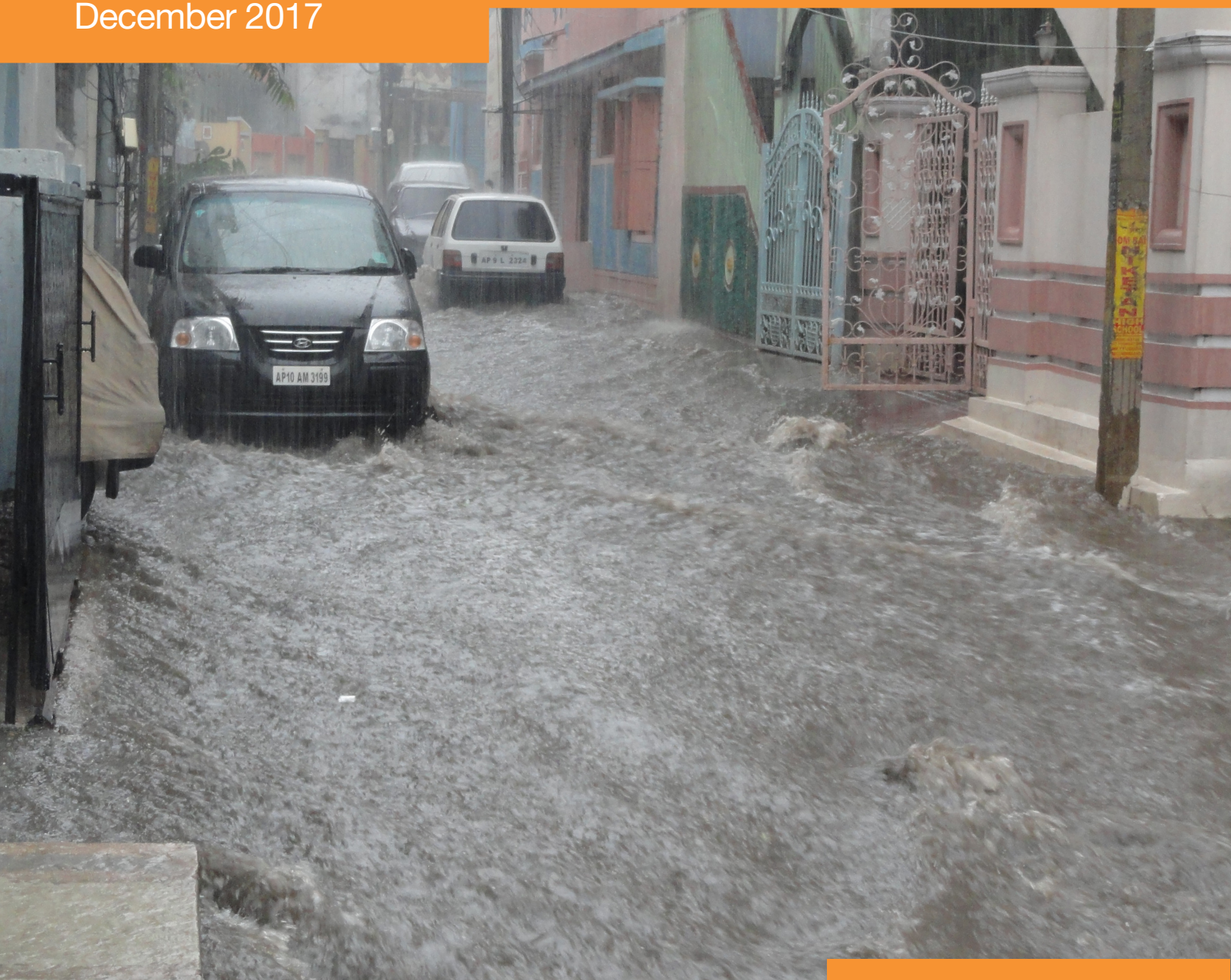


Quantifying resilience of water infrastructure to extreme precipitation events in urban areas

Report of Researcher Exchange May 2017

December 2017



INDIA-UK
Water Centre

भारत-यूके
जल केन्द्र

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The India-UK Water Centre promotes cooperation and collaboration between the complementary priorities of NERC-MoES water security research.

भारत-ब्रिटेन जल केंद्र एमओईएस-एनईसीआरसी(यूके) जल सुरक्षा अनुसंधान के पूरक प्राथमिकताओं के बीच सहयोग और सहयोग को बढ़ावा देने के लिए करना है

Front and back cover image: flood water street disaster, Pixabay (jsptoa)

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Executive Summary

This report outlines the activities carried out during a Researcher Exchange by Ms Chandra Rupa of the Indian Institute of Science, Bangalore hosted by Prof. Guangtao Fu, University of Exeter, UK. Quantifying uncertainties in short duration high intensity precipitation, which often causes heavy flooding in urban areas, is crucial as well as challenging. In addition, assessing risk, vulnerability and resilience of urban water infrastructure as a result of heavy precipitation events is equally important for supporting long-term planning and management decisions. However, extreme precipitation, vulnerability and resilience are all influenced by a wide range of factors, including climate change and socio-economic development. Therefore, this Researcher Exchange programme aimed to gain an enhanced understanding of extreme precipitation uncertainty and quantifying the risk, vulnerability and resilience of urban water infrastructure to flooding. The applicability is demonstrated through a pilot case study in Bangalore, India.

1. Activity Leads

The Activity was convened by the India-UK Water Centre (IUKWC) and undertaken by the Activity Leads:

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As a part of the Researcher Exchange program Ms. Chandra Rupa visited the University of Exeter between 1–21 May, 2017.

2. Researcher Exchange Aims

The India-UK Water Centre is based around five key cross-sectoral themes and aims to deliver a portfolio of activities across these themes. This researcher exchange program focused on the theme: Transforming science into catchment management solutions. The activity aimed to:

- Strengthen research capabilities in quantifying the resilience and project management skills,
- Develop a model for studying the spatial variation of precipitation in Bangalore city, develop a model to obtain flood hazard maps in the study area, urban flood management and develop guidelines for assessment of resilience of urban water infrastructure,
- Transfer the expertise of the host institute in the areas of risk and resilience assessment to IISc,
- Attend Water and Environment seminars and to attend workshops organised by the EPSRC network BRIM: Building resilience into risk management,
- Attend individual meetings with PhD and Post-docs working in the Centre for Water Systems group, and
- Explore research ideas for future collaborations.

3. Activity Structure

The Researcher Exchange was aimed at modelling extreme precipitation in Bangalore city and developing a model for obtaining vulnerable flooding areas and resilience/vulnerability assessment of urban water infrastructure in the study area. The primary objective was to develop a conceptual framework for addressing the problem of urban flooding and urban water infrastructure resilience analysis and learning the latest research outcomes from the Safe & SuRe (<http://safeandsure.info/>) project at Exeter. The secondary objective was to strengthen research capabilities of the two groups, build the ability to tackle research problems from a different perspective and exploring research ideas for future collaborations.

A statistical model was developed to study the spatial variation of precipitation in Bangalore city, a pilot study area (Hulimavu-Madivala catchment) was considered within the Bangalore city. The Madivala catchment has been fully developed and the Hulimavu catchment is under development. Both the temporal and spatial variations of precipitation, along with uncertainty in the return levels, over the study area have been obtained and the storm water network has

been modelled using the Storm Water Management Model (SWMM). Flood hazard maps for the study area are also now developed. From the flood hazard maps, possible areas of the flooding and critical locations were noted. The risk and reliability analysis of the existing storm water drains for various scenarios (e.g., choking of drains at critical locations, failure of weirs etc.) have been carried out with the help of Safe & SuRe project research teams expertise. Through the exchange the Lead Researcher has further extended their expertise in the uncertainty analysis for precipitation to obtain the probability of resilience of the urban storm water drainage network in the pilot study area. Meetings were conducted with the Safe and SuRe team to understand the urban water infrastructure resilience analysis. Expertize of the host institute (University of Exeter) in the areas of risk and resilience assessment has been acquired to perform risk analysis and obtain the resilience of urban storm water infrastructure in the study area.

In addition to the modelling work undertaken a number of individual meetings were arranged to understand the research works in the group: with PhD students (Mr. Arshan Iqbal, Mr. James Webber, Mr. Yuntao, Ms. Kimberly Bryan, Mr. Peter Melville-Shreeve, Ms. Sarah Bunney and Mr. Harry Liu), post-doctoral fellows (Dr. Cris Sweetapple, Dr. Fanlin Meng, Dr. Konstantinos Kakoudakis, Dr. Mingming Wang and Dr. Shima Mohebbi) and professors (Prof. Gaungtao Fu, Prof. David Butler, Prof. Slobodon Djordjevic, Prof. Zoran Kaplan and Prof. Raziye Farmani). The topics of discussions included details of the Safe and SuRe project, system resilience analysis, risk analysis and pipe failure analysis, flood intervention techniques, flood risk analysis and management, urban water systems, multi-objective optimization of water distribution networks, integrated modelling and spatial analysis to predict flood volumes using GLMs (Generalized Linear Models). Attendance at two visiting scientists' seminars also took place: one by Prof. Maria da Conceição Cunha, Professor at the University of Coimbra, Portugal on "Decision-making in water infrastructure planning and management: Main issues and challenges" and another seminar by Dr. Fanlin Meng on "Universal resilience patterns in complex networks" held as a part of Safe and SuRe discussion group was attended.

Towards the end of the exchange program, the activity lead visited Centre for Ecology and Hydrology (CEH), Wallingford. Discussions with Mr. Nick Reynard, Dr. Ponnambalam Rameshwaran, Ms. Lisa Stewart, Dr. Giuseppe Formetta, Dr. Eleanor Blyth, Dr. Virginie Keller, Mr. Nathan Rickards and Dr. Maliko Tanguy were helpful in obtaining the wide research insights. Topics of discussion included spatial and hydrological modelling of hydrological variables including precipitation and stream flow, estimating index flood with continuous hydrological models, depth-duration-frequency analysis for short duration rainfall events, land surface modelling in hydrological modelling, testing and calibrating JULES model, and features of the CEH-GEAR (Gridded Estimates of Areal Rainfall) datasets.

4. Activity Conclusions and Outcomes

4.1. Key outcomes

The key outcomes from the researcher exchange are:

- Development of a hydrologic model to determine floodprone areas and urban water infrastructure resilience analysis for a case study area within Bangalore city.
- Strengthening research capabilities of the two groups and build the activity lead's ability to tackle research problems from a different perspective and ideas for further research.
- Gaining research experience in the domain of urban flood risk and resilience analysis from researchers from a world leading group.

4.2. Conclusions

The main research outcome of the exchange is an enhanced understanding of the conceptual framework for addressing the problem of urban flooding, urban water infrastructure resilience analysis and the development of a case study in Bangalore to test the framework. This exchange significantly strengthened research capabilities of the two groups. It was agreed upon to continue work on identifying key principles or attributes of urban water resilience following the completion of the activity.

5. Annexes

ANNEX A: Exchange Agenda

time	
03.05.17	Meeting with Exchange host Dr. Fu, University of Exeter, UK
03.05.17 – 20.05.17	Conducting research on modelling extreme precipitation in the Bangalore case study, developing model for obtaining vulnerable flooding areas and resilience/vulnerability assessment of urban water infrastructure in the study area, developing a conceptual framework for addressing the problem of urban flooding and urban water infrastructure resilience analysis, learning the latest research outcomes from the Safe & SuRe (http://safeandsure.info/) project at Exeter. Further, strengthen research capabilities at the two groups, build the applicant's ability to tackle research problems from a different perspective and ideas for further research and exploring research ideas for future collaborations
05.05.17 – 17.05.17	Meetings at University of Exeter with Dr. Chris Sweetapple; Prof. David Butler; Mr. Arshan Iqbal, Mr. Peter Melville-Shreeve, Ms. Kimberly Bryan, Ms. Sarah Bunney, Mr. Harry Liu and Mr. James Webber; Prof. Slobodon Djordjevic, Prof. Zoran Kapelan, Prof. Raziye Farmani, Dr. Konstantinos Kakoudakis, Dr. Mingming Wang, Dr. Shima Mohebbi, and Dr. Fanlin Meng
10.05.17	Attending the Safe and SuRe discussion group seminar by Dr. Fanlin Meng Universal resilience patterns in complex networks
12.05.17	Attending the Water and Environment seminars by Prof. Maria da Conceição Cunha, Professor at the University of Coimbra, Portugal on "Decision-making in water infrastructure planning and management: Main issues and challenges"
18.05.17	Meetings with staff at the Centre for Ecology & Hydrology; Dr. Ponnambalam Rameshwaran, Ms. Lisa Stewart, Dr. Giuseppe Formetta, Mr. Nick Reynard, Dr. Eleanor Blyth, Dr. Virginie Keller, Mr. Nathan Rickards, Dr. Maliko Tanguy



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