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WATER, WATER EVERYWHERE (AND NOT A DROP TO DRINK)

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ROYAL STATISTICAL SOCIETY, 12 ERROL STREET, LONDON, EC1Y 8LX

This meeting shared four complementary perspectives on flood and drought risk: that of a statistician, an engineer, and an Environment Agency manager alongside other thoughts on broader issues relating to the insurance industry, housing and design shared by a senior academic researcher/professional consultant.

“Floods, Droughts and Fat Cows” (*Richard Chandler, Department of Statistical Science, University College, London*)

We discovered firstly that Richard’s presentation title reference to ‘fat cows’ was related to (possibly) the earliest long-range drought forecast - Joseph interpreting Pharaoh’s dream! He also reminded us that (fortunately) dreams are very rarely used to forecast droughts and floods now and that we rely mainly on the deployment of physical and statistical techniques.

Rain (and where it goes).....makes all the difference

If only it were as simple as too much rain leading to floods and too little rain leading to droughts. Instead, to comprehend why, for example, in August 2004 Slaughterbridge experienced a similar 2-hr rainfall to that at Boscastle but did not experience flooding in the same way, we need to understand more about the different types of rainfall and where the rain goes. A review of the events leading up to the UK floods in Boscastle in August 2004 helped to explain how a lot of factors came into play at a similar time: a rainfall of 60 mm of rain in 2 hrs (a total of 200 mm in 24 hours when the August average is around 150mm), the geology of the area (mostly shale and slate terrain which did not absorb water easily), waterlogged soil after previous rainfall and narrow valleys into which water flowed raising the river level by 3 metres.

An even more recent view of the weather episodes in late 2005 and early 2006 leading to the current forecast of water shortages in Southern UK this Summer brought the impact of different types of rainfall closer to home. All present were familiar with the below average rainfall in early 2005 leading to low groundwater levels at the end of the Summer 2005, a dry winter with little groundwater recharge and an above average rainfall in February this year. Groundwater levels have risen but have still left reservoirs low and as we are now well into the growing season, increased transpiration has made any groundwater recharge very unlikely. This all spells trouble.

A very brief summary of hydrological measurement and hydrological modelling approaches followed with an explanation of the path to better understanding of what the future might hold as offered by physical models. The latter were underpinned by standard statistical models paraphrased as ‘the past is the key to the future’ and mathematical models paraphrased as ‘what happens next depends on what’s happening now’.

Forecasting and predictions?

Richard explained that even these models could only be approximations of reality and that all models cope best with ‘smooth’ quantities such as temperatures and pressure; they tend not to reproduce

precipitation well. At 0400 hrs on the day of the Boscastle flood, the Met Office had been able to forecast the heavy rain which occurred later in the dayhowever, they were unable to pinpoint the location of the heaviest rainfall in advance. Nevertheless the forecast did mean that flood warnings were issued, emergency services were placed on standby and many lives were saved.

Looking ahead to the longer-term, it is clearly impossible to produce exact predictions of weather in say 30 or 50 years' time. What is usually done, therefore, is to try to determine how a particular greenhouse gas emissions policy would affect climate over a long period (often 30 years). The Intergovernmental Panel on Climate Change produces regular summaries along these lines; its last report in 2001 indicated big discrepancies between different models' projections of global mean temperature change over the next century, and even less agreement over precipitation. The Panel's next report is due in 2007 (a press release was issued on 1 March 2006) and it suggests smaller discrepancies. Richard pointed out that this is not the same as reduced uncertainty.

For the non-statisticians amongst us, Richard described the basic idea of the statistical model – one which describes patterns/frequencies in past data and represents uncertainty using probability. An example would be referring to a '70 % chance that rainfall will exceed x' which can also be related to other quantities i.e. we can use current ocean temperatures to forecast probabilities for rainfall in 6 months' time.

He made the case, however, for combining physics and statistics to get nearest to giving future scenarios for selected variables and then giving associated probability distributions. DEFRA and the Environment Agency are moving towards continuous simulation: the generation of long sequences of synthetic rainfall data which can be run through hydrological models.

We looked at a statistical model for a project at Manchester airport which was based on daily rainfall related to gridded monthly temperature, pressure and humidity (TPH) and the future TPH from a Hadley Centre physical model. The model simulates rainfall for past and future periods and produces many "equally likely" simulations leading to probability distributions for any quantity of interest. Its conclusion is that there is a tendency for wetter Winters and drier Summers in future. Indeed, this is the general opinion concerning the long-term i.e. that global warming will lead to warmer temperatures, enhanced evaporation: less groundwater recharge (leading to increased drought risk), more convection, hence intense rainfall (leading to increase flood risk) and sea level rise (leading to increased risk of coastal flooding).

However, Richard pointed out that the effects will not be the same across the UK, and we can only think sensibly in terms of probabilities i.e. we cannot say with certainty that x or y happened because of climate change but we can say that "if the climate changes as predicted then this kind of thing will be more common".

The big challenges for scientists are the uncertainty attached to the differences between climate and hydrological models and inexact measurement. In addition, there is a need to demonstrate that uncertainty assessments are credible, and to agree on the research priorities that will bring most benefit in the short-term. A further challenge is to convey information to stakeholders (including the public) in a way which is readily understood. For the public one of the challenges is asking questions that both test scientific thinking and encourage responses which are convincing.

However, ultimately, we all (the public and scientists) have to learn to live with uncertainty.



“Flood Risk Management” (Professor Jim Hall, School of Civil Engineering and Geosciences, University of Newcastle)

The legacy of 1953

Coastal floods of 1953 in which 307 people drowned in England and over 1800 in the Netherlands were instrumental in initiating the modern era of coastal flood management in the UK and Netherlands. The Thames Barrier, opened in 1984, is the most striking element of the engineered flood defence system designed after 1953, which is still serving London well. Current projections indicate that, whilst sea level rise means that the standard of protection is deteriorating, the barrier and neighbouring flood defence system will still in 2030 protected against a flood that is expected to occur on average once in 1000 years.

As well as the loss of 1,800 lives, the 1953 floods in the Netherlands inundated over 150,00 hectares of land, demolished 9,000 buildings and caused 67 breaks and hundreds of kilometres of heavily damaged dikes. The floods raised mathematical problems which were statistical, hydrodynamic and related to economic decisions and a Delta committee consisting of hydraulic engineers was appointed with the aim of designing measures to prevent similar disasters in the future.

In the Netherlands, beach sand dunes were raised by as much as 5m and the islands in Zeeland were joined by a series of dams. The polders -reclaimed land -involve the construction of dikes back to the mainland, draining the land in between to create areas where housing is built. To prevent the coastline from being swept away, sand spraying was introduced in 1990. The project involved transporting millions of cubic metres of sand and adding them to coastal areas.

Modelling Scenarios

Jim has worked and continues to work with both DEFRA and the National Assembly for Wales on their policies to "reduce risks to people and the developed and natural environment from flooding and coastal erosion". He described the responsibilities and remit of bodies at different levels from the national level (where national policy and long-term expenditure, planning and monitoring need to be decided) to the scheme/asset level where decisions need to be made about individual assets: companies, homes etc. He shared various scenarios focused on Pensarn and Kinmel Bays which showed the possible effects of waves, surge, a marine storm or indeed rainfall or fluvial storm on receptors such as people, houses, industries, infrastructure and ecosystems. Scenarios relating to engineering responses were also shared....and how decisions needed to be made about where and to what extent hard defences needed to be put in place to protect areas of high economic value and even to retreat/abandon certain areas.

Recent Office of Science and Technology's Foresight programme data show a comparison of Expected Annual Damage (EAD) for today compared to the 2080s as a percentage of GDP. These forecast a very significant increase in flood risk in world markets, the very area in which it might be possible to reduce flood risk by up to 25% if we were able to achieve a substantial reduction in emissions.



“Developing Evidence-based Policy: Sustainable Communities and Flood Risk” (Gary Lane, Environment Agency)

Gary explained that whilst the Department for the Environment, Food and Rural Affairs (DEFRA) and the Welsh Assembly Government are responsible for high level policy and strategy, laws, charges and appeals, the Environment Agency (the “Agency”) is responsible for translating law and Government policy into Agency policy and implementing it. It took on the responsibilities of the (now defunct) National Rivers Authority in 1996. Its remit is to improve the environment in England and Wales. Its vision is a better quality of life for everybody and an enhanced environment for wildlife.

The Agency is the single largest flood defence authority in England and Wales. It shares responsibility for this service with over 400 local authorities.

Taking the view that extreme floods will happen it is just a matter of time (!), the Agency aims to stop inappropriate development in high risk locations, to develop a timely and accurate flood warning system and to deliver sustainable investment in new defences. It has around 80% of the total Government funding for flood defence but the decision concerning how this is spent belongs to a number of Flood Defence committees.

Forecast of annual flood damage

The Office of Science and Technology recently estimated that the impacts of climate change could increase flood risk to £ 27 billion by 2080, up from just (!) £ 1.4 billion today. In England and Wales over 4 million people are at risk of flooding, property worth over £ 200 billion is at risk (a flooded semi-detached house will cost £ 15-£30k to repair).

Gary had prepared the Agency’s response to the floods in 2000 when 700 locations across the UK were affected by unprecedented rainfall, 10,000 homes and businesses were flooded (32% other than by significant rivers) but 280,000 properties were protected. The report had been written at a time when the Agency had just produced indicative flood maps and published these on internet; nearly one million map pages were served on launch day (7th December 2000).

The Agency now has both a large annual national awareness and education programme and decides where strategic flood risk assessments are needed, undertakes these assessments and develops regional strategies - planning at a regional and local level is absolutely key and engaging local authorities is vital. (He noted that in New Orleans, the local authorities were nearly invisible and local communities were left to fend for themselves).

DEFRA advocates a holistic approach that addresses all forms of flooding including fluvial and coastal flooding, and coastal erosion, through a range of Government policies. Sustainable development across flood and coastal erosion risk management policies are key and involve the Environment Agency being given a stronger strategic role in relation to all forms of flooding as well as coastal erosion.

As just one example of the work of the Agency we looked at one of its bigger programmes: Making Space for Water. This programme has a 20 year vision and includes a number of key themes. The theme ‘Holistic approach to managing flood and coastal erosion risk’ includes projects on urban flood risk and integrated drainage, risk mapping, groundwater flooding and land management. The theme ‘Achieving Sustainable development’ includes projects on building stakeholder and community engagement inter alia. The theme ‘Increasing Resilience to Flooding’ includes projects on resilience standards for new buildings and emergency planning response inter alia. The programme also has a remit to increase investment.

New flood map

5 million people in England and Wales live in the natural floodplains. The Agency has replaced an earlier 'indicative floodplain map' with a new flood map which enables homeowners and businesses in the floodplain to see not just whether their area is at risk, but what level of risk is carried. These maps are there to inform the public and local authority planners of potential flood risk, and also to encourage a dialogue with the Agency concerning the issues relating to new developments.

The likelihood of flooding has been calculated taking into account proximity to rivers/the coast using predicted water levels and taking the location, type and condition of flood defences into account. Low flood risk zones (zones 1) have a less than 1% chance of a flood occurring each year, and high flood risk zones (zones 3) have a more than 1% chance of a flood happening (in river areas) and a 0.5% chance in coastal areas. A 'Significant' risk means that the annual chance of flooding in that area is 1.3%, or a 1 in 75 chance of flooding each year. People living in these areas should know what the flood warning service is in their area, prepare a flood plan and find out how to make their home more flood resilient. A 'Moderate' risk means that the chance of flooding each year is 1.3% (1 in 75) or less, but greater than 0.5% (1 in 200). A 'Low' risk means that the chance of flooding each year is 0.5% (1 in 200) or less.

Sequential testing of new developments

Land use planning – in particular ensuring the sensible location of new developments - is the single most important factor in preventing flood risks increasing. The flood map enables the Agency to apply a sequential test to new developments, steering them firstly into zone 1 areas, then if no reasonable options are available, zones 2 and then 3 are carefully evaluated according to the type of development and residual risk.

Obviously defences cannot be built higher and higher and the long-term viability of a community and the cost of providing defences have to be considered. The Agency and stakeholders are looking to encourage resistance and resilience being built into the design of new developments. A considerable investment in the Thames/Olympic Gateway over the next 15 years is just one example of the work of the Agency to ensure that the best of streamlined flood defences and planning control are put in place in new development zones.

Gary said that more clarification is needed concerning responsibility for groundwater flooding (there is no one authority with control or mitigation for groundwater flooding). There also needs to be a better balance between the remaining risks and the extent to which that risk is insurable.



“Are insurers getting out of their depth?” (Professor David Crichton, Visiting Professor, University College, London and the University of Middlesex, Honorary Research Fellow, University of Dundee and Fellow of the Chartered Insurance Institute)

Insurers’ detailed mapping

Insurance companies are not getting out of their depth! David noted that the Environment Agency flood maps had been based on earlier work undertaken by an insurance company. Insurers are now mapping flood risk areas in considerable detail right down to the level of the individual property so that the premium is very closely tied in with risk actually carried (i.e. homeowners who are at risk are not being subsidised by those who are not to the same degree as even just a few years ago).

Whilst it is still marketing departments which make the final decision on the premium. Insurance companies are making full use of new technology. In the past decisions were based on underwriters’ calculation of the average historic claims costs, plus loadings for inflation, expenses, reinsurance and profit..... (it is now generally not so easy to calculate claims based on historic claims as climate change is making the past an unreliable guide to the future)....now traditional underwriting calculations are supplemented by a range of sophisticated measures and mechanisms (including e.g. Satellite InSAR to monitor ground subsidence which this methodology can do - down to the level of sub millimetre per year!).

The Risk Triangle

Insurance companies are also collecting data to quantify the exposure and vulnerability. David talked us through the Risk Triangle of: exposure, vulnerability and hazard - a helpful analytical tool and a possible framework for adaptation and modelling. The idea is that the area of the triangle represents the “risk”, while the sides of this triangle represent the hazard (e.g. flood water), exposure (e.g. if your house is on a floodplain), and vulnerability (i.e whether the house has been flood proofed). Altering any side of the triangle (hazard, exposure or vulnerability) alters the risk. Tying in exposure and vulnerability data gives much more reliable data on the true costs of flood damage for different types of properties/flood events. David’s view was that the data the government uses for assessing the value of building flood defences may not be so reliable.

Insurers are not keen to withdraw cover, but they do need to price cover to reflect the risk and are increasingly doing so. Truly affordable flood insurance is probably now a thing of the past and getting flood insurance at any price may be a problem for some.

We considered the “insurance template”: the maximum exposure for insurers to write flood risk at normal terms. We also looked at the likely cost of a policy to protect against a 1 metre deep flood. A flood of this kind will, on average, cost insurers over £35,000 (buildings and contents) in the Summer and more in the Winter when drying out times are much longer. In the Carlisle flood in January 2005, typical claims cost £50,000 (!) and many families had not returned to their homes a year later.

This year, it was decided that insurers do not have to quote for homes in high flood risk areas. If the risk for them is too high, they can withdraw cover. Increasingly insurers are also managing the risks by influencing local planning authorities (at least in Scotland this is very evidently the case).

Where to build?

However, with the pressure for more houses in England and Wales, more are being built in low lying flood risk areas (again, Scotland is a different case - there has been no new building in high risk areas).

In 2003, the Environment Agency was asked to advise on flood hazard for only 53% of major developments and 56% of local authorities ignored Agency advice when they received it. 600 developments were permitted on flood plains in England and Wales against Agency advice. We were all further astounded to hear that whilst developers can appeal against Agency decisions, local residents cannot appeal.

UK Insurers Flood Claims Database

UK Insurers have pooled their knowledge on claims costs and the industry now has the world's biggest flood insurance claims database. The industry is able to influence local authorities in a bigger way. David suggested that insurers are able to map exposure more accurately than the government, and, therefore, has the opportunity to manage the situation as they have the ability to influence local planners. Indeed this really does appear to be the case as in nearly 40% of cases in Britain, local authority planning decisions now follow insurance guidelines.

(Let's not forget) human factors

We saw some disturbing figures concerning particular human factors relating to floods particularly in relation to the percentage of flood survivors who report post flood health effects such as stiffness in joints, depression and stomach troubles20% of flood survivors suffer from gastro-intestinal problems and it is no wonder! perhaps it is only those who have experienced a flood who are aware that the water that enters their home is often contaminated by raw sewage! Sewage pipes in England – particularly the Victorian ones - are becoming dangerously overloaded. Property developers do not have to worry about building sewage pipes. Water companies do.

Although In Scotland development is not allowed unless the sewage system has spare capacity.....they have their own problems there too. During floods in Dundee two years ago, the new sewage system put in place in 2002 and designed for a 10-year flood event, faltered, creating a huge amount of work for drainage engineers and even more food for thought for sewer designers.

Design is key – the Canadian approach

Sewage system design is clearly key. So is building design.....whilst the Thames Barrier is a major design achievement, it was not designed for a 5 metre storm surge (along the lines of the one experienced in Denmark in 1999).

We saw a slide of the Thames River in Central London looking more than a little green, peaceful and without buildings.....our audience became extremely puzzled. Less so, however, when they learnt that this slide was of the Thames in London, Ontario, Canada – where the 'forest city's' policy since 1954 has been to not build in the 250 year floodplain and to buy up at market rates and demolish any existing property in the floodplain whenever it comes up for sale.

Climate change on the move.....

David's presentation gave us further food for thought (and reminded us of causes for concern). He described a world of hazards: increases in severe rainfall events, rising sea levels, increased wave heights, increases in the severity of storm surges, droughts and higher temperatures, and moreover inadequate drainage systems. Climate change seems to be moving North at the rate of 6 miles per year. Birds and fish are just about managing to keep pace with the rate of change but land animals, insects, habitats, houses and the wider infrastructure around them are not. With wetter winters and drier summers, the effects of the floods in Carlisle in January 2005 which resulted in 4,500 properties flooded, 10,000 homeless and insurance claims costing £250m, may be typical of the type of incidents we will see in the future if more is not done.

Scenario modelling

During the 20th century, the global sea level rose by around 20 cm, a rate that may be higher than at any time during the past thousand years. Were the major ice sheets of e.g. Greenland and West Antarctic (WAIS) to melt these would raise sea levels by several metres – if Greenland or WAIS were to melt this would effect a 7m sea level rise, if both melted, this could lead to a sea level rise of around 13m.

The Benfield Hazard Research Centre and UCL had produced three 'what if?' scenarios, showing the effects of 7m, 13m and 84m sea-level rises on the shape of the UK. When combined with the melting of either the Greenland or West Antarctic ice sheets and sea level by around 7m – sufficient to inundate many of the UK's coastal towns and cities. If both melted, then a rise of around 13m could occur. The 7m scenario would place Peterborough on the coast and melting of the gigantic East Antarctic ice sheet (EAIS) too could lead to a cataclysmic rise of 84m, which would drown much of Eastern and Southern England and separate Scotland from England and Wales.

David's view was that whilst it is too late to stop climate change, there is more that we could do to adapt to it. Exposure and vulnerability is increasing, and insurers seem to be doing more than government. Our modern houses with their reliance on chipboard and electronics are not resilient to floods or storms. If we are not willing to consider a future where we live in houses on stilts, then we need to get architects, planners and insurers to work together. Much more research needs to be undertaken.



Discussion

(Some excerpts from the audience-panel discussion that followed)

Q. What advice can the public now believe?

Gary Lane said that the Environment Agency has a responsibility to raise awareness of the risks (until 1996, the now defunct National Rivers Authority held information but had a different remit and the 'climate' in all senses, was different).

David Crichton pointed out that a person buying a house cannot be expected to be an expert in these matters and they have to be able to rely on local authorities and wider regulating bodies to keep them informed and to advise them. The possibility of people living in houses which are uninsurable, in potential danger and which they cannot move out of is one of the things which will really engage the public and bring the issues more directly to the attention of local authorities and planners.

The relationship between the planner, developer and architect is a key one. It is possible, in certain circumstances, for a buyer to sue a developer/planner/architect if he/she finds him/herself in a position where there is a flood risk attached to their property and they were not made aware of it. Already in some cases architects have decided not to proceed with a development because they cannot get professional indemnity insurance and this was deemed by one panel member to be evidence of insurers' influence starting to have some effect.

Gary and David both made reference to the excellent review undertaken by the Environment Agency into different types of kitemarked products which could serve as DIY defence for those at risk of floods.

The proactive use of products such as these has, in some cases, affected insurance premiums. David was, however, concerned that following the Autumn 2000 floods, many vulnerable people felt that it was incumbent upon them to purchase these items and although their anxiety levels may have dropped, in many cases it was not clear how much their level of defence had really improved and also whether the advice they received covered standards of installation sufficiently well.

There are tighter regulations in Scotland where defences invariably have to be designed to take climate change into account. In Scotland there is both a stronger dialogue with insurers...and more generally the view is taken that flood defence funding will not be forthcoming unless the defence offers at least 100 year protection++.... Almost every Scottish local authority will not allow new developments where the flood hazard exceeds 1 in 200 years. In comparison, the Jubilee River scheme which was designed to protect Windsor and Maidenhead in Berkshire only offers a 60 year standard of service and will not make it any easier for local residents to obtain insurance!

Q. Do the Dutch have any option other than to build higher and higher sea defences?

Jim Hall said that as Holland is Europe's most densely occupied country, and two-thirds of the Dutch live below sea level, the population is heavily dependent on engineered flood defences. Much of the Dutch coastline is a dune coastline so they do not have as many options as in the UK, however, they do not necessarily have an unsafe future and some of their approaches are ones we, in Britain, may find ourselves gravitating towards. Given ongoing climate change – involving a rise in the sea level alongside a sinking Dutch land basin - raising the level of dikes alone is longer sufficient. The focus has more recently shifted to controlled flooding of rivers 'a making room for rivers policy' to minimise damage. Now in the event of extremely high water levels, the Netherlands is investigating the use of emergency flood areas - giving rivers more space – and plans to use this approach if water levels in key areas rise too high.

Q. How can we make our case to government ensuring that it takes responsibility for its role in relation to climate change and the effects on the environment? (*question raised from the perspective of an environmental action group*)

Richard Chandler suggested that the best way to make a case to government is to refer to the particular risks attached to an event and how those risks were managed but it would not be possible to attribute particular events to government. (*The response was to suggest that attribution is important and if you do not do this then MPs/others cannot be held directly responsible for their lack of action in relation to climate change*). Richard further clarified that it is extremely difficult in statistical or factual terms to say exactly which of several factors led to an event happening. It is best to say 'if you do this, the probability of such an event in a particular time period is x'; you cannot, for example, directly attribute responsibility for the Boscastle flood to any one party.



N.B. Whilst the Royal Statistical Society very much welcomes the opportunity to provide an open forum for fresh thinking concerning issues of scientific import, the accounts and concerns raised during this event do not necessarily reflect RSS thinking or policy.