SESAME

Organisational Operational Response and Strategic Decision Making for Long Term Flood Preparedness in Urban Areas

Annual Report

2014

SESAME Annual Report 2014

Contents

Introduction

The EPSRC-funded SESAME project's second year has been busy and productive. All four Work Packages have made progress in terms of achieving the project's aim of creating a unified framework of academic knowledge and procedures that can be used to influence the behaviours of organisations faced with urban flooding and flood risk. As a reminder, the achievement of this aim is being pursued via four interdisciplinary research objectives:

(1) achieve a better understanding of business continuity processes and how private and public sector organisations behave and interact with each other in the immediate and longer term aftermath of flood events;

(2) establish how agent based modelling and simulation can improve organisational business continuity by means of representing attributes and simulating actions, interactions and the dynamic behaviours of different types of at-risk organisations and the consequences of these for both the short-term response to flooding and longer-term preparedness;

(3) assess the impacts of flooding on economic systems both within and beyond the immediately affected urban area and explore how changed behaviours could influence these impacts;

(4) develop and critically evaluate innovative approaches to the promotion of organisational behaviour change and adaptive organisational learning throughout the flood cycle.

In 2014, Work Package 1 (Durham and Leeds) has focussed on (i) the development of software agents to model small and medium enterprises (SMEs) in terms of their behaviour and attributes relevant to responding to and recovering from flood events, and (ii) using detailed hydrodynamic modelling for different flood scenarios to estimate water depths at regular time intervals during flooding in the case study area of Sheffield's Lower Don Valley region. Work Package 2 (Sheffield) has made progress on a number of fronts including the collection and analysis of case study data, stakeholder engagement and organising dissemination events. The focus in Work Package 3 (East Anglia) has been on the adoption of the Adaptive Regional Input-Output model and its use in assessing the economic costs associated with the 2007 flooding in the case study area of Sheffield. Work Package 4 (West of England and Kingston) has conducted semi-structured interviews aimed at gaining an improved understanding of the adaptive responses of SMEs after they have experienced a flood event. Further, stakeholder and business groups have been formed, which will help inform the e-learning tool to be developed.

Importantly, in addition to the formal project meetings which have taken place during the year, there have been a growing number of integration and collaboration activities across the various Work Packages. Such activities include the cross-cutting work on identifying the behaviours and attributes to be used in agent-based modelling and simulation, developing ideas for the e-learning tool, formulating analysis around insurance data, and discussing the relationship between the qualitative interview data and economic analysis.

The list of publications and engagement activities catalogued at the end of this annual report signify increased dissemination of the different strands of research being undertaken on the SESAME project. In order to disseminate our research, as well as writing papers, the team has been busy delivering invited presentations, media interviews and webinars.

Dr Graham Coates

Principal Investigator, SESAME

School of Engineering and Computing Sciences;
Institute of Hazard, Risk and Resilience;
Durham University.

Work Package 1

Agent-based modelling and simulation at an organisational level

Dr Graham Coates and Dr Chunhui Li (School of Engineering and Computing Sciences, Durham University)

Professor Nigel Wright and Dr Sangaralingam Ahilan (School of Civil Engineering, University of Leeds)

Aims

The aim of Work Package 1 is to develop an agent based modelling and simulation (ABMS) approach, coupled with flood modelling, to enable the investigation of organisational behaviour in the face of flood events. Achieving this aim involves developing:

- the agent-based model's (ABM's) virtual geographic environment, which is able to combine Ordnance Survey information with flood model output, to identify the businesses affected by flooding;
- agents to model businesses in terms of their attributes, behaviour, actions and interactions in response to flood events;
- an agent interaction network to enable simulations to be performed thus informing strategic decision making for longer term preparedness.

Progress

Building on last year's progress made developing the ABM's virtual geographic environment (VGE) and ensuring flood model output was compatible with this environment, progress in Work Package 1 has focussed on two main areas of work. On recruiting a new Post-Doctoral Research Assistant, Dr Chunhui Li, after 7 months since the departure of the previous researcher, Durham has primarily directed its attention to the development of software agents to model SMEs in terms of their behaviour and attributes relevant to responding to and recovering from flood events. Simultaneously, Leeds has focussed on performing hydrodynamic modelling for different flood scenarios to estimate water depths at regular time intervals during flooding in the case study area of Sheffield's Lower Don Valley, which is used as input for the ABM. Further, these estimates will be used in Work Package 3's economic modelling to assess the impact of flooding on SMEs and beyond.

Figure 1 provides an overview of the work being undertaken in relation to ABMS and flood modelling. The aim of framework is to establish how ABMS can be used to improve organisational business continuity of different types of UK businesses when responding to flooding by means of representing their attributes and simulating their actions, interactions and dynamic behaviours.

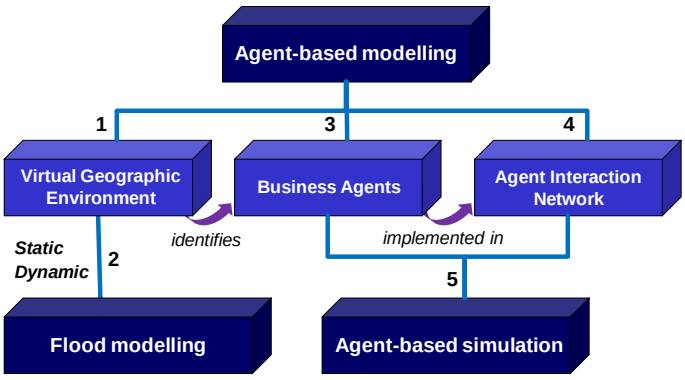

Figure 1: Overview of modelling and simulation framework

Stage 1 of the framework involves developing the ABM's VGE, which is able to combine Ordnance Survey (OS) information with flood model output, in Stage 2, in order to identify the businesses affected by flooding. Flood model output can be static in the sense of providing a single-shot footprint of the flood water in a geographical area, or dynamic in that the flood inundation varies with time thus bringing a temporal aspect to simulations which will be performed in Stage 5. Stage 3 relates to developing agents to model businesses in terms of their attributes, behaviour, actions and interactions in response to flood events. Stage 4 involves setting-up an agent interaction network to enable simulations to be performed, in stage 5, thus informing businesses how they might change their behaviour to better prepare for and respond to future flood events.

Business agents

Business Classification

As indicated in last year's report, Work Package 1 relies on several classifications within the Address Layer of OS MasterMap®, which are used within the VGE software: Base Function (1500 functions); National Land Use Database (NLUD) Code (41 groups); Valuation Office Agency Non-domestic Rates Primary Description (PDesc) Code (8 divisions and 108 sub-divisions); Valuation Office Agency Non-domestic Rates Special Category (SCat) Code (360 categories). In Work Package 2, Sheffield uses the United Nations Statistics Division's International Standard Industrial Classification (ISIC) of All Economic Activities, Rev.4, which has 21 high level activities and 99 sub-activities. In Work Package 3, East Anglia adheres to the Cambridge Econometrics' Multi-sectoral Dynamic Model (MDM-E3) of the UK economy, which consists of 46 industry types. To ensure consistency between Work Packages, Durham has mapped the 41 groups of the NLUD to the ISIC and MDM-E3 classifications. Further, it is the NLUD classification that will be used when defining behaviours and attributes to agents representing SMEs.

Agent behaviours and attributes

Within the SESAME project, modelling business agents' behaviours and attributes is being driven by information extracted from transcripts of interviews with SMEs at risk of flooding and/or which have experienced flooding. Last year, Durham reported on progress in relation to analysing a small number of transcripts of interviews with SMEs in Sheffield's Lower Don Valley conducted by colleagues from Work Package 2. From the same geographical case study area, Durham has now assessed 22 and 11 interview transcripts provided by Work Package 2 and 4 respectively. Information extracted relates to attributes such as business function, property, customers and suppliers. In terms of behaviour, information extracted is based on experience of major disruptions, in particular flooding during and post event, plans for business continuity both pre and post event, and impact on business operations. The interviews analysed have revealed that SMEs appear not to rely on formal structures or have flood plans in place should such a disruptive event occur. Rather, these businesses deal with emergency situations, such as flooding, through a variety of means, for example improvisation. In addition to relying on semi-structured interviews with SMEs, business agent design has drawn on a range of sources including Environment Agency (EA) literature outlining advice for businesses preparing for flooding and literature detailing business continuity management (BCM) systems' requirements (ISO223301). An important point to note is that in Work Package 1 we refer to SME behaviours extracted from interview transcripts as *existing behaviours* whereas those found in EA and BCM literature are referred to as *potential behaviours*. A distinction between the sources of these behaviours is made since this will provide the basis for a comparative analysis to be carried based on what SMEs did when flooded in the past and what SMEs may do when a flood event occurs in the future.

As part of the design of business agents, Durham has worked closely with colleagues from Sheffield, UWE and Kingston to ensure the behaviours and attributes being used to model SMEs are appropriate and relevant. For example, these colleagues have provided input on SME behaviours related to whether or not a behaviour is usually enacted while there is flood water in the premises, and is it usually enacted by a single employee or more than one employee, and is a behaviour generic or specific to a particular type or sector of SME? Also, indications have been given as to the priority of each behaviour in terms of when they would be enacted in the response timeline. This has, in turn, led to the development of SME agent behavioural flowcharts, which may be incorporated into Work Package 4 discussion group activities related to the development of an e-learning tool.

Work Package 1

Agent-based modelling and simulation at an organisational level (continued)

Flood modelling

Progress at Leeds has focused on the simulation of one in 100 year, 200 year and 1000 year flood events of the River Don at the Lower Don Valley region of Sheffield. As part of the Sheffield comprehensive flood review, the EA carried out a detailed modelling study for the Upper Don catchment from the headwaters to Jordan's Dam, 1km downstream of Meadowhall. The revised 1D-2D ISIS-TUFLOW hydraulic model of the River Don including the Little Don, Loxley and Rivelin provided by the EA has been used in this study. The 1D ISIS model represents the Don River channel and the 2D TUFLOW model represents the surrounding floodplain and highly developed urban areas where flood mechanisms are more complex. Buildings have been represented in the 2D model domains using high roughness areas and both the 1D and 2D models are dynamically linked. The Nursery Street Flood defence system is also incorporated into the model.

In this study undertaken, one in 100 year, one in 200 year and one in 1000 year flood events of the River Don have been simulated using a detailed hydrodynamic model to obtain corresponding flood extents. The River Lower Don flood defence is designed for a one in 100 year return period, therefore the extent of flooding produced for a one in 100 year flood event is not sufficient for subsequent ABMS. Simulation results for other higher return periods such as a one in 200 year and a one on 1000 year flood events are shown in Figure 2 at 10 hour time intervals over a 40 hour period.

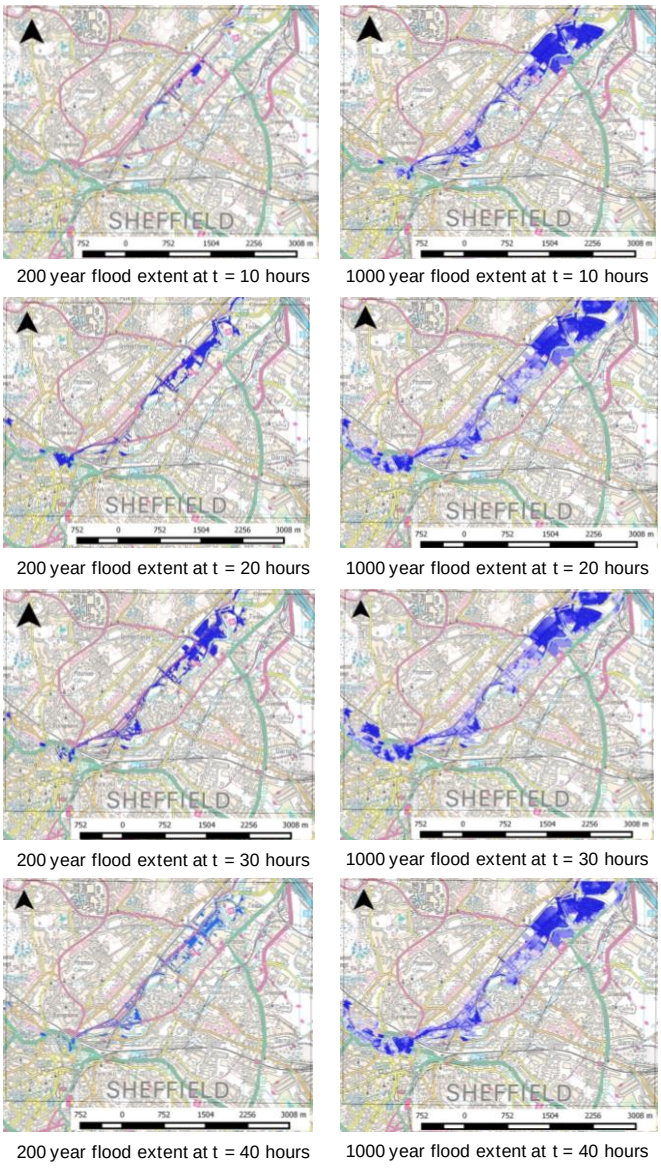

Figure 2: Flood inundation maps for Sheffield's Lower Don Valley

The data associated with the maps shown in Figure 2 provide the input for the ABM's VGE. The provision of dynamic flood inundation data will enable business agents to act according to the depth of water at different times throughout a simulation.

Future plans

In 2015, Work Package 1 will focus on making progress in a number of key areas, namely agent-based modelling and simulation and flood modelling.

- Agent-based modelling and simulation
  - Continue the design and development of business agents.
  - Commence the implementation of the agent interaction network required to enable agent-based simulations to be carried out.
  - Work across different Work Packages to define SME response strategies (in terms of what tasks employees undertake, when these tasks are undertaken and how many employees do so) and SME performance metrics, which can be incorporated within simulations to be carried out.
  - Commence preliminary simulations based on SMEs exhibiting *existing behaviours* and *potential behaviours* in accordance with interview and literature sources mentioned.
  - Disseminate research by preparing papers in collaboration with colleagues across Work Packages.
- Flood modelling
  - 2007 flood event simulation of the River Don, Sheffield
    Leeds is currently in the process of collating 2007 flow data of the River Don from a private consultant. As these data sets are collected by the consultant on behalf of a particular business operator, the Leeds team has been required to go through a number of people to get permission to obtain this dataset. Leeds has managed to pass through necessary channels and aims to obtain these data sets soon. Once relevant flow data sets are received from consultants, they will be in the position to simulate the 2007 flood event in the River Don.
  - Tewkesbury case study
    Tewkesbury, situated in Gloucestershire, was the worst affected part of the country when the floods hit in July 2007. The heavy rainfall overloaded drainage systems due to the influx of surface water and very high water levels in two main rivers, namely the Severn and Avon, leading to flooding in most areas in Tewkesbury. Leeds is willing to undertake this modelling exercise as Work Packages 2 and 4 have already interviewed in excess of twenty SMEs in this location. Nevertheless, to carry out this modelling work, the limiting factor is obtaining the data from the Environment Agency or whoever owns it. The added complication is that the nature of flooding in the Tewkesbury area is a combination of fluvial and pluvial flooding. Providing Leeds can obtain all the relevant data needed, it will develop a model and run the simulation within a couple of months.

Work Package 2
Business continuity processes

Dr Martina McGuinness and Dr Noel Johnson (Management School, University of Sheffield)

Aims

The aims of Work Package 2 are:

- to gain an understanding of businesses' response to flood events within their local, regional and national context, and behaviours of SMEs from their experiences of responding to flood events;
- to gather data which will help to inform ABMS (Work Package 1), feed into economic impact analysis (Work Package 3), and complement organisational learning and related e-learning initiatives (Work Package 4).

Progress

In the second year of the project, good progress has continued across a number of areas: collection of case study data; analysis of data; generation of research outputs; stakeholder engagement and dissemination events. There have also been further developments in collaboration and integration across the different Work Packages which can be seen in a range of activities and outputs.

Case studies

In addition to the Sheffield and Tewkesbury case studies reported in last year's annual report, a further three case studies of different flooding types were identified: Tyneside; Warwickshire; Wirral. A clear observation from this process is that a flood event may be a combination of more than one type of flooding. Data collection has been undertaken in these locales and analysis of these data has begun. To date, a total of 73 interviews have been undertaken with SMEs across a range of sectors, which have suffered the impacts of flooding (see Table 1). These interviews were semi-structured in nature, underpinned by a research instrument derived from the business continuity literature, policy and current best practice (ISO 223301). During the year, there were also discussions with Work Package 1 partners regarding the nature of the data required for the ABM, and Work Package 3 colleagues with respect to the data needed to supplement their economic modelling. Based on these discussions, some adjustments were made to the interview schedule. Interviews have ranged from 45 minutes to 2.5 hours.

Case study	Number of interviews	Flood type
Sheffield	27	Fluvial
Tewkesbury	17	Pluvial/Fluvial
Tyneside	6	Coastal/Pluvial
Warwickshire	17	Fluvial
Wirral	6	Coastal/Pluvial

Table 1: Case studies

Data from the Tyneside, Warwickshire and Wirral support our preliminary observations/findings from the initial case studies (Sheffield and Tewkesbury) which suggest that SMEs' ability to respond to and recover from flooding may be dependent, in part, on the nature of the business carried out together with the social capital embodied within internal and external networks. We have explored these themes further in the context of organisational continuity and resilience, and in particular with reference to issues emerging from the data such as 'initial conditions', 'path dependence', 'bricolage' and 'appropriable organisation' (social capital). In terms of the type of flood, there does not appear to be significant differences in organisational (SME) responses. More evident, is that SMEs with a closer relationship with the source of flooding (sea or river) tend to have a fuller understanding of the risk and behaviour of the source and may take appropriate actions in preparedness and response.

Research outputs

A number of outputs have been generated during the second year of the project, aimed primarily at academic audiences. These include papers as listed under publications on page 9 of this report.

Stakeholder engagement and dissemination activities

There was a concerted focus over the past twelve months to undertake non-academic related activities in order to disseminate some of the emerging findings from the project to relevant stakeholders from policy and practice. Moreover, a key aim has been to engage these stakeholders in discussion of the project's emerging findings and elicit their feedback on work to date. This has been a successful initiative, which has yielded valuable information for framing future directions.

As part of this, McGuinness successfully applied for funding from the Economic and Social Research Council to organise an event as part of their annual Festival of the Social Sciences. This seminar, 'Business as (un)usual: SMEs and flood risk' was aimed at SMEs and other stakeholders involved in flood preparedness and response. It was run as both a 'business breakfast' and 'early evening event', in a Sheffield hotel, in order to maximise the potential for SME owner/managers to attend. The seminar was also an opportunity for an integrated activity across Work Packages, with Coates, Johnson, McEwen, McGuinness and Wragg collaborating. Feedback from the two events was very positive. The seminar provided a source of feedback and additional data for the research, as well as developing the project network further in the Sheffield area.

Other activities undertaken by McGuinness and Johnson include:

- Briefing paper to the Environment Agency on SMEs and flooding to feed into their preparation of ministerial mandated action plan in response to the Somerset Levels flooding, 14 February 2014.
- Invited webinar to UK Flood and Coastal Erosion Risk Management Network (FCERM.net), 'SME resilience to flooding – a resource-based perspective', 12 May 2014.
- Invited webinar to UK Environment Agency staff on SMEs and Flooding, 'Flood resilience for SMEs: barriers to adaptation, 20 May 2014.
- Invited seminar to the Newcastle Institute of Insurers, 'Evaluating businesses' flood response strategies', 26 June 2014 (with Coates).
- Invited seminar to the Middlesbrough Institute of Insurers, 'Evaluating businesses' flood response strategies', 2 July 2014 (with Coates).

Future plans

Over the next 12 months, work will focus on the following:

- completion of the systematic review of business continuity literature with a view of the submission of a paper to a journal such as the *International Journal of Management Reviews* (June 2015);
- analysis of case study interview data utilising Nvivo software (ongoing);
- cross Work Package collaborative outputs;
- development of a cross Work Package paper on insurance;
- scoping of a methodological paper;
- scoping of the requirements for data collection from new technologies, based on analysis of interview data (to establish appropriate search strings/key words for relevant business continuity issues, identifiers and time frames) and the tendering process;
- generation of further project outputs, with other Work Package partners, as appropriate.

Work Package 3

Assessment of flooding impact on urban areas and wider economic systems

Dr Dabo Guan and Mr David Mendoza (School of International Development, University of East Anglia)

Aims

Analysis of the economy and society is central to understanding the broad impacts of flooding and identify cost-effective adaptation and mitigation measures. Assessments of flooding impacts have traditionally focused on the initial impact on people and assets, which are useful in understanding the immediate implications of damage, and in marshalling the pools of capital and supplies required for re-building post event. Since different economies and societies are coupled, especially under the current economic situation, any small-scale damage may be multiplied and cascaded throughout wider economic systems and social networks. Work Package 3 sets out to gain an improved understanding of the economic impacts of floods on SMEs, and the knock-on effects on the wider economy. Taken together, these can be described as the *flood footprint* - a measure of the total direct and indirect economic impacts caused by a flood event to the area that is flooded and to wider economic systems. To quantify the economic impact of flood events beyond the immediate local urban area affected, a flood footprint model is to be constructed based on adaptive input-output analysis. Work Package 3 involves:

- adapting the city scale Adaptive Regional Input-Output (ARIO) model to quantify the cost-benefit of adaptation measures for case study cities from a macroeconomic perspective.
- linking the city scale ARIO model with national input-output tables (for each case study city) to estimate the cost of local flooding to the national economy.
- integrating the ARIO model with results produced by Work Packages 1 and 2 to study the flood impact on SMEs and the economic benefits of SMEs' preparedness and adaptation.

Progress

The ARIO model, with a temporal dimension, has been adopted to assess the economic costs in Sheffield as the result of the flooding in 2007. To that aim, the concept of *flood footprint* is used as defined above. The setting up of the ARIO model consists of two main stages: data gathering and codification, and modelling design.

Data collection and codification

The data needed can be divided in two sets. One set includes the data related to the flood event and the affectation to the regional economy collected mainly from official reports on the disaster including the Environmental Agency; Department for Environment, Food and Rural Affair; Munich Re; news reports; information gathered in Work Package 2. Before being useful for the modelling process, this data must be codified in terms of productive capital that has been damaged through the use of damage functions. Thus, the data about the disaster characteristics (e.g. intensity and length) and their direct impact to the regional physical infrastructure (e.g. capital assets, equipment, households, public services, transport infrastructure) is translated into the productivity reduction for the affected economy, which constitutes the starting point from where the recovery will start. Additional data on labour structure and consumption patterns must be collected to calibrate the ARIO model's parameters. Information from Work Package 2 can be useful for this purpose. These parameters are mainly related to the adaptive behaviour of businesses and labour. The ARIO model takes the information to set up the labour recovery path as well as the recovery from reduced productivity caused by people affected, households flooded and delays from disruptions in transport infrastructure. Behavioural change in consumption patterns is also considered, where it is assumed a reduction in luxurious consumption after a disaster, while the supply of basic products is assured by local government. The second set of data is related with the regional economy, which provides the context in which the market forces, the disaster damage and the economic agents interact in the recovery process. This includes the regional economic data to feed the ARIO model comprising mainly of the input-output tables, which are a compendium of all the inter-industrial transactions of the economy and the interactions among different economic agents. These tables arrange all this information in a transparent way where the economy can be seen as a circular flow which is, in a pre-disaster situation, in equilibrium. For this project the information was taken from the Cambridge Econometrics' Multi-sectoral Dynamic Model (MDM-E3) which provides information disaggregated at 46 industrial sectors for each of the 12 NUTS1 level regions in the UK. From this, information on the economic structure of the City of Sheffield has to be collected to adapt the ARIO model to zoom in to the local economy. Additionally, the ARIO runs in a monthly time step, which implies that all the information must be considered in these terms.

Modelling design

All data must be arranged properly in order to make it suitable for the ARIO model and to translate the data of the damages into productive capacity reduction and from this to simulate the recovery path and calculate the indirect losses involved. Here, it is considered that the economy has recovered when the regional output reaches the pre-disaster level, and the product and labour markets are in equilibrium. For adapting the ARIO model at the city level, the information at NUTS1 level was statistically adapted, which in the case of the input-output tables was done using the Locations Quotients technique; this takes into consideration the relative share of Sheffield City (NUTS3) output in relation to the regional output and the size of intra-regional trade and a regional specialisation factor.

Assumptions

Due to the nature of the analysis, some data is lacking on the economic agents' behaviour post disaster implying some assumptions be made:

- In the absence of detailed information of the damage distribution for specific sectors, a weighted distribution of the losses considering the sectoral output has been applied.
- The affectation of labour is uniformly distributed according to the proportion of working people in affected homes.
- Similarly, to consider productivity reduction for transport delays, the recovery path is modelled exogenously.
- Household consumption behaviour is modelled exogenously, assuming a reduction of non-basic products and a recovery path indexed by the time and proportion of people displaced.
- The reconstruction demand is distributed exogenously among reconstruction sectors.
- A Proportional Rationing Scheme is considered for allocating the remaining productive capacity. This consists of prioritising business to business relationships, and if there is remaining product for final demand this is distributed in a proportional way.
- The reconstruction demand is partly supplied by imports, the maximum amount of which is equal to pre-disaster levels and there are no constraints in supply, but from the transport system only.

Preliminary results

With the data available and related assumptions, the design of the ARIO model for the Sheffield city case study has been carried out and preliminary results have emerged. The model estimates that after the 2007 flood it would take at least 20 months for the city's economy to fully recover and it would represent a flood footprint accounting for £571m, or 6.8%, of the city's Gross Value Added. From this figure and according to the data gathered from the damage reports, the direct and indirect losses account for £295m and £276m respectively. These figures indicate that indirect losses account for around one half of the total flooding damages and some sectors and regions beyond the impacted area can be indirectly affected by inter-sectoral economic interconnectedness.

Future plans

It is expected that refined data from Work Packages 1 and 2 will enhance the model's parameters, particularly data related to labour recovery path and final consumption behavioural change. Also, a sectoral analysis and sensitivity analysis of different rationing schemes will be carried out.

Work Package 4

Adaptive e-learning and behaviour change throughout the 'flood cycle'

Professor Lindsey McEwen and Dr Amanda Wragg (Department of Geography and Environmental Management, University of the West of England)

Dr Tim Harries (Business School, Kingston University)

Aims

This Work Package has two aims. The first is to understand what influences SMEs' long-term adaption to flood risk. The achievement of this first aim will feed into the development of the ABM, and will also inform the second aim: the development of an intervention to promote increased adaptation.

The proposed intervention will be a prototype digital learning tool that could, eventually, be made available across the UK. The academic literature and evidence from the research community suggest that the best way to change SME behaviours around flood risk is by embedding learning within relationships of trust and respect using a business framing. As it is currently envisaged, the tool will facilitate the generation of such relationships between SMEs and other businesses and organisations. It will also provide a virtual space in which SMEs can engage with flooding issues in terms that are familiar to them and that allow them to recognise and address their own priorities.

The final intervention tool will emerge from a process of co-creation: iterative engagement between the team, SMEs and national/regional stakeholders in business resilience. This process has already begun. Participants have already contributed to the design of the tool and will, in the next phase of the work, comment on emerging concepts/designs and test prototype versions.

Progress

Thirty-six semi-structured interviews have been conducted with business owners/managers from four case-study areas: Tyne & Wear (coastal flooding), Tewkesbury (pluvial and fluvial flooding), Swindon (pluvial flooding) and Sheffield (fluvial flooding). These address the barriers to, and facilitators of, adaptation. They were analysed using a combination of thematic analysis and discourse analysis. In addition, the first of a series of meetings have been held in which stakeholders and business people help determine the shape and content of the e-learning tool.

- *The Stakeholder Competency Group* (SCG) consists of regional and national stakeholders who are concerned with flood risk management and/or businesses and their behaviour. Membership includes the following organisations: Community Council for Somerset; Business Technology Initiative, UWE; Gloucestershire Rural Community Council; National Flood Forum; Climate South West; Gloucestershire County Council; Gloucester City Council; Federation of Small Businesses; Tewkesbury Borough Council; Gloucestershire County Council; Business in the Community; Gloucestershire Local Resilience Forum.
- *The Business Research Partnership Group* (BRPG) consists of around ten Gloucestershire SMEs.

These participatory meetings use discussion and projective techniques to elicit views and opinions on the development of the learning tool such as 'q-sort' exercises as shown in Figure 3.

Figure 3: Group members engaged in a 'q-sort exercise'

A weblog (Blog4SESAME.wordpress.com) has also been created – for knowledge exchange and discussion between the research team, members of the two groups and other interested parties.

Emerging findings regarding the learning tool

From the literatures on small businesses, *e-learning* and *the diffusion of innovations:* SMEs prefer informal, experience-based learning; willingness to learn from outsiders and to use e-learning depends on strategic orientation and area of operation; familiar solutions are generally preferred; outsiders are distrusted; long-term planning is not associated with running a small business; horizontal (e.g. business to business) learning is more effective than vertical (expert to business) learning; people are often prisoners of their experience (*path dependency / learning traps*) and of their expectations (only see what they expect to see).

From the interviews: Prominence of a self-reliance discourse; preference for business-to-business learning; narrow understanding of notion of adaptation; importance of benefit-cost analysis of potential adaptations; get-on-with-it discourse; great emphasis on explaining the causes of floods and attributing blame.

From the SCG and BRPG groups: The learning tool should... facilitate learning between businesses; address emotional resilience; use social media to keep it 'live'; comprise 'bite sized chunks' so that SMEs that consider themselves 'time-poor' can dip in small amounts of learning; be framed in a positive way; sign-post existing resources; be a forum for discussion and knowledge exchange; cover the needs of those affected indirectly by floods (e.g. by road closures); provide a space for reflection as well as/rather than for didactic learning.

Existing resilience tools and resources

A web search was conducted for tools and resources in the UK, USA, EU (and, forthcoming, Australia) that help SMEs adapt to flood risk and other hazards. This revealed two interactive web resources (*Resilience Healthcheck*, UK (see Figure 4); *Business Continuity Planning Suite*, USA). Most other resources comprised on-line/printed information. However, we also identified a business mentoring scheme (*Ready Business Mentoring Guide*, USA) and a video of businesses describing how they adapted to climate change (UK). Although there were examples of good practice, most resources seemed designed for larger businesses and/or relied too heavily on the transmission model of education (i.e. one-way information transfer).

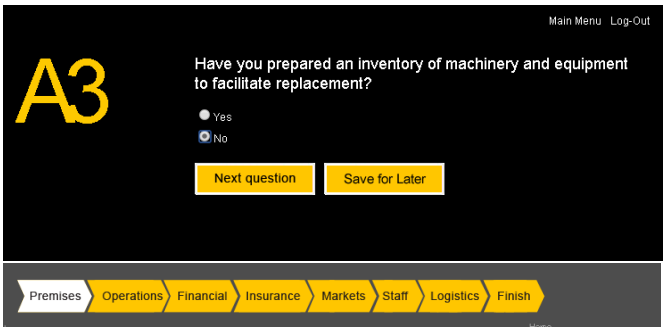

Figure 4: Screenshot from the Resilience Healthcheck

Work Package 4

Adaptive e-learning and behaviour change throughout the 'flood cycle' (continued)

Composition of the learning tool - provisional thoughts

We think it important that the tool is framed appropriately for SMEs – i.e. that it conforms to business culture, business language and limits itself to business-relevant content. It should be seen as a medium for business people to communicate with each other, rather than as a medium for external experts to communicate with businesses. It is vital that the tool is easily navigated and that users are able to "dip in" for short-duration learning experiences.

We currently imagine five areas of content:

(1) An interactive process visualisation (flowchart) that allows users to reflect on the stages/processes involved in the experience of flooding and post-flood recovery.

(2) A section on insurance (that includes digital stories of the experiences of SMEs, the state of play re flood insurance - Flood-Re etc.), anonymised quotes from interviews on how SMEs use insurance and the facility for users to share advice/experience.

(3) A section on emotional support and resilience.

(4) A section on practical protection measures (including digital stories and technical help sheets – see those by FEMA in the USA; e.g. Figure 5).

(5) A social networking space in which businesses exchange views and experiences.

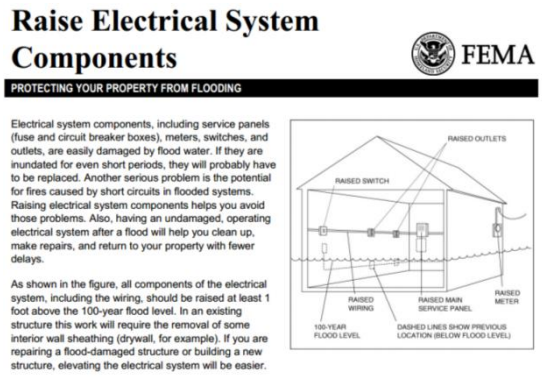

Figure 5: FEMA information sheet

All parts of the tool would include signposts to additional sources of support from statutory agencies. Sections 2, 3 and 4 (above) would include the use of digital stories.

We are consulting on the most appropriate technical platform for this tool – e.g. Android app, web-site etc.

Future activities against timeline

A key part of future activity is the process of co-production that will be used to develop the learning tool. This will involve iterative engagement with both our SCG and BRPG. The timing of this process and the other elements of Work Package 4 are as follows.

- December 2014: Develop expertise in digital storytelling for narrative work on adaptive learning and behaviour. This involves the additional skilling of the Work Package 4 team in the design and use of web-based storytelling (Netskills).
- January 2015: Create three trial digital stories (co-working with businesses in Tewkesbury) to capture critical reflections on post-flood adaptive learning and behaviour change.
- February 2015: Draft an outline/mock-up of the tool structure and content.
- February - April 2015: Convene the SCG to discuss the tool mock-up. Hold two meetings of the BRPG to collect guidance on the design/content of the interactive flowchart and the digital stories, and to discuss the mock-up of the tool. (To enhance interdisciplinary working, these will involve researchers from Work Packages 1 and 2.) Put the development of the tool out to tender (once the specification is agreed).
- April - May 2015: Develop a pilot version of the tool with examples of key elements (i.e. three digital stories, interactive process flowchart, design of shop window, mock-up of chat-room with artificial examples).
- June 2015: A final combined meeting of the SCG and BRPG to provide feedback on pilot version of tool and evaluate the co-production process.

Plan for research dissemination and knowledge exchange

The dissemination plan for research and knowledge exchange for Work Package 4 is provided below. Attention is given to maximising the impact narrative across disciplinary, professional/practitioner and business community audiences.

Dissemination strategy

Refereed journal articles

- Paper on issues influencing SME adaptation to flood risk – in a 'risk' journal.
- Paper on knowledges and learning for SME resilience – Environment & Planning C (and/or paper on resources that are integrated into/drawn on within local networks/ communities).
- Paper on SMEs and flood Insurance (working with Work Package 2) – e.g. International Small Business Journal, Journal of Flood Risk Management.
- Paper on co-production, with SMEs and stakeholders, of the learning tool – e.g. in Journal of Flood Risk Management.
- With Work Packages 1 and 2, paper on involving social science in the generation of an ABM – in a modelling journal.

Conference presentations

- European Geophysical Union, Vienna, May 2015.
- International Water Congress, Heriot-Watt, May 2015.
- Institute of British Geographers Annual Conference, August 2015.
- Defra/EA Flood and Coastal Erosion Risk Management conference.

Contributions to webinars/workshops

- Contribution to FCERM Webinar series (June 2015).

Web media

- Public blog and listserv for the SCG.

Legacy

A key consideration in ensuring a legacy for this project is finding a home/adopter for the embryonic learning tool. Current possibilities include the Federation of Small Businesses and the National Flood Forum, both of which are represented on the SCG. In addition, a local authority has expressed an interest in funding further development of the tool for future use in their area.

Publications

Forthcoming

McGuinness, M., Johnson, N. 'Exploiting social capital and path-dependent resources for organisational resilience', *Procedia Economics and Finance*.

Li, C., Coates, G., Johnson, N., McGuinness, M. 'Designing an agent-based model of SMEs to assess flood response strategies and resilience', International Conference on Flood Resilience, Zurich, 13-14 January 2015.

Li, C., Coates, G. 'Design and development of an agent-based model for business operations when faced with flood disruption', Complex Systems in Business, Administration, Science and Engineering, New Forest, England, 12-14 May 2015.

2014

Coates, G., Hawe, G.I., Wright, N.G., Ahilan, S. 'Agent-based modelling and inundation prediction to enable the identification of businesses affected by flooding', In Proceedings of the 4th International Conference on Flood Recovery, Innovation and Response (FRIAR 2014), Poznan, Poland, 18-20 June, 2014.

Coates, G., Guan, D., Wright, N.G., McGuinness, M., McEwen, L., Harries, T. 'SESAME: Finding ways of promoting SME adaptation to flood risk', In Proceedings of the 11th International Conference on Hydroinformatics (HIC 2014), New York, USA, 17-21 August, 2014. (Abstract only)

Ahilan, S., Wright, N.G., Coates, G., Sleigh, P.A. 'Using Agent-based Modelling with Inundation Predictions to Enhance the Resilience of Small Businesses', In Proceedings of the 6th International Conference on Flood Management (ICFM6 2014), Sao Paulo, Brazil, 16-18 September, 2014. (Abstract only)

McGuinness, M., Johnson, N. 'Exploring multi-level capacity building for flood resilience', International Workshop 'Resilience: Just Do IT?! Governing for resilience in vulnerable places.' University of Groningen, 9-10 October, 2014.

McGuinness, M., Johnson, N. 'Exploiting social capital and path-dependent resources for organisational resilience', 4th International Conference on Building Resilience, MediaCity UK, Salford Quays, 8-11 September 2014.

2013

Coates, G., Hawe, G.I., McGuinness, M., Wright, N.G., Guan, D., Harries, T., McEwen, L. 'A framework for organisational operational response and strategic decision making for long term flood preparedness in urban areas', In Proceedings of the 3rd International Conference on Disaster Management, A Coruña, Spain, 9-11 July 2013.

McGuinness, M., Johnson, N. 'Responding to changing paradigms of risk: managing flood risk and enhancing organisational resilience', In Proceedings of the Association of Geographical Societies in Europe (EUGEO) 2013 Congress, 'Changing Geographies and Geographies of Change', Rome, Italy, 5-7 September 2013.

Other publications

Briefing paper to the Environment Agency on SMEs and flooding, 14 February 2014 (McGuinness & Johnson).

Engagement

Invited presentations

EPSRC-LWEC Flood and Coastal Erosion Risk Management Network, Birmingham, 20 November 2013 (Coates).

Agent-based Modelling and Simulation in Flood Risk Management Workshop, Newcastle, 26 February 2014 (Coates).

Adaptation and Resilience in the Context of Change (ARCC) Network Assembly, Birmingham, 11 June 2014 (Coates).

FCERM Annual Assembly, Edinburgh, 19 June 2014 (McGuinness, Wragg).

Institute of Insurers (Newcastle) Seminar, Newcastle, 26 June 2014 (Coates & McGuinness).

Institute of Insurers (Middlesbrough) Seminar, Stockton, 02 July 2014 (Coates & McGuinness).

Exeter University Centre for Business and Climate Solutions knowledge exchange event, Taunton, 10 July 2014 (Wragg).

ESRC Festival of Social Science 'Business as (un)usual: flood risk and SMEs', Sheffield, 04 November 2014 (McGuinness, Coates, McEwen & Wragg).

Institute of Hazard, Risk and Resilience Seminar, Durham, 08 December 2014 (Coates).

Media interviews

Yorkshire Evening Post, 10 January 2014 (Wright).

LBC Radio, 10 February 2014 (Wright).

BBC Inside Out West, 11 February 2014 (Wright).

Radio 5 Live, Victoria Derbyshire, 14 February 2014 (Wright).

BBC Inside Out West Midland, 25 February 2014 (Wright).

Sky News, 11 & 16 February 2014 (Wright).

BBC Radio Cambridge, Naked Scientist, 09 March 2014 (Wright).

Webinars

EPSRC-LWEC Flood and Coastal Erosion Risk Management Network, SME resilience to flooding – a resource-based perspective', 12 May 2014 (McGuinness).

UK Environment Agency staff on SMEs and Flooding, 'Flood resilience for SMEs: barriers to adaptation', 20 May 2014 (McGuinness).