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Conference

How can we learn to live with floods? Challenges for science and management

Wednesday 15 March 2017

Report by Jeremy Watson

In the Winter of 2015/16, the UK reported the highest 24-hour and 48-hour rainfalls ever recorded. This resulted in catastrophic flooding in the Scottish Borders, Dumfries and Galloway and Aberdeenshire. At many locations, river flows significantly exceeded previous maxima. Hundreds of homes were evacuated – with some still not reoccupied – roads and bridges swept away, caravan parks destroyed and ancient castles undermined. Insured losses for the UK reported by the Association of British Insurers in mid-January 2016 were estimated at £1.3 billion.

Can anything be done to prevent this remorseless and repetitive damage? Will climate change exacerbate the problems? Is better flood prevention infrastructure the key, or is there a more effective way of stopping the water flow before it has a devastating impact on the lives of those in its way? This meeting explored the science underpinning flood risk management and the actions being undertaken by local authorities, SEPA and other public bodies to better manage flood risk and reduce the impact of floods.

Leading UK experts were asked by Professor Alan Werritty FRSE, Emeritus Professor of Physical Geography at the University of Dundee, to give their views on how best to manage flood risk and how this might be enhanced in Scotland.

1. Professor Chris Kilsby, Professor of Hydrology and Climate Change, Newcastle University

Professor Kilsby sought to examine whether current methods of statistical analysis could provide any evidence of a link between extreme rainfall events and climate change. He said his intention was to statistically review the nature of record-breaking extreme events, explore the uncertainties associated with short observational records and critique their use in current practice. His starting point was a 60-year, time series analysis of water flows in the River South Tyne at Haydon Bridge, Northumberland, which appears to show clusters of floods and an increase in clusters over time.

An increase in extreme events appears to occur, with the highest peak flows over that period in 2005 and the next highest just ten years later in 2015. But is that evidence of a trend, Professor Kilsby asked? Using standard statistical methodology on wider data, trends do appear and there is even spatial coherence, with different regions showing similar trends. So do time-dependent models offer the prospect of predicting the future? Professor Kilsby said there is still insufficient

data to eliminate uncertainty, and although there are several statistical methods for analysing the data, none of them appear to be any better than any other at present. However, they should not be discarded; they should be used as a base on which to build further analyses.

The problem at present, with time-series data and attributing flood events – and record-breaking events – to climate change, is what period to use, Professor Kilsby said. Although the South Tyne statistics, from 1962 onwards, appear to show a trend of record-breaking events, historical peak flows equal to or greater than 2005 are found. Floods in 1771 wiped out all the bridges on the River Tyne bar one. So, in a stochastic process, the expectation is that records will be broken. Statistical analysis shows that the chances of that happening are 80%, so a record-breaking event should be no surprise. The only surprise lies in the margin of the record breaking.

In conclusion, trend detection using flood data itself, is, Professor Kilsby maintained, "crippled by uncertainty", as only small time-series samples are available. When trying to attribute flood events to climate change, statistics are not enough on their own. More information is needed on the background of extreme events – such as climate and hydrology data – and how this is incorporated into flood forecasting is the interesting research challenge.

2. Dr Nick Reynard, Science Area Leader for Natural Hazards, Centre for Ecology and Hydrology

Are floods the new norm, Dr Reynard was asked? He said it was an important question for him, as his work involves understanding what happens when peak flows occur and then translating that into knowledge that the flood risk management community can use. The Centre for Ecology and Hydrology works on short-term forecasts and is also developing a surface water flooding tool. Can it provide useful long term flood predictions?

Addressing the question of whether floods are the new norm, Dr Reynard said the data suggests we are in a "flood rich" period, with a list of high rainfall events stretching from 2000 to 2016. However, there were also big floods in the UK in the 1940s and 1950s. Has anything changed? If floods are not more frequent, are they more severe? Data from the Thames from 1883 to 2014 suggest they do not appear to be getting more severe. So homing in on shorter time periods – such as 50-year time series – can identify a misleading trend. In addition, the data on sustained periods of high flows are weak, Dr Reynard said. Years of relative drought can be followed by extreme rainfall, so in such a hydrological "roller coaster", real trends can be missed.

What evidence is there that climate change is having an effect on the frequency of heavy rainfall events? Science is certainly telling us that the world is getting warmer and more warm air columns mean more rainfall, which increases flood risk. We have seen an increase in intensive winter rainfall and more extreme episodes, which are consistent with predicted climate change scenarios, said Dr Reynard. However, natural variability of the climate has to be taken into account.

Does any of this help us to manage flood risk now, whether at national or catchment level? The current guidance is to add 20% to peak flows and to protect against that; but is it appropriate or proportionate when we know that catchments all behave differently? "One size fits all" solutions are not the way forward, Dr Reynard concluded. The Centre is now working on a range of responses to climate change for floods of varying return periods, based on individual catchment characteristics; for example, given a 40% risk threshold, the allowance for climate change should be between 20% and 40%, depending on the region selected.

Q & A

Q: The overall conclusion is that the statistical data is not sophisticated enough as yet, as it only goes back 50 years or so. Doesn't that undermine confidence in what we are told about flood risks?

A: There hasn't been a flood in the last century greater than more recent ones. However, at the moment, climate variability is larger than climate change. That doesn't mean our predictions are not credible. There are a lot of data that increase our understanding of flood events. The use of historical data is just one of the techniques and we have to blend in other, emerging evidence.

Q: I have been in engineering hydrology since the 1960s and nothing has changed, in that there are occasional big floods and we have to deal with them in a practical manner. Shouldn't the money being spent on inconclusive science be diverted instead into solutions to flooding, rather than theoretical predictions?

A: We cannot act without science underpinning decisions. We have to consider what might happen because of climate change. We spend a lot of our time on solutions; the two cannot be separated. In any case, the amount of money spent on science, compared to solutions, is relatively small.

3. Professor Hayley Fowler, Professor of Climate Change Impacts, Newcastle University

Rainfall extremes appear to be increasing globally, so can predictions be improved by the development of new modelling techniques? As time-series data is limited, Professor Fowler said she was working on convection-permitting modelling (CPM), which gives a more realistic representation of convection and is better at simulating hourly precipitation characteristics that are poorly represented in coarser-resolution climate models.

Observations show that heavy rainfall is increasing on daily timescales in many regions, but can CPM predict when and where this might have a serious impact in ever-smaller areas prone to flooding?

A very high resolution (1.5km grid spacing) model – more typically used in weather forecasting – can simulate realistic hourly rainfall characteristics, including extremes, unlike coarser resolution climate models. This boosts confidence, Professor Fowler said, in the ability of these techniques to predict what might happen in future. The 1.5km model suggests increases in hourly rainfall intensities in winter and also future intensification of short-duration downpours in summer. Significantly, more events appear to exceed the high thresholds that indicate a higher risk of serious flash flooding.

The modelling suggests that summer precipitation intensity and, particularly short-duration heavy event intensities, may increase by between 30 and 40%. Heavy events, which produce more than 30mm of rain over short periods, show a five-fold increase. As climate change is likely to produce more frequent periods of heavy, intense rain, convection-permitting modelling will allow us to add value to predictions by reducing uncertainty, Professor Fowler said. It has the potential to be useful in many scenarios.

4. Mark McLaughlin, Flood Risk Management Planning and Policy Unit Manager, Scottish Environment Protection Agency (SEPA)

Mark McLaughlin deals with flood risk management planning at SEPA and helps to develop flood hazard and risk maps that, while central to the development of flood risk management plans and strategies, are also important communication tools, particularly for local communities.

He said that the initial fluvial flood hazard maps dating back to the 1990s, while appropriate for the technology at the time, now appear rather coarse and limited in scope. This apparent coarseness is a result of the huge improvements made in the decades since; higher resolution fluvial and coastal hazard maps being published in the mid-2000s. Surface water (pluvial) risk maps were subsequently published in 2013, as data and modelling methods improved to allow more detailed representation of this flood source.

The emphasis now is on catchment-based projects and raising the quality of the information generated and shared amongst flood risk management professionals and the public. As part of this work, SEPA has published *Flood Modelling Guidance for Responsible Authorities*.

Although much more detailed than ever before, Mr McLaughlin said that there remains inherent uncertainty in any flood study; the current flood maps, therefore, do have limitations that can be addressed. More information is needed on topography – through use of laser surveying techniques such as LIDAR – to improve flood risk management in fluvial areas. Coastal mapping needs to take physical obstructions – such as sea embankments – into account when assessing risk and to develop further the representation of dynamic processes, including the influence of waves. More investment is needed in improving pluvial data in conurbations, particularly around detailed modelling of the interaction between surface and sub-surface drainage systems.

One initiative is working on capturing real-time information during flood events to discover what actually happens, rather than what is predicted to happen. Hand-held devices which relay data back for analysis are being developed and trialled by operatives in the field. So far, the volume and quality of the information provided has been extremely useful.

Embedding climate change at the heart of flood risk management mapping is essential. While it is a challenge, the impact of climate change is potentially significant; a current estimate is that, due to climate change, the current number of properties at risk in Scotland will rise from around 108,000 properties to around 168,000 by 2080. Using the information contained in flood maps will support improved understanding and the development of capacity to adapt to the future climate, and enable informed, sustainable decisions on flood risk management.

Q & A

Q: There is a lack of pragmatic management of our rivers. There are obstacles that have a role in flooding that should be removed, yet there is no consultation with local people.

A: Mr McLaughlin said there were already in existence national and regional groups that meet with community representatives. Specific issues are addressed.

5. Professor David Balmforth, Executive Technical Director, MWH Global

With surface run-off such a complex challenge, how do we make our urban conurbations more resilient to flooding, asked Professor Balmforth? Past efforts have concentrated on infrastructure, but there is growing realisation that this approach is unsustainable, he said. We know that heavy rainfall will become more frequent and more severe, but the answer is not to build more infrastructures, such as storm drains, on grounds of cost alone. Urban areas have to become more resilient by stopping damaging flows from happening.

Drainage has three elements: the source of the flow; the receptor area; and the pathway down which water runs. Preventing damage involves creating different pathways to manage the flow between source and receptor, such as vulnerable houses or businesses. How can we do that? One example comes from Portland, Oregon, which uses rainwater disconnection – diverting it

from the drainage system into areas where excess water can naturally drain away. Measures such as placing water barrels outside homes to collect run-off from gutters is one method. Diverting gutter water into vegetated areas is another.

In wider areas, exceedance pathways have to be created. However, a poor example of an exceedance pathway is simply using a road for this purpose, as the road, inevitably, ends up somewhere. That somewhere could be a building, which then floods. One regularly-flooded village in Cornwall has overcome this by using an approach road as an exceedance pathway, but with specially-created peripheral points which allow flood water to drain into a nearby stream. The road is temporarily sacrificed, but the village is saved. Holland also provides many good examples. Housing developments have additional green space which has channels to take excess water. New roads are designed to divert water harmlessly into woodland. In Singapore, street-level entrances to the previously-flooded metro system have been raised to prevent flood waters getting in.

For the future, work is being done on housing communities on stilts, or on platforms that can float, when flood water pours into the area. Flood prevention is not the only benefit; 'blue-green' corridors in urban areas encourage biodiversity, amenity and health and wellbeing for people living in the area. We cannot afford to physically defend against all flooding exacerbated by climate change, Professor Balmforth concluded, so society has to move from defence to resilience.

6. Dr Mark Wilkinson, Senior Researcher in Catchment Hydrology, James Hutton Institute

Having identified a range of measures collectively labelled 'natural flood management' (NFM) (land use management, woodland planting and river and floodplain restoration), Mark Wilkinson sought to explain how they work, where in the catchment they are ideally placed and how, both individually and collectively, they can not only manage flood risk but also provide multiple benefits.

Using the source–pathway–receptor model, Wilkinson provided detailed examples of the deployment of NFM measures and their associated benefits. In the Tarland catchment in Aberdeenshire, the combined use of soil management, soil bunds (storage for multiple day events) and restored wetlands has reduced the impact of frequent muddy floods off farmland. At Balruddery Farm west of Dundee, where land value is high, the construction of riparian buffers at field margins has reduced both flood runoff and nitrate pollution in adjacent small water courses.

But as the scale for intervention increases, so does the amount of storage required, with natural storage often insufficient to meet the need. Questions then arise on the relative merits of many small ponds upstream versus offline engineered storage on floodplains downstream. The wider challenge of the optimal upscaling of measures, and the deployment of groups of measures, requires further research, not least in ensuring that their deployment doesn't radically change the sychronisation of tributary peak flows.

In terms of assessing the effectiveness of such measures, woodland planting is often widely applicable, but with benefits that will take time to emerge. By contrast, readily-deployed leaky barriers in small upstream reaches can yield immediate, if modest, impacts.

Key to effective implementation of NFM measures is communication with key stakeholders. An example is FARM TOOL (designed to help assess the risk of flooding from farm land and how to reduce it). This provides a simple way of assessing the roles of soil storage and flow connectivity in determining runoff from individual fields/plots, and has been successfully used to assist farmers identify measures that will reduce flood runoff and soil loss.

Also crucial to effective implementation is that the measures stay in place for the long term. Addressing this challenge requires catchment partnerships embracing all the key stakeholders and secure funding from a range of sources, both during and after project-based measures are installed.

Q & A

Q: Is there a trade-off between more engineering and more natural flood management?

A: Yes, but there is great excitement about what can be achieved by effective natural flood management. However, we should not mislead people about what it can achieve.

Q: Whose job is it to make sure that only the most effective measures are introduced? The flood risk management industry can only do what it is allowed to by policy and budget.

A: Who should lead on this? All of us. But we do need a group of flood champions, properly supported to keep pushing for all these measures. In this respect, partnership with community groups is essential.

7. Michael Cranston, Honorary Research Fellow, University of Dundee, and a consultant with RAB Consultants.

Michael Cranston directs and manages flood risk management projects across the UK and previously worked with SEPA for 14 years on the development of new approaches to flood forecasting and warning.

A Flood and Flood Risk Management Inquiry in 2008 emphasised the need for continual development of flood warning, with the role of flood warning dissemination formalised under the Flood Risk Management (Scotland) Act in 2009. But how effective is Scotland's flood warning system, and how can it be made better, Mr Cranston asked?

Prior to the 2009 Act, some councils and police authorities disseminated flood warnings, with *ad hoc* arrangements across the country. The Act gave SEPA that ability and its system went live in 2011; there are now 26,000 customers of the Floodline service. Flood forecasting systems are constantly being upgraded and surface water alerts are being introduced to extend the service from fluvial and coastal areas. SEPA coordinates with the Met Office for advance warnings and the warning system is now robust enough to provide daily, risk-based flood guidance. Coastal warnings have spread from only the Firth of Clyde in 2008 to the Solway Firth, Moray Firth, Loch Linnhe and the Forth and Tay estuaries.

The service is free and those who sign up receive text alerts that a *Flood Warning* has been issued for a certain area or areas. *Flood Alerts* – flooding is possible – are sent out a maximum of 36 hours in advance. *Flood Warnings* – flooding imminent – are sent out typically 3–6 hours in advance. *Severe Flood Warnings* are sent out when there is a significant risk to life, destruction of properties or local communities. But how is the effectiveness of the flood warnings being assessed, Mr Cranston asked? Around 300,000 messages were dispatched during the Winter Floods in 2015/16, but how do we know whether the warnings had any impact on reducing damage? What type of warnings worked? Were they too frequent or too few? Were they locally relevant enough to change behaviour?

One finding, from a recently completed project for the Centre of Expertise in Water, is that an overall satisfaction rating of 66% had been achieved through the Floodline service, Mr Cranston said. People want warnings and value them. How did they react after receiving warnings? Seventy-one per cent of those who stated they had registered with Floodline, deployed

property-level protection, 62% of landowners moved livestock and 42% moved vehicles. The conclusion is that most customers are happy with the service and do take action. However, they also request more information, better tailored to their local area.

8. Professor Edmund Penning-Rowsell, University of Oxford and Middlesex University

What happens after the flood? The insurance industry gets involved to compensate those who suffer losses – as long as they are insured. According to Professor Penning-Rowsell, the arrangements for flood insurance in Britain overall are strong with a well-developed market and a number of profitable companies; however, the system is far from perfect. Studies show that many low-income households do not insure and the situation is worse in Scotland than in the rest of the UK. One way of addressing this is the recent development of *Flood-Re* – the government-backed levy and pooling system – but, according to Professor Penning-Rowsell, the continued subsidy of flood insurance itself has flaws. It will only last for another 23 years and, perhaps even more crucially, it provides no incentive for those at risk to make their properties more resilient.

Other countries have different flood insurance arrangements. In France, flood insurance is compulsory; in Italy, less than five per cent of the population have it because it is optional. In the UK, those who have insurance have flood insurance because it is bundled in with cover for other perils (e.g., fire; theft). The problem is that if insurance is not compulsory, some people do not take out insurance, usually on grounds of cost, and the Scottish population is a bad offender. “Vulnerability” maps show flood damage is higher in Scotland, yet industry figures show insurance penetration levels are lower – 22.6% do not have insurance, compared to 21.6% in England. Of the poorest 10% of the Scottish population, 54% have no insurance at all, worse than in the rest of the UK. Why is this the case? Because the number of tenanted properties in Scotland is higher than the rest of the UK and tenants take out less insurance. In addition, more of the poorest 10% live in rented accommodation, again increasing the ranks of the uninsured.

So what are the solutions? As mentioned above, two years ago, in the absence of any government scheme at that time, the industry introduced the government-backed *Flood-Re* to help people living in high flood risk areas to afford premiums. This is a system in which a levy is taken from premiums and the money raised subsidises costs for residents of high risk areas. However, Professor Penning-Rowsell argued that subsidised premiums mean that some residents in those areas are not incentivised to pay in the short term for measures that will prevent their homes or businesses being flooded in the future. There is a risk that people will continue to live in flood-prone areas without making self-help improvements for many years. Irrespective of the merits of *Flood Re,* other ways to increase insurance penetration will have to be tried. These could include long-term insurance – rather than annually-agreed contracts, insurance only in winter, or only in real time when flooding is about to occur.

The industry also has another challenge, said Professor Penning-Rowsell. Claims for domestic flood damage are increasing. Average inflation-adjusted losses in 1977 were £5,176, but are £29,596 now because homeowners have more – and more expensive – possessions. “So how we can have affordable premiums when damage costs are going up so much is a mystery to me.”

9. Professor Ioan Fazey, Director of the Centre for Environmental Change and Human Resilience, University of Dundee

Flood barriers and natural flood management both have their place in creating flood resilience. However, Professor Fazey argued that greater resilience to flooding – among other hazards – also comes from greater engagement with the communities involved. This is being increasingly advocated as a way forward for reducing risk and vulnerability to natural hazards, especially with the growing threat of climate change. There are different dimensions involved, Professor Fazey said, including the need for an holistic approach, the requirement to view the work as a complex social process and the ability to navigate the tensions involved.

Why is engagement important, he asked, when making communities more resilient to climate change and extreme weather events? One example is a rural community in the Solomon Islands, in which social and economic pressures were becoming overwhelming. There was a rising population, less space, more cash crops to pay for more people but less space for food crops, and diminishing social cohesion. Once the effects of climate change were added, the community suddenly became even more vulnerable to collapse. Helping to deal with the issues that weaken social cohesion through direct engagement will make that community more resilient to the bigger issues that may confront it, Professor Fazey said.

Many thousands of miles away, the same factors were having an effect on social cohesion in the Scottish Borders, an area prone to flooding because of its fast-flowing rivers and riverside communities. Out of this came the Scottish Borders Climate-Resilient Communities project. This involved three communities with a history of flooding in the Scottish Borders and aimed to understand some of the critical factors that contribute to shaping community resilience in the context of climate disadvantage. The project aimed to understand how community resilience to climate change could be developed in different local contexts in practice, by supporting and facilitating engagement between members of local communities and other stakeholders, as well as drawing out lessons for policy makers and practitioners on how to support the development of community resilience in the context of climate change.

The project was structured around nine workshops (three per community) that brought together different organisations to examine issues and develop actions to build community resilience. A tenth workshop used the outcomes from the work within the communities to examine how a more integrated national policy landscape in Scotland could be developed.

As Professor Fazey made clear, the process is far from easy. Time has to be taken to build solid relationships. There is a significant need on the part of practitioners for facilitation skills and the capability to work through inevitable tensions. It can be a “messy” process, he concluded, but the opportunity for meaningful change makes it worthwhile for all involved.

Q & A

Q: When getting communities on board, how do you deal with preset views?

A: You go in as a learner. You need to understand the facilitation process and you have to be independent.

Q: How far away are we from getting useful information on surface flooding?

A: We still have some way to go on this. Warnings need to be more local and applicable to individuals. At the moment they can be too broad and not relevant enough.

Summing up the Conference proceedings, **Professor Roger Crofts FRSE** said that the following key points emerged:

First, existing scientific information and knowledge provides some clear messages, but cannot provide unambiguous answers, on flooding trends. Flooding has been evident over many generations and present trends are consistent with those from the past. Spatial variation in flooding is significant. Assessment of ocean and atmospheric circulation patterns gives predictions of more extreme precipitation events;

Secondly, living with flooding is a reality and should not be confused with the apparently unresolved arguments about the link between climate change and flooding;

Thirdly, it is vital that households obtain flood insurance, most especially lower-income households living in tenanted property;

Fourthly, great advances have been made in recent years in identifying the flooding problem, with more spatially-specific data and development of flood risk modelling;

Fifthly, flood warning systems are now more advanced but higher sign-up levels are needed;

Finally, to make progress in living with flooding, more integrated solutions are needed through natural flood management (recognising its limitations) and nature-inspired engineering, throughout catchments, especially focusing on intensively-managed land and on impermeable surfaces in urban areas, and meaningful involvement of all stakeholders (decision makers, affected households, land holders especially) throughout the process of assessment and management.

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Public Discussion Forum

How can we learn to live with floods? Challenges for science and management

Wednesday 15 March 2017

Report by Jeremy Watson

Chair: **Professor Garry Pender**, FRSE, Head of Environmental Engineering, Heriot-Watt University

Panel: **Professor David Balmforth**, Executive Technical Director, MWH**;**
Professor Edmund Penning-Rowsell, Oxford and Middlesex Universities**;**
Kirsty McRae, Scottish Flood Forum**;**
Jim Densham, Royal Society for the Protection of Birds**;**
Professor Chris Spray, Chair of Water Science and Policy, University of Dundee.

Professor Pender set the scene, explaining that the flood events of 2015/16, which particularly affected the northeast of Scotland, the southwest and the Borders, had injected urgency into the debate on living to learn with floods. Are our current flood defences doing their job, or is there a need for a different approach that can limit the damage caused by excess water flowing through our streets? Five experts were invited to give their views.

Professor Balmforth opened proceedings with a slide from Keswick, in northern England, that showed that even though flood walls had been built along the town's riverside, they were not always big enough to cope – water was pouring over the top. That is a "good illustration", he said, of why we now need to look beyond the flood management techniques in use in the UK, particularly as climate change was likely to exacerbate the problem in future years. We have to build flood resilience into our communities in different ways, but we should still not expect to protect everyone, every time, from floods.

Professor Penning-Rowsell said his concern is the flaws in the insurance system that pays out to compensate for loss after floods. Flood risks are no less in Scotland than in the rest of the UK, yet too many people north of the border are uninsured. Of the poorest 10% of the population, fully 54% do not have insurance – more than in other parts of the UK – which is a problem, because flood insurance is bundled up with other forms of insurance. Scotland also has more tenanted properties, which also means fewer insured households. Although the insurance industry introduced *Flood Re* in 2015 – a system in which there is a levy on premiums to reduce crippling payments in high risk areas – it will only last for another 23 years and is a

disincentive for homeowners to self-help. In addition, it is only available to those who actually take out insurance.

The Scottish Flood Forum works within communities to help those affected by flooding in whatever way possible – whether it be dealing with claims, navigating *Flood Re* or hiring contractors. **Kirsty McRae**, the Director, said how devastating flooding can be can be gauged by the fact that some people affected by the 2015/16 floods have still not returned to their homes. Although the science of flood management is improving, it is the social impact that is most important. Better planning and communication is needed to overcome recurring problems of getting people back on their feet and back in their homes.

For **Jim Densham**, speaking for the RSPB, climate change, and its impact on severe flood events, threatens the survival of iconic bird species and the wider countryside. One example of a return to natural flood management that has been successful is the removal of a sea wall in Nigg Bay and the subsequent return to salt marsh – a natural flood absorber – of the land behind. As the farmer involved lost agricultural land, there were negotiations to be held. Millions of pounds every year are given to farmers and landowners, to subsidise crop growing. Perhaps the emphasis should be more on payments for the other benefits that land can bring to a wider population.

Chis Spray is another advocate of natural flood management. To him, that is simply part of a whole catchment approach that begins with scrutinising catchments upstream of flooded towns and communities to see how the 'natural characteristics' of the catchment landscape could potentially be used to help temporarily store or slow up the flood waters. Simply building walls to hold back floods is no longer enough, he said. That structural approach should not be abandoned, because it is part of the solution, but we have to look at different ways of tackling the problem, starting with the upland sources where floods are generated, as well as addressing the river channels which act as pathways for flood waters. This could include building retention ponds in rural areas, restoring meandering rivers or even taking down flood walls and reconnecting rivers with their natural flood plains. The challenge is to bring farmers on board and decide who pays for the changes. And, Professor Spray asked, is this sustainable as the long-term approach?

Q & A

Q: There does not appear to be any difference in building regulations in flood plain areas. Should we make sure there is a difference?

A: David Balmforth: If we are going to build on flood plains then, of course, the building regulations should be different. Different, flood-resistant materials should be used on ground floors, for instance. People should not be afraid of doing that. We may have to build in flood plain areas for several reasons, but the buildings must be suitable.

Q: If a building floods regularly, does it become uninsurable?

A: Edmund Penning-Rowsell: No. There are specialist insurers; more likely are problems with mortgage providers.

Kirsty McRae: *Flood Re* should help with this.

Q: Is it correct that rented properties are not covered by *Flood Re*?

A: Edmund Penning-Rowsell: Yes. Tenancies are considered to be commercial ventures so landlords are excluded as small businesses. However, tenants can insure against damage to contents.

Q: Ballater [Aberdeenshire] suffered considerably in the 2015/16 floods. The 2009 Act states that SEPA should work together with local communities on solutions. Yet no proper flood warnings were given and, after the event, engagement with the local community has been poor and has reached an impasse. How can we get out of this situation?

A: Chris Spray: The 2009 Scottish Flood Risk Management Act requires that the various responsible authorities have to work in partnership with the local community. However, if the authorities come up with a top-down engineering solution while the local community has other ideas, then potentially there is going to be conflict. Locally-focused Flood groups are part of the way forward. SEPA has now become very good at engaging and I hope this particular problem can be moved forward.

David Balmforth: It is a big challenge sometimes for professionals to engage with communities. It takes time to build up relationships.

SEPA representative on question posed on behalf of Ballater Flood Group: What happened in Ballater was terrible. The speed and the depth of the flooding was traumatic and it happened in an unexpected way because of a breach of an embankment. We did issue flood warnings, but they may not have been at the right level, and that is something we are working on. We are working with the local council and community groups in the aftermath. I totally understand the frustration of the community, but we have to make sure the solutions we arrive at are the right ones.

Q: What confidence should we have in flood defences, when they appear to fail so often?

A: Edmund Penning-Rowsell: In 2014, there was big east coast storm surge and, by and large, the defences held. But will they hold in future? What we have to ensure is that they are continually fit for purpose.

David Balmforth: There is a view that if you are behind a flood wall then you won't get flooded. However, we know that they have their limits and they do fail. If you do get flooded, then there is

no point in replacing like for like because the same thing is likely to happen again next time. Properties have to be converted quickly to give them more flood resilience.

Jim Densham: We should not have a system that depends on landowners putting up barriers as a solution. We should instead pay farmers to allow their land to flood.

Q: Are beavers good or bad in alleviating flooding?

A: Chris Spray: It depends. Some landowners may not agree, but as a scientist, he would argue that their presence is beneficial to flood risk management. Their river engineering activities, such as building dams, helps slow the flow, while they also bring benefits for the local ecology. However, it is also clear that they can cause damage, so their presence has to be carefully managed. Beavers have been reintroduced into many, indeed most, other countries across the whole of Europe and there is a growing body of evidence as to their benefits, alongside practical experience in active management of conflict.

Jim Densham: You don't have to pay them and they do their own maintenance, so they have to be a good thing. As long as they are in the right place, they can do fantastic work.

David Balmforth: My worry is that you would need an awful lot of beavers to have a real impact.

Q: Should people buy houses in flood risk areas?

A: David Balmforth: We should certainly make it clear to buyers that they are buying in a flood risk area. We have made big strides in flood risk management planning, but that information needs to be made more widely available.

Kirsty McRae: It is difficult if people keep buying houses in flood-prone areas. What we need is much more information available to buyers in documents such as Home Reports. The information is out there, but is not necessarily getting to the right people.

Q: Around 110,000 properties in Scotland are at risk of flooding. A much smaller number are at high risk. Not all of the owners will take steps to protect their properties. Do we need to address that gap or do we hope that *Flood Re* is sufficient?

A: Kirsty McRae: Yes, we do need to address that gap. We need flood resilience measures in all of these properties. But there has to be financial help.

Edmund Penning-Rowsell: I suspect that most of those 110,000 properties are only at risk during rare, extreme events. Do we need to do anything about it? What we need is better information on the degree of risk.

David Balmforth: I am a homeowner. I have looked at what would happen if my land flooded and what action is needed to prevent damage. If everyone did that we would not have such a big problem after flood events.

Q: I am a farmer in receipt of subsidies. Brexit may change that. When it comes to natural flood management, how will you induce farmers to go along with that?

A: Chris Spray: Work by Dundee University and others supported by the Scottish Government has explored with farmers their attitudes to the introduction of different types of NFM, including the cost to the farm business, and how they might wish to be paid compensation were different measures to be introduced. In the US, they frequently use land easements as a means to promote the sustainable management of waterside land for water quality, conservation and flooding benefits. This means that if a famer sells the land, conservation easements go with it.

(This has tax benefits for the owner). So there are methods. What we really need to do is ally science and engineering with working with people on the land. Brexit may change the current subsidy system, but this can be replaced. In the future, we may need to see this as farmers being paid/subsidised to 'farm' flood control (rather than other crops or livestock) as part of their farm business.

Jim Densham: Parliament is already talking about payouts for carbon sequestration. Equally, we could have payouts for flood risk management. We need this kind of contract with farmers.

David Balmforth: We could do this (pay farmers to manage flood risk), but my concern is that 30 years down the line we will realise we are importing 80% of our food.

Q: Should curtilage measures be incentivised in towns?

A: David Balmforth: Yes. There is a lot we can do in terms of properties and streets. What would it take to persuade homeowners to capture the first 15mm of rainfall?

Q: Where is the excess water coming from? Is it from sporting estates, too many deer, dreadful upland forestry, or wind farm developments with miles and miles of roads? Do we need to nail this down and make sure people pay for bad management?

A: David Balmforth: There is an argument that the polluter should pay. Should flooders pay? If they are made to do so, then the money should all go into a pot to be spent on flood alleviation measures. If a landowner comes up with flood alleviation measures, then they should be able to dip into the pot. We need creative solutions.

Q: Are there any restrictions on building on flood plains?

A: Yes, Scottish Planning Policy provides the framework for managing development in areas at flood risk. No development should take place in areas of highest risk and key infrastructure, such as schools and hospitals, should only be built in areas beyond the flood plain. Planning authorities follow this advice when making planning decisions.

The Vote of Thanks to all the speakers, chairs and other contributors was offered by Professor Garry Pender FRSE, after which the discussion forum was concluded.