans (UoL); Adrian McDonald (UoL); Martina McGuinness (UoS); Gordon Mitchell (UoL); Jouni Paavola (UoL) and; Piran White (UoY).

2.6 Flood risk perceptions, impact of flooding on SMEs and barriers/opportunities to adapting to increased flood risk

Research has explored flood risk perceptions in the UK media and among the public during the 2015-2016 winter floods (in Yorkshire & Cumbria) to better understand how preparedness could be improved among those who are at risk from flooding (**Flood Forecasting**). We have also explored the impact of flooding on specific actors such as small and medium size enterprises (SMEs) in Calderdale, Yorkshire, and how their resilience could be improved. Moreover, we have investigated the barriers to and enablers for adapting to increased flood risk in Yorkshire in the future changing climate in light of stakeholder views and perceptions.

Tools/Models/Datasets that could be used in iCASP projects:

- 'Fuzzy spray can' tool to assess public perception of e.g., flood alleviation. This is an interactive online map. Participants can be asked questions such as: "Where are areas that have flooded in the past?" and "Where are flood alleviation schemes in place in your catchment?"The intensity of the spray shows the value of the scheme. Different related questions can then be asked, with the data saved as GIS outputs.

Potential applications:

This research base can help inform the evaluation and choice of ecosystem based adaptation measures and to identify barriers and opportunities for their implementation. The methodological practices have been developed to involve stakeholders and to harness their knowledge, expertise and perceptions so that decisions about measures and implementation plans are better informed.

List of academics working this area:

Steve Carver (UoL); Paola Sakai (UoL) and; Jouni Paavola (UoL)

3. Water Quality

Key contact: Prof. Pippa Chapman (p.j.chapman@leeds.ac.uk)

The Universities of Leeds, Sheffield, York, Durham and Manchester house world-leading teams undertaking fundamental research on the response of freshwater systems to increasing pressures from climate change and human activities such as agriculture, industrialisation and urbanisation. These pressures all have implications for water quality and biodiversity. This research can be used to (i) reduce the impacts of agricultural, industrial and urban pollution, (ii) improve the quality of water entering water treatment works, and (iii) reduce the spread of invasive non-native species, in order to protect and restore freshwater ecosystems, manage them more sustainably and reduce water treatment costs. There are opportunities to co-develop iCASP projects related to the following areas:

3.1 Slowing the Spread of Invasive Non-Native Species (INNS) via better biosecurity

There is an evidence base for cost-effective pragmatic biosecurity measures that can be undertaken by those active in the water environment. It has also identified opportunities and barriers to biosecurity. Several projects are focused on the iCASP region, including in the Yorkshire Dales.

Tools/models/datasets that could be used in iCASP projects:

- An open access e-learning module (https://openeducation.blackboard.com/mooc-catalog/courseDetails/view?course_id=_1189_1).
- Data sets on how hot water treatments improve biosecurity.

Potential applications:
Use of e-learning resources and development of partner/stakeholder focused training and resources. By developing and embedding evidence based biosecurity policy and practice, partners can reduce the risk of the introduction and spread of INNS (with costs to the UK of ~£1.7bn pa). The cost effectiveness of the e-learning resources to reduce economic (water treatment and flood management) and social (recreation, tourism) impacts can also be assessed.

List of academics working on this work area:
Alison Dunn (UoL) and; Claire Quinn (UoL)

3.2 Ecological response of rivers to moorland burning, instream woody debris, extreme floods and water abstraction

There has been wide-ranging research investigating the impact of moorland burning **(See Section 4.3)**, extreme floods, woody debris and water abstraction on water quality and instream macro-invertebrates. Further expertise within the iCASP universities is related to fisheries.

The Effects of Moorland Burning on the Ecohydrology of River basins (EMBER) project researched the impacts of moorland burning on peatlands within Yorkshire, investigating the impacts on hydrology, water chemistry, soil properties and aquatic ecosystems of the burned and unburned areas. The EMBER project involved long term monitoring (5 years) on water table depth using sensors; flow level, water temperature, electrical conductivity and pH in each river catchment using sensors and manual collection of water samples to assess major ions, metals, nutrients and suspended sediment.

The impact of instream woody debris has been assessed in relation to fish and macro-invertebrates in gravel bed rivers in Alaska. However, the techniques and theories can be applied to Yorkshire. Woody debris is also being assessed in terms of changes in the physical characteristics of the river (**See** **Section 2.4**).

Tools/models/datasets that could be used in iCASP projects:

- High quality data sets and experimental findings on the effect of prescribed burning (principally for grouse shooting interests) on peatland vegetation, peat soil properties, and the ecology of streams in blanket peatlands.

Potential applications:

Using hydrogeological models (**Flood Forecasting and climate resilience**, **Drought and Flood Mitigation**), long-term data sets and the science from these projects could generate land management tools that predict the impact of heather burning, instream woody debris, extreme floods and water abstraction (**Drought and Flood Mitigation; See Section 2.4**) on instream biota.

List of academics working on this work area:

Lee Brown (UoL); Joseph Holden (UoL); Megan Klaar (UoL) and; Shelia Palmer (UoL)

3.3 Understanding and predicting the sources and impacts of nitrate contamination on groundwater quality

Research has been carried out to identify the sources and transport pathways for nitrate within chalk aquifers with research carried out on the Yorkshire Chalk aquifer; and to use isotopic approaches to distinguish agricultural-derived nitrate (**Sustainable Agriculture**) from other anthropogenic and natural sources. Pathways within sandstone aquifers in North-West England (Sherwood sandstone) have also been investigated, which could be applied to the sandstone aquifers in Yorkshire.

Tools/models/datasets that could be used in iCASP projects:

- Datasets looking at the flow pathways within aquifers.
- Modelling using a mesoscale hydrological model (mHM) which incorporates groundwater data.

Potential applications:

Co-development of groundwater nitrate mitigation plans, including definition of safeguarding zones around abstraction wells; development of land-management approaches (e.g. controls on fertiliser applications in nitrate vulnerable zones).

List of academics working on this work area:

Ian Burke (UoL); Sumit Sinha (UoL) and; Jared West (UoL)

3.4 Understanding the mobility of pesticides and pharmaceuticals, including the impact of rainfall events, and the occurrence, fate and effects of pesticides and emerging contaminants in catchments

Research has been carried out into how veterinary antibiotics behave and move in soils (**Sustainable Agriculture**) and how they transfer to ground and surface waters. This was done through field- and catchment-scale experimentation (UK and China) and development of mathematical models. The focus was on priority contaminants including metaldehyde and propyzamide and the design of effective strategies to manage risk of water contamination.

Tools/models/datasets that could be used in iCASP projects:

- SPIDER is a distributed, catchment-scale model run at hourly resolution to simulate pesticide transfer to surface waters from drained agricultural land.
- Datasets on impacts of different management strategies (targeting of pesticide use, soil management, buffer strips, detention ponds etc.) on pesticide / animal pharmaceutical delivery to the stream network.
- Prioritisation approaches for rapid screening of emerging contaminants to inform policy response and design of monitoring strategies.

Potential applications:

Using the science base which can model flow response to rainfall **(Flood Forecasting**) combined with the science understanding of pesticide mobility offers the opportunity to create a model/tool to predict when pesticide concentrations will be high within streams, rivers and ground waters. This would enable water companies to switch off abstraction at critical times thereby dramatically reducing operational treatment costs and also saving capital costs.

By understanding the sources of pesticide contamination, effective management strategies can be designed to improve water quality and reduce the need for water treatment.

For known contaminants such as pesticides, knowledge on catchment vulnerability can be used to refine monitoring strategies and identify priorities and opportunities for mitigation. For emerging contaminants, a systematic sift of data sources for large numbers of potential contaminants can be done to identify likely problems and establish cost-effective monitoring strategies.

List of academics working on this work area:

Alistair Boxall (UoY), Steve Banwart (UoL) and; Paul Kay (UoL).

3.5 The occurrence, fate and effects of emerging contaminants in rivers

NERC Science has improved our understanding of the occurrence, fate and effects of pharmaceuticals on freshwater ecosystems. This includes: the development and application of sensitive and robust analytical methods for detecting a wide range of active pharmaceuticals ingredients in surface waters, sediments and biota (including extensive monitoring campaigns in the Rivers Ouse, River Calder, River Aire and River Foss catchments); the development of exposure modelling approaches for estimating concentrations of pharmaceuticals in river systems; and the development of approaches for estimating the uptake and effects of pharmaceuticals in aquatic systems. High resolution studies have been undertaken whereby diurnal samples have been assessed in order to understand the temporal variation in pharmaceuticals within rivers. The impact of pharmaceuticals on the riparian zone, in relation to leaf litter breakdown has also been investigated on Silsden Beck, West Yorkshire.

Metaldehyde (**Sustainable Agriculture**) has been widely studied across the partner universities, including work on the occurrence of metaldehyde within the River Ouse Catchment and the relationship between catchment properties and metaldehyde concentrations. Land-use management strategies have been assessed to understand the improvements to water quality in relation to metaldehyde. Degradation trials have been undertaken, which can be applied to water treatment works in both surface water and groundwater.

Tools/models/datasets that could be used in iCASP projects:

- Liquid chromatography– tandem mass spectrometry (LC-MS-MS) methods for detecting a wide range of pharmaceuticals in waters, sediment and biota; exposure models for pharmaceuticals in European rivers; datasets on absorption, persistence and effects of pharmaceuticals in aquatic systems; access to Intelligence-led Assessment of Pharmaceuticals in the Environment (iPiE) database and iPiE predictive system; Virtual Fish Ecotoxicology Laboratory (VFETL) for studies of the effects of toxic chemicals (e.g. pharmaceuticals) on biological organisms.
- Data collected over a two and a half-year period (2008–2011) to quantify the presence of metaldehyde in rivers and finished waters across the River Ouse drainage basin**.**
- Modelling using the following open source models e.g., Environmental Fluid Dynamics Code (EFDC), meso scale hydrological models (mHm), hype; specifically nitrate.

Potential applications:
The work undertaken has been in partnership with several water companies such as Yorkshire Water and Thames Water. The application of the research is to reduce treatment costs for water companies.

List of academics working on this work area:
Alastair Boxall (UoY); Lee Brown (UoL); Ian Burke (UoL); Thorunn Helgason (UoY); Paul Kay (UoL); James Moir (UoY) and; Sumit Sinha (UoL).

3.6 Continuous water quality monitoring: development of novel sensors

There is a growing need to monitor contaminant (e.g. nutrients, metals, micropollutants) concentrations more effectively in freshwater systems. Novel cost-effective water quality sensors for deployment in the soil and water environments have been developed. These include biosensors (including for metaldehyde, **Sustainable Agriculture**): small chips that can be placed on a carousel within a river to provide real time data.

Tools/models/datasets that could be used in iCASP projects:

- Datasets on the effectiveness of novel sensors such as biosensors.

Potential applications:
Work with regulators and industrial partners to further develop these new state of the art sensors, scope the market and advance technology transfer to a commercial organisation.

List of academics working on this work area:
Paul Kay (UoL); Paul Millner (UoL); James Moir (UoY) and; Maria Romero-Gonzalez (UoS).

3.7 Best management practices to reduce transport of sediment, nutrients and contaminants from soil to waters (Sustainable Agriculture)

NERC projects and others funded by Defra and Yorkshire Water have investigated the impact of changes in land/soil management to reduce water pollution by suspended sediment, nutrients and other contaminants. This has involved working closely with farmers in Catchment Sensitive Farming projects and monitoring effects in watercourses within study sites in Ingbirchworth and Nidderdale, Yorkshire. The installation of residuum lodges (small dams) in relation to reducing the input of suspended sediment to reservoirs has been investigated in Halifax, West Yorkshire.

Tools/models/datasets that could be used in iCASP projects:

- The use of GIS using multi-criteria evaluation (MCE), in which different GIS layers can be assigned different values to identify agricultural land management practices which cause surface water pollution in drinking water supply catchments, has been applied to the River Ouse, Derwent and Wharfe catchments.

Potential applications:

Changes in land/soil management to reduce chemical losses from soil to ground and surface waters. Economic evaluation of mitigation options can be produced to demonstrate business benefits of any land management change to farmers and water companies.

List of academics working on this work area:

Pippa Chapman (UoL); Richard Grayson (UoL) and; Paul Kay (UoL).

3.8 Modelling urban diffuse pollution to support sustainable urban drainage systems (SUDS) planning and catchment pollution budgets

A GIS model was built to identify hot-spots of diffuse urban pollution across a river basin, at fine spatial scale to support installing SuDS **(Drought and Flood mitigation; Section 2.2)** within existing development. The model has been applied to the Ribble Basin, a Water Framework Directive (WFD) UK sentinel catchment.

Tools/models/datasets that could be used in iCASP projects:

- A database is available for 18 common pollutants, with urban diffuse pollution values specific to a range of urban land uses.
- The model maps the location of diffuse urban pollution hot spots under a range of probabilistic conditions; quantifies urban diffuse pollutant load to receiving waters; and assesses the impact of land-use change on urban non-point source runoff quality
- Construction industry guidance on SUDS planning (CIRIA SUDS manual)

Potential applications:

The model has already been applied in work with UK water companies, Defra, EA, Scottish Environment Protection Agency and WRc (an Independent Centre of Excellence for Innovation and Growth). The model has facilitated pollution appraisal at a river basin scale to support investigative monitoring and emissions at source and can be applied to help locate the sites that are causing a failure under the WFD water quality standards. The model can be used in whole catchment water quality management, and in planning to understand where SuDS would have the greatest beneficial effect on pollution reduction.

List of academics working on this work area:

Gordon Mitchell (UoL).

3.9 Impact of upland management and restoration on water quality

A number of NERC, Defra and water company -funded projects have looked at both measuring and modelling the impact of management (heather burning, sheep grazing) and change (drainage, drain-blocking, revegetation, changing vegetation and climate) in upland peat catchments across the Pennines upon water quality and carbon storage (**Peatland Ecohydrology; Section 4.2**). With respect to water quality the focus has been on water colour, dissolved organic carbon and particulate organic carbon, and the factors that control their flux from peaty headwaters to water treatment works. Solutions to some of the challenges associated with valuing water quality improvements from peatland restoration have also been developed.

Tools/models/datasets that could be used in iCASP projects:

- Datasets and experimental findings on the effect of ditch blocking on dissolved organic carbon (DOC) losses from peatlands to streams and rivers.

Potential applications:

Work with land managers, restoration agencies and water companies to develop guidance on best methods of restoration for maximum benefits to water quality and other ecosystem services such as carbon sequestration (**Peatland Ecohydrology**) and flood prevention (**Drought and Flood Mitigation**) downstream.

List of academics working on this work area:

Tim Allott (UoM); Anthony Blundell (UoL); Pippa Chapman (UoL); Martin Evans (UoM); Richard Grayson (UoL); Joseph Holden (UoL); Julia Martin-Ortega (UoL); Sheila Palmer (UoL) and; Fred Worrall (UoD).

4. Peatland Ecohydrology

Key contact: Prof. Andy Baird, University of Leeds (a.j.baird@leeds.ac.uk)

The Universities of Leeds, Sheffield, York, Durham and Manchester house world-leading teams undertaking fundamental research on the ecohydrological functioning of peatlands. Their work is multi-disciplinary and includes field investigations (observational and experimental studies), laboratory work, and computer simulation. They have undertaken numerous NERC-, Defra-, EA-, and other stakeholder- funded projects on how peatlands respond to management (e.g., prescribed burning, and drainage ditch construction and blocking) and climate change (e.g. changes in temperatures and rainfall regimes), and have experience of working in a wide range of peatland types from blanket bogs, to raised bogs, to floodplain fens, with much of their work taking place in Yorkshire. They are strongly placed to collaborate on management projects that seek (i) to conserve and restore peatland ecosystem services and (ii) to project how future management and climate change will affect key sites and landscapes over timescales of decades to centuries.

This world-leading capability is well-illustrated by the following projects.

Example projects and capability
The projects are listed below by broad theme. Projects are listed only once (under the theme to which they are the closest fit). However, many projects are cross-cutting and deal with issues from more than one theme. Where key people are noted, they are listed alphabetically. In addition, although many of the projects involve(d) people from a range of institutions, only those people associated in some way with iCASP are noted.

4.1 Fluvial export of carbon from peatlands

Research has been carried out to understand the carbon flux from peatlands, vital for calculating and understanding carbon budgets which could be used to implement upland carbon stewardship schemes. Export of carbon from peatlands has been investigated with regards to peat blocks; the distribution of carbon export between river loads and gaseous output; whether the decrease in acid rain can account for the increase in dissolved organic carbon in river systems and; the role or pipes in transporting carbon away from peatlands by increasing connectivity with rivers.

• **Significance of macroscale peat flux for carbon export in upland fluvial systems (NERC grant)**
Martin Evans (UoM) and Jeff Warburton (UoD)

• **Greenhouse gas emissions associated with non gaseous losses of carbon from peatlands – fate of particulate and dissolved carbon (Defra grant)**
Tim Allott (UoM), Pippa Chapman (UoL), Martin Evans (UoM), Joseph Holden (UoL), Catherine Moody (UoL), Sheila Palmer (UoL), and Fred Worrall (UoD)

• **Influence of recovery from acidification on the dynamics of dissolved organic carbon (DOC) in organic soils (NERC grant)**
Pippa Chapman (UoL)

• **The role of pipes in carbon export from peatlands (NERC grant)**
Andy Baird (UoL), Pippa Chapman (UoL), and Joseph Holden (UoL)

4.2 Drainage (ditches, gullies) and ditch/gully blocking effects on peatlands

Research has looked at process based measurements to understand the hydrological response of peatlands to drainage and restoration. Including research on hydrological, fine sediment and water colour production (**Water Quality, Section 3.9**), transport and storage processes involved. Research has updated policy and guidelines and offered insights into how restoration practices influence the carbon budget and the global warming potential of peatlands.

- **Hydrological, fine sediment and water colour response of managed upland wetlands (NERC post-doctoral fellowship)**
Joseph Holden (UoL)

- **Making Space for Water (Defra, Environment Agency, Moors for the Future Partnership)**
Tim Allott (UoM), Martin Evans (UoM)

- **Monitoring carbon flux from restoration and wildfire sites on blanket peat (Moors for the Future, Defra, Natural England)**
Martin Evans (UoM) and Fred Worrall (UoD)

- **Understanding gully blocking in deep peat (Moors for the Future)**
Martin Evans (UoM)

- **Cors Fochno hydrological research and management study (Environment Agency and Countryside Council for Wales [Natural Resources Wales])**
Andy Baird (UoL)

- **Managing peatlands as carbon stores (NERC training grant – CASE award)**
Andy Baird (UoL), Pippa Chapman (UoL), Gemma Dooling (UoL)

4.3 The impact of burning on blanket peatlands (soils, vegetation, and streams)

Research has increased understanding of the effects of prescribed vegetation burning on blanket peatland ecology (moss and other plant cover), hydrology, chemistry and physical properties, and on the hydrology, water quality and biota of rivers in upland peat-dominated catchments. The research has been used to inform various stakeholders about the environmental effects of burning.

- **EMBER: Effects of Moorland Burning on the Ecohydrology of River basins (NERC grant)**
Lee Brown (UoL), Joseph Holden (UoL), and Sheila Palmer (UoL)

- **Understanding plant-soil feedback effects impacted by prescribed peatland burning to inform policy and site condition assessment procedures (NERC training grant – industrial CASE award)**
Joseph Holden (UoL), Alice Noble (UoL), and Sheila Palmer (UoL)

4.4 Greenhouse gas fluxes (methane CH_4 and CO_2) between peatlands and the atmosphere

Research has investigated how restoration affects methane emissions from restored peatlands and the best restoration methods for reducing methane emissions and maximising net carbon uptake. A range of sites have been monitored from near pristine bogs to sites affected by drainage, peat extraction, intensive grazing and arable agriculture to quantify greenhouse gas budgets for each site (including carbon dioxide, methane, nitrous oxide) and other pathways of carbon loss (drainage water).

- **Investigation of peatland restoration (grip blocking) techniques to achieve best outcomes for methane and greenhouse gas emissions / balance (Defra grant)**
Andy Baird (UoL), Pippa Chapman (UoL), and Joseph Holden (UoL)

• Lowland peatland systems in England and Wales – evaluating greenhouse gas fluxes and carbon balances (Defra grant)
Andy Baird (UoL), Pippa Chapman (UoL), Joseph Holden (UoL)

• Restoration of blanket bog vegetation for biodiversity, carbon sequestration and water regulation (Defra grant)
Andreas Heinemeyer (UoY)

• The role of natural and artificial pools in northern peatland carbon cycling (NERC grant)
Andy Baird (UoL), Pippa Chapman (UoL), and Joseph Holden (UoL)

4.5 Ecohydrological modelling and peatland regime changes / tipping points

Research has looked at the combined effects of climate change and changes in land use and management. The research has looked at tipping points in the provision of ecosystem services (Water Quality, climate mitigation and cultural services) and the economic, social and cultural value of avoiding these tipping points versus reaching them. The insights can be used to inform management and policy.

• Understanding ecosystem stocks and tipping points in UK blanket peatlands (NERC directed programme)
Andy Baird (UoL), Martin Dallimer (UoL), Julia Martin-Ortega (UoL), Mark Reed (UoN), and Dylan Young (UoL)

4.6 Peatland ecosystem services evaluation

Research has been completed on the public perception and value of benefits that can be obtained from peatland restoration, the research has been translated to policy makers and practitioners. • **Economic benefits of peatland restoration: making the numbers count for policy (Scottish Government and Economic Social Research Council)**
Julia Martin-Ortega (UoL)

- **Ecosystem Services of Peat - Phase 1 (Defra funding)**

Pippa Chapman (UoL), Joseph Holden (UoL) and Fred Worrall (UoD)

4.7 Communicating the benefits of peatland restoration to the public

A set of communication tools that provide an introduction to, and the benefits associated with improving peatland conditions, based in Scotland. The communication tools include interactive e-learning modules, which has freely downloadable text and drawings associated with peatlands.

• Valuing Nature Network and Valuing Nature Programme (Scottish Government, NERC and Economic Social Research Council)
Julia Martin-Ortega (UoL)

4.8 Public willingness to pay for peatland restoration

Surveys have been conducted to almost two thousand Scottish Residents, which include monetary estimates of the values people assign to peatlands, and their willingness to support peatland restoration.

• Valuing Nature Network and Valuing Nature Programme (Scottish Government, NERC and Economic Social Research Council)
Julia Martin-Ortega (UoL)

4.9 Steps required for spatially explicit economic impact assessment of peatland restoration

Research has been carried out to investigate the steps required to conduct a spatially explicit economic impact assessment of peatland restoration in terms of ecosystem services.

• Valuing Nature Network and Valuing Nature Programme (Scottish Government, NERC and Economic Social Research Council)
Julia Martin-Ortega (UoL)

Example data and models from these projects:

- High quality data sets and experimental findings on the effect of prescribed burning (principally for grouse shooting interests) on peatland vegetation, peat soil properties, and the ecology of streams in blanket peatlands
- Datasets on the effect of both natural and artificial pools on peatland hydrological functioning and peatland carbon balance
- Datasets and experimental findings on the effect of ditch blocking on peatland hydrological regime (water tables, overland flow, ditch flow)
- Datasets and experimental findings on the effect of ditch blocking on peatland vegetation (in particular the abundance of *Calluna*, *Sphagnum* spp., and *Eriophorum* spp.)
- Datasets and experimental findings on the effect of ditch blocking on peatland greenhouse gas (methane (CH_4) and carbon dioxide (CO_2)) exchanges with the atmosphere
- Datasets and experimental findings on the effect of ditch blocking on dissolved organic carbon (DOC) losses from peatlands to streams and rivers
- Computer models of peatland hydrological 'behaviour' (DigiBog_Hydro), including effects of ditches and ditch blocking on water-table depths and regimes
- Computer models (the full DigiBog, MILLENNIA) that can simulate how peatlands grow over timescales of decades to millennia and also how peatlands may degrade or change (changes in peat depth and properties, and changes in peatland morphology, carbon balance, and vegetation) in response to management (e.g., grazing, ditch construction and blocking) and future climatic warming
- Linking of novel methods of ecosystem services (ES) valuation with peatland models to establish how the value of different ES may change over decadal timescales

Potential applications of the datasets and models:

- Datasets and experimental findings can be used to help refine burning regimes on upland sites to maximise carbon storage and sequestration potential, to optimise peat wetness for a range of ecosystem services, and to reduce heather (*Calluna*) dominance (increase the cover of peat-forming taxa)
- Use process-based peatland models (e.g., DigiBog_Hydro) to simulate how different patterns and intensities of ditch blocking are likely to affect water-table depths and regimes in blanket peatland restoration projects. Hydrological models can, therefore, be used to guide restoration efforts at the hillslope and catchment scale. For example, water-table maps (for hillslopes and even catchments) can be constructed for different restoration schemes to help identify the option that provides the best 'hydrological outcome'.
- Use peatland models (e.g., DigiBog, MILLENNIA) to simulate how peatland carbon balance (peat properties and peat thickness) and vegetation may respond to management (e.g., ditching, ditch blocking, and grazing) and climate change over the next 20-100 years. The model could be used to optimise management so that key preferred outcomes are rendered more likely.

- Use novel methods of estimating the monetary and non-monetary valuation of ecosystem services offered by peatlands to investigate how different types of management and climate change will affect peatland ecosystem services over the next 20-100 years

5. Sustainable Agriculture

Key contact: Prof. Jonathan Leake (j.r.leake@sheffield.ac.uk)

World-leading teams at the Universities of Leeds, Sheffield and York are researching how to improve the cost effectiveness of cropping and investigating the most appropriate tillage systems to balance arable production and environmental protection. This work includes the development of tools such as drone-based sensors to help farmers manage herbicide-resistant blackgrass and other weeds. A major focus is soil management to improve drought resilience and to reduce the risks and consequences of floods. Research expertise in this theme is partly underpinned by NERC funded research at The University of Leeds farm, which is commercially run. Experimental plots and field-scale demonstration trials address the issues of soil and crop performance in relation to tillage and crop rotation management and the use of microbial inoculants such as mycorrhizal fungi to increase crop health and soil quality.

5.1 Tillage and land management effects on soil fertility, soil structure and its hydrological functioning

Research in the SoilBioHedge project based at the University of Leeds farm and in a network of collaborator organic, conventional and no-tillage arable farms across the Vale of York and North Lincolnshire is investigating how management of arable land affects the hydrological functioning of soil and soil fertility.

Tools/Models/Datasets that could be used in iCASP projects:

- Datasets on key hydrological functions in soils including infiltration rates and soil pore size distributions, soil water storage capacity with parallel measures of soil bulk density and organic matter content and how these are effected by the management practices and tillage systems.
- Datasets on nutrients in soil solution in fields and under hedges and field margins in relation to tillage and arable cropping.
- Datasets on inherent soil fertility assessed by wheat bioassays on soil from different tillage and chemical input management (conventional versus organic, tilled versus no-tillage).

Potential applications:

Research into arable soil properties and how they change in response to different management is focussed on properties that are important for hydrological functioning of individual fields, and that will scale up to effects that impact flood risks (**Drought and Flood Mitigation**) and consequences across the iCASP area.

List of academics working this area:

Steve Banwart (UoL); Pippa Chapman (UoL); Jill Edmondson (UoS); Les Firbank (UoL); Richard Grayson (UoL); Thorunn Helgason (UoY); Mark Hodson (UoY); Joseph Holden (UoL); Jonathan Leake (UoS).

5.2 Soil quality restoration and improved hydrological and biological functioning through the use of grass-clover leys in arable rotations

The SoilBioHedge project is determining how important soil properties, such as water-stable aggregates, and earthworm populations, which have been depleted by intensive arable cultivation, can be restored through the use of short-term leys in combination with reducing tillage. The research is determining how quickly the biology of arable soil and its functions recover under leys, and also whether the relatively undisturbed soil under hedges and in field margins is important for the recolonization of fields by 'ecosystem engineers' such as earthworms. The work includes studies of soil water-holding capacity and infiltration rates. It includes high spatial and temporal resolution data collected on soil temperatures and moisture content at different depths and distances from field margins in arable fields and ley strips introduced into the fields.

Tools/Models/Datasets that could be used in iCASP projects:

- Datasets on soil solution chemistry including nitrates.
- Datasets on soil temperatures and moisture content at different depths and distances from field margins in arable fields and ley strips.
- The work is aiming to produce a tool to guide farmers as to the soil quality benefits likely to be gained by inclusion of grass-clover leys in arable rotations.

Potential applications:

Leys are increasingly being used as a tool to control blackgrass, but can bring a number of important benefits to soil and the wider environment. This includes building soil fertility through use of legumes fixing nitrogen and stimulating the activities of beneficial mycorrhizal fungi and repairing soil structure. This results in greatly increased soil water storage capacity and infiltration rates, partly mediated by greatly enhanced earthworm generated macropores. Increasing the proportion of land in leys is likely to reduce the rates of runoff, and risks of flooding (**Drought and Flood Mitigation and Flood Forecasting**). These research findings when integated into catchment-scale hydrological models could help to establish the potential flood risk reductions achieved by such rotations.

List of academics working this area:

Steve Banwart (UoL); Pippa Chapman (UoL); Jill Edmondson (UoS); Les Firbank (UoL); Richard Grayson (UoL); Thorunn Helgason (UoY); Mark Hodson (UoY); Joseph Holden (UoL); Jonathan Leake (UoS).

5.3 Increasing soil and crop resilience to drought and flooding

Please note this section is currently in development.

Research is determining how inversion ploughing versus non-inversion tillage and continuous arable cropping versus short-term leys affects crop performance under conditions of soil saturation (surface flooding) and extreme drought. The method uses monolith blocks of soil removed from conventional arable fields near Tadcaster, close to the geographical centre of the iCASP area. The research is determining: how the different tillage and continuous cropping versus leys affect the resilence of wheat production in response to drought and surface flooding, and its recovery from these stresses during the main part of the growing season; how earthworm activities respond to drought and surface flooding and their subsequent recovery on return to ambient conditions; and how soil structure, water-holding capacity and infiltration rates of land under different tillage and crop rotation systems responds to extreme events such as droughts and flooding.

Tools/Models/Datasets that could be used in iCASP projects:

Potential applications:
Droughts and floods are predicted to present increasing challenges to UK farmers and to catchment management (**Flood Forecasting and Climate Reslience**, **Drought and Flood Mitigation**). Better understanding of how different soil and crop management systems affect the resilience of soil and crops to these stresses will help guide farmers and land managers as to how to try to reduce these risks. Understanding the wider-catchment scale consequences of resilience to these stresses, and how soil responds and recovers on rewetting after drought or drainage after flooding, is important not only for farmers, but also may be important for managing subsequent flood risks.

List of academics working this area:

5.4 Soil organic matter – yields and water and carbon storage

There is a substantial body of research on how farming practices such as leys, reduced tillage and growth of woody bioenergy crops affect soil organic matter content. Low soil organic matter content constrains the fertility, water, and nutrient holding capacity of soils, constraining yields and flood risk mitigation contribution, as well as soil carbon storage and sequestration.

Tools/Models/Datasets that could be used in iCASP projects:

- Datasets on soil organic matter by depth for soils under hedges, in field margins and under arable land and sown grasslands of different ages to establish the effects of different land management practices on soil carbon sequestration.
- Datasets on the different kinds of urban land uses and how the organic carbon quantities in soils in urban areas compares to those in arable land.
- High spatial scale tree-planting model linked to GIS that is able to identify urban areas suitable for willow coppice bioenergy cropping (which can be planted in flood-prone areas or areas of land suitable for storing excess drainage water), and to calculate the quantity of fuel that could be produced and the amount of carbon stored that could be used to offset fossil fuel emissions.

Potential applications
Research is identifying the arable land management practices in the iCASP area that retain the most organic matter, and these could help to guide management decisions to increase soil carbon storage, and on flood mitigation actions, whilst retaining high yields.

List of academics working this area:
Pippa Chapman (UoL); Richard Grayson (UoL) and Jonathan Leake (UoS)

5.5 Effect of grass buffer strips to reduce transport of contaminants and nutrients from fields to catchments (Water Quality)

Experimentation of buffer strips and field (~1ha) manipulation to develop soil process models of how to deploy grass buffer strips to help protect catchments from agricultural run-off.

Tools/Models/Datasets that could be used in iCASP projects

- GIS model that identifies the geospatial variation in nutrient, contaminant, and greenhouse gas sources and sinks and quantify fluxes at the catchment scale.

Potential applications:
This research is identifying how buffer strips reduce agricultural run-off. A better understanding of this has wider implications for water quality (Section 3.9) and reducing the associated cost of water treatement.

List of academics working this area:
Steve Banwart (UoL); Joseph Holden (UoL); Richard Grayson (UoL) and; Paul Kay (UoL).

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