Drought Symposium: Drought Risk and Decision Making

7th of September 2015, Exeter College, Oxford

Summary of Oral Presentations

By Alice Chautard, with inputs from Franziska Gaupp, and Helen Gavin

Jim Hall, University of Oxford: Introduction

Introduction:

- Looking at drought from a combination of perspectives (and in fact a highly interdisciplinary combination of funders supporting the project)
- Aims to develop the thinking, methodology and framework to inform risk-based decision making i.e. making use of some explicit analysis of impacts form a range of different perspectives (economic, social, environmental)
- To some extent risk-based decision-making is happening already (e.g. 2009 Water Resource Plan) BUT there is still some disconnection between water resource planning and drought planning. Besides, the process is overall utility focused with limited quantification of the scale of different impacts.
- Thanks to funders.

Helen Gavin, University of Oxford: Introduction to UK Droughts and Water Scarcity Programme

Presentation of UK Drought and Water Scarcity Programme, and the four projects it has funded:

- *WP1*: Analysis of Historical Drought (in a nutshell: aiming to understand past drought, and how we reacted to them, to be better prepared for future droughts and thus shape our policies). Led by Jamie Hannaford at CEH
- *WP2*: Forecasting Drought (in a nutshell: improve forecasting of drought). Led by Len Shaffrey at University of Reading
- *WP3*: Impacts of Droughts – 2 projects. DRY: looking at social and physical science elements, led by Lindsey McEwan at UWE. And the MaRIUS Project, led by Jim Hall at the University of Oxford.

Christina Cook, University of Oxford: Regulatory governance arrangements for water scarcity and drought in the UK

- Research focuses on: understanding how drought and water scarcity are regulated in the UK: how the law works in practice; regulatory tools as part of a wider governance space; How can are environmental science and economic knowledge used and can they be better connected;
- She reviews the different actors involved in the governance space, and the relationships they have with one another. She then reviews some of the main tools used for governing and regulating water services, and presents some of the findings of her research.
- Notes on the governance space:
    - The department for environment, food and rural affairs is the lead government ministry;
    - On the regulatory side: environment regulator, water quality regulator; economic regulator;
    - The Environmental Agency;
    - Water and Supply providers;
    - consultants
- Mapping the governance space – how:
    - Looking at droughts planning; EA Abstraction reforms; historical experience of drought permits and orders (2003-06; 2010-12 droughts).
    - *Methods*: Academic literature, government policy, company documents, regulatory analysis (law and regulation), empirical work (interviews: water company, water regulators, companies, farmers etc.)
- Main pieces of legislation: Water Industry Act 1991 (what companies need to do):
- Mapping drought planning in England (relations between different actors)
    - Black box: much of the planning is subject to administrative law review.
    - EU: no specific water scarcity and drought directive, but WFD, SEA and HRA
    - Defra has legislation: Water Industry Act, policies based on white paper that frame drought planning

- EA: provide a guidance document that water companies can use when drafting drought plans;
- Drought Management Options:
  - Demand type measures (incl. hose pipe bans) vs. supply type measures (incl. drought orders and permits). **Main findings**:
    - *Temporary use bans* – findings: companies apply them in many different ways and for different reasons (only for domestic use; each company uses different 'formula' different combination of measures;
    - *Drought permits* (companies apply for DP from EA):
    - *Drought orders* can restrict use or impact abstractions and discharge (ordinary or emergency DO);

    → *Context is key; one size does not fit all; past experience of drought is very important in how companies develop their drought plans;*
- **Role of Consultants is key**: they have major relations with the EA, Ofwat, water companies and virtually every actor of the governance space; bring invaluable expertise;
- **Other finding**: variability in relationship between EA and water companies (places where this is working well, and others where it isn't necessarily so).
- How environmental science and economic knowledge are used – e.g. strategic environmental assessment: how are companies are understanding the value of these tools, when do they use them or not. Work in progress.

Benoit Guillod, University of Oxford; Western US drought attribution, and the generation of synthetic multi-year UK drought events for risk-based impact studies

Western US drought attribution, and the generation of synthetic multi-year UK drought events for risk-based impact studies

- Meteorological hazards
- Two projects:
  - Western US Drought: Whether climate change played a role in drought generation
  - MaRIUS : generation of synthetic multi-year UK drought events for risk-based impact studies
- By definition extreme events are rare, so very difficult to quantify probability; In general look at the probability or the frequency of an event, and how that has changed over time (how that correlates with climate change).
- Use Weather@Home -- simulate a lot of different weather events
- US Drought Project:
  - Potential reasons for the drought:
    - Western US climate affected by ENSO; when the drought started it corresponded with La Nina conditions, so it was thought drought was caused by La Nina; however we are now entering into El Nino condition and the drought is continuing.
    - 'The Blop' – anomaly of sea surface temperature in winter 2013-14 (very warm anomaly in north eastern Pacific >2 degrees Celsius)
    - Climate Change?
  - Run simulations to test hypotheses using Weather@home (18 months run: 12/2013-05/2015) in order to **test what is to blame for the US drought: climate change, the 'blop' or natural climate variability. Analysis ongoing.**
- MaRIUS: Using Weather@home to produce a synthetic set of droughts and heat waves. weather@home is a public science initiative whereby people can run climate models on their private computers (see: climateprediction.net)
  - Creating two drought datasets:
    - A hind cast of past droughts (goes back to 1850)
    - Synthetic event set of present and future hydrometeorological droughts in UK

Lola Rey, University of Cranfield: Evidence of increasing resilience in the irrigated agricultural sector in the face of increasing water scarcity

Evidence of increasing resilience in the irrigated agricultural sector in the face of increasing water scarcity

- Research Question: Are there any evidence to suggest that farmers are more resilient to drought and water scarcity?

- Usually farmers are the first affected by drought; In the UK irrigated is highly productive (total 250M pounds from irrigated agriculture in a dry year).
- Past UK droughts: 1976 is remembered as one of the most severe droughts, but looking back in time, there have been many other. Have farmers become more resilient?
- Case Study in the Anglian region: where most of irrigated agriculture is concentrated; EA manages the abstraction through statutory licensing system.
- *Methodology*:
    - Farmers Interviews: risk perception; impacts of past droughts; response/management; areas for improvements; climate change
    - Drought Managers: management actions; drought abstraction
- Results:
    - Many different ways of looking at drought;
    - Most farmers see drought as a *very important* risk for the business (73% believe droughts will be a great problem in the future);
    - The way farmers respond to drought has changed: In the last drought farmers agreed to take some voluntary restrictions in order to avoid mandatory restrictions – working together.
    - 2010-12: more positive about how farmers have managed droughts: received better forecasting, better information.
    - Coping vs. adapting:
        - Short term adaptation (coping): change in irrigation patterns etc.; most important factor when responding to drought is the type of crops grown; sensitivity of the crops.
        - Long term actions: investment in alternative water sources (e.g. on farm reservoirs).
    - Farmers see the EA as being more proactive (EA meeting with farmers, more engaged, provide more information)
    - Area for improvement: farming sector should have a more central role in water resource management; better forecasting; more flexibility in the way the water is allocated/used (e.g. use of water trading)
- *Conclusion: farmers are adapting in the Anglian region, and seem to have a more positive attitude about the role of the EA. Increasingly collective action (creation of water abstraction groups, which are useful for farmers during drought).*

Paul Whitehead, University of Oxford: Impacts of Droughts on Water Quality

- Water Quality impacts of drought in the UK
- Key Water Quality Variables to consider: DO, nutrients: Phosphorous, nitrogen; sediments; carbon; acidification; metal; organics; ecology (fish, microphytes); In this presentation Paul reviews some of these WQ variables and how drought impacts them by looking at specific research case studies he has been involved with/ and how MaRIUS contributes to fill the gaps.
- The Upper River Kennet ecology and Dissolved Oxygen
    - Decaying macrophytes at the end of the summers: affects fish/ecology; specific to low flow/eutrophication;
    - Important from an ecology point of view: drop in dissolved oxygen affects river ecology, fish can die.
    - **Understand and model interactions between flows, concentrations, ecology; which is what the Water Quality dimension of MaRIUS aims to research.**
- Thames Water Quality & Flow 1974-76
    - As flow decrease, increase concentration in phosphorous (less dilution). Mass balance models can simulate that effect.
    - Serious from a WQ point of view: moving away from the Water Framework Directive.
- Flushing-Effect: what happens post-drought (key element in MaRIUS)
    - Flush of nutrients moving down the river. Can these be modelled?
- 1975-2008: Dunham WQ series: useful for exploring long term trends; form an ecology point of view research how species are changing over time.
- Model the whole of the river Thames System. Using INCA: linking what is happening on the land system (agriculture, urban etc.), and what is going on in the river. In particular model P concentrations.
- New: creating a new model for algae, applying phytoplankton model.
- Alex Elliott is modelling reservoir
- Climate Change: how is CC affecting water quality?
- Conclusion and main research questions:

- Focus on the Thames is a key part of the MaRIUS project, but MaRIUS aims to focus on the national scale
- How does water quality constrain water resources?
- How do we build knowledge into water planning models?
- How will CC affect droughts & Water quality?

Len Shaffrey, University of Reading: IMPETUS: IMproving PrEdictions of Drought To inform USer decisions

- Research aim to improve forecasting of drought in the UK; part of WP2. (Meteorological aspects + hydrological aspect)
- Seasonal forecast: meteorological conditions that cause drought in the UK:
  - NAO (Q: how predictable are NAO oscillation on seasonal time-scale? A few-years ago we would not have been able to predict NAO a couple month in advance; predictions are now getting better)
  - UK precipitation and rainfall: linear relationship with NAO; use the information to down-scale forecast.
- Other research question: Focus on longer time-scales: inter-annual precipitations (comparison between east and west of UK)
- From a hydrological perspective: linking land surface models with recharge models/groundwater models (BGS looking at groundwater aspects).
- IMPETUS: consideration of water demand, which is very tricky (with focus on specific areas);
- Question around up-take of drought forecasts: how should probabilistic forecasts be used to inform decision-making?
- Over-all issue of scale (geographic and time) is central: aims to improve resolution.

Emma Weitkamp, UWE: DRY - interweaving of science and narrative in decision making about drought, water scarcity and heat waves

- Bridge between science (hydrology/ecology) and
- One of the 2 projects under WP3: Develop a resource for drought risk management.
- Draw a range of perspectives from the scientific community & from other drought stakeholders (anybody with an interest in drought): **explore how these different groups understand and relate to drought research and drought risk**. Aim to bring together the different knowledges.
- Project looks at 7 catchments – chosen to represent different climate gradient, urban/rural.
- Use the 'deficit' approach: Historical belief that if we can communicate science better, the decision-making process will be better. It turns out this is not true: a lot of other factors influence decision-making. So how can we integrate these different factors/knowledges/understanding of drought? How can we bring them together to aid the decision making process?
- Different elements of the research:
  - **Natural science workshop** which brings together scientific modellers, artists, and other science communicators.
  - Collect stories about how people live drought, the human faces behind drought
  - **Citizen science aspect** how to bring/engage citizens in the data collection/science aspects of drought (e.g. tree measurements)
  - **Narrative workshop at catchment level** to think about how drought modelling will impact on local level.

Kevin Collins, Open University: DrIVER - Designing social learning systems for improving drought monitoring and early warning

- DRIVER Project: Improving the link between hydro-meteorological drought characterization of drought and environmental and socio-economic impacts. How relevant are drought indicators at capturing drought impacts/severity? How can we better design indicators to incorporate elements of drought impacts?
- Methodology: Combine hydro-meteorological and socio-economic data such as reports, and social learning approaches to incorporate stakeholders' views and experiences of drought.

- Workshop around the following question/conversation: how do we know we are in drought? Pulling out a range of issues that matter for stakeholders involved:
    - Issues around forecasting, impacts, resilience, governance etc.
    - Issues around public health
    - What kinds of drought are we in? Impacts on the economy.
    - Vulnerability
- Key finding: There are many different kinds of droughts, so people experience drought in different ways

Rebecca Pearce, Stuart Barr, Exeter University: History - Constructing social timelines of droughts in the UK

- Understanding of historical drought: how have droughts emerged and what have the impacts been? Building a large database by collecting interviews (available online).
- Providing a deep understanding through narrative based research to understanding how drought occur, emerge and how they are managed through the context in which people live and work. How *place* matters. How *context* matter.
- Providing a cultural, social, economic, political context to a drought inventory, by listening to people, how they were affected and how they managed drought.
- What is social-science bringing:
    1. There is no record around how reports and drought policy documents have emerged, how decisions were made.
    2. These documents do not say much about spatiality about how drought emerged. Research illustrates that droughts emerged at different magnitude in different places, even though covered by the same water authority.
    3. Resilience: how people cope or don't cope.
    4. How drought event occurs through time (how water authorities react/not react in time; and how meteorology interacts with people's experience of drought).
- Methodology: interviews (open; un-structured, no time limit; interviewee guide the discussion, not interviewer); build up time-line for the drought by looking at drought reports/archival, policy documents, newspaper articles;
- E.g. families getting some water from standpipes close to their house, and the water comes out black. They are told to use as much water as they want (so no water saving);
- Build up to interesting account about what is going on socially during a drought. Make connection between different accounts.

Catharina Landstrom & Eric Sarmiento, University of Oxford: MaRIUS – Seeing scales in drought and water scarcity management

- Focus on the narratives around scale. Spatial scale is a key element of studying and understanding drought (national scale: government agency, legislators, policies; regional scape: water resource norms, rivers, catchment; local scale: communities, individual water resource use)
- How are scales produced, how can we understand them?
- *Eric Sarmiento*: focus on two local case studies –
    - River Kennet and river Lead: how do communities understand and experience drought.
    - Methods: Semi-structured interviews (people who live along rivers, artists, environmentalists, river keepers etc.) and archival work.
    - What happens at local scale is not necessarily local: connected to other scales (impacts down-streams). No clear lines between different forms of knowledge in understanding the river (e.g. river keepers interact with environmentalists, authorities etc.).
- *Catharina Landstrom*: how experts know and understand drought.
    - Creation of a new scale via mathematical models; accessing it with instruments, the scientific tool-box. The scales are created in the practices: they are socially constructed.
- Some of the key questions looked at in these studies are the following:
    1. Are translations between scales taken into account in drought science (implications?)
    2. Is drought knowledge hierarchically ranked; are more vocalized forms of knowledge de-valued relative to science?
    3. What are the impacts between different scales of action?

Christopher Duffy, Penn State University, USA: On the concentration-discharge signature of drought in rivers: a dynamical systems view

How do we calculate hydrologic time?

- Kinematic age of water along a flow path
- Analogy with population

- As long as there is water going into the system, there will be finite age in the system. If the water is turned off, the concentration stays the same and the age goes up. Droughts are like clocks: they slow down water cycle, so tracer ages in proportion with time.
- A truly dynamic system: particles in the system a function of flow and the concentration and vary tremendously;
- Study at Pennsylvania catchment: map age of water over water-shed (=mapping of older and younger mapping with implications for the droughts). Observed trend slowing down the hydrological cycle over 30 years, and hoping to determine what causes the trend: the climate (drying) or the ecology (e.g. tree growth leading to water use: a biological drought).
- Implications: the hydrological cycle is decelerating due to biology or climate change

Greg Garfin, University of Arizona, USA: Coping with Drought in the American Southwest

- Drivers of South-west
  - Diverse topology, climate and hydrology
  - La Nina/El Nino weather
  - PDO
- One consequence of drought is the increase in conifer mortality (as a result of water stress, increase life span of pests, forest fires and erosion). Fires are extremely costly!
- Water Management causes of water scarcity in the Colorado river basin: over-allocation in the late 1900 of the Colorado river (the C river was allocated during a wet period – not reflective of average river hydrology)
- Other causes of the California drought:
  - Population increase over the last century;
  - Expansion of agriculture (thus increase in agricultural water demand); to make up for surface water shortages, farmers have been using groundwater leading to over-abstraction and aquifer stress;
  - Farmers shifting from vegetable crop to nut crops (high value crops, very water demanding);
  - Rise in per capita demand;
  - Climate change?
- Planning:
  - California 1st drought plan, 2010. Attempt at integrating water resources planning and drought planning; however, failed to consider droughts would occur faster. No requirements for agricultural contingency plans.
  - Arizona
    - Groundwater management act 1980 (to be put into practice in 2025)
    - State law that fail to acknowledge connection between ground wand surface water
    - Good thing: very active state drought monitoring committee; water providers and agencies are required to provide contingency plans;
    - Little assessment of past drought; of the water-energy-food nexus;
- **Conclusion**: we can learn from the successes and the failures; need to be more creative and imaginative (use wider array of options: conservation, developing new infrastructure, technologies).

Peter Wallbrink, CSIRO, Australia: Using water management models to support risk based decision making for climate and agriculture in South Asia: The Indus basin

- Working in 3 basins: 1. 2. Brahmani Baitarni (working with 3 states to help them understand the basin planning); 3. Indus Basin (Take more ownership of their part of the Indus water treaty;
- *Indus Basin*:
  - Characterized by uncertain hydrology; uncontrolled use of groundwater; relationship between GW and surface water not well understood; increase in demand;

  - Aim is to develop a model that allows water managers across boundaries to take care of the day to day management of the river; manage uncertainty; plan potential future uses under climate change scenarios;
  - Capacity Building
- *Brahmani Baitarni Basina*
  - Aim: Basin planning to help them take ownership of their future; Build consensus with the states around using the model for water management planning;
  - Modelling flows under different scenarios
- Conclusions:
  - Engage with stakeholders at many levels;
  - Need to share knowledge;
  - Underpins process for risk based food and drought management;

Lee Godden, Melbourne University, Australia: Drought and water scarcity issues in Australia

- Drought is a relative concept. We have a social system that responds to a physical system. We cannot understand drought in a unique straight-forward way. In this context, the following questions become relevant and important to consider:
  - If risk is relative and water scarcity influenced by socio-cultural factors, what does it mean to be responding to the impacts and uncertainties?
  - What exactly are we responding to? (e.g. by focusing on droughts we forget the cyclical nature of droughts: the combination of droughts + floods)
  - How we frame the problem is key to the decision making process.
- Australia's Adaptation to droughts demonstrates how complexity was governed across scales
- Australia Water Law
  - Australia inherited UK riparian doctrine in water law → process of adjustment… does not fit with Australian geography
  - Australia as a country of water dreamers and drought deniers
  - Crown vested water resources early 20th century
    - Crown government has control;
  - Reforms from 1980s
    - clear that there was extensive over-allocation
    - early drivers for water law reform was water quality (salinization)
- Water Law and Policy Reform → how to deal with severely over-allocated basins
  - 1994. First stage of reform; separate land and water entitlements (can be shared, bought, leased, mortgaged); MDB cap; start to think about environmental requirements
  - 2004: national water initiative
    - series of principles; improved security of water allocation
    - encourage water conservation
  - 2007 – water act
    - basin plan – sustainable diversion limit (limit has been contested)
    - climate change risk formula (largely a financial risk formula – who bares the cost of change?)
    - separation land/water; unbundling of entitlements in rural areas
  - Conclusions:
    - A LOT of public money invested
    - SDL very contested
    - But considerable economic benefits from NWI reforms (70% reduction of water diversion in drought)
    - Putting in place the legal framework for water trading
    - New entity: commonwealth environmental water holder (largest holder of water entitlements)
- More recently other innovative options have come to the fore to rethink the water supply (e.g. desalination: Making Melbourne 'Drought Proof'; urban design; rain-water harvesting).
- Innovation is key here. We must start to re-think the 'hydro-social contract', rethink path dependency. Rethinking the cities as a catchment (Urban Design), using the cyclical natural of drought and flood.
- Conclusion: Initial problem framing is critical (What is drought? Could we start planning for them as the norm?); Australia had a hard look at its own legal structures and changed them. Truly innovative and creative changes.