THE CORFU PROJECT AND ITS WORK IN DHAKA

Michael Hammond[1], Albert Chen[2], Slobodan Djordjevic[3], David Butler[4], David Khan[5], S. M. Mahbubur Rahman[6], William Veerbeek[7], Friso Schlitte[8], Sharon Birkholz[9] and Ole Mark[10]

[1] *Centre for Water Systems, University of Exeter, Exeter, UK, e-mail: m.j.hammond@exeter.ac.uk*
[2] *Centre for Water Systems, University of Exeter, Exeter, UK, e-mail: a.s.chen@exeter.ac.uk*
[3] *Centre for Water Systems, University of Exeter, Exeter, UK, e-mail: s.djordjevic@exeter.ac.uk*
[4] *Centre for Water Systems, University of Exeter, Exeter, UK, e-mail: d.butler@exeter.ac.uk*
[5] *Institute of Water Modelling, Dhaka-1000, Bangladesh, e-mail: dmk@iwmbd.org*
[6] *Institute of Water Modelling, Dhaka-1000, Bangladesh, e-mail: smr@iwmbd.org*
[7] *UNESCO-IHE Institute for Water Education, Delft, the Netherlands, email: dinarch@xs4all.nl*
[8] *Hamburg Institute of International Economics, Hamburg,Germany, email: schlitte@hwwi.org*
[9] *Cranfield University, Cranfield, UK, email:* s.a.birkholz@cranfield.ac.uk
[10] DHI Water & Environment, Hørsholm, Denmark, email: omj@dhigroup.com

ABSTRACT

The Collaborative Research on Flood Resilience in Urban Areas (CORFU) project is funded by the European Commission. It aims to lead to a more scientific management of flood risk, and increase the resilience of cities to flooding, through joint research and investigation. The project involves partners from Europe and Asia, and eight case study cities, one of which is Dhaka. This paper will describe in greater depth the specific aims and methodologies of the project, and describe the progress to date conducted in the Dhaka Case study and the next steps in the project.

Keywords: *Flood risk management, flood impact assessment, resilience, climate change, urbanisation*

1. INTRODUCTION

Urban flooding is a growing phenomenon, whose impacts are expected to increase in the future as a result of two trends. The first is as a result of climate change and an expected increase in extreme rainfall. The second, and perhaps the dominant trend, is the growrth in urbanization. The world's population is increasing, as is its urban portion. In 1970, the world's urban population was reported to be 1.35 billion. By 2011, this was estimated to be 3.63 billion, and by 2050, this is projected to have grown to 6.25 billion (United Nations Population Division 2011).

As exposure to urban flooding has and expected to increase in the future, the paradigm of flood resilience has been developed as a way of thinking about improved flood risk management (Zevenbergen et al 2008). As the risk of flooding cannot be eliminated, it is argued that cities and the people that live in them should become more resilient to flooding.

In order to investigate the questions that arise from increasing flood risk, and the challenge of making cities resilient, the CORFU (Collaborative Research on Flood Risk in Urban Areas) project was developed (www.corfu7.eu). The CORFU project is funded by the European Commission's Seventh Framework Programme under its Environment theme. The project is working with partners and on case study cities from Asia and Europe, each with their own characteristics and flooding problems. The eight cities are Barcelona, Beijing, Dhaka, Hamburg,

Mumbai, Nice, Seoul and Taipei. This paper will describe the aims and methodologies of the project, and describe the progress made in Dhaka case study to date.

2. PROJECT AIMS AND METHODOLOGY

The overall aim of the project is to allow partners from Europe and Asia to learn from each other, through the joint investigation, development, implementation and dissemination of flood management strategies, that will enable a more scientifically sound management of urban flooding and its consequences into the future. The project aims at enabling cities to become more resilient to flooding. By this, we mean that cities should become more able to resist, absorb, accommodate to and recover from the effects of a flood hazard, while preserving and restoring its essential structures and functions. More detail on the CORFU approach can be seen in Djordjević et al (2011).

The project is comprised of several concurrent methodological steps, which are structured in a Drivers-Pressures-States-Impacts-Response (DPSIR) framework. The first part of this framework is to consider the drivers that exert pressures upon the urban system with respect to flooding. These include socio-economic changes, such as economic growth and population increases that lead to changes in land-use, as well as climate change that may lead to changes in the patterns of extreme weather events. Coupled scenarios that include these drivers and pressures are being developed that will permit modelling of the changing state of the urban system.

The next step is to understand the nature of the flood hazard through urban flood modelling. The state of the art in flood hazard assessment will be enhanced through advanced hydraulic modelling. Real time urban flood forecast systems will be developed and improved, including improved techniques for data assimilation and uncertainty assessment.

The third area of the project is to gain a better understanding of the full range of impacts that floods can have on cities. These include damage to properties and infrastructure, as well as business interruptions, risk to human life through drowning, and the outbreak of waterborne diseases. To achieve this, a flood impact assessment model will be developed that will incorporate all these different impacts and applied in the case study cities.

The fourth area of work is to assess and enhance flood risk management, or flood resilience strategies. These strategies will be assessed under the different scenarios of drivers and pressures, and their effectiveness will be evaluated by considering the costs of these measures and the benefits that accrue as a result of reduced flood impacts.

It is intended that the work in the project is iterative, as the assessment will need to consider various feedbacks into different phases. For example, flood resilience strategies that lead to reductions in flood risk may lead to changes in land-use patterns, which will change the future development of the city, and thus the urban growth scenarios described in the first area of work.

3. WORK IN DHAKA

Dhaka is one of the project's case study cities. It is the capital city of Bangladesh, with a reported population of 15.4 million in 2011. The UN has projected its population to be 22.9 million in 2025 (United Nations Population Division, 2011). As its population is greater than 10 million, it is one of the 23 cities in the world that were recognised by the UN as a megacity in 2011. Dhaka lies in

the delta of the Ganges-Brahmaputra-Meghna system, and has a high risk of flooding. The city itself is surrounded by a network of rivers; the Turag lies to the west, the Buriganga to the south, the Balu to the east, and the Tongi Khal to the north (Faisal et al., 1999). The Greater Dhaka area has an area of approximately 275 km^2, and consists of a western zone, which has some protection against flooding, and an eastern zone, which does not.

Much of the population lives in informal settlements, which in the eastern part of the city are in some of the lowest lying land, and increases their vulnerability to the flooding hazard. Dhaka has witnessed severe flooding in recent years, with notable flooding events in 1998 and 2004. In 1998, almost the entire eastern zone, and 20% of the protected western area was inundated (Faisal et al., 2003). With the rapid urbanization and development of city infrastructure, the flood risk is expected to rise. As Dhaka is the seat of government for a country of approximately 120 million people, and provides many essential services and functions, effective flood risk management is essential to Dhaka and Bangladesh as a whole.

Flood hazard maps have been developed for Dhaka City using detailed hydraulic models. The eastern and western parts of Dhaka City have been modelled in two sections. A MIKE URBAN model developed by DHI was used to create the drainage model for Central Dhaka. The drainage network consists of a network of underground pipes and open channels. There are 9.7 km of box culverts, 40 km of open channels, and 134 km of pipes. This data was derived from secondary data collection and consultation with stakeholders. The drainage system is heavily influenced by the condition of the outfall water levels, which includes a large reservoir for storm water detention. This is controlled by a sluice gate and a battery of pumps. The outfall water level observed during monsoon condition was used, and typical gate and pump operation rules were used. The MIKE URBAN model couples the 1D drainage network with a 2D surface flow model to represent overland flow.

In the undeveloped eastern part of the city, the drainage works through natural channels. A DHI MIKE 11 model was used. This model is a 1 dimensional model that incorporates hydrology modules. This is then coupled to a 2D surface flow model using DHI MIKE FLOOD. The surface model used for both the eastern and western part of the cities relied on 25m by 25m raster grid DEM.

In order to assess the impacts of flooding, land-use data were collected from various sources and compiled. For this study, Object Oriented Data which can represent indivudal properties as polygons, each with individual attributes were used. The data for each building represents includes information on the building use, its structure, the number of stories, and the year of construction. As urban change in Dhaka is rapid, it is impossible to have a perfect representation of the current state of the city, and the data collected represents the best knowledge that exists of the period 2005-2006.

The damage to property caused by flooding can be assessed by means of combining information on the building type with the inundation characteristics and applying damage functions. The damage functions used in Dhaka relate the property damage to the flooded depth. In an earlier study in Khulna City (ADB, 2010), depth-damage curves were derived for 5 land use categories: residential; commercial; industrial; manufacturing; and roads. These curves had been developed from household survey data and refined with information from focus group discussions. Similar work is currently underway in Dhaka City to produce similar depth-damage curves. As GIS software tool has been developed to enable the calculation of property damage as a result of

flooding and applied in Dhaka using preliminary depth-damage functions. An example of the results are shown in Figure 1.

The next stages of the project are to consider and apply scenarios of economic and population growth, as well as changes in land-use. Projections of GDP growth have been derived from an econometric model that uses past data to extrapolate national trends. These trends can be regionalised to the Dhaka City area. These trends have been related to changes in the structure of economy. These trends are naturally uncertain, and therefore, a range of scenarios are being developed that represent low to high growth scenarios.

As well as economic growth, scenarios of population growth for Dhaka City are being derived. These will be linked to an urban growth model that is being developed. The urban growth model is based on a Cellular Automata model (a rule based model) that represents the urban cover in 300m by 300m raster cells. Scenarios of the drivers and pressures are being made for the present day until 2050. The urban growth model will alter the perviousness useed in the flood model, and when combined with scenarios of changes in extreme rainfall

Finally, the flood damage model is being improved to be able to incorporate these changes as well as modelling the effects of the incorporation of resilience measures. These will include structural measures such as improved flood embankments and drainage, as well the implementation of improved flood warning and dissemination. Survey work has already been undertaken to gain a better understanding of the relationships between livelihood, relationships, and awareness, and their link withh risk perception and the way in which people respond to flood hazards.

4. CONCLUSIONS

The CORFU project is an excellent example of international collaboration between Bangladeshi and international partners, working on solutions to the challenges faced in Dhaka and other cities as a result of increasing urbanisation, economic growth, climate change and a growing flood risk. Although there is still much work to be done, the project is making good progress, and aims to provide local stakeholders with tools that will lead to improved flood risk management and increased flood resilience.

ACKNOWLEDGEMENTS

Research on the CORFU (Collaborative research on flood resilience in urban areas) project was funded by the European Commission through Framework Programme 7, Grant Number 244047.

REFERENCES

Asian Development Bank (ADB), 2010. Strengthening the Resilience of Water Sector in Khulna to Climate Change. Manila: ADB

Djordjević, S., Butler, D., Gourbesville, P., Mark, O., and Pasche, E., (2011). "New policies to deal with climate change and other drivers impacting on resilience to flooding in urban areas: the CORFU approach". Environmental Science & Policy, Vol. 14(7), pp. 864-873.

Faisal, I.M., Kabir, M.R., Nishat, A., (1999). "Non-structural mitigation measures for Dhaka City". Urban Water 1(2), pp. 145–153.

Faisal, I.M., Kabir, M.R., Nishat, A., (2003). "The disastrous flood of 1998 and long term mitigation strategies for Dhaka City". Natural Hazards Vol 28(1), pp. 85–99.

United Nations Population Division (2011) "World Urbanization Prospects: the 2011 revision". The Population Division of the Department of Economic and Social Affairs of the United Nations. Available online at http://esa.un.org/unpd/wup/index.htm.

Zevenbergen, C., Veerbeek, W., Gersonius, B., Van Herk, S., 2008. "Challenges in urban flood management: travelling across spatial and temporal scales". Journal of Flood Risk Management Vol.1(2), pp. 81–88.

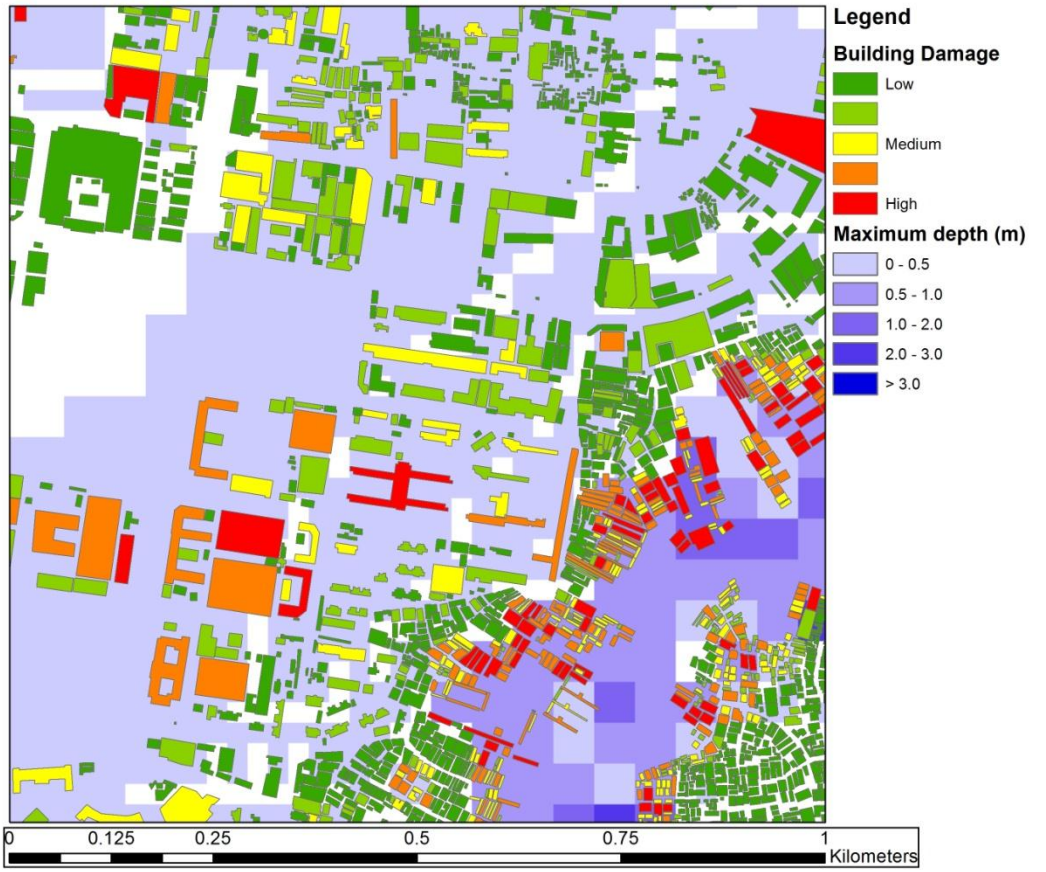

Figure 1: Preliminary results on flood damage per building