China-UK Urban Flooding Symposium Report
16-17 October 2017

Introduction

This report summarises the main content and themes to arise from the China-UK Urban Flooding Symposium hosted by the Nanjing Hydraulic Research Institute (NHRI). Over the course of 16 October, the symposium heard from a series of speakers and panel discussions from Chinese panellists organised by the NHRI and the Chinese Academy of Engineering and the UK delegation organised by the UK Royal Academy of Engineering. Following a technical visit on the morning of 17 October, a roundtable was conducted to explore areas of potential areas of China-UK collaboration. This report aims to identify the key themes of discussion from across the Symposium, with attention given to capturing areas that were identified as potentially fruitful foci for future collaborative activity.

Key themes

Some common trends were very clearly discernible across the inputs received from speakers. There was clear recognition that climate change is introducing increasing uncertainty within the meteorological system that needs to be assimilated into decision making. In addition to climate change, rapid urbanisation in China has caused an associated increase of non-permeable surfaces, heat island effects and a pronounced increase in the intensity and frequency of local rainfall events.

There is a need to increase flood resilience in both the UK and China and in both cases this needs to be a cross disciplinary effort and with a need for collaborative learning across research, municipalities and governments at national and local scales.

Beyond these core themes, the content of presentations and discussions across the symposium can be summarised across four key domains: 1. systems for data collection and assimilation; 2. systems modelling; 3. decision-making and planning, and; 4. evaluation of interventions and learning.

Systems for data collection and assimilation

There are two broad categories of strategic tools that are required; those that inform urban planning and design decisions and those that provide real-time monitoring and forecasting.

The symposium heard several talks on existing systems for rainfall monitoring and there was general agreement that integrated systems for gathering dynamic data incorporating rain gauges, radar and satellite data were needed. These systems are complicated, predictive models need to assimilate large amounts of dynamic, real-time information and each monitoring technology has their own errors, inaccuracies and limitations. It is therefore crucial that meteorological services work closely with the engineering community.

Advances in computing power as well as radar systems mean that the costs of systems are significantly reducing and significant increases in the capability of rainfall monitoring systems and, for example, the clean-up of radar signals are being made. In the case of radar technology, this is crucial since rainfall is so close to the ground that radar reflection off buildings and other features is inevitable.

It was noted that cities are currently not making the most of crowd-sourced data to correct and/or validate information from radars and model predictions. The German

Meteorological Service, for example, has an application whereby citizens can confirm or deny whether it is raining, allowing the meteorological service to correct its own information.

It was noted that, supported by the UK government's Newton Fund, the Climate Science for Service Partnership (CSSP) China is an existing partnership between the UK Met Office, the China Meteorological Administration (CMA), the Institute of Atmospheric Physics (IAP) at the Chinese Academy of Sciences, and other key institutes within China and the UK. The focus is on building the basis for services to support climate and weather resilient economic development and social welfare, accelerating collaborative research and development programmes and prototyping climate services.

Systems modelling

A great many examples of modelling, for cities, areas or particular developments (for example, Beijing Daxing Airport), were presented during the symposium. These demonstrated the need and progress toward developing tools that link rainfall data with hydrological modelling to convert surface run-off to river flows and convert from hazard to impact on dwellings, infrastructure, etc. However, some particular challenges were discussed, including:

- Accurate depiction of the spatial and temporal distribution of rainfall remains a key challenge and, added to this, climate change is causing phenomena which are not present in the observational record. Dealing with such uncertainty remains a key challenge.
- Cities are spatially large and, since buildings and a city's 'micro-features' substantially influence the extent of flooding experienced, it is important to achieve a high level of resolution within models
- In China, the rapid rate of urbanisation requires the rapid updating of flood models
- Access to data can be a challenge, including working across administrative departments for better data access and assimilation.

Examples covered in the symposium demonstrated that the capability now exists for modelling the flow of flood water and debris, such as cars, through an urban environment with increasing precision. This is now such that planners and designers can feasibly make virtual modifications to the design and layout of urban spaces to interrogate the flood dynamics and risks, for example, the vulnerability of busy areas or the risks posed by debris flows and potential channel blockages. This capability has particular utility where cities are being designed from scratch, as in some Chinese cases.

Decision-making and planning

It was generally recognised across the discussions at the symposium that cities are not isolated but are hydrologically situated in wider catchment areas; integrated hydrological and catchment management at this scale is needed. Urban water systems must also be recognised as multi-functional – while flood risk needs to be managed, there are also resource allocation, ecological, cultural and economic dimensions.

It was also recognised that, although there was very significant potential for two-way China-UK knowledge exchange, that specific solutions would need to be tailored to specific local characteristics.

While high quality data and flood modelling activities are a key activity, a great many speakers across the symposium raised the need for ensuring that results had a meaningful impact on decision-making across two main domains: urban planning and design; and flood preparedness and response.

<u>Urban planning and design for flood risk management</u>

There is a need for a significantly more informed view of how decisions on urbanisation and urban design affect flood risk and the options available to mitigate and manage

these risks. There is also, however, a need to find the best decision-making approaches under deep uncertainty, requiring flexible adaptation given the evolving nature of the risks involved. This tends to depend on planning for a range of scenarios, without knowing how reality will unfold; for example, climate change scenario simulation is critical to cities such as Shanghai where, for example, sea level rises will have dramatic consequences.

A key development in urban planning and design within the Chinese context has been the 'sponge cities' drive proposed by President Xi Jingping in 2013. The central tenet of this initiative is that cities be designed to absorb, store and purify as much water as possible and release this water in a managed way that mitigates flood risk and maximises its utility. Other country-based initiatives identified throughout the symposium were: Sustainable Urban Drainage Systems (SuDS) (UK), the Active, Beautiful, Clean Waters Programme (Singapore) and Water Sensitive Urban Design (Australia).

Event forecasting, preparedness and response

It is important to rehearse responses to predicted flood events and to analyse the consequences of response decisions, identifying points of vulnerability. As such, a common theme throughout the symposium was the need to better understand and improve the interface between forecasting activities and outputs and flood preparedness and response. For example, the UK Met Office now has a target lead time for forecasting surface flooding in London of 2 days and it is clear from the UK experiences that the UK Met Office and Environment Agency can dramatically assist and improve the response by working with first responders.

It was felt that anything that can bring structure and rigour to emergency preparedness is a valuable contribution. On this, the roundtable event heard how agent-based modelling enables the simulation and rehearsal of flooding events and the examination of how uncertainties propagate through the system. Lessons can be learnt for emergency response, regarding behaviours and vulnerabilities can be minimised.

Evaluation of interventions and learning

The symposium heard examples of adaptation measures being integrated into hydrological models – for example, the introduction of green roofs in London – to order to perform cost-benefit analysis against a range of climate scenarios. Nevertheless, in both national contexts, there is a need to better understand the cost-benefit analysis of adaptation measures encompassed by the SuDS and sponge cities drives. A systematic approach should be taken as there is the chance to lower the cost of managing flood issues as well as maximising the potential benefits across areas such as water quality, biodiversity, health and amenity within local areas. In the UK, CIWEM has produced high-level recommendations for policy measures that would promote SuDS and these include needing to better recognise and integrate the available benefits, beyond analysis solely on a flood management basis.

There was discussion about the need to better understand the key problems that are experienced on the ground and the need for stakeholders to collaborate at the earliest possible stage to understand the problems to be solved. The challenge of clearly communicating results and uncertainties from modelling was discussed, as was the need for interdisciplinary examination of how information and warnings are received and acted upon (or not).

Solutions are not solely technical, there is a need for institutional mechanisms to, for example, work across governments and agencies, as well as to align funding sources. Talks and discussion also highlighted the need for attention to how design standards are set, their acceptability, as well as how better uptake of adaptation measures can be driven. For example, in the UK, any development over 10 homes is required to integrate SuDS unless these are demonstrated to be inappropriate, however, this doesn't seem to act as an effective driver for recognising and properly integrating the various social, cultural and ecological benefits that can be realised as part of SuDS schemes. This requires more evaluation of the benefits realised post-installation, though a lack of skills

in planning authorities to both properly plan and evaluate schemes was identified. However, this also points to the need for clear guidance on best practices, for example on assessing multiple outcomes/benefits.

Experiences were shared from the UK highlighting the importance of listening to the issues of citizens as well as the need to account for and manage issues such as 'flood tourism' (where there is an influx of people to a hazardous area specifically because an extreme event is occurring).

Forward-view: potential areas of China-UK collaboration

In general, the very high rate of urbanisation within China presents both the opportunity and need for knowledge sharing and collaboration. It was recognised that many cities in China are challenged by fragile infrastructure and vulnerability to flooding. Within this, participants also stressed that while the development of mega-cities was an important urban development in China, they should not be the sole focus. It was noted that approximately 50% of the newly urbanised population are not in large cities but in smaller cities and this population required attention. The intention of the Chinese leadership is for a new urban model to be established, which will form an important step in China's innovation drive. The UK was invited to engage with this, to help develop a new approach to urbanisation in China that increased water and ecological quality as well as flood safety.

Specific areas that were foreseen as both potentially fruitful and necessary for further work were as follows (these have been presented in order as no form of prioritisation was discussed as part of the talks or the roundtable):

- The roundtable session opened with discussion on whether the two national academies of engineering could collaborate on developing the principles of integrated urban flood management; possibly producing a joint statement on this. Any such statement would need to cover the four domains of the integrated flood management 'system' outlined above (1. systems for data collection and assimilation; 2. systems modelling; 3. decision-making and planning, and; 4. evaluation of interventions and learning).
- There is a need to take an institutional perspective on the sponge cities drive and to co-ordinate the urban planning system in China. Value was seen in an interdisciplinary effort on how to engage and include urban planners, authorities and emergency responders to ensure that quality evidence reaches and improves decision-making at both urban planning and preparedness and response stages.
- Further evidence-building on the cost-benefit of:
    - the SuDs and sponge city measures that can be integrated into urban design
    - forecasting and preparedness systems and methodologies
    - how standards and best practices for the above can best be driven.
- Standards in urban design are critical given the level of investment and the implications of decisions. A common interest in design standards was identified and value was seen in examining the standards between the two countries, including on how these perform under the uncertainty of climate change.
- Work to extend the work on the direct impacts from flooding events to incorporate greater analysis on the longer-term health and epidemiological risks. Flooding also causes psychological damage to individuals and communities, for example when homes are contaminated with human waste and these aspects require further understanding.
- Integration of radar monitoring systems form a key part of intended projects at the Chinese Academy of Engineering, this presents the opportunity to cooperate

on system development. More generally, it was recognised that ongoing work was required to develop integrated systems for sensing and measurement and the assimilation of this data into modelling. A key part of this work needs to be on linking up the meteorological system with the hydrological system. As higher resolution flood forecasting and integration of rain and risk forecasting develops, there is a need to find practical examples to test and explore implementation and practically improve the link between forecasting and the reduction of risks and vulnerabilities.

- There is currently a divide between deterministic and stochastic approaches to modelling, however both approaches can be complementary and there is a need to achieve both high resolution and stochastic models. While organisations such as the UK Environment Agency need quick-time modelling, they also need to be brought into the planning of cities and there is an opportunity for China to develop better stochastic modelling capabilities to assist in flood responses.
- Building on the work on agent-based modelling, discussed at the roundtable, the potential for the use of models and simulated environments to rehearse decisions, better understand behaviours and explore their consequences for health and property with all public services (police, local officials, etc.) should be explored further. Both UK and the Chinese meteorological services produce enough outputs that would allow this type of 'gaming' activity. It was felt that developing these types of learning activities would be highly valuable.
- A key area in which the UK has knowledge and experience to share is in flood insurance. In contrast to the UK, China is only just developing insurance systems and there is a lot they might learn from the UK. There was a stated desire to explore this further.
- The potential to hold further technical symposiums to develop these and potentially other areas as well as to keep up-to-date on urban development and opportunities to integrate research and engagement with government and institutions was raised.