Seventh International Conference on Flood Management (ICFM7)

5 - 7 September 2017

“Resilience to Global Changes - Anticipating the Unexpected”

University of Leeds, UK

Book of Abstracts

Oral Presentations

Design Of Defences

43. Implementing Risk Based Standards for Flood Defences
Mr Robert Slomp, Rijkswatestaat, Netherlands

64. Economic optimization of multiple lines of defence in flood defence systems
Prof Bas Jonkman, Delft University of Technology, Netherlands

70. Development of a Standard Testing Framework for Evaluating Temporary Flood Barriers
Mr Kasper Lendering, Delft University of Technology, Netherlands

93. Forensic analyses and hindcasting of the Breitenhagen levee failure
Mr Job Kool, Delft University of Technology, Netherlands

136. How do our flood defences perform during floods?
Mr Jaap Flikweert, Royal HaskoningDHV, United Kingdom

147. Resilient infrastructure networks – Optimization of resource location for managing flood emergencies
Mr Fulvio Domenico Lopane, Newcastle University, United Kingdom

213. Catchment Systems Engineering: a holisitic approach to flood management
Dr Caspar Hewett, Newcastle University, United Kingdom

245. A new partial factor approach for assessing the reliability of flood defenses
Dr Robert Slomp, Rijkswatestaat, Netherlands

272. Systematic geophysical and geotechnical embankments survey in the area of the Humber Estuary and Yorkshire
Dr Vojtěch Beneš, G IMPULS Praha spol. s r.o., Czech Republic

43. Implementing risk based standards for flood defences

*Slomp, Robert *[1] Detmar H*,*

** Rijkswaterstaat, Ministry of Infrastructure and the Environment*

[1] Details for contact author (Robert Slomp, Robert.slomp@rws.nl, +31320298532, Lelystad the Netherlands

KEYWORDS: assesment and design of flood defences, uncertainty,

ABSTRACT

On January 1st 2017 the Netherlands formally will adopt a more risk-based flood risk management policy. This will be carried out through a change in legislation, the new risk base standards will be laid down in an update of the Water Act. The design water level methodology of 1958 and safety standards of 1996, will then be formally abandoned as the major policy tool in risk assessment and funding of flood defences. The flood defence assessment is important for managers of flood defences since national and regional funding for reinforcement is based on this assessment. The research and development of Flood Defence Assessment tools project (WTI2017) is responsible for the development of flood defence assessment tools for the 3600 km of Dutch primary flood defences, dikes/levees, dunes and hydraulic structures. The Design Tools project adds functionality for coping with climate change and evaluating the influence of large scale projects e.g. harbour or river enlargement.

This new policy is based on maximum allowable probabilities of flooding per area. A uniform maximum level of acceptable individual risk has been determined, this is the probability of life loss of 1/100 000 per year for every protected area in the Netherlands. Safety standards for the flood defences have been adjusted using information from cost benefit analysis, societal risk and large scale societal disruption due to the failure of critical infrastructure.

A major issue to be tackled was the development of user-friendly tools for assessment and design to be used by managers of flood defences, rather than just by a number of experts in probabilistic assessment. Data management and the experience with the new software are main issues to cover in courses and training in 2016 and 2017. All in all, this is the largest change in the assessment and design of flood defences since 1996, when probabilistic techniques were first introduced for determining hydraulic boundary conditions for design water levels and waves (wave height, wave period and direction for different return periods). To simplify this policy change, the assessment still consists of a three-step approach, moving from simple decision rules, to the current methods for semi-probabilistic assessment, and finally to a fully probabilistic analysis to compare the strength of flood defences with the hydraulic loads.

Design and assessment consist of a step by step approach, starting with semi-probabilistic assessment and design and finishing with a full probabilistic approach.

A fully probabilistic method results in more precise assessments and more transparency in the process of assessment and reconstruction of flood defences. This is of increasing importance, as large-

scale infrastructural projects in a highly urbanized environment are increasingly subject to political and societal pressure to add costly additional features.

64. Optimization of flood risk reduction through multiple lines of defence

Berchum, E.C. van[1], Jonkman, S.N.*, Timmermans, J.S.*, Brody, S.D.***

** Delft University of Technology, Delft, the Netherlands*

*** Texas A&M University, College Station, TX, USA*

[1] Delft University of Technology, Faculty of Civil Engineering and Geosciences, Stevinweg 1, 2628 CN Delft, the Netherlands

KEYWORDS: Flood defences, flood risk reduction, economic optimization, flood risk modelling

INTRODUCTION

Floods can have a huge impact on the regions they affect. The impact of these disasters can be reduced with a flood risk management system. Flood-prone regions often require a combination of interventions to reduce the risk to an acceptable level. The amount of risk reduction provided by various interventions can be quantified using probabilistic risk analysis.

The interdependence between multiple lines of flood defences within the same flood risk management system can have a large effect on the flood risk in a region. For example, the height and strength of a coastal levee greatly affects the impact of any inland flood risk reduction measures, like vegetation for wave attenuation. This can be investigated with the use of probabilistic risk assessment. However, assessing such flood defence systems can be computationally very intensive, as well as time-consuming. Although methods have been developed to optimize a single type of intervention (e.g. defences (Kind, 2014; Duipuits and Schweckendiek, 2015)), there are no generic approaches that address combinations of interventions.

In this paper, a new model is presented that is able to (1) simulate combinations of flood risk reduction measures and (2) optimize these based on costs, economic risk reduction, and environmental impact. A key feature of the model is the capability to incorporate different types of interventions, including barriers, dikes, wetlands, non-structural interventions, modifications of structures, and buyouts. This is kept computationally workable by using simple, yet realistic representations of the system elements in the form of fragility curves, cost curves, and damage curves. This form of modelling follows earlier explored concepts described in (Haasnoot, 2014) and (Kwakkel, 2013). Other aspects such as societal and environmental impacts will be discussed qualitatively and ranked with other indicators.

SIMULATION MODEL

The model is built up out of three parts: the *Damage Model*, the *Risk calculation* and the *Optimization Model*. Figure 1 shows how the different parts interact and which actions are included.

The *Damage Model* calculates the construction cost, environmental impact and estimated damage

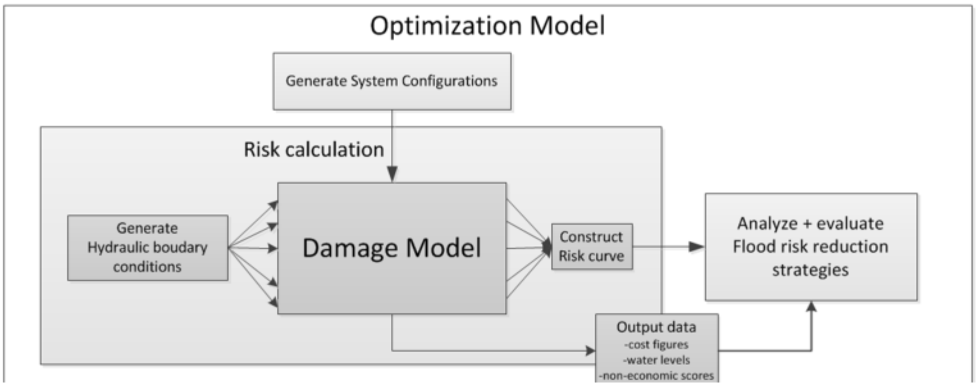


Figure 1 - Schematization of the interaction between the Damage Model, the Risk Calculation – which cycles through the Hydraulic Boundary conditions – and the Optimization Model, which cycles through the Flood risk reduction strategies.

cost for a single storm. This is done by combining three layers of information for the region: the Region lay-out, the Flood risk reduction strategy – consisting of the chosen combination of flood risk reduction measures – and the Hydraulic boundary conditions. This is illustrated in Figure 2. The impact of a storm on the region and the flood risk reduction strategy is calculated using simplified hydraulic formulas (Jonkman & Schweckendiek, 2015; Van der Meer et al., 2016).

The *Risk calculation* uses this combination to calculate the estimated value of damage. It repeats the calculations from the Damage Model for storms with different return periods. With this information, it is possible to construct a risk curve. The basis is a set of (flood) scenarios with their probablities and consequences (cf. Kaplan and Garrick, 1981)

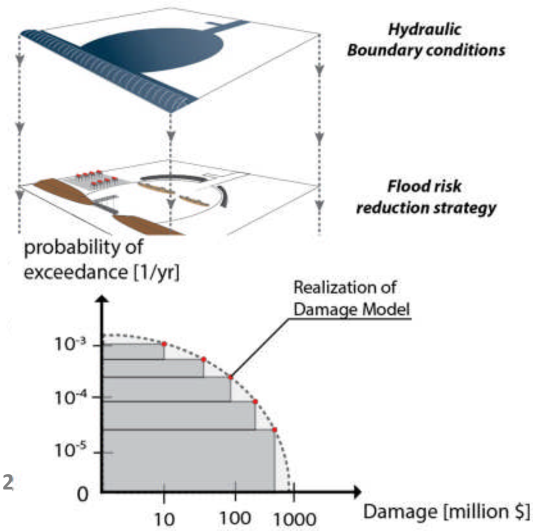


Figure 2

The graph shows the probability of exceedance of an event with a certain damage level. The expected damage can also be computed from this information. How this risk curve is constructed by combining the Damage Model with the Risk calculation, can be seen in figure 2.

EVALUATION TOOL

The strength of the model is the ability to compare large numbers of strategies with both structural and non-structural flood risk reduction measures, such as levees, oyster reefs, improving evacuation routes, and steering urban development locations. This evaluation is done in the *Optimization Model*. It provides the input for the Damage Model, analyzes the output, and investigates how the risk profile of the region reacts to different design choices, for example by identifying design trade-offs.

Figure 3 – graphical representation of how the Risk curve (the dotted line) is constructed by combining the results of different damage calculations as part of the Risk calculation. The rectangles illustrate how the total expected value of damage is derived by numerically integrating the risk curve.

By searching for design trade-offs, one could think of trade-offs between project goals (e.g. "High environmental scores are hard to achieve in combination with low barrier heights inland") or trade-offs between design choices (e.g. "Placing a relatively low barrier at the coast significantly diminishes the impact of Nature-based solutions in the first protected area*").*

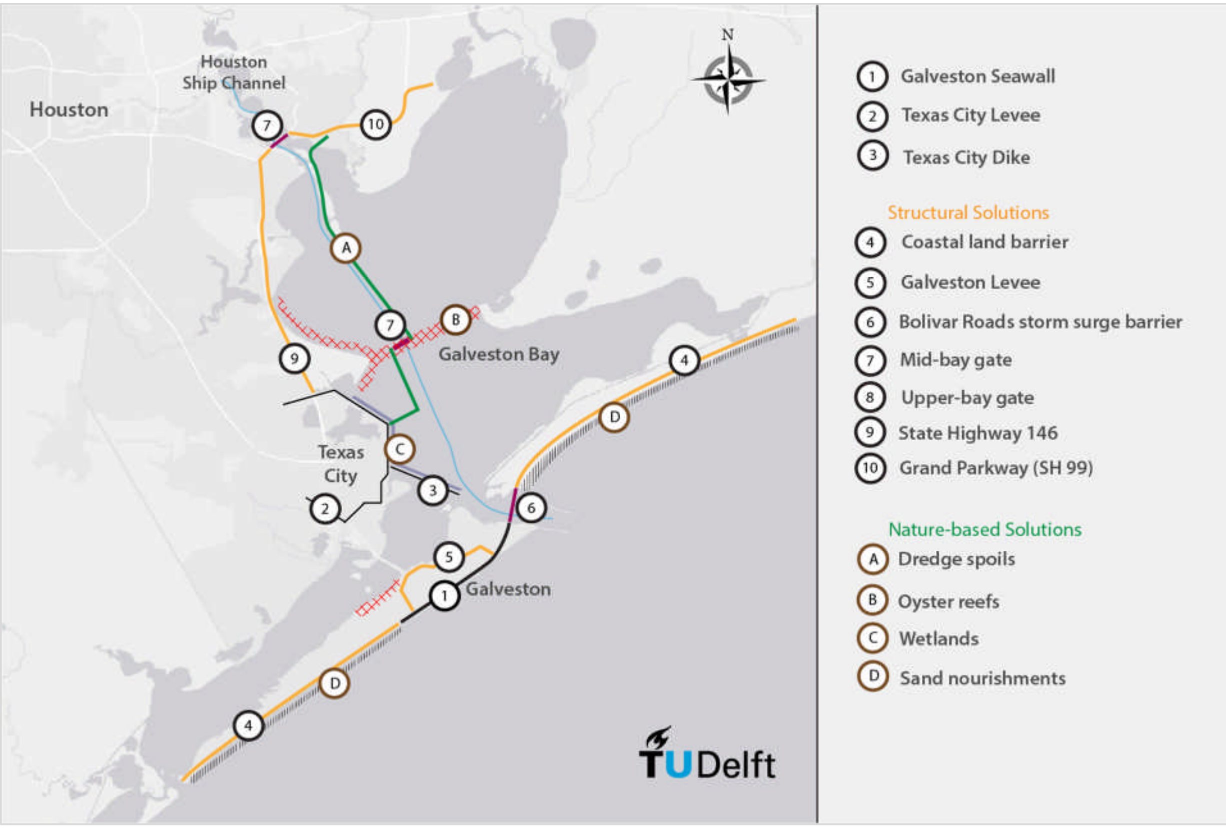
SYSTEM OPTIMIZATION

A stylised case study based on the Houston-Galveston Bay Area in Texas was used to demonstrate the model (van Berchum, 2017). It was able to show how the region reacts to design choices, for example by providing insight into the change of effectiveness of wetlands around the bay depending on the investments in coastal structures. The case study included both structural and non-structural

Figure 3 – map of the Galveston Bay Area with implemented and identified possible flood risk reduction measures.

measures, ranging from levees and storm surge barriers to *Nature-based Solutions* like wetlands, and spatial planning measures like raising insurance premiums.

The model is designed to be used as a decision-making tool during early phases of a design. Especially



during the conceptual design phase, when design choices are impactful and information is scarce, it can provide valuable insights and save precious time and money in finding attractive solutions for reducing risks for high-vulnerability areas threatened by coastal flooding.

REFERENCES

Berchum, E.C. van (2017). Flood Risk Reduction System Optimization. Application to the Galveston Bay Area. Interim Report. TU Delft, Delft. The Netherlands

Dupuits, E.J.C. and T. Schweckendiek (2015). Flood Risk and Economically Optimal Safety Targets for Coastal Flood Defense Systems. Proceedings of the 12th International Conference on Applications of Statistics and Probability in Civil Engineering (ICASP12), Vancouver, Canada, July 12-15.

Haasnoot, M., Van Deursen, W. P. A., Guillaume, J. H., Kwakkel, J. H., van Beek, E., & Middelkoop, H. (2014). Fit for purpose? Building and evaluating a fast, integrated model for exploring water policy pathways. Environmental modelling & software, 60, 99-120.

Jonkman, S. N., & Schweckendiek, T. (2015). Flood Defences. Lecture Notes CIE5314. Delft: Delft University of Technology.

Kaplan, S., & Garrick, B. J. (1981). On the quantitative definition of risk. *Risk analysis, 1*(1), 11-27.

Kind, J.M. (2014). Economically efficient flood protection standards for the Netherlands. Journal of Flood Risk Management 7(2): 103-117.

Kwakkel, J. H., & Pruyt, E. (2013). Exploratory Modeling and Analysis, an approach for model-based foresight under deep uncertainty. Technological Forecasting and Social Change, 80(3), 419-431.

Meer, J. W. van der, Allsop, N. W. H., Bruce, T., De Rouck, J., Kortenhaus, A., Pullen, T., . . . Zanuttigh, B. (2016). Manual on wave overtopping of sea defences and related structures. An overtopping manual largely based on European resreach, but for worldwide application. Retrieved from www.overtopping-manual.com

Zwaneveld, P. and Verweij, G. (2014). Economisch optimale waterveiligheid in het IJsselmeergebied. Technical Report 10, CPB, The Hague, 2014

70. Development of a Standard Testing Framework for Evaluating Temporary Flood Barriers

Lendering, K.T., Sebastian, A.G.*, Jonkman, S.N.**

** Delft University of Technology*

1 Delft University of Technology, Faculty of Civil Engineering and Geosciences, Stevinweg 1, 2628 CN Delft, the Netherlands

KEYWORDS: floods, flood risk reduction, extreme weather, innovation, climate adaptation, temporary flood barriers

ABSTRACT

Floods are the costliest and deadliest weather-related disaster globally. With higher population density in flood prone areas, increased urban development, and projected climate impacts, the frequency and severity of flooding in Europe is predicted to rise. While permanent flood defences have been shown to be more economically effective and reliable in the long-term than temporary flood barriers, they are expensive upfront, socially and politically complex, and time-consuming to build (Lendering et al., 2015). To adapt to climate change and mitigate flooding in the short term, it will be necessary to identify and test temporary flood barriers which can be quickly deployed during a flood event to mitigate risk. Moreover, in some areas, where permanent structures may be phsyically (or socially) infeasible, temporary (or semi-permanent) flood barriers may become a permanent strategy for mitigating floods.

Sandbags have traditionally been used as temporary flood barriers for emergency deployment. However, they are labor intensive and time consuming to construct, and they generate considerable solid waste and require significant clean-up effort after the hazard has passed (Biggar and Masala, 1998; Wibowo and Ward, 2016). To overcome these limitations, temporary flood barriers have been developed as alternatives to sandbags. In many cases, these innovative measures are easier to handle, faster to deploy, easier to remove, and often perform better than sandbags. Nevertheless, they have not been widely tested in operational environments, and skepticism about their performance and lack of a standard testing protocol has inhibited their uptake by water authorities and municipalities (Delfland Waterboard, 2016).

In this paper, we propose a standard testing framework for evaluating the technical effectiveness of temporary flood barriers in laboratory and operational environments. The standard testing framework is applied to **three** inovative flood barriers and their technical effectiveness in terms of re-usability, effectiveness and reliability is compared to the literature on sandbags.

REFERENCES

Biggar, K., Masala, S., 1998. Alternatives to sandbags for temporary flood protection Disaster Services

Branch Emergency Preparedness Canada. Alberta, Canada.

Delfland Waterboard, 2016. Personal Communication.

Lendering, K.T., Jonkman, S.N., Kok, M., 2015. Effectiveness of emergency measures for flood prevention. J. Flood Risk Manag. ICFM6. doi:10.1111/jfr3.12185

Wibowo, J.L., Ward, D.L., 2016. Evaluation of temporary flood-fighting structures, in: FLOODrisk 2016 - 3rd European Conference on Flood Risk Management. E3S Web of Conferences, Leon, France, pp. 1–10. doi:10.1051/e3sconf/201 60703017

93. Forensic analyses and hindcasting of the Breitenhagen levee failure

Kool, J.J.[1], Kanning, W.* , Jommi, C.*, Jonkman, S.N.**

** Delft University of Technology*

1 j.j.kool@TUdelft.nl, Delft University of Technology, Faculty of Civil Engineering and Geosciences, Stevinweg 1, 2628 CN Delft, the Netherlands

KEYWORDS: Flood defences, Forensic analyses, Statistical analyses

ABSTRACT

The hindcasting of levee failures can provide valuable information about levee strength, strength models and dominant factors that contribute to failure. It is however not always clear how and why a levee failed as evidence (such as detail subsoil composition) is not present anymore.

This paper discusses a levee that failed in 2013 near Breitenhagen in Germany, which is called "the Breitenhagen case"(Grubert, 2013). The Breitenhagen levee failed due to long lasting high water level causing an inner slope instability slide. The resulting flood caused severe damage in the hinterland.

In order to investigate the failure, both visual analysis and sensitivity analysis is used to identify the most likely failure modes and most likely contributions to failure. The visual analysis is based on photo and video footage which makes it possible to provide markers that help to understand the whole system and reveal all possible causes of this particular levee. With the help of different sensitivity analyses a comparison is made between several different models, failure models(e.g. Bishop, 1954) in which mean values and upper and lower bounds are considered in order to determine which modelling choices would lead to (modelled) failure. The analyses contain next to the soil parameter variations, the influence of the roots of a nearby tree, the influence of long term high water and the influence of an old levee reparations which disturbed the soil structures.

The results show that best estimated of parameters do not necessarily explain the failures of the levee. It is likely that the main factors that help explain failure are transient effects and roots.

REFERENCES

Bishop, A. (1954), The use of the slip circle in the stability analysis of slopes, First Technical Session: General Theory of Stability of Slopes, 7-17

Grubert P. (2013), Saaledeich bei Breitenhagen, Geotechnische Untersuchungen der Bruchstelle Empfehlungen zur Sannierung

How do our flood defences perform during floods? Ten years of lessons learned and putting them into practice

Flikweert, J.[1], Hollingsworth, C.**, Burdett, S.*** and Simm, J.*****

** Royal HaskoningDHV*

*** Environment Agency*

****Royal HaskoningDHV*

*****HR Wallingford*

[1] Rightwell House, Bretton, Peterborough, PE38DW, +44 7887 632814, jaap.flikweert@rhdhv.com

KEYWORDS:

- Flood events
- Asset management
- Lessons learned and continuous improvement
- Flood defence performance

ABSTRACT

Flood defences are only called into action a few times in their life, so if a large flood does occur, it is important to learn from their performance. The Environment Agency have carried out a structured review of defence performance after each of the major events since the 2007 Summer floods, up to and including the winter 2015/16 floods. These reviews have focused on lessons learned for asset management, at both local and national scale. This presentation will look back over the six reviews carried out in that period, drawing out overarching conclusions about how English flood defences perform during floods based on real life experience, and how this has driven and is driving improvements to asset management and design, supported by research.

The six reviews covered all major breaches or near-breaches, but also assessed assets that survived against the odds. Each review typically started with site visits to collate factual information but also to understand the local asset managers' point of view and collect anecdotal evidence, essential to establish the story of the flood event. This was used to determine the failure modes that occurred, supported by hydraulic/geotechnical modelling as required.

Key conclusions were that visual condition can only tell so much about risk of breach, and that local irregularities are often the trigger for failure. This has influenced how the Environment Agency prioritises its asset management investment in relation to Condition Grade, and has initiated focused studies to identify weak points such as transitions and historical channel crossings.

147. Resilient infrastructure networks - spatial optimisation applied to emergency management

Lopane F. D.[1], Dawson R. J.*, Barr S.*, James P.**

** School of Civil Engineering and Geosciences, Newcastle University, NE1 7RU, UK*

[1] f.d.lopane2@newcastle.ac.uk , Newcastle University, NE1 7RU, UK

KEYWORDS: Flood risk, Spatial optimisation, Genetic algorithm, Emergency management.

ABSTRACT

Motivation and aim

Climate change and intensely increasing urbanisation are going to increase the risk of natural hazards that cities and infrastructures are going to face in the near future. Infrastructures can be considered as the pillars on which cities are built on, consequently, protecting them means to make cities more resilient. Such necessity is made clear in the *National flood resilience review* (2016), which committed £2.3 billion for reducing flood risk and coastal erosion.

This research aims to apply spatial optimisation to flood emergency management in order to increase the resilience of cities and infrastructures facing extreme weather hazards. The purpose is to create an optimisation framework that could be a support tool to decision makers and planners. This approach can face both close future emergencies and long period planning, in the sense that, according to the needs, spatial optimisation can be useful to organise emergency response in the best possible way (e.g. optimisation in resources location) or be the base of future urban development planning regarding sustainability objectives and adaptation or mitigation of climate risks (Caparros-Midwood *et al.*, 2017).

Method

Genetic algorithms are considered one of the best options for solving optimisation problems (e.g. simulated annealing) (Loonen *et al.*, 2007). An implemented genetic algorithm is therefore used in this research in order to achieve a multi-dimensional optimisation in order to balance potential trade-offs and to produce different Pareto-optimal outcomes, which can be the base of future flood defences and infrastructure design (Caparros-Midwood *et al.*, 2015).

The optimisation algorithm solves a number of competing tensions, that include: (1) the identification of, and the cost of using, possible sites to store emergency management resources; (2) the identification of key infrastructure locations (power substations, water treatment etc.); (3) the cost of different amounts of emergency resources; (4) the transport optimisation for moving temporary flood defences and other resources into place; and (5) the transport routes (including bridges) that are vulnerable to flooding disruption between storage sites and infrastructure locations.

REFERENCES

Caparros-Midwood, D., Barr, S. and Dawson, R. (2015) 'Optimised spatial planning to meet long term urban sustainability objectives', *Computers, Environment and Urban Systems*, 54, pp. 154-164.

Caparros-Midwood, D., Barr, S. and Dawson, R. (2017) 'Spatial Optimization of Future Urban Development with Regards to Climate Risk and Sustainability Objectives', *Risk Analysis*.
Loonen, W., Heuberger, P. and Kuijpers-Linde, M. (2007) 'Spatial Optimisation in Land-Use Allocation Problems', in Koomen, E., Stillwell, J., Bakema, A. and Scholten, H.J. (eds.) *Modelling Land-Use Change: Progress and Applications*. Dordrecht: Springer Netherlands, pp. 147-165.
National flood resilience review (2016). Department for Environment, Food & Rural Affairs, Cabinet Office, The Rt HonBen Gummer MP, The Rt Hon Andrea Leadsom MP.

213. Catchment Systems Engineering: a holisitic approach to flood management

Hewett, Caspar J.M.[1], Quinn, Paul F.* and Wilkinson, Mark E.***

** School of Civil Engineering and Geosciences, Newcastle University, UK.*

*** The James Hutton Institute, Aberdeen, UK*

[1] *caspar.hewett@ncl.ac.uk*

KEYWORDS: Catchment Systems Engineering

ABSTRACT

Catchments today are largely the product of human activity. They have been engineered. The negative impacts of some of this engineering such as agriculture intensification and deforestation need to be addressed but the answer is not a simple matter of doing the opposite. Nor is non-intervention an option. We propose a Catchment Systems Engineering (CSE) approach that incorporates and expands on existing approaches including Natural Flood Management, Green infrastructure, Sustainable Drainage Systems, Nature-Based Solutions and the 'Working With Natural Processes' framework combined with traditional 'hard'; engineering to provide a practical approach to improving catchment function. The approach is predicated on the need to take a holistic view of catchments and to make proactive interventions that provide multiple benefits.

The problems CSE seeks to address are international in reach with impacts that cannot be overstated. From flooding to droughts, algal blooms to soil erosion, the negative response of catchments to poorly managed human activity requires intervention. The CSE approach recognizes the need to understand better how the catchment hydrological water balance has changed and what the impact is of those changes on issues such as floods, droughts and environmental degradation. However, the emphasis is placed on *how we can act* to engineer catchment systems to a safer functionally-appropriate level. CSE is the means by which we can alter the processes of the whole catchment to provide multiple benefits whilst recognizing the trade-offs between reducing flood and drought risk directly, improving water quality and creating healthy habitats for wildlife.

Here we set out the philosophy behind CSE, proposing a mitigation and adaptation approach for intensively exploited landscapes undergoing climate change. If a catchment is creating excessive runoff and insufficient recharge then it must be brought back into a healthy water balance. Therefore managing runoff flow pathways during a storm is vital and must be close to the point of generation. If a catchment has lost its slowing and storage capacity we should engineer it back into the system. Thus the primary strategy underpinning CSE is to alter attenuation capacity by holding water in catchments. The strategy is to create infiltration zones, flood storage, sediment traps, wetlands, change roughness and flow pathway length and make best use of floodplains through managed inundation. A variety of methods that act at all scales are employed to change attenuation by adding storage capacity to catchments. Features employed include swales, bunds, ponds and grassy filters,

buffer strips, ditches that hold water and trap top soil lost through erosion, small headwater floodplains that store water, wetlands and woodland.

A series of examples are presented where such features have been applied successfully to reduce flood risk and provide multiple benefits from reduction of sediment and pollutant export to creation of habitats and recreation opportunities.

245. A new partial factor approach for assessing the reliability of flood defenses

Jongejan R.B[1] and Bottema M.***

** Jongejan Risk Management Consulting*

*** Rijkswaterstaat WVL*

[1] Schoolstraat 4, 2611 HS, Delft, The Netherlands, tel. +31 6 1499 6316,

Ruben.Jongejan@JongejanRMC.com

KEYWORDS: flood defense, probabilistic methods, partial factor methods, technical guidelines

1. Introduction

The Netherlands is protected against major floods by a system of primary flood defenses. The primary flood defenses have to comply with flood protection standards from the Water Act. These were updated in January 2017. They are now defined in terms of maximum allowable probabilities of flooding. In the past, the standards were defined in terms of exceedance probabilities of loads that primary flood defenses should be able to safely withstand.

Periodic safety assessments are performed to establish whether the Dutch primary flood defenses comply with the flood protection standards from the Water Act. Because of the change in the type of standard, a new instrument had to be developed for assessing the safety of primary flood defenses (Slomp *et al.*, 2016). This new instrument is called the WBI2017.

The WBI2017 consists of simple screening methods as well as probabilistic and semi-probabilistic methods for detailed assessments. Semi-probabilistic methods rest on a partial safety factor approach. This approach allows engineers to evaluate the reliability of flood defenses without having to resort to probability calculus (also see e.g. Nowak and Lind, 1979; JCSS, 2001; Arnold *et al.*, 2013). The semi-probabilistic method is more practical for design purposes. To ensure consistency between probabilistic and semi-probabilistic assessments, the partial factors in existing semi-probabilistic assessment rules had to be (re)calibrated.

For reasons of efficiency, transparency and consistency across failure mechanisms, a standardized code calibration procedure was developed. This paper gives an overview of this procedure, illustrates its broad applicability and ends with a discussion of the broader lessons learned from the code calibration studies.

2. Code calibration procedure

The WBI2017 code calibration procedure involves:

1. *The derivation of a cross-sectional target failure probability for the failure mechanism under consideration.*
   A semi-probabilistic evaluation is typically performed for a two dimensional profile, for a single failure mechanism. The safety standards, however, are defined as failure probabilities for all failure mechanisms together for stretches of about 5-30 kilometetres. Because of spatial variability and imperfect correlations between failure mechanisms, a cross-sectional reliability requirement for an individual failure mechanism has to be smaller than the standard of protection.

2. *The selection of representative values and the types partial factors to be used in semi-probabilistic assessments.*
   A representative value is a value with a particular cumulative or exceedance probability. For resistance variables, representative values are typically 5% quantile values or average values, depending on the importance of the uncertainty related to the resistance variable. For the hydraulic load, the represenative values are typically values with an exceedance probability equal to the standard of protection. Making these representative values depend on the standards was done for pragmatic reasons, since standards range from 1/100 to 1/100,000 per year. It also facilitates comparisons between the old and new assessment rules.

3. *A comparison between probabilistic and semi-probabilistic analyses for a broad range of cases.*
   The values of all but one partial factor are fixed on the basis of the calculated FORM-influence coefficients for a broad range of cases and a chosen Hosofer-Lind reliability index. Stability factors are then calaculated for each test case with these partial factors. The result is a stability factor (semi-probabilistic) and a reliability index (probabilistic) for each test set member.
   Sufficiently safe values of the remaining safety factor ($\gamma_{\beta T}$) can be obtained from the comparison between probabilistic and semi-probabilistic analyses. Partial safety factors that are broadly applicable may sometimes be too conservative. This gives rise to a tradeoff: differentiating between groups of cases may reduce conservatism, but it may also be impractical.

A more detailed desciption of the steps in the WBI2017 code calibration procedure is given in Figure 1.

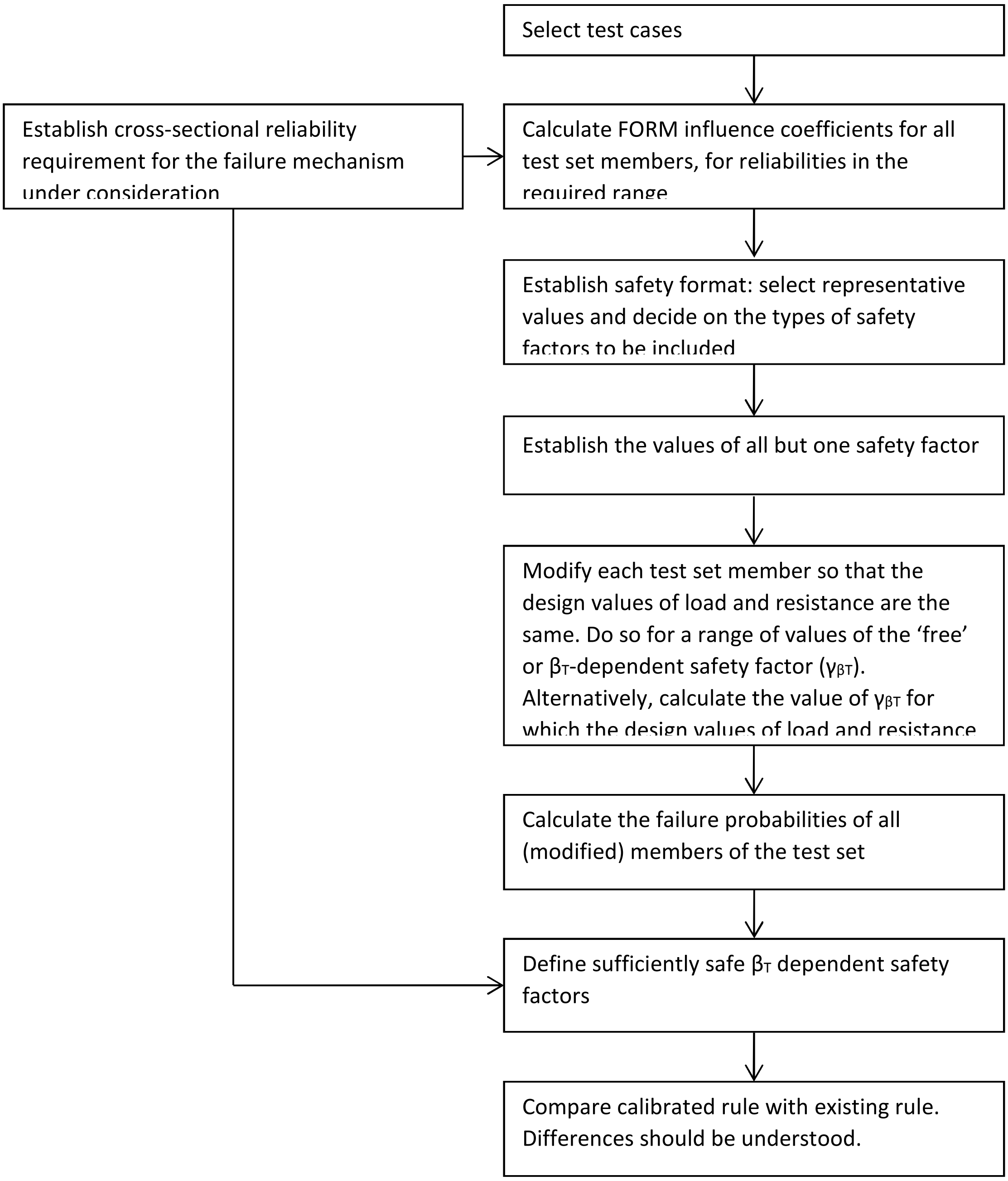


Figure 1. Code calibration procedure (Jongejan, 2017).

3. Results

Semi-probabilistic assessment rules have been developed for the following failure mechanisms:

1. Internal erosion (uplift, heave and piping)
2. Slope instability (macro instability)
3. Dune erosion
4. Block revetment failure caused by wave impacts
5. Asphalt revetment failure caused by wave impacts
6. Grass revetment failure caused by wave impacts
7. Grass revetment failure caused by wave run-up

As an example, the relationship between calculated reliability indices and stability factors for slope stability is shown in Figure 2 below. These stability factors have been calculated with a model factor of 1.06, material factors of 1.0, and the 5% quantile values of material properties. The continuous line shows the chosen definition of $\gamma_{\beta T}$ as a function of the cross-sectional target reliability index β_T.

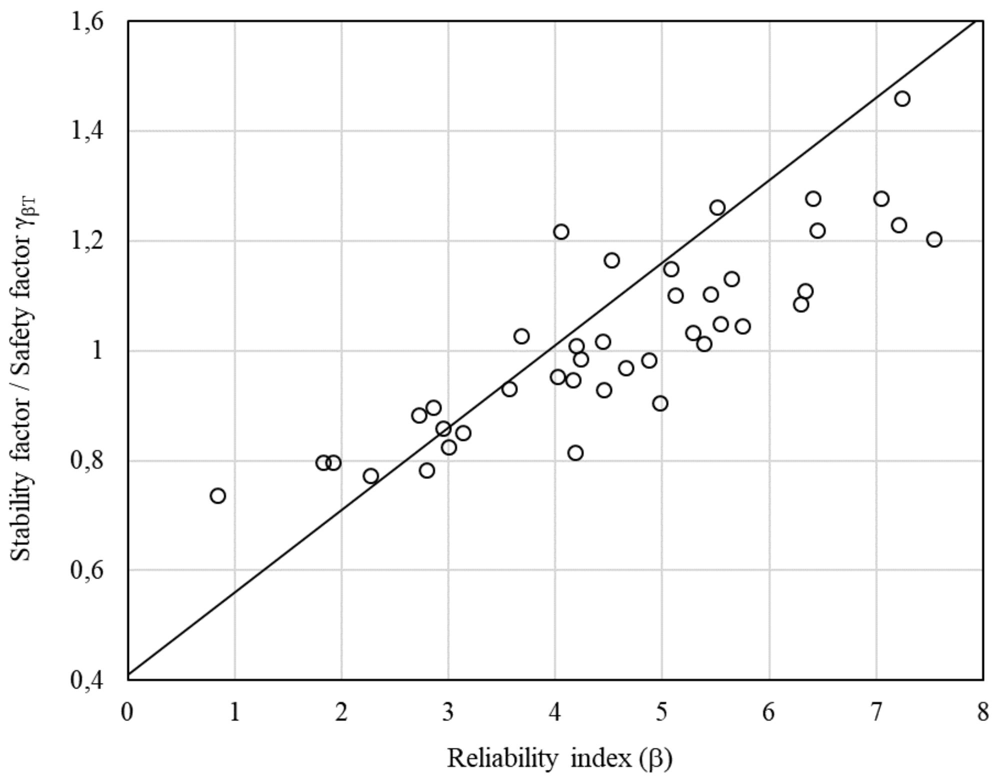


Figure 2. Calculated indices and factors of safety (dots), together with the chosen defintion of $\gamma_{\beta T}$ (Kanning, *et al.*, 2017).

4. Discussion

In a code calibration, a distinction is made between:

1. reliability requirements,
2. the modelling of physical processes or phenomena and

3. the uncertainties related to models and model inputs.

Engineering models have not always been developed with this distinction in mind. The code calibration studies triggered valuable discussions on modelling practices and implicit safe and unsafe biases, which in turn led to changes in models, inputs and outputs. As such, the calibration studies have also helped the move towards a fully probabilistic approach to flood protection, a move that will take many more years to complete.

References

Arnold, P., Fenton, G. A., Hicks, M. A., Scheckendiek, T. and Simpson, B. (eds) (2013) *Modern Geotechnical Design Codes of Practice, Implementation, Application and Development*. Amsterdam: IOS Press.

JCSS (2001) *Probabilistic Model Code*. Joint Committee on Structural Safety.

Jongejan, R. B. (2017) *WBI2017 Code calibration,*. Rijkswaterstaat, Ministry of Infrastructure and the Environment.

Kanning, W., Teixeira, A., Van der Krogt, M. and Rippi, K. (2017) *Derivation of the semiprobabilistic safety assessment rule for inner slope stability*. Deltares, report no. 1230086-009-GEO-0030.

Nowak, A. S. and Lind, N. C. (1979) 'Practical code calibration procedures', *Canadian Journal of Civil Engineering*, 6(1), pp. 112–119. doi: 10.1139/l79-012.

Slomp, R., Knoeff, H., Bizzarri, A., Bottema, M. and Vries, W. de (2016) 'Probabilistic Flood Defence Assessment Tools', in Lang, M., Klijn, F., and Samuels, P. (eds) *Proceedings of the 3rd European Conference on Flood Risk Management (FLOODrisk 2016)*. Lyon: E3S Web of Conferences.

272. Systematic geophysical and geotechnical embankments survey in the area of the Humber Estuary and Yorkshire

Beneš V.[*], Normandale D.[**], Čejka F.[***], Boukalová Z.[†1], Simm J.[††]

[*] *G IMPULS Praha spol. s r.o., Czech Republic*

[**] *Environment Agency, United Kingdom*

[***] *VODNÍ ZDROJE a.s., Czech Republic*

[†] *METCENAS o.p.s., Czech Republic*

[††] *HR Wallingford Ltd, United Kingdom*

[1] *Zuzana Boukalová, METCENAS o.p.s., Tleskačova 1329/16, 32300 Plzeň, Czech Republic; Tel.: +420 602 771 783, e-mail: zuzana.boukalova@metcenas.cz*

KEYWORDS: Embankments and levees; Defence integrity; Geophysics; Non-intrusive investigation; Risk analysis

ABSTRACT

In the past 10 years, the eastern part of central England has repeatedly been affected by sudden floods caused by extreme climate events, such as tidal waves increased by storm surges, or heavy rainfall. In many areas, levees were damaged from overbank flow or breached as a consequence of overtopping or erosion taking place within the levee or in the underlying materials. It has therefore been necessary to repair or raise the levees in selected areas. In order to properly design and perform the renovation of the levee system, it is important to determine its existing condition, particularly the material composition, foundation conditions and occurrence of local inhomogeneities in the levees, such as old unknown drains, buried pipes and utilities, old riverbeds and material heterogeneity. The optimal approach for these purposes appears to be the combination of a geophysical and a follow-up geotechnical investigation.

Since 2014, systematic geophysical surveying of the levee system in the Humber estuary and Yorkshire has been carried out. Up to the present time, approximately 146 km of levees have been surveyed. This report provides a description of the survey methods entitled GMS (Geophysical Monitoring System) that combines quick and effective methods for general levee description (e. g. the Slingram method) and methods providing detailed description of the characteristic as well as anomalous sections (e. g. electrical resistivity tomography – ERT, spontaneous polarization method – SP). By way of example, several results from the geophysical measurements and their comparison with the results of the follow-up geotechnical drilling investigation are presented as well. The investigation results have been imported into the GIS of the levee manager, which will facilitate their future utilisation. In this way, repeated geophysical measurements can be planned to detect changes taking place after the levees have been repaired or to examine the condition of selected problematic

areas under flood loading. This approach has potential to make a significant contribution to ensuring the continued resilience of earthen flood levees and the communities they protect, across the globe.

Economic impacts, loss of life and damage estimation

Economic impacts, loss of life and damage estimation

45. The contribution of disaster management to integrated flood risk management strategies: lessons learned from the Netherlands
Dr Bas Kolen, Delft Safety & Security Institute at Delft University of Technology, HKV Consultants, Netherlands

79. Flood risk management: What can we learn from drought policy?
Dr Rosalind Bark, University of Leeds, United Kingdom

82. Urban Flood Damage Assessment using GIS : Case Study Hanoi, Vietnam
Dr Mohamed Kefi, United Nations University Institute for Advanced Study of Sustainability (UNU-IAS), Japan

101. United States Flood Risks and Flood Risk Management
Mr Doug Bellomo, US Army Corps of Engineers, United States

169. Adapting an agent-based model for flood evacuation in informal settlements
Prof Richard Dawson, Newcastle University, United Kingdom

240. Advancing disaster risk assessments by integrating adaptive behaviour – an agent-based model approach
Mr Toon Haer, VU University Amsterdam – Institute for Environmental Studies, Netherlands

269. BN-FLEMOps pluvial – A probabilistic multi-variable loss estimation model for pluvial floods
Mr Viktor Rözer, GFZ German Research Centre for Geosciences, Germany

278. Supporting resilience by better considering disruption of extreme events in risk assessment: methodologies, tools and lessons learned from the risc-kit project
Dr Christophe Viavattene, Flood Hazard Research Centre at Middlesex University, United Kingdom

315. Trends in flood exposure and vulnerability: Europe 1870–2016
Mr Dominik Paprotny, Delft University of Technology, Netherlands

45. The contribution of disaster management to integrated flood risk management strategies: lessons learned from the Netherlands

*Dr.ir. Bas Kolen. *[1], Jos van Alphen. **

** Delft Safety & Security Institute at Delft University of Technology, HKV Consultants.*

*** staff Delta Programme Commissioner*

[1] Botter 11-29, 8232 JN Lelystad, the Netherlands, B.kolen@hkv.nl, +31 320 294242

KEYWORDS: floodrisk management, disaster management, evacuation strategy

EXTENDED ABSTRACT

An integrated flood risk management (IFRM) strategy consist of a comprehensive set of measures to reduce the risk: protective measures (to reduce the probability of a flood), and land use planning and disaster management (to reduce the consequences of a flood. In the Netherlands this is called a 'multiple layer safety approach', other countries refer to 'multiple lines of defence'. In the development of IFRM strategies one of the main challenges is to define the contribution of disaster management to the reduction of risk, especially when experience with floods is rare and flood awareness is limited.

In the Netherlands since January 2017 new legal flood protection standards apply for all primary flood defenses. The tolerable probability of failure of each flood defense is partly based on the individual risk of drowning from a flood, a cost benefit analyses and group risk (Van Alphen 2016). Historic floods, especially of 1995, show that evacuation is a realistic phenomenon, can be enhanced by early warning and emergency preparation. Therefore the effectiveness of preventive evacuation (expressed as 'evacuation fraction') was taken into account in the development of the new flood protection standards. The evacuation fraction describes the expected number of people in a threatened area that can leave the threatened area prior to a dike breach. With large effectiveness (i.e. a large evacuation fraction) the number of inhabitants remaining in the threatened area is reduced, and so does the potential loss of life which is defined using the model of Jonkman (2007). In this paper we discuss Dutch experiences with the estimation of the evacuation fraction and the validation of these results by disaster management authorities for the use in risk analyses.

Estimation of the evacuation fraction

For the Dutch situation the evacuation fraction is defined for areas that are threatened during the same event of possible large scale flooding, which are assumed to be independent (e.g. floods from a coastal storm surge vs floods from high river discharge, see Figure 1). For each situation specific highways are flooded and not available for evacuation (as for example the Afsluitdijk). The independent evacuation areas are described in Table 1.

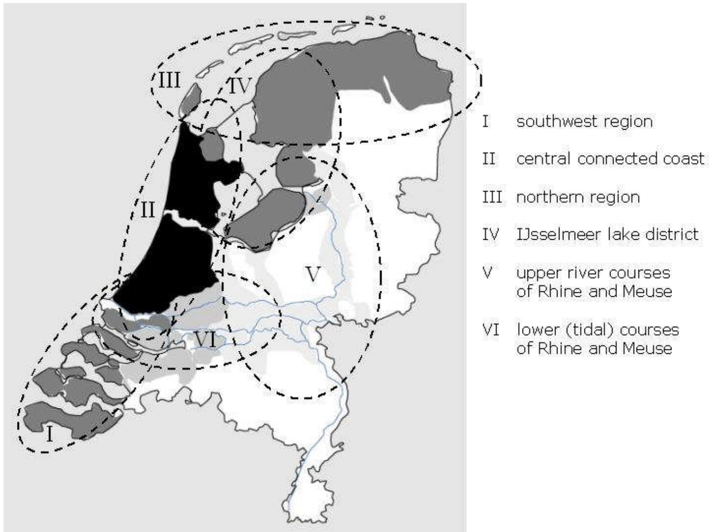


Figure 1: Areas threatened during the same event in case of extreme river discharge or storm surge (ten Brinke et al 2010)

The evacuation fraction is calculated using event trees taking into account the number of people that can evacuate within a range of time intervals available (Kolen 2013). The probability distribution (see Table 1) of the available time (AT) for evacuation is defined at Delphi sessions taking early warning processes and disaster management documents and procedures into account. For storm surges related events it has been taken into account that the 24 hours prior to a dike breach are not available for evacuation because of extreme speed if wind.

Table 1: Probability distribution of available time (AT) for evacuation and evacuation capacity (EC) per area

	4 days		3 days		2 days		1 day		No time	
	EC	AT	EC	AT	EC	AT	EC	AT	EC	AT
Southwest region (I)-Zeeuws Vlaanderen (connected to Belgium)	nvt	nvt	nvt	nvt	75%	50%	0%	40%	0%	10%
Southwest region (I)	nvt	nvt	nvt	nvt	52%	50%	0%	40%	0%	10%
Central connected coast (II)	61%	5%	45%	10%	25%	30%	0%	45%	0%	10%
IJsselmeer lake district (east) (III)	nvt	nvt	nvt	nvt	78%	40%	60%	40%	0%	20%
IJsselmeer lake district (west) (III)	nvt	nvt	nvt	nvt	80%	40%	80%	40%	0%	20%
Northern region (IV)	78%	5%	71%	20%	47%	50%	0%	15%	0%	10%
Upper river course Meuse (V)	nvt	nvt	nvt	nvt	77%	50%	74%	40%	0%	10%

Upper river course Rhine (V)	nvt	nvt	79%	20%	77%	50%	67%	20%	0%	10%
lower tidal courses of river Rhine and Meuse (VI)	nvt	nvt	nvt	nvt	59%	20%	0%	50%	0%	30%

The evacuation capacity EC, the number of people that can evacuate as a function of time (see Table 1 for the EC over time per area) is estimated with traffic models taking several management strategies for evacuation into account:

- Reference: inhabitants are assumed to be free in choice regarding their method of evacuation;
- Nearest exit: evacuees are assumed to evacuate to the nearest exit, regardless of capacity and use of this exit;
- Advanced traffic management: evacuees are optimally divided over the available exit points, taking the capacity of these exit points into account;

Aa more detailed description about these evacuation management strategies is provided by Van Zuilekom et al (2005). The application of these management strategies for the Netherlands is described by Kolen (2012). As a result region specific evacuation scenarios are defined that describe the number of people that can leave the area as a function of time. Based on the possible strategies for evacuation the most pessimistic and optimistic scenario contributes each for 20% and the middle scenario for 60%. We also assume a non-response factor between 10% (river areas) and 20% (coastal areas) of the inhabitants.

Based on the available time and potential evacuation capacity scenario's the area specific evacuation fraction presents the statistical expected value (Figure 2). A bandwidth for uncertainty is due to e.g. limited knowledge about the effectiveness of preparations, human behavior of evacuees, limitations posed by extreme wind conditions).

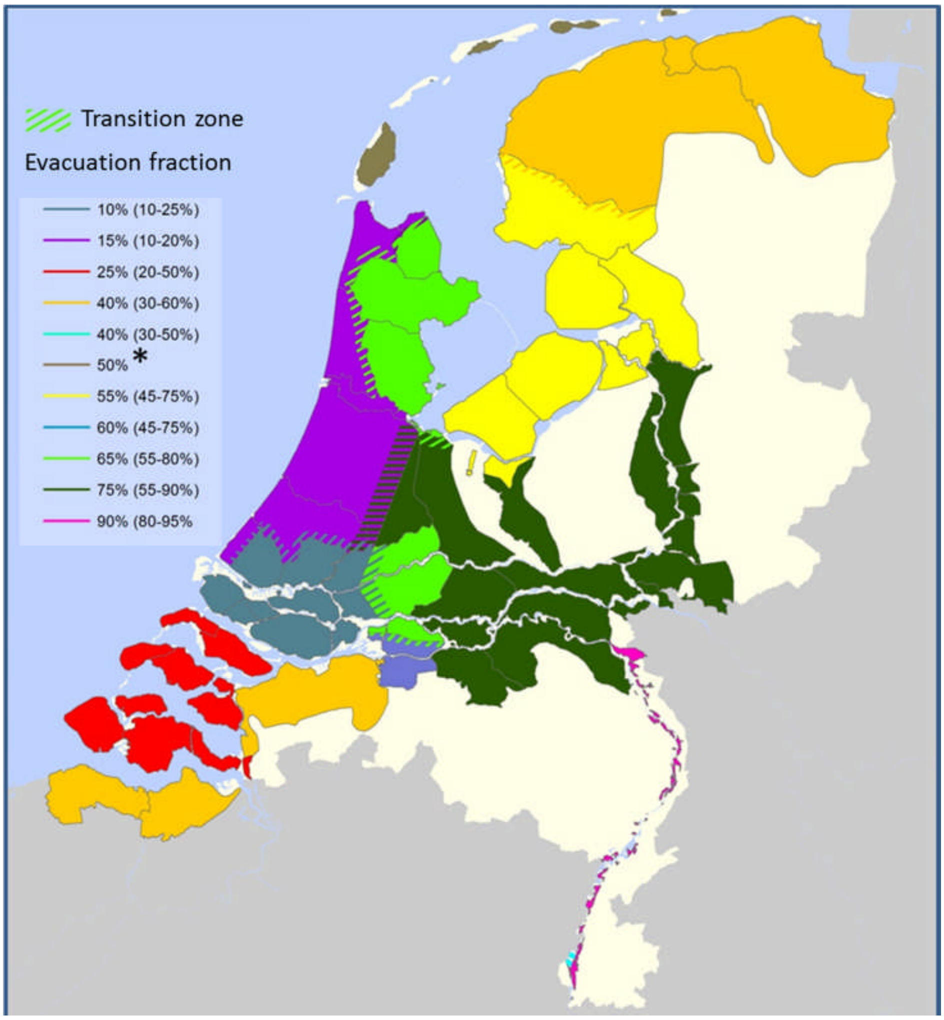


Figure 2: Evacuation fraction

Since disaster management authorities have little knowledge about the effectiveness of their preparation, the pessimistic margin of the evacuation fraction is used for the new flood protection standards. This was approved by the disaster management authorities.

Concluding remarks

The future challenge is improve the quality of the evacuation fraction estimates. The program 'Water and Evacuation' is aimed to increase flood awareness within the disaster management authorities and improve their preparation on evacuation as well as the communication to the public and private sector. Another initiative is to develop a new (international) database to collect empiric information for new flood- and evacuation events to develop a more detailed insight in the effectiveness of measures and improve loss of life and evacuation models (De Bruijn et al 2017). In this way it is expected that in 2020 uncertainties can be reduced and more accurate evacuation fractions can be estimated.

References

Van Alphen, J. (2016), The Delta Programme and updated flood risk management policies in the Netherlands. J. Flood Risk Manage, 9: 310–319. doi:10.1111/jfr3.12183

Jonkman S.N. (2007) Loss of life estimation in flood risk assessment. Theory and applications. PhD thesis Delft University

ten Brinke W.B.M, Kolen B, Dollee A, van Waveren H and Wouters C.A.H. (2010). Contingency planning for large-scale floods in the Netherlands. Journal of Contingencies and Crisis Management 18(1).

Kolen B. (2013). Certainty of uncertainty in evacuation for threat driven responses; Principles of adaptive evacuation management for flood risk planning in the Netherlands. PhD Thesis University of Nijmegen.

K.M. van Zuilekom, M.F.A.M. van Maarseveen and M.R. van der Doef (2005). A Decision Support System for preventive evacuation of people. In Geo-information for disaster management, edited by P. Zlatanova Van Oosterom, S. Fendel, E. M. : Springer Berlin Heidelberg.

Kolen B. and Helsloot, I. (2012). Time needed to evacuate the Netherlands in the event of large-scale flooding: strategies and consequences. Disasters 36 (4):700-722.

De Bruijn, K.M., Jonkman, S.N., Kolen, B., Riedstra, D. (2017). Building an event database for flood fatalities. 7th International Conference on Flood Management (ICFM7). Leeds.

79. Flood risk management: What can we learn from drought policy?

Bark R.H.[*1]

** University of Leeds*

[1] Details for contact author: School of Earth and Environment, University of Leeds, LS2 9JT, 0113 34 35567, R.H.Bark@leeds.ac.uk

KEYWORDS: stranded assets, wet-year options, co-benefits, resilience.

SPECIAL SESSSION

Land for Flood Risk Management

ABSTRACT

Natural hazards are often described as collective but in practice managed in isolation inhibiting learning from one context to another.

Objectives This special session provides a forum to connect drought and flood risk management through the medium of land management. The scale of flood and drought hazards requires catchment scale solutions; a scale at which traditional incentives that focus on private benefit-only may fail. Incentive and funding mechanism design must therefore provide private benefits sufficient to encourage adoption from landholders and managers (Leeuwis, 2004) and public benefits to those funding the initiatives.

Methods We draw insights from case study analysis of drought management policy in the southwest USA and southeast Australia and catchment-based approaches in the southwest, northwest and northeast England. In drought prone regions this has included dry-year options and we explore the potential of this economic instrument for flood prone England as well as highlighting other innovative initiatives that join up the catchment.

Results To meet the challenge posed by increased flood risk (CCC, 2016) policy makers have shown interest in wet-year options, whereby farmers would be paid to have their fields flooded to protected downstream areas. Drawing on dry-year option schemes in the USA we outline the mechanisms to achieve a fully-operational wet-year option scheme. Further, we find catchment-based approaches and nature-based solutions trailed in England have resonance with Australian drought policy that promotes localism and experimentation.

Conclusions Our focus is on landowner and land manager incentives to adopt new land management practice that benefits public good type benefits such as biodiversity and flood regulation. We find the contrasting pressure context – drought and flood – provides scope for learning around theory development and implementation strategies. In so doing it also connects flood risk management to natural capital initiatives (DEFRA 2015; NCC 2015), the insurance value of ecosystems (Baumgärtner

2007; Pascual et al., 2015), and the literature on how to increase landholder and land management adoption of innovative schemes (Leeuwis, 2004).

REFERENCES

Baumgärtner, S., 2007. The insurance value of biodiversity in the provision of ecosystem services. Nat. Resour. Model. 20 (1), 87–127.

CCC (2016). UK Climate Change Risk Assessment 2017. Synthesis report: priorities for the next five years. July 2016.

DEFRA. 2015. The guide to cross compliance in England 2015. Department for Environment Food & Rural Affairs. Crown copyright.

Leeuwis, C. 2004. Communication for rural innovation. Rethinking agricultural extension. 612 (Blackwell Publishing: Oxford, UK).

NCC. 2015. *The state of natural capital. Protecting and improving natural capital for prosperity and wellbeing.* Natural Capital Committee, London

Pascual, U., Termansen, M., Hedlund, K., Brussaard, L., Faber, J.H., Foudi, S., Lemanceau, P., Jørgensen, S.L. 2015. On the value of soil biodiversity and ecosystem services. Ecosystem Services, 15: 11-18.

82. Urban Flood Damage Assessment using GIS: Case Study Hanoi, Vietnam

Mohamed Kefi.[1], Binaya Kumar Mishra*, Ammar Rafiei Emam* and Kensuke Fukushi***

** United Nations University Institute for Advanced Study of Sustainability (UNU-IAS)*

*** Integrated Research System for Sustainability (IR3S), The University of Tokyo*

[1] 5-53-70 Jingumae, Shibuya-ku, Tokyo 150-8925,

Tel : +81-3-5467-1212, Fax : +81-3-3499-2828, Email : kefi@unu.edu

KEYWORDS: Flood Damage, spatial analysis, Ti Lech river

ABSTRACT

Introduction

Due to several factors such as climate change, socio-economic impacts and Land Use and Land Cover Change, flooding events occurred with high intensity and an increase of frequency. The flood risk is observed in all areas of the world and its consequences can conduct to catastrophic disaster. It is considered as the most devastating natural hazards which can lead to negative economic and social impacts. Moreover, flood damage can be classified to direct and indirect categories, tangible and intangible losses. The damage assessment established in several regions reported that catastrophic flooding could have very negative and costly consequences. Due to the development of urbanization and severe weather conditions, many south-east Asian megacities such as Hanoi are considered as flood-prone areas and their vulnerability to flood risk is high.

Objective

The main objective of this research is to estimate urban flood damage in Hanoi using an approach based on the integration of hydrologic and economic data in Geographic Information Systems (GIS)

Methods

There are many urban rivers in Hanoi but in this study, we focused on the impact of To Lich river which affected several districts and caused huge damages during the flood of 2008. The approach applied was based on spatial analysis which requires the integration of several data related to flood characteristics (depth in particular), land use classes and properties value. Flood risk are obtained from FLO-2D model. Furthermore, the value assigned to land use category is assumed to be the replacement cost of degraded areas. Moreover, the flood Depth-Damage function which is useful to determine expected flood damage was also established for particular asset class.

Results

The finding shows that about 113 km^2 were inundated and several districts of Hanoi such as Ba Dinh, Hoan Kiem, DongDa or Hoang Mai were affected by the natural disaster. The flood hazard map pointed out that about 36% of the area had a depth greater than 0,5 m which may increase the risk of physical damages on the one hand and vulnerability of local population on the other. Costly damages were detected in the urban districts rather than rural Districts. Ba Dinh and Dong Da districts were seriously affected. The projected flood of 2050 indicated that the economic estimated damages are considerable. For this reason, appropriate short to long-term countermeasures should be implemented.

Conclusions

This work will be useful for local decision-makers and planners to identify inundated areas and to enhance decision makers' awareness and preparedness to reduce the risk of flooding event in megacities. This study can also contribute to establish sustainable strategies to control flood events.

101. United States Flood Risks and Flood Risk Management

Doug Bellomo[1]Lisa Bourget*[1], Katie Noland*[1]*

** United States Army Corps of Engineers, Institute for Water Resources*

[1] *7701 Telegraph Road, Casey Bldg., Alexandria VA 22315* Douglas.A.Bellomo@usace.army.mil

KEYWORDS: U.S. Flood Programs, Life Safety, Economic, U.S. Flood Risk Characterizations

ABSTRACT

Flood risk management (FRM) practitioners increasingly suggest that flood risks are growing in many areas of the Unite States. Among the evidence cited is the significant loss of life and property damages resulting from a series of major riverine and coastal flood events experienced since 2005, continuing property development in floodplain areas and changing land use conditions within watersheds, as well as the aging of existing levee systems and other hazard reduction infrastructure. And there is an increasingly vocalized belief that sea level rise and climate change are increasing the likelihood of extreme flooding in many parts of the United States.

In 2006, in response to concerns about rising flood risks and the distributed nature of U.S. flood risk management authorities and responsibilities, the U.S. Army Corps of Engineers (USACE) established the National Flood Risk Management Program (NFRMP) as a small part of a much broader set of flood risk management responsibilities. The long-term goal of the NFRMP is to ensure the economy, society and natural landscapes within the US are well-positioned to withstand, recover from, and adapt to ever-changing flood risks, in part by increasing coordination and communication across government (State, Local, Federal, and Tribal) agencies that influence or have an impact on the magnitude or distribution of flood risks. A complementary focus of the NFRMP is characterizing relative flood risks at the national scale.

Meanwhile, the U.S. Congress has expressed concerns about flood risks and flood risk management efforts at the national scale. The U.S. Congress, through legislation, directed the Executive Branch to prepare and submit a report that provides 1) a technical assessment of comparative flood risks for human life and property faced by different regions of the country, and 2) a policy assessment of flood risk management programs and recommendations for improving those programs. Recent appropriations partially fund the anticipated effort.

In support of the NFRMP goals and the investigation called for by Congress, a small USACE study team based at the USACE Institute for Water Resources (IWR) is working to compile a comprehensive review of how flood risk has been characterized in the U.S., and to identify what and possibly how federal FRM programs may influence local choices that can affect flood risk. The USACE study team is working with a practitioner team comprised of governmental partners beyond USACE that provides additional perspectives, information and insights into their activities, and feedback on study work in

progress.

This presentation will provide a preview of early study findings including what has been learned about the economic and life safety risks floods present in the United States, any gaps in knowledge regarding the nature and magnitude of those risks, and the potential influence of federal FRM programs on decision-making by communities (local governments) and their residents (households and businesses) that can affect flood risk today and potentially into the future.

Adapting an agent-based model for flood evacuation in informal settlements

Butters O., Dawson R. J.**[1]*

** * Fisherman's Rest, Mirale, Blantyre, Malawi.*

*** Newcastle University, School of Civil Engineering and Geosciences, Newcastle upon Tyne, NE1 7RU*

[1] *e: richard.dawson@newcastle.ac.uk t: +44 191 208 6618*

KEYWORDS: agent based model; flood incident management; informal settlement

ABSTRACT

Effective flood incident management (FIM) requires consideration of human responses. Agent based models (ABM) have gained increased traction as a tool to support flood incident management as they are able to represent human interactions with the physical and natural environment. However, A regular criticism is their reliance on a large number of different datasets, and often requiring bespoke data acquisition activities. For example, an ABM model for FIM developed by Dawson et al. (2011) integrates remotely sensed information on topography, buildings and road networks with empirical survey data to fit characteristics of specific communities.

Here we adapt this model to apply it to Kibera, Kenya - one of the largest informal settlements in the world. In contrast to the UK where significant volumes of high resolution geospatial data are readily available, in Kibera we relied predominantely on open datasets, that were augmented with some social survey data collected by development agencies , to implement the model. However, the population, infrastructure and mobility characteristics in Kibera are quite different to locations in the UK. Therefore, a number of additional developments and changes were required to represent informal processes, infrastructure and development – for example there are few cars and only limited road infrastructure that is suitable for vehicle-borne evacuation.

A number of simulations were performed that suggested 1-2% of the population were vulnerable to dangerously deep water in extreme events. A number of evacuation locations were tested which higlighted the benefits of using refuges. However, their success was highly dependent on their location. Using a church in the East of Kibera exposed five times as many people as any other site considered in isolation. Compounding the impacts of flooding under some scenarios was significant overcrowding and congestion on key routes heading South and West.

Despite the paucity of data we were able to generate results that could greatly assist in the developments of future FIM plans for the Kibera slum.

REFERENCES

Dawson, R. J., Peppe, R. and Wang, M. (2011) An agent based model for risk-based flood incident management, *Natural Hazards*, 59(1):167-189 (doi: 10.1007/s11069-011-9745-4).

240. Advancing disaster risk assessments by integrating adaptive behaviour – an agent-based model approach

Haer, T.[a 1], Botzen, W.J.W.[a,b] and Aerts, J.C.J.H[a]

[a] Institute for Environmental Studies (IVM), Vrije Universiteit Amsterdam, Amsterdam, Netherlands
[b] Utrecht University School of Economics (U.S.E.), Utrecht University, Utrecht, Netherlands.

[1] *De boelelaan 1085, 1081HV Amsterdam, T:+31205988941, E:toon.haer@vu.nl*

KEYWORDS: Agent-based modelling, adaptive behaviour, disaster risk policy, flood risk, high performance computing

ABSTRACT

Background: In the past decade, floods in Europe affected over four million inhabitants, killing almost a thousand, and leaving over five thousand homeless (Guha-Sapir et al., 2017). These numbers are expected to worsen due to socio-economic growth and climate change. Accurate flood risk assessments are important for the adequate design of Disaster Risk Reduction (DRR) and Loss and Damage (L&D) policies. Current flood risk projections commonly assume that either adaptation remains constant, or try to mimic adaptation through external scenarios. Such static approaches misrepresent the dynamic response of humans, as they are influence by flood events, flood risk communication, and incentives to reduce risk (Haer et al., 2016a; 2016b).

Objectives: In our study, we move towards an improved flood risk assessment, by integrating the adaptive behaviour of key agents, such as government and households, in a flood risk assessment framework. By doing so, we can better inform policy-makers on the manoeuvre space of DRR and L&D policies.

Methods: We integrate adaptive behaviour in a large-scale European flood risk framework through an agent-based modelling approach. This allows for the inclusion of heterogeneous agents, which dynamically respond to each other and a changing environment. We integrate state-of-the-art flood risk maps based on climate scenarios (RCP's), and socio-economic scenarios (SSP's), with agents that behave autonomously based on (micro-)economic behaviour rules. We run the simulations on a High Performance Computing cluster to facilitate the micro-level computations on a macro-level. We simulate different behaviour strategies, ranging from real-world behaviour to economically optimal behaviour.

Results/conclusions: By modelling different behaviour strategies, we quantify for the first time the potential manoeuvre space to steer risk reduction behaviour. Our results show that even under the RCP8.5 climate scenario, proactive and rational adaptive behaviour of governments and households would largely offset the increase risk caused by climate change and socio-economic growth. This emphasizes the need for policies that steer governments towards proactive action, such as the EU

flood directive, and policies that steer households towards rational behaviour, such as financial incentives to reduce risk. The methodology is applied to flood risk, but has similar implications for other natural hazards.

REFERENCES

Guha-Sapir, D., Below, R., & Hoyois, P. (2017). EM-DAT: International Disaster Database,. Retrieved from www.emdat.be

Haer, T., Botzen, W. J. W., & Aerts, J. C. J. H. (2016a). The effectiveness of flood risk communication strategies and the influence of social networks—Insights from an agent-based model. *Environmental Science & Policy*, *60*, 44–52. doi:10.1016/j.envsci.2016.03.006

Haer, T., Botzen, W. J. W., Moel, H. De, & Aerts, J. C. J. H. (2016b). Integrating Household Risk Mitigation Behavior in Flood Risk Analysis : An Agent-Based Model Approach. *Risk Analysis*. doi:10.1111/risa.12740

269. BN-FLEMOps pluvial - A probabilistic multi-variable loss estimation model for pluvial floods

Rözer V. [1], Kreibich H.*, Schröter K.* and Merz B.**

** GFZ German Research Centre for Geosciences, Section Hydrology 5.4, Telegrafenberg 14473 Potsdam, Germany*

[1] Viktor Rözer, GFZ German Research Centre for Geosciences, Section Hydrology 5.4, Telegrafenberg 14473 Potsdam, Germany (e-mail: vroezer@gfz-potsdam.de, Phone: +49 331 288-28991)
KEYWORDS: pluvial floods, urban flooding, flood risk assessment, loss modelling

ABSTRACT

Pluvial flood events, such as in Hull (UK) in 2007, Copenhagen (Denmark) in 2011 or Münster (Germany) in 2014, have caused severe losses to urban dwellings in Europe and elsewhere in recent years. These floods are caused by storm events with high rainfall rates well above the design levels of urban drainage systems, which lead to inundation of streets and buildings. Therefore, pluvial floods often happen with little warning and in areas that are not obviously prone to flooding. With a projected increase of the frequency and intensity of heavy rainfall events, the pluvial flood risk for Northern and Central Europe is expected to increase in the future. For an efficient risk assement and adaptation of urban areas to pluvial floods, a quantification of the flood risk is needed. So far, only few loss models have been developed particularly for pluvial floods. These models usually use simple waterlevel- or rainfall-loss functions and come with very high uncertainties. In order to account for these uncertainties and improve the loss estimation, we present a probabilistic multi-variable loss estimation model for pluvial floods based on empirical data. The model was developed in a two-step process using a data-mining approach and a comprehensive database comprising 783 records of direct building and content damage of private households. The data was gathered through computer-aided telephone interviews with flood-affected households after four different pluvial flood events in Germany between 2005 and 2014. In a first step, tree-based machine learning algorithms, such as (conditional) random forests, bagging regression trees and gradient boosting machines were used to identify the most important loss influencing factors among a set of more than 35 candidate variables. These variables comprise hydrological and hydraulic aspects, early warning and emergency measures undertaken, the state of precaution of a household, building characteristics and socio-economic status of the household. In a second step, the most important loss influencing variables were used to derive a probabilistic multi-variable pluvial flood loss estimation model by learning a Bayesian Network (BN). The model was validated using cross-validation. Together with the ability to cope with incomplete information and expert knowledge, as well as inherently providing quantitative uncertainty information, it is shown that loss models based on BNs are a promising approach for pluvial flood risk assessment.

278. Supporting resilience by better considering disruption of extreme events in risk assessment: methodologies, tools and lessons learned from the risc-kit project

Viavattene C., Priest S.*, Owen D.**

** Flood Hazard Research Centre*

[1] c.viavattene@mdx.ac.uk

Middlesex University The Burroughs Hendon London NW4 4BT

KEYWORDS: Risk Analysis, resilience, vulnerability, business continuity, infrastructure.

ABSTRACT

Objectives

Natural hazards can generate indirect impacts extending far beyond the exposed areas and the direct aftermath of the event. The recognition of such impacts in risk assessment is essential for preparing, mitigating against such events and for increasing the resilience of coastal communities. However the assessment is often limited to the direct impacts (e.g. total damages to assets, exposure of the population and the environment). These numerical estimates might provide a good indication of the scale of the hazard, yet are insufficient to totally value the losses. However the consideration of higher losses poses certain methodological challenges and requires changes in loss assessment approach as well as in the valuation and comparison of the risk.

Methods

This paper investigates these challenges and proposes new methodologies for assessing the disruption of storm events. Eight impacts are considered in the approach: household displacement, a financial recovery of households and businesses, business supply chain disruption, ecosystem recovery, risk to life, utility and transport disruptions. These methodologies are incorporated in the open-source INDRA model (INtegrated DisRuption Assessment). The model was tested on various European Coastal case studies to compare hotspots at the regional scale using a multi-criteria analysis.

Results

Lessons learned and the challenge in the assessment of indirect impact be discussed. In particular a data quality score approach has permitted an analysis with each case study highlighting the needs in data collection for feeding the model. Certain countries, in particular, are very poor data for any of the indicators, others more advanced in their flood assessment practices only require to consolidate their knowledge in particular aspect. Specific indicators such household displacement or insurance penetration are poorly surveyed for instance and limits the understanding on long-term social impacts. The assessment of systemic impact is also often limited due to the absence of information on network such as important business supply chain and critical infrastructures, yet essential to better understand potential cascading effects and large scale impacts.

315. Trends in flood exposure and vulnerability: Europe 1870–2016

Dominik Paprotny[1], Oswaldo Morales-Nápoles*, Bas Jonkman**

** Department of Hydraulic Engineering, Faculty of Civil Engineering and Geosciences, Delft University of Technology*

[1] Stevinweg 1, 2628 CN Delft, The Netherlands, +31 (0)15 27 82610, d.paprotny@tudelft.nl

KEYWORDS: flood losses; flood risk; NUTS regions

ABSTRACT

Objectives

Since the beginning of the second industrial revolution in the second half of the 19th century, Europe's society and economy has been profoundly transformed. The population doubled in the last 150 years, together with more than fourfold increase in number of dwellings and 30-fold increase in production value in real terms. At the same time, rural population dropped, and share of agriculture in production declined from 30% to a mere 2%. Cities that once have been small and very densely populated evolved into less cramped, but quickly sprawling metropolitan areas. All those trends were not without effect on flood exposure and vulnerability, two crucial components of flood risk. The study aims to reevalute reported flood losses (population killed or affected, monetary value of losses, inundated area) so that for each flood event that occurred since 1870, flood losses relative to potential damage given the size of the flood event could be calculated.

Methods

In order to be able to calculate potential losses during any flood event within the study's timeframe, a set of high-resolution maps of land use, population, production and assets distribution is needed. Firstly, such detailed maps of population and land use at 100 m resolution was compiled for year 2011/2012. From this 'baseline' other maps for other time points (decenially 1870–1970 and five-yearly 1975–2020) could be calculated. However, for those other time points we only know the total population and land use at regional level. Hence, for each time step, the population and the different land use classes had to be redistributed inside each region in order to match the regional totals. Several methodologies were used in order to provide the best approximation for each land use class and population. Most effort was put to estimate past and future residential urban areas (where most population lives) and lands used by agriculture and infrastructure. A database of population, land use and economy at NUTS 3 regions was compiled for this study. Estimates of production and assets were disaggregated from regional or national level to a 100 m grid based on population and land use. Information on flood events, each with a flood extent defined using NUTS 3 regions, was also collected. Finally, the exposure maps were intersected with flood zones taken from pan-European flood hazard models.

Results

The study will present results of trends in exposure and vulnerability. Most important are the relative losses, showing changes in flood vulnerability. A sensivity analysis will also be carried out. A statistical analysis of factors influencing the changes in vulnerability: demographic, economic, political will be presented.

Risk Mapping

38. Flood Susceptibility Assessment of the Kosi Megafan in India using Frequency Ratio and Fuzzy Logic Approaches
Mr Mehebub Sahana, Department of Geography, Jamia Millia Islamia (A central university), New Delhi India

125. Flood Risk Management Plan in Segura River Basin
Mr José García, Confederación Hidrográfica del Segura, Spain

140. Flood Foresight: A near-real time flood monitoring and forecasting tool for rapid and predictive flood impact assessment
Dr Elizabeth Wood, JBA Consulting, United Kingdom

143. A step towards risk-based flood forecasting. A pilot application in Dumfries, Scotland
Dr Daniel Bachmann, Deltares, Netherlands

152. A comparison of approaches to risk-based flood modelling in the US and Europe
Mr Andrew Tagg, HR Wallingford Ltd, United Kingdom

232. More accurate calculation of hazard factor using simulation-derived flood characteristics
Xingwei Chen, Fujian Normal University, China

247. FLOODSS: Science-driven cyber-platforms for community action
Dr Marian Muste IIHR-HYdroscience & Engineering, The University of Iowa United States

362. Urban flood modeling based on FLO-2D in Hanoi, Vietnam
Dr. Binaya Kumar Mishra, United Nations University, Japan

38. Flood Susceptibility Assessment of the Kosi Megafan in India using Frequency Ratio and Fuzzy Logic Approaches

Mehebub Sahana, Priyank Pravin Patel**[1]*

** Department of Geography, Jamia Millia Islamia, New Delhi, India*
*** Department of Geography, Presidency University, Kolkata, West Bengal, India*
(Email: mehebubsahana@gmail.com, priyank.geog@presiuniv.ac.in, Telephone: +91-9830353124)
[1] Contact author

KEYWORDS: flood susceptibility, fuzzy logic, frequency ratio, Kosi megafan

ABSTRACT
The Kosi megafan in eastern India is subjected to frequent inundation and river avulsion. The embankments breached during such floods and the resultant areas submerged, cause considerable loss of lands, livelihoods and even lives. Determination of the susceptibility of sites within the megafan to flooding is thus a crucial component of gauging their vulnerability to such events, towards promulgation of protection and mitigation measures.

Objectives:

The study analyses the site susceptibility to flooding in eight districts of the eastern Indian state of Bihar, which lie within the Kosi megafan, and have historically reported the most instances of flooding.

Methods:

A spatial database was constructed, comprising of a flood inventory map based on historically submerged areas from previous flood events and allied thematic maps based on twelve flood causative parameters extracted from high resolution satellite imagery and a digital elevation model, which became the flood conditioning factors for performing the flood susceptibility mapping. These parameters were the study area's lithology, land use and land cover, soil texture, drainage density, slope angle, aspect and curvature, surface elevation, flow direction, annual average rainfall, Topographic Wetness Index and distance from drainage lines. All such conditioning factors were transformed into a raster-gridded spatial database for application of the Frequency Ratio and Fuzzy Logic models to delineate the flood susceptibility zones. A two step approach, having an initial training phase, in which flood pixel identification and the assigning of weights was done, and then the validation procedure, wherein the obtained susceptibility map was verified with the flood inventory map, was applied for each of the two models. For validation and accuracy determination of the outputs, the Receiver Operating Characteristics (ROC) Curve and the Seed Cell Area Indexes (SCAI) methods were used.

Results:

The western and southern part of the study area is most susceptible to flooding due to the traversing and convergence of the principal drainage lines over this section. The distance from the river of a particular site is one of the main conditioning factors due to its influence on the overspill spread and magnitude, followed by the elevation of the adjacent tracts. Verification results using the ROC Curve method shows that the area under curve (AUC) was 0.8693 and prediction accuracy was 86% in the Frequency Ratio model while 0.9035 and 91% for Fuzzy Logic model. This greater reliability of the Fuzzy Logic model (91% accuracy) as opposed to the Frequency Ratio model (86% accuracy) for flood susceptibility mapping was also attested to by the generated SCAI values of flood susceptibility classes.

Conclusions:

A viable and accurate framework for flood susceptibility analysis is ascertained, which helps identify the most vulnerable sites within the Kosi megafan.

125. Flood Risk Management in Segura River District

José García., Mariano Jimenez**, Elena Martínez**[1], Sonsoles González**, Cristina Lobera**, Pedro García de Mendoza***

**Segura River Basin Authority*

***INCLAM.S.A.*

[1]elena.martinez@inclam.com

KEYWORDS: Directive 2007/60/EC, flood hazards and risks maps, Bidimensional Hydraulic Model, huge alluvial floodplains, Flood Risk Management Programme.

INTRODUCTION AND OBJETIVE

The Flood Risk Management Programme (FRMP) of the Segura River Basin District (Segura RBD) was developed according to the requirements of the Directive 2007/60/EC on the assessment and management of flood risks (FD), which was transposed to the Spanish legislation by the Royal Decree 903/2010. It was approved by the Government through the RD 18/2016, on January 15th. The main goal of the FRMP is to accomplish a coordinate action involving all the public Administrations (central, regional and local) and society, in order to reduce flood risks and the adverse consequences of floods. It is founded in a set of measures that must be implemented by each of the Administrations involved according its competency, under the principles of solidarity, coordination and environment respect.

As it is well known, Directive 2007/60/EC requires 3 tasks: (i) a preliminary flood risk assessment (PFRA) and the Areas of Potentially Significant Flood Risk (APSFR) identification, (ii) flood mapping comprising hazard maps and risk maps and (iii) the flood risk management programmes (FRMP) implementation. These three milestones have to be reviewed every 6 years.

SCOPE

The study covers the entire Segura RBD, with a surface area of 19,025 km² and a population of about 2 million people.

Segura River Basin presents a very irregular hydrological regime characterized by frequent droughts and intense rains. This torrential hydrological regime (flash flood) and the anthropic modification of flooded areas due to urban and agriculture development, are frequently causing severe damages. Thus, this basin has suffered the worst consequences and the greatest number of casualties in Spain. To cope with this problem a 20-years structural defense programme against floods has been implemented.

METHODOLOGY

- ***First milestone: PRELIMINARY FLOOD RISK ASSESSMENT***

This first risk assessment is based on a record of historical flood episodes (230 from 1485 to 2012), previous flood prone areas studies, geological and land uses available data, simplified hydraulic study results and a survey to several technicians from River Basin Authority, Emergency Services, Town Councils, etc. At last, 1,500 km of river reaches- out of 20,000 km- have been identified being at flood risk. These potential flooded river reaches had been classified according to a damage index and, finally, 540 km of river have been choose as APSFR , since they accumulated 85% of the total potential damages. Another 745 km at certain flood risk level have been also considered.

- ***Second milestone: FLOOD HAZARD MAPS AND FLOOD RISK MAPS***

Flood Hazard Maps

A Digital Terrain Model and a Digital Surface Model have been obtained as a topography base using Lidar data of National Geographical Agency. These data has 1 meter cell sized and 15 cm of altimetry accuracy. The topographic surface covers 150,000 ha.

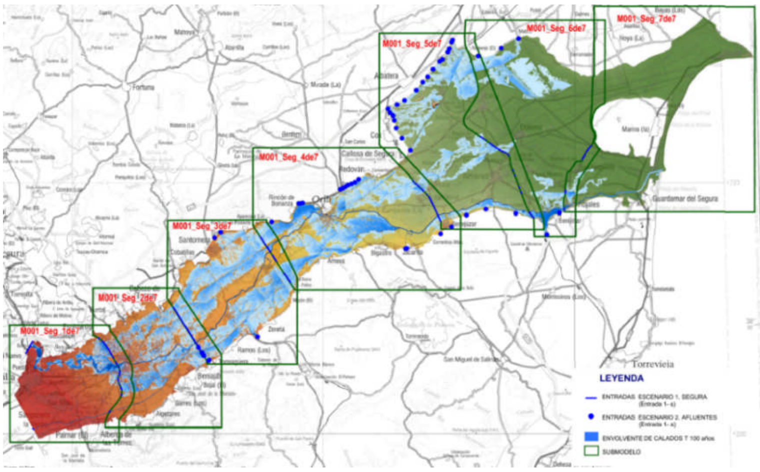
A hydrological study has extended to the whole Segura River Basin District. HEC-HMS, hydrological event model, has been used taking into account two hydrological regimes: natural and modified (considering 21 dams). Both of them have been calibrated through discharge gate data and compared with available Dam Management Rules and flow rates derived from the "Maximum Flows Map" software, developed by the Center for Civil Works Studies and Experimentation of Spain (CEDEX). For the aforementioned study, the Segura River Basin District area had been divided into 151 catchments.

The subsequent hydraulic study has been especially complex due to main rivers can have floodplains more than 9 km wide, often crossed by rail and roads networks, irrigation channels, etc. Hence, it has been used a two-dimensional model in a variable regime (GUAD-2D developed by INCLAM and the University of Zaragoza) for studying the hydraulic behaviour of 1,285 km of river reaches. An area of 143,000 ha has been modelled and 170 two-dimensional models have been set up, including 1,035 structures.

Maximum surface modelled in a single model	**Maximum number of square cells per model**	**Maximum number of triangle cells per model**	**Maximum number of structure per model**	**Maximum number water inlets conditions per model**	**Maximum number outlets conditions per model**
123 Km^2	17.397.914	4.234.754	55	22	13

Main parameters: maximum values of hydraulic models.

When a large river reach is simulated, such as Segura, Guadalentín or Albujón rivers, along 68.3, 95.8 and 47.6 km respectively, it had been necessary to get concatenated models overlapping 0.5 to 1 km.



Segura River models continuosly

Six periods of return have been considered: 5 10, 25, 50, 100 and 500 year-event. To run these models it has been necessary to use a simulator manager developed by INCLAM and a computer center with 4 powerful calculation servers and 100 processing units.

Modelling results have been complemented with geomorphological cartography previously obtained and calibrated with historical flood data. Furthermore, these maps have also been validated with the field data obtained after the flood events happened in 2012 and 2016.

Two-Dimensional hydraulic results in Pulpí and floods photography, 28-09-2012

<u>Flood Risk Maps</u>

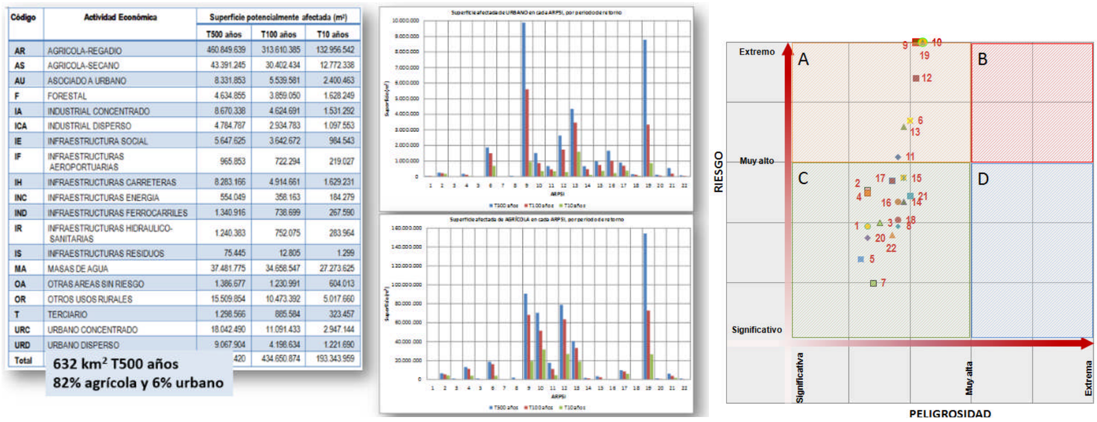
Risk maps had been obtained as a result of crossing hazard maps with exposure and vulnerability maps. These last maps have been carried out according to the Directive methodology. To assess flood damages, unit values have been assigned to every economic activity and they have been calibrated with available data from the 2012 flood event. Finally, an economic assessment per APSFR has been obtained using the following arithmetical expression.

$$\text{Economic valuation}_{\Delta F}\,(€) = \text{Affected area}_{\Delta F}\,(m^2) \times \text{unit Value}_{\Delta F}\,(€/m^2) \text{ x Hazard Coefficient.}$$

Flood risk maps indicate the potential adverse consequences associated with floods under several probabilities, expressing the elements affected: population, economic activity, polluting industries, environmental protection zones (SCIs y SPAs), and other special elements in accordance with Emergency Services.

Based on the flood hazard and flood risk maps, the APSFRs have been characterized and plotted in a dispersion diagram which allows to identify at first sight the hazard and risk degree each one is submitted.

The evaluation findings provide that 365,000 people are affected by a 500 yr-event, and 70% of them living in the middle and low plains of the Segura River. Out of a total of 632 km^2 affected, 82% are agricultural areas and 6% are urban areas. More than one million euros have been quantified as average annual losses.



Código	Actividad Económica	Superficie potencialmente afectada (m²)		
		T500 años	T100 años	T10 años
AR	AGRICOLA-REGADIO	460.849.639	313.610.385	132.956.542
AS	AGRICOLA-SECANO	43.391.245	30.402.434	12.772.338
AU	ASOCIADO A URBANO	8.331.853	5.539.581	2.400.463
F	FORESTAL	4.634.855	3.859.050	1.628.249
IA	INDUSTRIAL CONCENTRADO	8.670.338	4.624.691	1.531.292
ICA	INDUSTRIAL DISPERSO	4.784.787	2.934.783	1.097.553
IE	INFRAESTRUCTURA SOCIAL	5.647.625	3.642.672	984.543
IF	INFRAESTRUCTURAS AEROPORTUARIAS	965.853	722.294	219.027
IH	INFRAESTRUCTURAS CARRETERAS	8.283.166	4.914.661	1.629.231
INC	INFRAESTRUCTURAS ENERGIA	554.049	358.163	184.279
IND	INFRAESTRUCTURAS FERROCARRILES	1.340.916	738.699	267.590
IR	INFRAESTRUCTURAS HIDRAULICO-SANITARIAS	1.240.383	752.075	283.964
IS	INFRAESTRUCTURAS RESIDUOS	75.445	12.805	1.299
MA	MASAS DE AGUA	37.481.775	34.658.547	27.273.625
OA	OTRAS AREAS SIN RIESGO	1.386.677	1.230.991	604.013
OR	OTROS USOS RURALES	15.509.854	10.473.392	5.017.660
T	TERCIARIO	1.298.566	885.584	323.457
URC	URBANO CONCENTRADO	18.042.490	11.091.433	2.947.144
URD	URBANO DISPERSO	9.067.904	4.198.634	1.221.690
Total		[illegible]420	434.650.874	193.343.959

Characterization of the APSFRs´s flood hazard and flood risk.

- ***Third milestone: FLOOD RISK MANAGEMENT PROGRAMMES***

The FRMP of the Segura RBD covers every approaches of flood risk management, focusing on prevention, protection and preparedness and taking into account the characteristics of the particular river basin, considering the climate change effects. The measures proposed by the competent administrations are included in its program of measures (PM). These have different territorial scopes: nationwide, regional, by hydrographic demarcation and by APSFR.

The Segura River PM has 98 measures, including river and hydrological-agroforestry restoration, linear infrastructures drainage improvement, flood prediction, emergency services, land use management and urban planning, measures to promote insurance, and feasibility analysis of the structural measures through the cost-benefit studies that justify them.

For the development process of the PM, working groups have been created. This way, existing problems have been analysed and possible measures to solve or mitigate them have been planned by the different actors involved. After a process of consultation and consensus, these measures have been integrated into the PM, guaranteeing their coordination and compatibility to achieve the FRMP objectives. Likewise, the PM has a follow-up programme, which includes 78 indicators to verify the compliance degree of the FRMP during the 6 years following its approval.

CONCLUSIONS

It is highlighted the need to use a great accuracy two-dimensional simulation in order to obtain a high quality hazard and risk maps. This has enabled the sound characterization has the Segura RBD flooding problem, what has been turn up essential to programme and prioritize the measures of the FRMP.

REFERENCES

European Commission (2007). Directive 2007/60/EC on the assessment and management of flood risks.

Spanish Government (2010). Royal Decree 903/2010, on evaluation and management of flood risks.

EXCIMAP, 2007, Handbook on good practices for flood mapping in Europe.

FEMA, USA 2001, 2: Understanding your risks: identifying hazards and estimating losses.

Cea, M., & Rodriguez, M. (2015). Two-Dimensional Coupled Distributed Hydrologic–Hydraulic Model Simulation on Watershed. Pure and AppliedGeophysics, 1-14.

140. Flood Foresight: A near-real time flood monitoring and forecasting tool for rapid and predictive flood impact assessment

Wood E.[1], Revilla-Romero B.*, Shelton K.†, Berry R.*, Bevington J.*, Hankin B.*, Lewis G.**, Gubbin A.*, Griffiths S.*, Barnard P.*, Pinnell M.* and Huyck C.†*

** JBA Consulting, South Barn, Broughton Hall, Skipton, BD23 3AE, 01756 799 919, elizabeth.wood@jbaconsulting.com*

*** ImageCat Limited, 150 Minories, London, EC3N 1LS, 0207 264 2180*

† ImageCat Inc., 400 Oceangate, Long Beach, California, 90802, USA, +1 562 628 1675

[1] JBA Consulting, South Barn, Broughton Hall, Skipton, BD23 3AE, 01756 799 919, elizabeth.wood@jbaconsulting.com

KEYWORDS: Flood Foresight, Screening, Monitoring, Forecasting

ABSTRACT

The hours and days immediately after a major flood event are often chaotic and confusing, with first responders rushing to mobilise emergency responders, provide alleviation assistance and assess loss to assets of interest (e.g., population, buildings, utilities). Preparations in advance of a forthcoming event are becoming increasingly important; early warning systems have been demonstrated to be useful tools for decision markers. The extent of damage, human casualties and economic loss estimates can vary greatly during an event, and the timely availability of an accurate flood extent allows emergency response and resources to be optimised, reduces impacts, and helps prioritise recovery. In the insurance sector, for example, insurers are under pressure to respond proactively to claims rather than waiting for policyholders to report losses. Even though there is a great demand for flood inundation extents and severity information in different sectors, generating flood footprints for large areas from hydraulic models in real time remains a challenge. While such footprints can be produced in real time using remote sensing, weather conditions and sensor availability limit their ability to capture every single flood event across the globe.

Flood Foresight (www.floodforesight.com) is an operational tool consisting of three components, developed to meet the universal requirement for rapid geographic information, before, during and after major riverine flood events. The tool provides spatial data with which users can measure their current or predicted impact from an event – at building, basin, national or continental scales. The Screening component uses global rainfall predictions to provide a regional- to continental-scale view of heavy rainfall events up to a week in advance, alerting the user to potentially hazardous situations relevant to them. The Forecasting component enhances the predictive suite of tools by providing a local-scale view of the extent and depth of possible riverine flood events several days in advance by linking forecast river flow from a hydrological model to a global flood risk map. The Monitoring

component provides a similar local-scale view of a flood inundation event but in near real time, as an event unfolds, by combining the global flood risk map with observed river gauge telemetry. Immediately following an event, the maximum flood extent is also generated. Users of Flood Foresight will be able to receive current and forecast flood extents and depth information via API into their own GIS or analytics software. Currently operational for the UK and Europe; the methods presented can be applied globally, allowing provision of service to any country or region.

This project was supported by InnovateUK under the Solving Business Problems with Environmental Data competition.

143. A step towards risk-based flood forecasting. A pilot application in Dumfries, Scotland

Stuparu D.[1], Bachmann D.*, Ververs M.*, Brown E.**, Boelee L.**, Tavendale A.****

** Deltares, Boussinesqweg 1, 2629 HV Delft, The Netherlands*

[1] *+31(0)625640533; dana.stuparu@deltares.nl*

*** HR Wallingford, Howbery Park, Wallingford, Oxfordshire, OX10 8BA, United Kingdom*

**** Scottish Environment Protection Agency (SEPA), Strathearn House,Lamberkine Drive, Perth, Scotland, PH1 1RX, United Kingdom*

KEYWORDS: flood forecasting, impact, ensemble, probabilistic

ABSTRACT

The Scottish Environment Protection Agency (SEPA), Deltares and HR Wallingford have recently collaborated to develop new tools and techniques to extend existing flood forecasting capabilities. The focus was on developing timely 'impact' information to support flood response activities. Within this research, the River Nith to Dumfries was used as a pilot catchment.

SEPA operates a Delft-FEWS based flood forecasting and warning system which consists of multiple models that use numerical weather predictions to estimate future river levels and flows. Over time, SEPA's flood forecasting system has continually evolved to incorporate the latest science and technology. This study focussed on the following aspects:

1. Live flood maps: forecasting flood inundation;
2. Live impact information: number of properties affected and damages;
3. Ensemble runs: incorporating meteorological uncertainty.

These elements were connected to the existing forecasting system in a framework titled FEWS-Risk.

Flood inundation mapping was performed using HR Wallingford's Rapid Flood Spreading Model (RFSM-EDA). The RFSM-EDA is a 2D inundation model that is used for rapid flood inundation prediction in practical run times, appropriate for operational use. The RFSM-EDA was setup using Lidar digital elevation data on a 5 metre grid. For the Dumfries catchment the RFSM-EDA embedded in FEWS-Risk framework takes 5 minutes to run a 2 day simulation.

Part of the FEWS-Risk framework, the potential damages were assessed by linking the flood depths with receptor impact information using Delft-FIAT (Flood Impact Assessment Tool).

The possible benefits of including uncertainty in the forecasts using ensemble forecasting were also explored. To achieve this, 5 ensemble members were randomly generated based on Storm Frank

(December 2015) data and used as boundary conditions for the RFSM-EDA model. The simulations were used to calculate the probability of exceedance of a given water level threshold.

The results were presented and discussed at a workshop hosted at the Scottish National Centre for Resilience, with delegates attending from SEPA, Scottish Fire and Rescue Service, Police Scotland, Scottish Government and Dumfries & Galloway Council.

Feedback indicated that the strength of such risk-based operational modelling is greatest for events and regions where impacts are unknown. Communication of risk is a challenge, but guidance with long lead times and high uncertainty can still be useful (e.g. to trigger preparation). Information regarding the onset of floods is especially useful for flood preparedness. Overall, probabilistic forecasting can give good guidance in advance of a flood event but needs to link closely with operational procedures to maximise its effectiveness. Results from this pilot study indicate that the FEWS-Risk framework may have great potential in helping to minimize flood impacts.

152. A comparison of approaches to risk-based flood modelling in the US and Europe

Ben Gouldby,Jonathan Simm*[1], Jim Murphy ** and Mike Seering.***

** HR Wallingford, UK*

*** AECOM, USA*

[1] HR Wallingford, Howbery Park, Wallingford OX10 8BA United Kingdom, tel 01491 822355, email: j.simm@hrwallingford.com

KEYWORDS: Flood Risk Mapping, Flood Insurance

ABSTRACT

The approach to floodplain risk management in the US has evolved around the National Flood Insurance Program (NFIP) and as such is largely focused on establishing Flood Insurance Rate Maps (FIRM) that specify insurance rates in zones that are anticipated to fall within the zone of inundation that is determined to be associated with the 0.01 percent chance of occurrence during any given year (i.e. 100-yr Flood). While this approach offers a wide range of information for floodplain managers and communities to make decisions about how to best manage at risk portions of their communities, it is not a truly risk-based approach to floodplain management. Furthermore, in order to sustainably fund the US National Flood Insurance Program (NFIP), a way has to be found to determine the actuarially based premiums which should be paid by home owners. This imperative has driven the work that will be reported in this paper.

Risk, defined as the probability of consequence (e.g. in dollars), enables a broader understanding of: a) the variability of flooding in time and space; b) the pathways that exist between the flooding source and the flood prone area, including the effect of levees (flood defences); and c) the variable probability of occurrence across the floodplain. The paper reviews various full risk based mapping approaches that have either been proposed for the US by various organisations or already adopted in a number of European countries and within the insurance industry. It identifies key challenges for changing the approach in the US in terms of data requirements, methodological tool development, upskilling and communication and concludes by setting out a tentative road map for the US to move from the current system through to the full systems-based flood risk analysis method.

232. More accurate calculation of hazard factor using simulation-derived flood characteristics

Zhidong LIN, Xingwei CHEN*†[1]*

** College of Geographical Sciences, Fujian Normal University, Fuzhou, China*

† Fujian Provincial Engineering Research Center for Monitoring and Assessing Terrestrial Disasters, Fuzhou, China

[1] Address: Room 315, Shao Yifu Building, Fujian Normal University, Shangsan Road, Fuzhou 350007, China

Telephone/fax: 86-13067215215; Email: cxwchen215@fjnu.edu.cn

KEYWORDS: precipitation; flood; hazard factor; HEC-HMS; Jinjiang watershed

ABSTRACT

Regional flood disaster assessment is important for flood disaster estimate and management. According to disaster system theory, the evaluation index of risk identification is usually selected from hazard factor, disaster environment and hazard bearing body. Hazard factor for flood disaster risk assessment is usually calculated with precipitation data due to the difficulty to obtain the spatial distribution of flood peak discharge. However, it is not well understood whether using flood characteristics data, instead of precipitation data, will yield a better estimate of hazard factor.

In this study, the two hazard factor calcuation methods were compared for more reasonable assessment of regional flood disaster. Jinjiang watershed, situated in south-eastern China, was selected as a study area. It is one of the regions where convective rainstorms and typhoon storms occur frequently in summer, and the loss caused by flood is often tremendous. The annual maximum flood events occurring from 1972 to 1979 were selected. Hazard factor based on precipitation characteristics, including the average precipitation volume and average precipitation intensity for the selected flood events in 30 rainfall stations, was calculated as usual. Meanwhile, in order to solve the difficulty of obtaining the spatial distribution of flood peak discharge, a model for the storm-flood simulation based on the Hydrologic Engineering Center-Hydrologic Modelling System (HEC-HMS) was built. The flood characteristics such as peak discharge and flood volume of these flood events in 55 sub-basins were obtained from the simulation using the HEC-HMS model. Then the hazard factor based on flood characteristics in each sub-basin was also calculated.

The results show that the spatial variation of hazard factor was similar between the two methods (calculated either from precipitation characteristics or from flood characteristics), with a gradual increase from northwest to southeast and a higher value on the downstream and the estuary. With the method using flood characteristics, there is a more even distribution of areas identified with the 5 different risk levels, and a larger area was identified with the top risk level. In summary, we show that it is feasible to apply spatial distribution data obtained from hydrological model simulation to flood

characteristics derivation and hazard factor analysis, and this method provides a more reasonable result than traditional methods of hazard factor estimation.

247. FLOODSS: Science-driven cyber-platforms for community action

Muste M.

IIHR-Hydroscience & Engineering, The University of Iowa, Iowa City, IA 52242, U.S.A.; Phone: 319-384-0624; Email: marian-muste@uiowa.edu

KEYWORDS: decision-support systems, flood risk mitigation, flood resilience, web-GIS, strategic partnership

ABSTRACT

The sciences underpinning the investigation and mitigation of floods have made great progress paralleling advancements in other hydroscience-related areas. The continuously improving flood-focused numerical models and observational infrastructure have steadily enhanced our capabilities to predict floods with high-fidelity temporal and spatial resolution hence reducing the uncertainties associated with flood risk management. The progress made so far in scientific knowledge does not flow simply from science into decision- and policy-making because of incomplete knowledge on processes (limited understanding of large-scale hydrology/hydraulics) as well as methodological and technological constraints (lack of cyberinfrastructure to efficiently and quickly integrate data with models).

The lack of complete scientific knowledge has too commonly led to invalid predictions, especially for conditions that fall outside the range of available records. The distrust in modelling results leaves no other alternative for flood managers than to rely on methods that too broadly and empirically address the range of conditions associated with flooding. Typically such strategies comprise information gathered, in fragmented ways, from simulations with over-simplified models, and/or third party data and information sources. The available data are generally insufficient, scattered in various repositories, and lacking the spatio-temporal resolution needed to resolve details of flood propagation. The flood scientists and decision-makers have continuously indicated the need for integration of high-resolution cross-disciplinary data with simulation models into web-based platforms where the incoming data are seamlessly ingested in the models in real, or near-real, time.

The flood focused decision-support system (FLOODSS) envisioned through this paper is an interactive ***problem-solving environment*** that assembles in one place a mix of existing and customized software models and tools (for aggregating various hydro-meteorological data, hazard mapping, economic losses, risk mapping, linking models, visualizing scenarios, etc) and computer and communication technologies to facilitate the presentation of decision-making outcomes (i.e., intervention alternatives assessed for financial and societal aspects) into a language understood by all stakeholders. The challenges in the design and prototyping of this computing environment extend well beyond the reach of a single-discipline group, specialized institute or even nation. It requires conceptualization efforts followed by coordinated research and technological developments at a global scale with the

involvement of all relevant flood mitigation stakeholders (national and local executive institutions, private business, academia, public and communities). Such an ambitious endeavour can only be attained through the formation of a trans-disciplinary and trans-institutional collaboration with international dimensions.

The paper reviews first the types of currently-available DSS for floods and offers a conceptual framework for FLOODSS architecture and functionality. The emphasis is set on the FLOODSS features that share the data, information and knowledge encapsulated in the FLOODSS platforms and engage the community in decision-making for flood-risk reduction and increased resilience. Finally, the paper proposes a road map for long-term engagement and collaboration to attain the FLOODSS vision.

362. Urban flood modeling based on FLO-2D in Hanoi, Vietnam

Rafiei Emam A.[1], Mishra B.**, Kumar P. **, Masago Y. **, and Kappas M. **

** Department of Cartography, GIS nad Remote sensing, University of Goettingen, Germany*

*** United Nations University, Institute for the Advanced Study of Sustainability,Tokyo, Japan*

[1] Goldschmidtstr. 5, 37077 Göttingen, Germany, Phone: +49(0)551/39-8029, Fax: +49(0)551/39-8020, E-mail:rafiei99@gmail.com

KEYWORDS: Inundation, water management , climate projection

ABSTRACT

Since last decade the urbanization in Hanoi city of Vietnam has been very fast which has caused serious urban flooding. The situation is getting worse by extreme weather events due to climate change. Therefore, it is crucial to evaluate urban flooding in this area. For this aim, FLO-2D model, a two-dimensional hydrological and hydraulics model, was employed in this research to simulate the flood inundation in the urban area in different return periods based on current and future climate projections. To do this, first the model was set up based on the storm event dated on Novembr 2008. We calibrated the model by optimizing some model parameters, and further the model was validated by some observed data during the storm incident. The validated model was used to predict the flood inundation based on landuse and climate change projections. The predicted flood depth was classified in four depths in which greater than 0.5 meters as a high hazard situation. The results showed extremely increased in inundation areas entire city, approximately 40 % more than the current condition. Based on the results it is extremely needed a great attention in the south and west of Hanoi city, as these areas are expected to be extremely affected by floods.

Vulnerability Assessment

20. Investigation and Assessment on Flash Flood in Yulin Municipality, Guangxi, China
Mr Li Changzhi, China Institute of Water Resources and Hydropower, Research China

57. Real time floodrisk management
Dr Bas Kolen, TU Delft, Netherlands

156. Supply chain fragility and flood disruption: understanding the impacts of supplier and customer proximity
Dr Namrata Mis, University of West of England, United Kingdom

351. A methodology to include long-term financial recovery in flood risk assessment
Dr Sally Priest, Flood Hazard Research Centre at Middlesex University, United Kingdom

20. Investigation and Assessment on Flash Flood in Yulin Municipality, Guangxi, China

Changzhi Li[1], Miao Zhang[1], Kaibo Luo[2], Changjun Liu[1], Dongya Sun[1]

1. *China Institute of Water Resources and Hydropower Research, Yuyuantan South Rd. Haidian District, Beijing, China, 100038;*
2. *Office of Yulin Municipal Flood Control and Drought Relief Headquarters, Yudong Rd. Yulin District, Guangxi, China, 537000*

1 Introduction

Yulin is a municipality-level-region in the southeast of Guangxi Zhuangzu Autonomous Region of China, covering area of 12,838 square kilometers. The conditions of climate, geography and residents in the Yulin Municipality make it a flash flood prone area. First of all, this area is subjected to subtropical monsoon climate with mean annul precipitation about 1,650mm, but rainfall concentrating from June to August, and attacked frequently by rainstorms of frontal rain, terrain rain, typhoon rain and convectional rain. Secondly, Yulin City is located in the Yulin Basin and sounded by the Darong Mountain in the north, the Liuwan Mountain in west, the Stone Mountains in the east, and low hills in the south. The Nanliu River originates at the Darong Mountain and runs through the Yulin Basin from northeast to southwest. Generally, the areas of the Yulin Basin, hill area and mountainous area cover 17.6%, 49.4% and 33% of the entire territory, respectively. Thirdly, the local people in mountainous-hill area, potentially threatened by flash flood, reach 5.10 million, 74% of the total population (6.9 million in 2016) in the Yulin Municipality.

The Yulin Municipality includes seven counties, namely, Yuzhou District, Fumian District, Rongxian County, Luchuan County, Bobai County, Xingye County and Beiliu County. All of these counties suffer badly from flash floods. In the past years, great efforts were made to mitigate flash flood hazards, such as primary early warning system development, and training and exercising for common people, etc. However, all of these cannot work well at acceptable level. Moreover, rapid developments have increasingly coming up in the mountainous-hill areas in recent years, then more and more lives and properties are facing threat of flash floods. Hence, a municipality-wide project, Flash Flood Investigation and Assessment in Yulin* ("the Project" for abbreviation), were conducted from 2013 to 2015 to make clear how flash floods are and how to deal with them, with aim as follow: 1) detecting the flash flood area and villages, 2) estimating flash flood magnitude for riverside villages, 3) evaluating existing flood control capacity of riverside villages, and 4) improving current early warning system.

2 Project Techniques

Early warning is currently the most important measure against flash flood hazard, and depends on a comprehensive system that is an integrated package of data collection and transmission equipment, forecasting models, response plans and procedures, and human resources. Data are transmitted to the systems at or above county level that include tools to display and inspect the incoming data to determine if a flash flood threat exists and tools to forecast occurrence of a future threat. When a threat is recognized, through observation or prediction, and warnings are issued, actions begin as early as possible to protect lives and property. In general, flash flood warning begins with data collection and depends on comparisons of observations to thresholds that are from rainstorm-runoff modeling.

Hence, data collection is fundamental for successful early warning on flash flood prone area and villages, rainfall depth in real time, existing flood control capacity of riverside villages, and the physical

---

* *In the Project, flash flood investigation refers to: (1) identifying flash flood prone area and village, (2)collecting data for flash flood magnitude estimation, and (3)evaluation current early warning system and flash flood event survey; flash flood assessment means: (1) rainstorm analysis in watershed, (2) current flood control capacity evaluating, (3) flash flood risk analysis, and (4) rainfall depth threshold estimating for riverside villages.*

conditions of small river basin. One of the important aims of The Project is aimed to acquire fundamental data for early warning analysis as much as possible that is done by investigation on the spot. Surveying flash flood events in the past and hydrologic and hydraulic estimation are used to identify flash flood prone area and villages. For flash flood estimation, it is necessary to collect local geographic data for watersheds, and measure river channel sections nearing the riverside villages, and gather available hydrologic records, while evaluating existing flood control capacity for riverside villages is performed by rainstorm-runoff modeling, water stage threshold determination, and flash flood risk zoning and mapping. Meanwhile, the improvement of current early warning systems is the most important in the aims of the Project, conducted by retrogressive rainfall-runoff modeling, analyzing rainfall depth threshold for flash flood detection for riverside villages.

3 Flash flood hazards investigation

3.1 Identifying flash flood prone area and villages

Flash flood prone area and village identification was done through examining flood remarks investigation and flash flood events on the spot in the past. The areas and the main protected objectives, such as villages, towns, schools, enterprises and tourist sites, etc., threatened by flash flood, were highlighted in the working base map; the houses, and the population, were summed up and input to a special database for flash flood information management. The statistic presents that the flood prone area in Yulin reaches near 6,800 square kilometers, and about 87 thousand people threatened by flash flood, and the protected objectives includes 5 county cities, 100 towns, 3,148 villages, and 71 enterprises. Among the villages, 874 villages closing to streams were selected as typical samples for flash flood assessment.

3.2 Collecting data for flash flood magnitude estimation

Many data have to be acquired for flash flood magnitude estimation. First, the use of rainfall data is essential and fundamental to the rainstorm-runoff process, the rainfall data are the driving force in the relationship. Second, the available historic flash flood records are important to verify the parameters and identify the rainstorm-runoff model. Third, geographic data for small river basin is the fundamental for rainstorm-runoff modeling. Fourth, river channel longitudinal and transversal shape is necessary for rainstorm-runoff modeling and rainfall depth threshold analysis for riverside villages. As a result, the basic data had been collected and cleared up successfully, including the technical manual-*the Manual for Rainstorm-runoff Consulting Chart in Guangxi* (*the Manual* for abbreviation; Department of Hydrology and Water Resources, Guangxi Zhuangzu Autonomous Region, 1984), the GIS data with all features and the remote sensing image for each county, and the characteristic parameters for small watershed covering the whole Yulin Municipality.

3.3 Evaluating current early warning system

As mentioned above, great efforts have been made in current early warning system. Up to now, rain gauges, stage gauges, video monitoring, and electric cables are used as data collection and transmission for rainfall depths, water levels, and other indices of watershed conditions. In fact, the current early warning system is very flimsy due to electric power failure, or equipment damage, or procedure suspending, or some of them, etc. The results of investigation indicated that the number of autonomous stations for hydrologic information, water stage gauge, rain gauge, meteorology reached 147, 41, 465, 109, and that of manual stations of wireless warning broadcast, rain gauge, and water stage gauge are 672, 1443 and 113. Just in term of amount, the rain gauges cover 64% of the monitoring equipment; hence, rainfall depth monitoring is the emphasis in the current early warning system.

3.4 Surveying flash flood events in the past

It is quite helpful for flash flood hazard mitigation to survey the reasons, the activity routines, the flood peak magnitude, and the losses in flash flood events in the past. At the same time, this surveying is quite conducive to identify directly flash flood prone area. This job was done by looking up historical records in flood disaster annals at or above county level, interviews and investigation with local people, and field measurement. For each flash flood event, the survey contents includes: (1) when, how long, and how to act was the flash flood; (2) how was the rainfall depth and process; (3) how was the watershed at that time, such as area, landform, soil type and moisture content, and vegetation cover, and so on; (4) how were the flood mark, longitudinal and transversal section of river channel, (5) flood peak discharge and runoff volume of flash flood, (6) return period estimation of flash flood event, (7) loss on life and property, and (8) socioeconomic status in the watershed at that time. The incomplete statistical outputs present that there were 141 flash flood events since 1950, over 600 people killed or lost, and about 200 houses ruined due to flash flood.

4 Flash flood assessment

4.1 Fundamental for flash flood assessment

Using flash flood investigation results and basic data processed, flash flood assessment is conducted for 874 riverside villages within flash flood prone areas. Rainstorm runoff modeling is pivotal for flash flood assessment. The concepts of storm pattern, rain duration, discharge threshold, and soil moisture content are the fundamental for flash flood assessment.

4.2 Estimating flash flood magnitude

Flash flood magnitude estimation refers mainly to obtain the peak discharge and flood volume with typical returned periods for each riverside village. For the purpose of flash flood magnitude estimation, the standard rainfall frequencies include 5-, 10-, 20-, 50-, and 100-year. With the assumption that frequencies of storm and flood are identical, and based on the standard rainfall frequency, the design storm with time of concentration as duration were first computed, the relationships of flood stage vs. flood discharge determined with Manning's Formula, design flood analyzed for each control cross-section* for each riverside village. The validity of resulting peak flow, flood volume, rising duration, flood profile, and peak stage were examined by data from flash flood events. In the Project, the flash flood magnitudes for the 874 riverside villages were estimated.

4.3 Evaluating current flood control capacity of riverside villages

Using the results obtained in flash flood magnitude estimation, various flood analyses and assessments will be conducted for riverside village and town within flood-prone area. These tasks include the existing flood conveying capacity evaluation, flood risk zoning.

Current flood control capacity is expressed as a flood frequency corresponding to the flood stage threshold and peak flow. Flood stage threshold is determined by field survey. The stage-discharge relationship or Manning's equation was used to determine peak discharge corresponding to flood stage threshold. Statistical method or interpolation method was used to determine flood frequency corresponding to the peak discharge.

Flood stage thresholds at each control section were determined based on field surveys of population-elevation relationship for villages, towns and cities along the river. Population and household under each flood frequency were determined, and existing flood conveyance capacity maps were produced. Flood risk zoning was determined in accordance with returned period (P). The high, medium and low level of risk are designated as $\mathrm{P} < 5$, $5 \leq \mathrm{P} < 20$ and $\mathrm{p} \geq 20$. In the Project, the current flood control capacities for the 874 riverside villages were all evaluated.

4.4 Analyzing rainfall depth threshold for riverside villages

Rainfall depth threshold for flash flood early warning can be determined using retrogressive rainfall-runoff modeling based on discharge threshed for a riverside village; rainfall amount and rainfall duration are the key aspects of rainfall depth threshold. The basic concept and approach are as follow: using detailed hydrological modeling to simulate flood hydrographs at each riverside village

* *Control cross-section: used for discharge threshold estimation for protected object.*

inside a watershed; determining the lag time based on the peak-precipitation time and peak-flood time, using the lag time to backtrack rainfall depth threshold at each riverside village.

The analysis was performed according to the following steps: step 1, determining rainfall duration according to the time of concentration of a watershed; step 2, estimating the discharge threshold for each riverside village based on its warning stage using discharge and water stage transformation by Manning's formula; step 3, assuming typical soil moisture conditions for runoff volume analysis; step 4, selecting rainfall pattern for precipitation series input, for during hydrological analysis, a hypothetical precipitation series was constructed by assuming an initial total rainfall value and distributing the total rainfall amount to each time step based on the rainfall pattern; step 5, rainfall depth threshold computation and analysis was conducted by error and trial procedure, this hypothetical precipitation series in step 4 was input into the model, and the resulted flood hydrograph at each riverside village was compared with pre-determined discharge threshold; if computed peak flow differs from discharge threshold significantly, the initial total rainfall amount will be adjusted, and the simulation repeats, until the simulated peak flow at each riverside village matches pre-determined discharge threshold within pre-defined tolerance.

In the Project, the rainfall depth thresholds for the 874 riverside villages were evaluated.

5 Conclusions

The conditions of climate, geography and residents in Yulin, a municipality-level region in southeast of Guangxi, China, make Yulin a flash flood prone area, suffering badly from flash floods in the past years. A municipality-wide project, Flash Flood Investigation and Assessment in Yulin, was conducted to acquire fundamental data for flash flood early warning system development as much as possible. Early warning is currently the most important measure against flash flood hazard, and rainstorm runoff modeling is the key technique for flash flood detection. The project was performed in seven counties of Yulin Municipality from 2013 to 2015, and the main conclusions are drawn as follow: 1) the flood prone area in Yulin reaches about 6,800 square kilometers, 2) about 8.2 thousand people threatened by flash flood, 3) current system for flash flood monitoring and warning should be improved that include 121 hydrological stations, 62 water stage gauges, 439 rain gauges, 672 broadcasts, and 7 county level warning systems, 4) about half of the selected riverside villages are only able to control flood with returned period less than 10 years, 5) rainfall depth thresholds with typical durations for soil moisture contents of wet, common and dry conditions were analyzed for each villages and generalized according to administrative regions at town-level. The outcomes of the Project will be quite helpful for flash flood management in Yulin in the future.

Acknowledgements

Thanks for finical support of project "National Flash Flood Hazard Prevention and Control (2013-2015)".

References

the Manual for Rainstorm-runoff Consulting Chart in Guangxi. Department of Hydrology and Water Resources, Guangxi Zhuangzu Autonomous Region, 1984.

CHEN J.Q., ZHANG G.S. 1984. *Rainstorm-runoff Computation for Small Watershed* (M). Water Resources and Hydropower Press. (In Chinese)

57. Real time floodrisk management

Bas Kolen[1],**, Marit Zethof *, Karin de Bruijn ***,*

*Evert Hazenoot *****

** HKV Consultants*

*** Delft University of Technology, Delft Safety & Security Institute*

**** Deltares, Department of Flood Risk Management*

***** Waterboard of Rivierenland*

[1] *Botter 11-29, 8232 JN Lelystad, Netherlands, B.kolen@hkv.nl, +31 320 294242*

KEYWORDS: Flood risk, emergency management, uncertainty, mapping.

ABSTRACT

The central issue for authorities (as well as the public) is how and when to respond to forecasted extreme water levels on rivers, lakes and along the coast and large-scale flooding is an actual risk. The decision-making process is influenced by contradicting information, overloads and gaps in information, rumours, uncertainties in forecasts, the consequences of a flood and the effectiveness of measures. Emergency measures can be taken to reduce the probability of flooding(e.g. placing sand bags), other measures can be taken to reduce the consequences of a flooding (such as evacuation of inhabitants). For many of these measures, decisions are made days or hours prior to the expected moment of occurrence of the flooding. Using forecasts of water levels, by definition uncertain, and forecasts of the strength of levees, decisions can be made based on the acceptability of the actual flood risk level. The concept of risk can be used to prioritise measures in case of limited time.

In this paper we present a (semi-probabilistic) method to develop risk based operational water management and emergency management based on integral flood risk assessments. The application of the method is discussed based on a pilot study for the waterboard of Rivierenland.

The method integrates forecasting of water levels, levee assessments, inspections, effectiveness of emergency measures and realtime flood risk mapping.. To define the conditional probability of failure we use fragility curves for each levee section. These take different mechanisms of failure as seepage, overtopping and macro instability into account and link water levels to conditional probability of failure.

We combine the conditional probability of failure and the uncertainty in hydraulic loads with flood scenarios which are prepared in advance. These flood scenarios describe the consequences of a flood over time given a set of boundary conditions. These scenarios describe economic damage or loss of life. The consequences of a flood mainly depend on the location, size and number of breaches and the hydraulic load. Infinite flood scenarios can be defined, therefore we use classes of scenario's representing a range of possible scenario's for each section of a levee. Combining the expected water levels, conditional probability of failure and flood scenarios, real time (conditional) risk maps are developed. These maps can be used to identify the high risk areas and support emergency services to prioritise decisions with regard to the areas to evacuation, the protection of critical infrastructure and emergency measures to reduce the conditional probability of flooding.

The pilot study shows the potential benefits of this method. We also discuss challenges we encounter when integrating this risk based approach in crisis management mechanisms.

156. Supply chain fragility and flood disruption: understanding the impacts of supplier and customer proximity

Bhattacharya Mis N., Lamond J.**[1]*

** University of the West of England*

*** University of the West of England*

[1] 3q12 Frenchay Campus, CFCR,University of the West of England, Bristol, BS16 1QY , +44 (0) 1173287722 , Namrata.Bhattacharya-Mis@uwe.ac.uk

*K*EYWORDS: proximity, repeat flooding, supply chain, customer, supplier

ABSTRACT

Objectives

Businesses are increasingly vulnerable to direct and indirect impacts of repeat flooding events. In a complex disaster scenario, failure in one interdependent component of the supply chain such as in-house processing, adequate supply of materials, integration of number of suppliers, proximity of customers, and customer demand may trigger a ripple effect throughout the system, decreasing performance of the other components thereby making it more fragile towards potential breakdown. There is a growing body of literature laying emphasis on the urgent need for better understanding of disaster impact on supply chains but none address the issue of proximity and fragility of repeatedly flooded businesses. The focus of this paper is therefore to understand the implications of repeated flood events on supply and demand sides with reference to proximity to affected businesses.

Methods

This study takes an empirical approach and investigates flood impact on firms in multiple business sectors using a postal self-completion questionnaire sent to businesses throughout the UK in December/January 2016. The sample was selected from areas with high risk of flooding which have been affected by repeated flooding in the past. The survey sought information about experience of flooding and consequent damage, interruption to trade and supply chain, finance and recovery after the flooding. The questions specific to the spatial aspects of supply chains included length of business operations in current premises; the distribution of proximity of customers, suppliers and workers; and the impact of disruption on supplier, customer base and business operations. Descriptive spatial and statistical analysis of the data was performed to understand the interlinkage between different components of supply chain.

Results

The results indicate that impacts range from direct in-situ effect due to reduced access to the business site to indirect disruption as a result of disturbance in customer or supplier base. There is an

causality between temporary closure and loss of customer base. The fragility of businesses is observed to be higher for those having a lower flexibility in labour access, working hours and replacement. Location of suppliers and maintenance of market demand within a given timeframe is considered very important for determining level of disruption to the businesses. The impact varied according to the affected area and the location of suppliers.

Conclusions

Floods impact on all sectors within different constituents of supply chain; however it varies on the basis of the proximity of proportion of customer; supplier and labour base to the impact area. With the increased frequency of floods, businesses which are repeatedly flooded are more fragile towards potential failure, therefore there is a need to understand the risk by identifying opportunities and plan proactively towards mitigation to reduce business disruption.

351. A methodology to include long-term financial recovery in flood risk assessment

*Priest, S.J. *[1], Viavattene, C.*and Owen, D.**

** [1] Flood Hazard Research Centre, Middlesex University The Burroughs, Middlesex University, +44(0)2084115527, S.Priest@mdx.ac.uk.*

KEYWORDS: Risk Assessment, Recovery, Insurance, Compensation,

ABSTRACT

Recovery strategies play an invaluable role in facilitating individual and community recovery from the often devastating impacts of flooding. Not all households and business will have to recover independently of any assistance, and there are a diverse set of financial recovery mechanisms (including government compensation, government and private-market insurance, tax relief, charity) used internationally to assist financially those affected by coastal hazards. However, although financial deprivation is a recognised indicator of vulnerability, the presence or absence of any approaches or their effectiveness is rarely considered within risk assessments and as such considerations of long-term financial recovery are incomplete.

This research aims to address this gap and introduces a semi-qualitative approach to assess the ability of households to financially recover from flooding. The method utilises a matrix-based approach to identify and assign the various potential states of financial recovery likely to be achieved by domestic households and businesses. Two matrices have been developed one for businesses and one for domestic properties. Each matrix has two different inputs, the degree of direct impact and a categorisation of recovery mechanisms. The first input is one more traditionally included within risk assessments and relates to the severity of the expected direct impact of the hazard that a receptor will experience. These direct impacts are categorised as Very High, High, Medium and Low. For the second input, a typology of receptors has been developed to characterise the type and degree of financial assistance each property will receive (or have access to) following an event. This has been based on international analyses of the commonly adopted approaches to assisting financial recovery from flood events. For example, for domestic properties the categories include; Not insured, Not insured but has self-insurance Fully insured, Partially insured, High degree of government compensation, Low degree of government compensation).

For each cell in the matrix a score is provided, as well as a qualitative description/justification of the likely level of long-term financial recovery. This is based on existing literature, past event data and expert judgement from a range of interviews, Importantly, this assessment does not aim to provide an absolute quantitative value for the financial amount or percentage that is able to be recovered, but instead presents a scale of financial recovery impacts from 1 (full recovery) to 5 (very low

recovery). An example application of the North Norfolk coast is presented which highlights the procedure for implementation and potential data required. The method can be applied with various degrees of detail depending upon data availability and application requirements. Although in some cases the degree of available data may be low and there are limitations to the approach, the method developed permits inclusion of the presence and impact of financial recovery mechanisms, a key feature lacking from existing risk assessments.

Impact on infrastructure

102. Impact of pluvial flooding and adaptation in urban transport systems

Ms Maria Pregnolato, Newcastle University, United Kingdom

135. Modelling flood damage to lifelines: data requirements and critical points

Dr Daniela Molinari, Politecnico di Milano, Italy

102. Impact of pluvial flooding and adaptation in urban transport systems

KEYWORDS: flooding, risk, adaptation, transport, infrastructure

ABSTRACT

Motivation and aim

Short duration, high intensity rainfall can be extreme events causing significant disruptions to transport networks and traffic operations, and climate change is projected to increase the magnitude and impact of such extreme events. Despite the severity of the phenomenon has been acknowledged by Local Authorities and the public, disruption costs of flooding are currently calculated using silo-based approaches [1]. This paper presents an integrated framework that couples simulations of flooding and transport networks, integrating hazard, vulnerability, impact and consequences [2]. It calculates the impacts of disruption and the effectiveness of potential adaptation options, like traditional (grey infrastructure *e.g*. floodwalls) and alternative measures (blue-green infrastructure *e.g.* green roofs, ponds). The findings will support local authorities in making improved business cases to adapt urban infrastructure and road networks to extreme flooding events.

Methodology

This study advances an integrated framework [3] to quantify the flooding risks from extreme rainfall, measured in terms of expected travel time across the road network. The method is driven by the Flood Estimation Handbook (FEH) methodology that is combined with a high resolution urban flood model, to provide depth and velocity of floodwater [4]. Hazard layers and empirical analysis of vehicle speeds in different depths of flood water are used to determine the impact of a given event on journey times, which results in a transport accessibility model. A damage function, constructed from a range of observational and experimental data sources is used to relate flood depth to vehicle speed. This allows a more realistic approach than the typical method of categorizing a road as either 'blocked' or 'free flowing'. To estimate the costs and rank the adaptation options a range of options are applied across the network. A criticality index is presented which demonstrates a metric to prioritize intervention options in the road network.

The benefit of climate adaptation options are measured over 50 years. Using the Green Book method of Net Present Value (NPV) to compute the long term costs and benefits, discounted to present day rates to account for inflation [5]. The NPV of the benefits in terms of risk reduction, NPV_r, is calculated by summing over the disruption cost, $D(x)$, and likelihood, $\rho(x)$ of a range of flood events, for a life-span N of 50 years and a discount rate r of 3%:

$$NPV_r = \sum_{i=1}^{N} \frac{\int \rho(l_i) D(l_i)\, dx}{(1+r)^i} \qquad (1)$$

Results and conclusion

The framework is demonstrated on Newcastle-upon-Tyne in the UK and shows that adaptation

decreases delays to travelers under all scenarios. For example, grey infrastructure measures, such as the improvement of the drainage system capacity, across the network can reduce the impact by up to 50% for 1 in 10 years event (low intensity, high probability event). Results are compared by computing the NPV_r for the different considered strategies, developing a tool to support decision-makers in prioritizing investment to maximize returns and make the business case.

1. Aerts, J., et al., *Climate Adaptation and Flood Risk in Coastal Cities*. 2013, Taylor and Francis.
2. Pregnolato, M., et al., *Potential impact of climate change on flooding disruptions to urban transport networks.* ASCE Journal of Infrastructure Systems, 2017. **Accepted**.
3. Walsh, C.L., et al., *A spatio-temporal modelling framework for the integrate assessment of cities*, in *Earth Systems Engineering 2012: A technical symposium on systems engineering for sustainable adaptation to global change*. 2012, Centre for Earth Systems Engineering Research, Newcastle University: Newcastle upon Tyne, UK.
4. Kjeldsen, T.R., *The revitalised FSR/FEH rainfall/runoff method*, in *Flood Estimation Handbook*. 2007, Centre for Ecology and Hydrology.
5. HM Treasury, *The Green Book: appraisal and evaluation in central government.* . 2013, HM Treasury: London (UK).

Insurance and building level protection

281. How improved flood damage data can improve compensation procedures for businesses

Mr Martin Dolan, Oxford Brookes University and Aquobex, United Kingdom

296. Improving the flood risk management of commercial properties – Can surveyors help?

Dr Heidi Kreibich, German Research Centre for Geosciences, Germany

135. Modelling flood damage to lifelines: data requirements and critical points

Molinari D.[1], Menoni S.***

** Department of Civil and Environmental Engineering, Politecnico di Milano, Milan, Italy*

*** Department of Architecture and Urban Studies, Politecnico di Milano, Milan, Italy*

[1] *Daniela Molinari, Department of Civil and Environmental Engineering, Politecnico di Milano, Piazza Leonardo da Vinci 32, 20133, Milan, Italy, +0039 02 23996206, daniela.molinari@polimi.it*

KEYWORDS: flood damage to lifelines, flood damage to networks, flood damage data

ABSTRACT

Lifelines are crucial for the wellbeing of our communities as they provide different services and ensure the transport of people and goods. Accordingly, direct and indirect damage suffered by lifelines in case of flood can represent a big share of total observed damage.

Lifelines have the fundamental characteristics of systems, i.e. they group into networks elements dynamically correlated to each other in order to perform a function. Such networks are then strongly interlinked, i.e. they depend on each other for their functionality or maintenance, so that many factors can weaken a network. First, there are inherent factors, i.e. the lack of resistance to the water element of the different networks' components. Second, there is a low ability to stand and absorb dysfunctions (shall they be internal or external to the network, i.e. outages); and finally, there is an insufficient capability of recovery.

Given this complexity, modelling flood damage to lifelines is not an easy task. In fact, there are not many models that allow modelling flood damage to lifelines in a comprehensive way, the main limitation being the huge amount of data required for their definition, calibration, validation and implementation. Still, effective flood risk mitigation requires modelling damage to lifelines.

In this contribution, we compare available and required data for modelling flood damage to lifelines using: (i) the model developed by Eleutério et al. (2013) as an example of available modelling tools and (ii) data coming from the case studies analysed in the EU project IDEA (http://www.ideaproject.polimi.it) as an example of emblematic available information. This exercise highlights: (i) which data are presently available to model damage to lifelines and at which scale, (ii) which types of damage (e.g. direct, indirect, physical, financial) can be presently modelled according to (i), and finally (iii) which is the data gap to be filled in order to improve our capacity of modelling damage to lifelines in a comprehensive way.

REFERENCES

Eleutério J., Hattemer C. and Rozan A. (2013). A systemic method for evaluating the potential impacts of floods on network infrastructures. Nat. Hazards Earth Syst. Sci., 13, 983-998, doi:10.5194/nhess-13-983-2013

281. How improved flood damage data can improve compensation procedures.

M. Dolan.[1], D. Molinari**, S. Menoni**, R. Ogden*** and N. Walliman****

** Oxford Brookes University and Aquobex.*

*** Politecnico di Milano, Milan, Italy.*

**** Oxford Brookes University, UK.*

[1] *Martin Dolan, Architectural Engineering Research Group, 203a John Payne Building, Oxford Brookes University, Gipsy lane Campus, Oxford, OX3 0BP. (include address, telephone/fax, email etc.)*

KEYWORDS: Resilience, insurance, data, foresnic disaster investigation

ABSTRACT

In the UK flooding is reported as the greatest threat from climate change to properties (ABI, 2009) with increasing likelihood and impact. As evident in literature, the intensity of business disruption to UK business sector, and to SMEs in particular, is significant (Li, 2015) which, coupled with the increasing risk, become an issue for individual businesses on the micro level and for the larger economy at the macro level. Insurance is one of the key measures to adaptation to climate change related risks and unlike many industrialised countries, the UK developed a private flood insurance scheme more than half a century ago.

As part of the EU funded, IDEAS Project, this research identifies and proposes how improved data collection and analysis can improve the compensation processes with a particular focus on businesses.

This paper firstly outlines the background to the insurance landscape in the UK with a brief summary of the way in which compensation was provided in the aftermath of the 2007 floods in Gloucestershire with a focus on businesses and infrastructure based on reports produced by the Association of British Insurers (ABI), conversations with the British Damage Management Association (BDMA), insurance company representatives, business owners, and infrastructure companies representative.

Further to this an examination of the procedures involved in the assessment of damage following a flood and the setting of premiums at the time of purchase of a flood insurance scheme was carried out through a review of the literature and through interviews with insurance industry representatives and business owners. The impacts of these procedures on businesses and insurance companies was assessed through interviews with business owners and with claims managers and risk modellers from leading UK insurance companies.

The paper then goes on to offer insight into how improved flood damage data collection, management, sharing and a forensic disaster analysis can facilitate more speedy assessment of damage and accurately and rapidly calculate claims payments to business in relation to business interruption and to building damage.

The conclusions from the research were the need for improved and standardised data collection procedures, a shared database, a standardised business evalution checklist for premium setting and a standardised damage checklist for damage assessment during the claims process. Suggestions are also offered on how these changes can be implemented.

REFERENCES

ABI (2009) Preparing the UK for climate change: ABI's new adaptation strategy London,Association of British Insurers. London.

Li, C., Coates, G., Johnson, N., McGuinness, M. (2015). Designing an Agent-Based Model of SMEs to Assess Flood Response Strategies and Resilience. International Journal of Social, Behavioural,Educational, Economic and Management Engineering 9 (No. 1).

296. Improving the flood risk management of commercial properties – Can surveyors help?

Heidi Kreibich[1], Namrata Bhattacharya Mis[2], Faith Chan[3], Burrell Montz[4], David Proverbs[5], Sara Wilkinson[6], Jessica Lamond[2]*

[1]GFZ German Research Centre for Geosciences, Section 5.4 Hydrology, Potsdam, Germany

[2]Centre for Floods Communities and Resilience, Faculty of Environment and Technology, University of West of England, Bristol, UK

[3]School of Geographical Sciences, The University of Nottingham Ningbo China

[4]Department of Geography, Planning, and Environment, East Carolina University, Greenville, NC USA.

[5]Faculty of Computing, Engineering and the Built Environment, Birmingham City University, Birmingham, UK

[6]School of Built Environment, University of Technology Sydney, Australia

[*] Contact author: Tel. +493312881550, fax +493312881570, kreib@gfz-potsdam.de

KEYWORDS: Flood risk; damage mitigation; commercial property; international; surveyors

ABSTRACT

Background and Objective

Damage due to floods has increased dramatically during the last few decades, and further increases are expected due to global climate change. To counteract this increasing trend in flood risk, many countries shift towards more integrated flood risk management. Damage-reduction measures at the property level are an important component of this strategy. However, information about what motivates companies to undertake such measures remains scarce. The objective of this study is to analyse what role surveyors play in improving flood risk management of commercial properties under various regulatory and insurance regimes.

Methods

72 semi-structured interviews with surveyors and other professionals with experience in providing flood risk mitigation advice for commercial properties were undertaken in Australia, China, Germany, the UK and the US. The interviews were transcribed and analysed by country and across countries to explore common features and enable cross-country learning.

Results and Conclusions

Surveyors are found to be providing important advice on: building adaptation and reinstatement; surface water drainage systems; assessment of risk, and development of risk maps including advice on flood precautionary measures, etc. However, there is much potential for this advice to be broadened and deepened. Insurers have the potential to be key stakeholders in encouraging the uptake of flood risk mitigation interventions across all countries with potential to increase the involvement of surveyors and raise standards in flood risk mitigation at the property level.

DESIGNING FOR UNCERTAINTY

158. Adaptation in cities? The case of Genoa, Italy

Dr Grazia Di Giovanni Gran Sasso, Science Institute, Italy

307. Flood Resilience in the Water Sensitive City

Prof Richard Ashley, UNESCO IHE, United Kingdom

384. Managed Retreat and Flood-Risk Mitigation through Community Relocation

Mr Nicholas Pinter, University of California Davis, United States

158. Adaptation in cities? The case of Genoa, Italy.

*Grazia Di Giovanni**

** Ph.D. candidate, Gran Sasso Science Institute, L'Aquila (Italy)*

[1] Details for contact author. Email: grazia.digiovanni@gssi.infn.it). Address: Viale Francesco Crispi 7, 67100 L'Aquila (Italy). Phone: 0039 347 0409 519

KEYWORDS: flood risk reduction; adaptation practises; urban resilience; Genoa.

INTRODUCTION

The history of many cities is a history of disasters and reconstructions, within continuous changing processes between persistence and transformation challenging nature-related and climate-related uncertainties. Genoa, city of about 586.000 inhabitants[1] in North-West Italy, is affected by severe hydrogeological instabilities and represents an emblematic case of recurrent floods (aggravated also by landslides) in urban contexts. The high steepness of Liguria's territory cut by several watercourses, with peculiar tendency to heavy rains and flash floods, and decades of massive urbanization led Genoa to experience several dramatic floods, the last one occurred in 2014 (Brandolini, Cevasco, Firpo, Robbiano, & Sacchini, 2012; Faccini, Luino, Sacchini, Turconi, & De Graff, 2015). How to intervene in so complex urban contexts? Relying on interviews and fieldworks, literature and document analyses, the study presents some initial comments to on the main works ongoing in the city to reduce flood risk, in the light of recent national programs for soil conservation,

GENOA, LIGURIA

Genoa is an ancient city (its origins date back to the Roman Age) grown around the harbour and tight between the coast line and the Apennines. This peculiar morphology makes Genoa a city without a territory to ordinary expand on (among the others: Bobbio, 2008; Tizzoni, 2000): consequently, the urban development – for allocating residential and industrial functions – was assured by very dense urban fabrics, and by massive soil exploitation, both along coastal zones, both climbing the several river valleys that converge towards the sea (Fig. 3).

[1] http://demo.istat.it/pop2016/index.html

Fig. 3. Genoa and its catchments, modified by the author from Brandolini et al., 2012, p. 948 (CC Attribution 3.0 License)

Even the steepest slopes where urbanized, heavily constraining and covering the watercourses and building inside the stream beds. The history of the city itself is the cause and the effect of high hydrogeological risk, which involves several wide areas of the city, even the most central ones. Bisagno and Fereggiano creeks (tributary of the first) (Fig. 4 – 4) flood recurrently, and caused among the worst damages in the recent flash floods (2011, 2014) (Rosso, 2014): on 4th November, Bisagno flooded reaching a peak flow with return period (T) around 30 years; in some tributaries the peak flow had T larger than 100 years (Silvestro et al., 2016).

Fig. 4. Bisagno creek. On the back, the railway station Genova Brignole with the beginning of the covering of the river bed until the sea mouth. In the front, the medieval Sant’Agata bridge, damaged by the floods – photo by the author, May 2017

Fig. 5 - 6. Fereggiano course (on the left) and its inflow (channelled) into Bisagno (on the right) – photos by the author, May 2017

PROJECTS FOR RISK REDUCTION – A RECENT HISTORY

After the last floods, important interventions started in the city to address the flood risk, in particular in the Bisagno catchment: the combination of the raising of the Bisagno cover – longer than 1 km, built during the fascist period with a clear underestimation of the flow rate to be ensured (Faccini et al., 2015; Rosso, 2014) – with an underground 3,7 km draining tunnel for the Fereggiano stream (partially designed and built since the late ‘90s, but never completed), should sensitively reduce future the scale of future floods and related damages (Fig. 7 – 6).

Fig. 7 - 8. Viale delle Brigate Partigiane, works on the Bisagno cover – photos by the author, May 2017

Fig. 9. Mouth of Fereggiano draining tunnel – photos by the author, May 2017

The costs for the complete accomplishment of the works is estimated around € 275 million, and financed by "Italia Sicura", a Mission Structure established in 2014 as part of the Presidency of the Council of Ministers against hydrogeological disasters and the for the development of water infrastructures. The funding guidelines are based on a "rewarding-approach policy": local institutions have to present quite detailed plans of action to obtaining funds (e.g. efficiency assessment, cost/benefit analysis, analytical study of risk and post-intervention residual risk), demonstrating a consistent investment in long-term prevention and design activities (Galletti et al., 2017).

TOWARDS "ADAPTATION" MEASURES?

The study has presented some initial notes – to be further expanded – on the programs and interventions ongoing in Genoa to reduce flood risk[2]. In contemporary cities affected by nature-related risks, to build coherent paths of intervention bridging the implementation of short-term actions (for tackling urgent risks) with the definition of long-term adaptation policies (for fostering urban resilience through innovative forms of urban development and management) appears as a critical necessity (Rijke, 2014; Zevenbergen, Veerbeek, Gersonius, & Van Herk, 2008). How to flexibly promoting risk reduction through ordinary urban transformations overcoming the common emergency-oriented tactics represent a specific challenge in the fields of urban planning and design, as highlighted by the case of Genoa. Nevertheless a great knowledge about flood hazards, vulnerability and exposure held by local research institutes, university and public institutions, and the huge losses due to the recurrent floods, to transform existing urban fabrics (with all the economic and social activities hosted) through transformations retrofitting risk reduction-oriented measures still origins multiple clashes in the city. Technical (in terms of design solutions, often bounded to no more adequate pluviometric parameters or return periods, above all in a changing climate (Silvestro et al., 2016), normative (in terms of property rights, urban planning, accumulated praxis), cultural (e.g. collective propensity in "living with water") and governance challenges (in terms of balancing long-term policies and priorities with short political programs) have found partial solutions in the case of the intervention on Bisagno though Italia Sicura programs, but interviewees, reports and document still testify the inclination to ordinary over-exploitation of the natural resources and river beds, and to ex-post reactive interventions

REFERENCES

Bobbio, R. (2008). Genova. Morfologie e governo di un'area metropolitana anomala. In U. De Martino (Ed.), *Il governo delle aree metropolitane* (pp. 81-98). Roma: Officina Edizioni.

[2] http://www.comune.genova.it/cantieri

Brandolini, P., Cevasco, A., Firpo, M., Robbiano, A., & Sacchini, A. (2012). Geo-hydrological risk management for civil protection purposes in the urban area of Genoa (Liguria, NW Italy). *Natural Hazards and Earth System Sciences, 12*(4), 943. doi:https://doi.org/10.5194/nhess-12-943-2012

Faccini, F., Luino, F., Sacchini, A., Turconi, L., & De Graff, J. (2015). Geohydrological hazards and urban development in the Mediterranean area: an example from Genoa (Liguria, Italy). *Natural Hazards and Earth System Sciences, 15*(12), 2631-2652. doi:https://doi.org/10.5194/nhess-15-2631-2015

Galletti, G. L., Delrio, G., De Vincenti, C., Curcio, F., D'Angelis, E., & Grassi, M. (2017). *Italiasicura. Il piano nazionale di opere e interventi e il piano finanziario per la riduzione del rischio idrogeologico*.

Rijke, J. S. (2014). *Delivering change: Towards fit-for-purpose governance of adaptation to flooding and drought.* (Doctoral Dissertation), TU Delft, Delft University of Technology and UNESCO-IHE, Institute for Water Education, Leiden.

Rosso, R. (2014). *Bisagno. Il fiume nascosto*: Marsilio Editori.

Silvestro, F., Rebora, N., Rossi, L., Dolia, D., Gabellani, S., Pignone, F., . . . Masciulli, C. (2016). What if the 25 October 2011 event that struck Cinque Terre (Liguria) had happened in Genoa, Italy? Flooding scenarios, hazard mapping and damage estimation. *Natural Hazards and Earth System Sciences, 16*(8), 1737-1753. doi:https://doi.org/10.5194/nhess-16-1737-2016

Tizzoni, P. (2000). Il riassetto idrogeologico e la difesa del suolo: le linee di intervento della provincia. *Urbanistica DOSSIER, 28*, 37-38.

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, 1*(2), 81-88. doi:http://dx.doi.org/10.1111/j.1753-318X.2008.00010.x

307. Flood Resilience in the Water Sensitive City

Ashley R.M.[1], Gersonius B.*, Zevenbergen C.*, Rijke J.*, Radhakrishnan M.*

** UNESCO IHE, Westvest 7, 2611AX. Delft, The Netherlands & Cooperative Research Centre for Water Sensitive Cities, Monash University, Melbourne, Australia*

[1] *R.Ashley@sheffield.ac.uk*

KEYWORDS: Flooding, resilience, water sensitive, urban design

ABSTRACT

Objectives: As part of the Australian Cooperative Research Centre for Water Sensitive Cities (CRCWSC) it has been necessary to develop frameworks, procedures and methods for the effective inclusion of resilience to flooding within the approach to developing and sustaining water sensitive cities. The paper provides an overview of four years of development of the processes to embed flexibility, adaptability and hence resilience into the Water Sensitive City via Water Sensitive Urban Design (WSUD).

Methods: These included reviews of extant methodologies for the above, case studies in Rotterdam (Netherlands), Can Tho (Vietnam), Melbourne and Perth (Australia), of flood risk and the various ways of responding using adaptation pathways, tipping points and types of measures. These have been further developed from published and earlier research by the authors and others. A number of workshops were held with practitioner communities in these countries, methodologies drafted and refined in consultation and several guidance documents published: https://watersensitivecities.org.au/content/flood-resilience-in-water-sensitive-cities/

Results: These show that there are certain generic methods of approach to ensuring that resilience is ensured in the Water Sensitive City. However, there is not one single encompassing methodology that can be applied to every case, although a framework has been developed to guide practitioners and decision makers. This paper will summarise the various reports and outputs to show which approaches are applicable under which conditions, citing the practical examples from the case studies. The results apply widely and are not only applicable in an Australian context. Several conference papers have been presented and one PhD thesis completed.

Conclusions: It is feasible to ensure that a Water Sensitive City is resilient to flooding and also to droughts. The methods presented and case examples provided in the paper illustrate this.

REFERENCES (example)

Gersonius B., Ashley R M., et al (2016). Flood resilience in Water Sensitive Cities. CRC for water sensitive cities. https://watersensitivecities.org.au.

384. Managed Retreat and Flood-Risk Mitigation through Community Relocation

Nicholas Pinter[1], David Casagrande**, and Nicholas Santos†*

** Dept. of Earth and Planetary Sciences, Univerity of California Davis*

*** Dept. of Sociology/Anthropology, Lehigh University*

† Center for Watershed Sciences, Univerity of California Davis

[1] Dept. of Earth and Planetary Sciences, Univerity of California Davis, 1 Shields Ave., Davis, CA 95616 USA, npinter@ucdavis.edu

KEYWORDS: Flood hazard, mitigation, resilience, community relocation

ABSTRACT

Objectives: The primary goal of this project has been to assess the vulnerability of rural floodplain communities. In particular, we have studied communities' capacity to recover from catastrophic flooding and local attitudes that present opportunities and challenges to mitigation of flood hazard. The focus of this research was on the dozen or so small US towns that have responded to flooding by moving themselves, entirely or almost entirely, off the floodplain. One or two examples of wholesale community relocations in response to flood risk are known by experts and researchers in the field (e.g., Valmeyer, Illinois and perhaps Soldiers Grove, Wisconsin), but a number of other such relocations have occurred over the past century or so, and wholesale relocations have not until now been rigorously studied as a distinct topic.

Interviews and Surveys: Our team conducted fieldwork including extensive interviews, a large regional survey, analyzed the hydrology and topography and other geospatial characteristics of floodplain communities, and completed a geostatistical model of relocation opportunities. Interviews and survey results documented patterns of community vulnerability and impediments to mitigation. A total of 648 valid household survey responses were obtained and extensively analyzed. Among a wide range of results, our analyses suggest that policies aimed at enhancing recovery should recognize how social resources are distributed, connected, and strained at various points during disasters.

Geostatistical Modeling: This project also developed a quantitative statistical model to assess mitigation potential for towns in floodplains with repetitive losses due to flooding. It used a calibrated statistical model to look at the criteria that past town relocations have used – and future community relocations may use – to assess and selection relocation sites. Model calibration was based on the relocation of 11 mostly Midwestern towns that moved from locations in a floodplain to locations outside of a floodplain between 1937 and 2008.

Discussion and Conclusions: Research on community relocation has recently moved from mostly theoretical into mainstream political discussions. Among his last acts while in the White House,

President Obama instructed 11 federal agencies to develop a framework for "managed retreat" -- a policy for relocating entire towns threatened by climate-driven flooding and rising sea levels. Current foci include Isle de Jean Charles in the Louisiana Delta, its relocation funded with $96 million from the National Disaster Resilience Competition, and the Alaska coastal village of Kivalina to be funded by the Dept. of the Interior.

Past mitigation successes and past failures highlight that many, perhaps most, problems in the mitigation process are linked to either (1) time delays or other issues associate with their ad hoc, post-disaster nature, or (2) the real threat posed to floodplain communities by piecemeal erosion of population and economic base. We suggest that these problems could be dramatically reduced if such initiatives were rigorously planned in advance, and implemented as the wholesale community scale.

Urban flood risk management (i)

35. ResilSIM—A Decision Support Tool for Estimating Resilience of Urban Systems to Flooding
Prof Slobodan Simonovic, The University of Western Ontario, Canada

52. Investigating how SMEs’ behaviours can enhance resilience to flooding using agent-based modelling and simulation
Dr Graham Coates, Durham University, United Kingdom

62. Lessons from 1998 and 2016 Wuhan Floods – the keys for improving urban flood management in Chinese megacities?
Dr Faith Chan, University of Nottingham Ningbo China, China

66. Runoff charactersitics of cultivation practices for woodland creation: field evidence from the Menstrie catchment
Ms Martina Egedusevic, Heriot Watt University, United Kingdom

105 Exploring a GIS-SD Approach for Quantifying Health Sector Resilience base on Leptospirosis Infections
Dr Charlotte Kendra Gotangco, Department of Environmental Science, Ateneo de Manila University, Philippines

120. Health consequences of urban flooding: Risk of infectious gastroenteritis spread via floodwater
Dr Yoshifumi Masago, United Nations University – Institute for Advanced Study of Sustainability (UNU-IAS,) Japan

132. Developments in flood alerting and monitoring solutions for the benefit of emergency responders
Mr Paul Drury, Ambiental, United Kingdom

173. Flood risk evaluation in small urban areas
Prof Verónica Botero Fernández, Institución Universitaria Colegio Mayor de Antioquia, Colombia

35. ResilSIM—A Decision Support Tool for Estimating Resilience of Urban Systems to Flooding

Simonovic, S.P.[1], Schardong, A.*, Irwing, S.*, and Nirupama***

** Department of Civil and Environmental Engineering, The University of Western Ontario, London, Ontario, Canada*
***Disaster & Emergency Management, Faculty of Liberal Arts & Professional Studies, York University, Toronto, Ontario, Canada*

[1] simonovic@uwo.ca, +1(519)661-4075

KEYWORDS: resilience, urban flooding, adaptation, infrastructure

ABSTRACT
Objectives: This manuscript proposes the concept of ResilSIM - a decision support tool that rapidly estimates the resilience (a modern disaster management measure that is dynamic in time and space) of an urban system to the consequences of natural disasters.

Methods: Damages to urban systems as a result of water-related natural disasters have escalated in recent years. The observed trend is expected to increase in the future as the impacts of population growth, rapid urbanization and climate change persist. To alleviate the damages associated with these impacts, it is recommended to integrate disaster management methods into planning, design and operational policies under all levels of government. The ResilSIM, web-based tool (with mobile access), operates in near real-time. It is designed to assist decision makers in selecting the best options for integrating adaptive capacity into their communities to protect against the negative impacts of a hazard.

Conclusions: ResilSIM is developed for application in Toronto and London, Ontario, Canada. It clearly emphasizes how the incorporation of different combinations of adaptation options maintain or strengthen basic structures and functions of municipal infrastructure in the event of a flood.

52. Investigating how SMEs' behaviours can enhance resilience to flooding using agent-based modelling and simulation

G. Coates[1], C. Li*, S. Ahilan** and N. Wright†*

** Department of Engineering, Durham University*

*** School of Civil Engineering, University of Leeds*

† School of Engineering and Sustainable Development, De Montfort University

[1] Dr Graham Coates, School of Engineering and Computing Sciences, Durham University. Tel. (0191) 3342479. E-mail: graham.coates@durham.ac.uk

KEYWORDS: Flood modelling, Agent-based modelling, Small businesses.

ABSTRACT

Objectives

Recent years have seen flooding cause major disruption to UK businesses resulting in significant losses to the economy. Given Small and Medium sized Enterprises (SMEs) in the UK account for 99.9% of businesses, 60% of the working population and 47% of annual turnover, there exists a need to investigate ways in which this size of business can better prepare for, respond to and recover from flooding thus making them more resilient to these disruptive events. The objective of this research is to enable such an investigation using computer modelling and simulation of a flood event and the actions of SMEs immediately prior to, during and in the short-term aftermath of the event.

Methods

To investigate the effect of SMEs' behaviours in response to and recovery from flood events, flood modelling and simulation has been coupled with agent-based modelling and simulation (ABMS). The development of a virtual geographic environment capable of accurately representing any UK location has provided a platform for inundation prediction to be integrated with ABMS of SMEs' response to and recovery from a flood event. Inundation prediction enables all flood affected SMEs within the geographical area of interest to be identified, and the flood depth at their respective premises and adjacent roads to be known at each simulation time step. Simultaneously, ABMS in the flood affected area allows the actions taken by SMEs to be simulated. Based on semi-structured interviews with over 100 SMEs with experience of flooding, the development of agents to model and simulate SMEs during and in the aftermath of a flood event provides a means of investigating how changes in their preparedness could lead to improved response and recovery.

Results

A case study has been undertaken of the severe 2007 flooding in Tewkesbury, Gloucestershire. This

study has investigated the effect of different preparedness behaviours of manufacturing SMEs on the response to and recovery from flooding in relation to expediting the resumption of operations. Results include key performance metrics of manufacturing SMEs that provide an indication of the effectiveness of the preparedness behaviours of each business modelled. Based on the simulation results, suggestions have been made as to which behaviours may provide most benefit to manufacturing SMEs in terms of responding to and recovering from flood events.

Conclusions

Based on the case study undertaken, computer modelling and simulation has shown that physical measures taken to protect manufacturing SMEs' premises offer a greater means of minimising the disruption to business operations than social measures. However, social measures, such as mutual aid, do contribute in enabling manufacturing SMEs to maintain operations during flooding.

92. "Lessons from 1998 and 2016 Wuhan Floods - the keys for improving urban flood management in Chinese megacities?" *FKS Chan*[1], Xiaotao Cheng **, Yangbo Chen† and James Griffiths**

** School of Geographical Sciences, University of Nottingham Ningbo China*

*** Institute of Water Resources and Hydropower Research, Beijing, China*

† School of Geography and Planning, Sun Yat-Sen University, Guangzhou, China

[1] *Dr FKS Chan (School of Geographical Sciences, University of Nottingham Ningbo China Ningbo 315100, China, +8618867859622, faith.chan@nottingham.edu.cn)*

KEYWORDS: Wuhan, Flood, urbanization, climate extreme, flood preparedness and post-disasters management.

ABSTRACT

Wuhan is the largest city in Central China and lying on the middle section of Yangtze River after the Three Gorges Dam. The geographical location is strategically important for socio-economy for railway logistic, manufacturing and educational sectors in China. Unfortunately, the city has been severely inundated from two floods in 1998 and lately in 2016.

Objectives

This paper aims to investigate the hydrological pattern of two big floods through substantial secondary data analysis from previous literature. Some specific objectives as follow in this paper: (i) Investigation from the precipitation records and the water levels of catchment and lakes around Wuhan from the metrological data; (ii) Investigate the impacts of both 1998 and 2016 big flood events (and impacts to the city and surrounding areas) and will investigate in-depth of the post-disasters management from the municipal government; and (iii) Comparison of the post-disasters management from other Chinese megacities and learning the good practices on reduction of post-disaster impacts from the Wuhan case.

Results

In this study, the result show that serious flood impacts were occurred according to two major factors: (i) climate extreme and intensive precipitation; (ii) human-induced rapid urbanisation and land-use changes. However, flood preparedness and post-disasters management has been much improved in Wuhan, and could be a good practice to improve current urban flood management for other Chinese megacities. Future challenge of flood risk is emerged due to continuous pressure of economic growth, demographic and climate change in urban China, which requires well equipped climate tools for improving resilience and promote adaptations in current flood management strategies.

Conclusion

The paper learning from the Wuhan case and lessions that concludes building urban resilience in Chinese megacities is vitally important, with respect the current socio-economic developments and constraints, and the difficultes of climate relocations and migrations for flooding. We recommend flood prepardness and post-flood disasters managagemetn are the key to improve climate resiience, and a sustainable option for long term flood management in Chinese megacities. (325 words)

66. Runoff characteristics of cultivation practices for woodland creation: field evidence from the Menstrie catchment

Egedusevic, M.[1], Allen, D.*, Beevers, L.*, Vaughan, A.^, Cullen, S. †, Nisbet, T.R.[#] and Haynes H.**

** Water Academy, School of Energy, Geoscience, Infrastructure & Society, Heriot-Watt University, Edinburgh. EH14 4AS.*

^ Tilhill Forestry, Duckburn Park, Stirling Road ,Dunblane. FK15 0EW.

† Clackmannanshire Council, Roads and Transportation, Kilncraigs, Greenside Street, Alloa, FK10 1EB.

 # Forest Research, Alice Holt Lodge, Farnham, Surrey. GU10 4LH.

[1] Arrol Building, School of Energy, Geoscience, Infrastructure & Society, Heriot-Watt University, Edinburgh. EH14 4AS. mve1@hw.ac.uk

INTRODUCTION

Natural Flood Management (NFM) practices include planting catchment woodland as a technique for potential attenuation of runoff to mitigate downstream flooding and deliver multiple ecosystem services (e.g. habitat, amenity). The Scottish Forestry Strategy (2006) aims to increase woodland cover from 17.1% to 25% of Scotland's land area by the second half of this Century. To realise this ambition, it requires ~15,000 ha of new woodland to be created per annum, developed strategically to assist in mitigating climate change, stimulating economic development and providing a range of other benefits, including sustainable flood management. According to The Scottish Forestry Strategy (2006), upland afforestation, as part of an NFM strategy can reduce flood runoff by increasing evapotranspiration, interception and soil infiltration. It can also induce lower runoff peaks and extend lag times between rainfall and flow peaks (NFM Handbook, 2015). Moreover, Farley et al. (2005) studied a 26 catchment dataset and established a relationship between afforestation effects and the water balance. They showed that annual runoff after afforestation was 44% lower when grasslands were converted to forestry in comparison with pre-planting stage.

NATURAL FLOOD MANAGAMENT CASE STUDY OF MENSTRIE BURN

Menstrie village in Clackmannanshire, central Scotland, has a history of repeated floods due to overbank flow from the Menstrie Burn (a hillslope tributary of the River Forth). In August 2004 approximately 30 properties were flooded (Clackmanshire council, 2005). An even larger event occurred in 2012, demonstrating a continuing vulnerability of this Hillfoot village to flooding.
In 2015, one of the largest modern-day woodland creation projects (636 ha of woodland planting within a larger 1002 ha property) was implemented in Clackmannanshire, Central Scotland, upstream of Menstrie village. In total, 47% of the Menstrie Burn catchment was subject to the planting of, predominantly, productive conifer woodland (Sitka spruce). This scale of land use change was expected to provide elements of Natural Flood Management in the medium to long term, but concerns were raised about the potential for pre-planting cultivation to increase flood flows in the

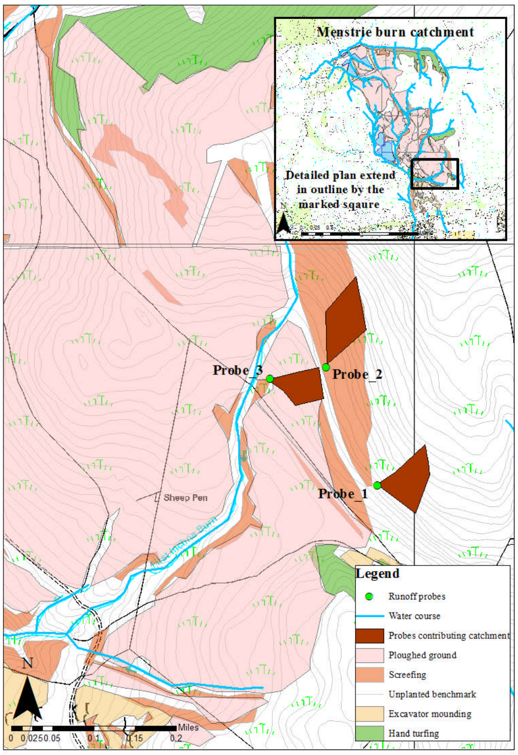
shorter-term. Soil conditions and the nature of the vegetation dictated the need for cultivation to achieve successful establishment of the woodland and a range of cultivation techniques were employed across the site to match soil and slope conditions. Each of these cultivation techniques has the potential to impact surface water runoff in different ways, particularly in the short term.

Thus the aim of this research presented was to compare, by field measurement, differences in runoff response between the main types of cultivation to assess the potential effects of cultivation selection on flood risk.

METHODOLOGY

Three study plots (Table 1 and Figure 1), capturing a range of cultivation techniques and slope were established in the Menstrie Burn catchment (Figure 1) and runoff monitored at ≤15 minute resolution in each of: an unplanted control of unimproved rough grassland/bracken (Probe_1); an area of ploughed ground (~0.5m depth) installed with regular 'lifts' to create natural breaks/buffers within the furrows (Probe_3); a zone of screefing, where trees were hand-planted (Probe_2). The probe instrument consists of a senix sonda and electronic data logger that measures and records surface runoff from each plot. The probes were all installed in February 2016. Rainfall is measured using an automatic rain gauge located in upper part of the Menstrie catchment, maintained by SEPA.

Table 1: Location and physical characteristics of deployed runoff probes



	Probe_ 1	Probe_ 2	Probe_ 3
Aspect	WSW	WSW	WSW
Cultivation	Unplanted control	Screefing	Plough ground

Underlying soil type	Brown earth	Brown earth	Brown earth
Mean slope	22.5	17.5	16
Catchment	Inch 1	Inch 1	Inch 1
Elevation	370-400	380-425	350-380
Catchment area (m^2)	5232	8298	6434

DATA ANALYSIS

Early stage data analysis focused upon sixteen discrete rainfall-runoff events. A rainfall-runoff event was defined as one with >2 mm rainfall and a minimum inter event time of 3 hours.

Seven months of data were analysed (February to May 2016 and December 2016 to February 2017), with gaps during the summer period due to equipment failure.

Some general features of data sets are (Table 1):

(1) The ploughed ground and screefed plots produced a larger runoff volume compared to the unplanted control plot,

(2) Time to runoff peak ranged between 1-24 hours, although 11 events (ploughed ground), 9 events (screefing) and 8 events (unplanted control) have values of 1 to 5 hours,

(3) The water volume is significantly different between the three study plots (Figure 2),

(4) If the event on 22nd of December 2016, has been exempted as an exceptional event, then water volume generated by the ploughed plot is slightly above $100x10^3$l, above 25 $x10^3$l for the screefed plot and slightly under 1 $x10^3$l in the unplanted control.

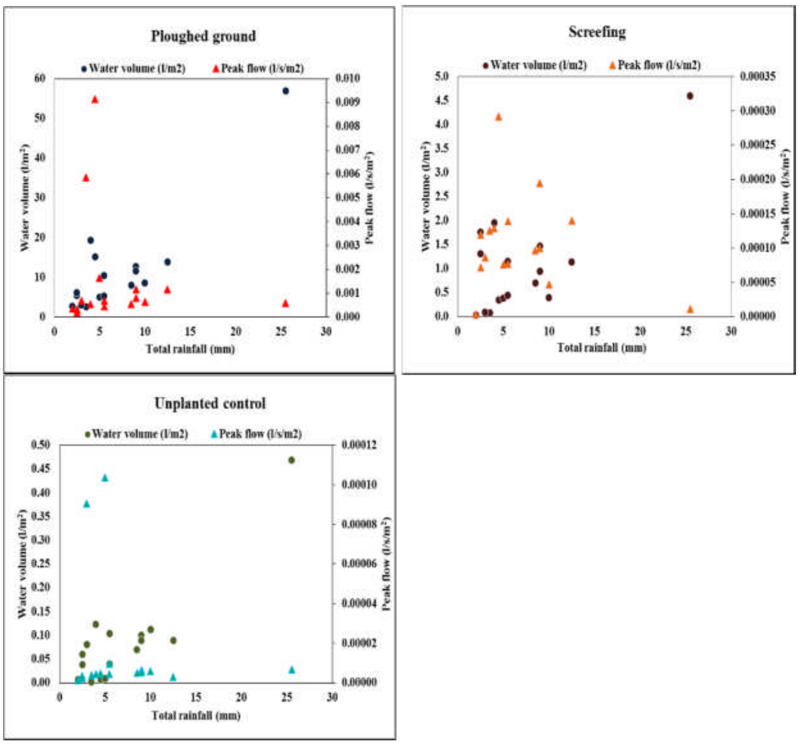


Figure 2: Graphs showing effects of rainfall events and volume of water/peak flow generated from the catchment area of the ploughed, screefed and unplanted control plots.

Table 1: General features of data set

Date	R Total rainfall (mm)	Rd Rainfall duration (h)	Ri Rainfall Intensity (mm/h)	Peak flow (l/s) Qp Plough ground	Qs Screefing	Quc Unplanted control	Volume of water (x10^3 l) Wp Plough ground	Ws Screefing	Wuc Unplanted control
26 March 2016	9	15.75	0.57	6.10	1.61	0.04	66.61	7.79	0.64
28 March 2016	2	0.75	0.62	1.78	0.03	0.01	14.08	0.24	0.04
2 April 2016	3.5	4.25	0.82	30.70	1.04	0.02	13.73	0.70	0.01
25 April 2016	4.5	3.50	1.29	47.88	2.42	0.03	79.37	2.85	0.04
2 May 2016	5	4.00	1.25	8.55	0.63	0.67	26.04	3.15	0.06
3 May 2016	3	2.25	1.33	3.64	0.72	0.58	15.86	0.74	0.52
9 December 2016	2.5	6.75	0.37	1.02	0.99	0.01	28.47	14.61	0.25
14 December 2016	2.5	7.75	0.32	1.68	0.60	0.02	32.41	10.83	0.39
16 December 2016	4	6.25	0.32	2.89	1.07	0.03	101.31	16.20	0.79
22 December 2016	25.5	68.50	0.37	3.07	0.09	0.04	298.00	38.13	3.02
2 January 2017	10	2.50	4.00	3.35	0.39	0.04	45.25	3.34	0.72
3 January 2017	9	7.50	1.20	4.16	0.83	0.03	61.13	12.22	0.57

9 January 2017	8.5	24.75	0.36	2.84	0.80	0.03	42.30	5.82	0.45
28 January 2017	5.5	16.25	0.34	2.38	1.16	0.06	27.94	3.67	0.67
31 January 2017	5.5	2.75	2.00	3.59	0.64	0.03	54.61	9.58	0.25
3 February 2017	12.5	3.75	3.33	6.08	1.16	0.02	72.78	9.47	0.57

DISCUSSION

Initial analyses of the data collected looked to investigate the relationship between W volume of water (l), R rainfall (mm) and Q peak flow (l/s). The volume of water is defined as the specific volume observed during hydrograph and total rainfall is observed summed rainfall over event duration.

The work first looked at simple linear regression between variables in Figure 3 and found high correlation between R (mm) and W (l/s), with estimated R^2 of 0.76, 0.56 and 0.79 for the ploughed ground, screefing and unplanted control. The ploughed ground generated the largest increase in runoff with rainfall, indicative of plough furrows channelling and speeding-up surface flows. However, calculated runoff volumes often exceeded rainfall for the ploughed plot, indicating an issue with the integrity of plot boundaries. This will be the subject of future analyses.

Bearing in mind that woodland creation has been associated with an ability to slow down run-off and reduce downstream flooding, comparison between rainfall events considered rainfall intensity to be a significant factor for future predication of catchment hydrology and run-off decreasing. However, rainfall events with a large amount of rain and low intensity show lower peak flow.

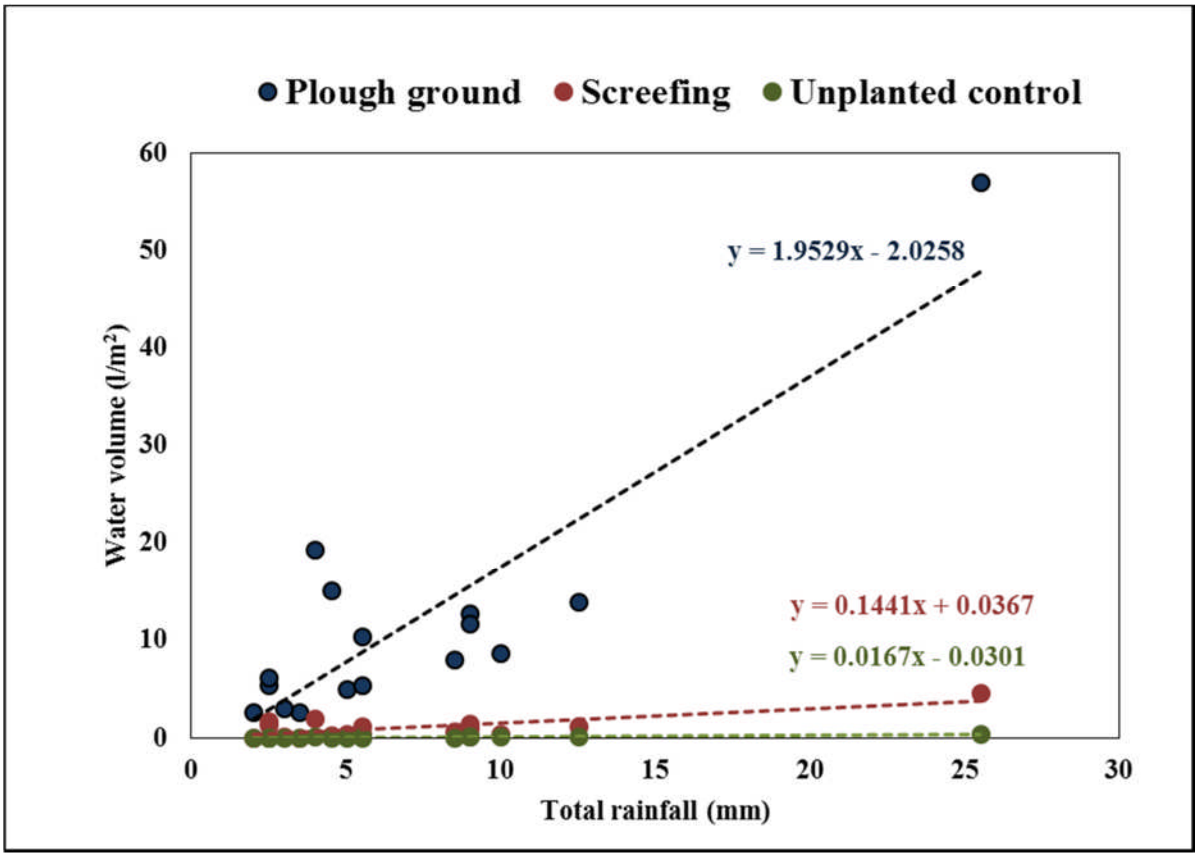


Figure 3: Linear regresion of total rainfall and water volume data

CONCLUSION

This research aimed to assess the short-term consequences of a large scale woodland planting project. Analyses of sixteen rainfall events suggests that pre-planting site cultivation can have a significant effect on surface runoff. More work is needed to analyse differences between cultivation treatments and understand how these affect pathways of water movement and downstream flood risk. It will also be interesting to look at how cultivation effects on runoff change through time and interact with the increasing influence of the growing woodland crop. Future analyses will investigate the relationships between hydrological processes and the catchment response.

REFERENCES:

Scottish Executive, 2006, Scottish Forestry Strategy. Forestry Commission Scotland. pp.87. IBSN: 0-85538-705-X

Natural Flood Management Handbook, 2005, SEPA,

Final Report, Flooding in Menstrie Foothills, Clackmannanshire council, 2005

K.A. Farley, E.G. Jobbagy, and R.B. Jackson, 2005, Effects of Afforestation on Water Yield: A Global Synthesis with Implications for Policy. Global Change Biology, 11, 1565-1576.

105. Exploring a GIS-SD Approach for Quantifying Health Sector Resilience based on Leptospirosis Infections

C. Kendra Gotangco[1], John Wong**, Justin See***,Emil Gozo†, Flordeliza del Castillo†, John Edward Perez††,John Paolo Dalupang***,Celine Vicente†, Emma Porio***, and Antonia Yulo-Loyzaga†*

** Dept. of Environmental Science, Ateneo de Manila University*

*** Health Sciences Program, Ateneo de Manila University*

**** Dept. of Sociology and Anthropology, Ateneo de Manila University*

† Manila Observatory

†† Marine Science Institute, University of the Philippines

[1] Department of Environmental Science

3rd floor, Manila Observatory building, Ateneo de Manila University

Loyola Heights, Quezon City, Philippines 1108

Email: kgotangco@ateneo.edu

Telephone: 632-4264321

KEYWORDS: resilience, system dynamics, Geographic Information Systems, susceptible-infected-recovered model, leptospirosis

EXTENDED ABSTRACT

Objectives:

The study explores how a systems approach be applied to quantitatively and dynamically measure resilience, particularly for the health sector. The spread of leptospirosis in Metro Manila during a flooding event is used as an exploratory case. The study also tests new methods employing the coupling of spatial mapping techniques with system dynamic modeling.

Methods:

The concept of tracking system performance to quantify resilience (Simonovic and Peck, 2013) was adapted, but integrated with a classic S-I-R (susceptible-infected-recovered) System Dynamics (SD) model (a simplified version of the stock-flow diagram is shown in Figure 1). Factors considered as contributing to infection and recovery rates are adapted from those identified by city health officers and experts in a workshop aimed at developing causal loop diagrams to explain mortality due to leptospirosis (Wong et al., 2015). The major stocks in the model are the susceptible population, who may become infected population, who may, in turn, either recover or develop permanent complications or die. Those who recover are returned to the population stock since there is no certain immunity to leptospirosis, according to our consultation with the health sector. The infection rate is influenced by educational (e.g. seminars or community assemblies) and behavioral (flood avoidance and taking of prophylaxis) factors. The recovery rate is influenced mainly by whether persons can be

accommodated by health facilities and given treatment. The ratio of people who are not infected and do not have permanent conditions to total population was used as the basis for the resilience measure.

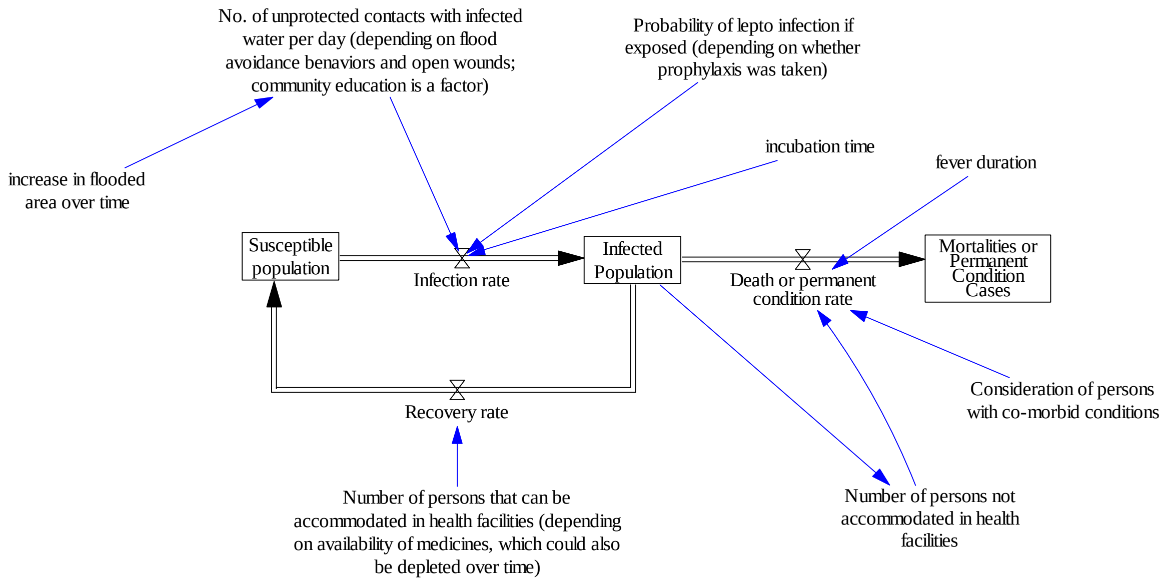


Figure 1. Simplified System Dynamics Diagram adapting SIR to Quantify Resilience

Some simplifying assumptions were employed in this initial model: The model assumes that those who attended community assemblies on leptospirosis understood the content and will act appropriately to avoid exposure. Medicines are the primary consideration for patient care – health care centers will accommodate patients for treatment if there is still a stock of medicines. Treatment is assumed to be as necessary for recovery. Those are given the course of treatment will recover and return to the “susceptible” stock, while those who do not receive this will be directed to the “mortalities or permanent condition” stock. The probability of infection is also independent of flood height and differences in cleanliness/sanitation in affected areas. It is assumed that if there is a flood, it has the capacity to infect populations with leptospirosis.

An innovation explored in this study was the coupling of Geogrpahic Information Systems (GIS) output on flooded areas to the SD model, using Python scripting. This method was developed by Peck et al. (2014). To implement the GIS-SD coupling, riverine flooding of a section of Marikina River is considered. Flood model outputs for the river sections traversing Barangay Kalumpang (Marikina City) and Barangay Santolan (Pasig City) were mapped in ArcGIS. These maps represented the maximum flood extent or flood peaks on August 19 and August 20, 2013, during the extreme rainfall event brought by the Habagat (Southwest) monsoon enhanced by Tropical Storm Trami. The Python script was programmed to read the shapefiles and calculate the increase in flooded area, which is then passed on to the SD model to calculate for exposure to flood waters.

Barangays Kalumpang and Santolan have an estimated population of 57,744 people (NSO, 2010) and occupy an area of approximately 2.8 km^2. Due to the lack of primary data-gathering in this area, the values of model variables were drawn from secondary literature or are assumed / dummy variables for preliminary testing.

Results:

The Health Sector Resilience Measure based on the leptospirosis incidence in the study area is shown in Figure 2. One (1) is considered as the baseline performance. The decrease is minimal, and this due to an underestimate of the flooded area. The GIS maps only contained riverine flooding and did not yet incorporate inland flooding of low-lying areas. The delay in the decrease of the resilience measure is due to the incubation period for leptospirosis. The measure does not return to baseline due to the stock of people who suffer mortality or permanent complications.

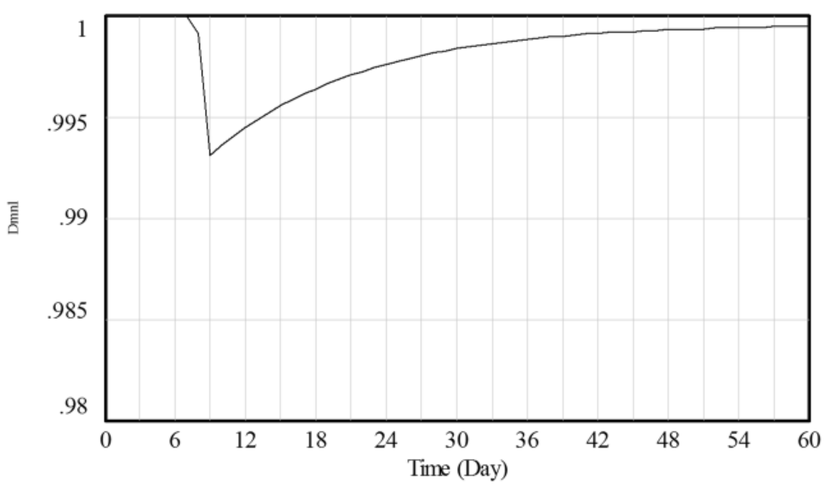


Figure 2: Health Resilience Measure based on Leptospirosis Incidence

Although these are preliminary results, they reflect the expected trend in the resilience measure, and they successfully incorporate the GIS-SD linkage. Major improvements required to increase the utility of the model are:

(1) Complete flood maps, including both riverine and inland flooding. For extreme rainfall events like Typhoon Ketsana during which flood levels increased rapidly over the course of a day, a finer-resolution time scale – e.g. hourly maps instead of daily – would also be needed as input.

(2) Primary data-gathering to better estimate and validate the community-based programs, typical behaviors (e.g. flood avoidance practices) of people exposed to floods, and epidemiological data specific to the community.

With these improvements, policy scenarios for the given community can be better identified and explored through system dynamics modeling.

Nevertheless, with this exploratory model for the health sector, we see that resilience is an interplay not only of factors typically considered under hospital systems (e.g. administering treatment to infected persons), but also social factors (e.g. community education), psychological / behavioral factors (e.g. individual choices to protect selves from infection) and environmental (e.g. increase in flooding extent). This makes the case all the more for an inter-sectoral city resilience analysis that draws from different approaches. In this particular example, we demonstrate the possibility of coupling spatial mapping and modeling tools to the system dynamics platform. Future improvements can build on this coupling to achieve more dynamism and contextualization.

REFERENCES:

National Statistics Office (NSO) (2010) 2010 Census of Population and Housing: National Capital Region [online]. http://psa.gov.ph/sites/default/files/attachments/hsd/pressrelease/National%20Capital%20Region.pdf [accessed: 26 July 2016].

Peck, A., Neuwirth, C. and S. Simonovic (2014). Couplings Systems Dynamics with Geographic Information Systems: CCaR Project Report [online]. Report No. 086, Dept. of Civil and Environmental Engineering, University of Western Ontario, Canada. http://www.eng.uwo.ca/research/iclr/fids/publications/products/86.pdf [accessed: 23 July 2016].

Simonovic, S. and Peck, A. (2013) Dynamic Resilience to Climate Change Caused Natural Disasters in Coastal Megacities Quantification Framework. British Journal of Environment and Climate Change, 3(3), 378-401.

Wong, J.Q., Bautista, Bautista, C.A. and Concepcion, M., et al. (2015). IRIACC-CCAR: Systems Dynamics Modelling of Flood Related Leptospirosis Workshop. Report submitted to the Manila Observatory Coastal Cities at Risk (CCaR) Project, 9 March 2015, Quezon City.

ACKNOWLEDGEMENTS:

This study was implemented under the project 'Coastal Cities at Risk (CCaR): Building Adaptive Capacity for Managing Climate Change in Coastal Megacities', under the International Research Initiative on Adaptation to Climate Change. This work was carried out with the aid of a grant from the International Development Research Centre (IDRC), the Canadian Institutes of Health Research (CIHR), the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Social Sciences and HumanitiesResearch Council of Canada (SSHRC), Ottawa, Canada.

120. Health consequences of urban flooding: Risk of infectious gastroenteritis spread via floodwater

Yoshifumi Masago[1], Biyana Kumar Mishra*, Pankaj Kumar*, Ammar Rafiei Emam* and Kensuke Fukushi***

** United Nations University – Institute for the Advanced Study of Sustainability*

*** Integrated Research System for Sustainability Science, University of Tokyo*

[1] 5–53–70 Jingumae, Shibuya-ku, Tokyo 150-8925, Japan; e-mail: masago@unu.edu

KEYWORDS: urban flooding, infectious gastroenteritis, quantitative microbial risk assessment, climate change, urbanization

ABSTRACT

Background: Urban flooding and heavy rainfall are often associated with waterborne infectious diseases. Flooding causes municipal wastewater to overflow from urban sewerage, septic tanks, and latrines, all of which contain pathogenic microorganisms. As it is expected that the climate change would increase the frequency and intensity of flooding, infectious diseases spread via floodwater would be of great concern especially in urbanized areas in developing countries. However, the risks of infectious diseases caused by pathogens in floodwater have not been well documented.

Methods: We evaluated potential health risks of infectious gastroenteritis using the quantitative microbial risk assessment (QMRA) framework. Scenarios for different levels of inundation are developed in order to simulate and analyze exposure to waterborne pathogens and probability of infection by pathogens due to incidental ingestion of floodwater. The QMRA model was combined with two other models, inundation simulation model using FLO-2D and HEC-RAS and water quality simulation model using WEAP, to simulate health risks caused by enteric pathogens spread via flood water. Various future scenarios (e.g. precipitation, population, urban development) were developed in selected megacities in Southeast Asian countries to project the potential health risks in the future.

Results: The suite of simulation models we developed to investigate water quality, inundation status, and floodwater-borne infectious diseases enabled us to project future urban water environment in multiple aspects. The model revealed that the rapid population increase and urbanization, together with the climate change will deteriorate microbial water quality, increase the intensity of urban floods, and potential risk of infection. Especially, the increase in the number of potential patients was outstanding because it is affected cumulatively by all of the aspects considered in the models. Thus further research in this topic is necessary to understand future status of urban water environment, and to develop effective measures to mitigate effects of urbanization and climate change in various aspects.

132. Developments in flood alerting and monitoring solutions for the benefit of emergency responders

Dr Justin Butler and Paul Drury. [1]

** Ambiental*

[1] Ambiental, Science Park Square, Brighton, BN1 9SB.

+ 44 (0) 203 857 8535. justin.butler@ambiental.co.uk, paul.drury@ambiental.co.uk

KEYWORDS:

Flood Forecasting, Flood Monitoring, Flood Risk, Remote Sensing, Hydraulic Modelling

ABSTRACT:

Objectives

Through early alerting of imminent floods and through precise monitoring of flood evolution it is possible to action an improved response to flooding events in order to better protect lives and property. Flood risk specialists Ambiental is an established provider of flood hazard maps, flood risk assessments and catastrophe models for the insurance industry, for governments and for non-governmental organisations in the UK and internationally. In recent years the company has undertaken several innovative research projects which have resulted in the development of tools and techniques for the advancement of flood prediction and monitoring. It is the aim of this presentation to showcase these technologies and to explain the benefits they offer to those involved in flood emergency response.

Methods

This presentation will explore how Ambiental has applied emerging scientific techniques and data sources in order to produce improved flood data products. It will provide insights into how the company builds hydraulic models to simulate flooding and demonstrate how high precision can be achieved through superior input data. It will also demonstrate how predictive accuracy is still achievable even when input data is sparse or lacking, such as when modelling floods in low-income developing countries. Ambiental is working with governments in South-East Asia to map flood risk and deliver flood forecasting technologies which predict when flooding will occur. This is provided through integrated software platforms which can issue alerts and forewarn the authorities so that disaster response teams can be mobilised and vulnerable people can be evacuated to safety. Further to this Ambiental is working with leading satellite data providers to develop systems which are able to monitor floods as they occur. Through smart-tasking of Synthetic Aperture Radar satellites it is possible to capture high resolution data from flood events and ensure that the data captured is acquired at the right time and in the right place.

Results

Through implementing the latest scientific techniques of flood modelling and image processing, coupled with innovative post-production techniques using Geographic Information Systems, it has

been possible to derive highly accurate flood extents and flood depth predictions. Moreover, it has been demonstrated that this data can be obtained in short timeframes and delivered via automated delivery systems, so that it is available rapidly enough to be of considerable benefit to emergency response teams. This system was tested during storm Desmond and proved successful in deriving flood extents which validated extremely well against actual recorded observations on the ground.

Conclusions

Whilst it is often not possible to prevent floods occurring it is achievable to dramatically reduce the negative impacts of flooding through a better understanding of the potential risks in order to make detailed disaster plans. If response coordinators are able to detect an impending flood early enough then this can allow sufficient time to make preparations and mobilise the response efforts. Through having rapid access to data products which monitor floods it is possible to provide emergency responders with a much clear understanding of the precise extent of flooding and react accordingly. With flood hazard predicted to increase in the future and with the expected increases in the number of people and properties exposed to flood risk there is a growing need for better quality data and for more certainty in flood predictions. This presentation will demonstrate how Ambiental is working to offer solutions which meet this need.

173. Flood risk evaluation in small urban areas

Edna Margarita Rodríguez-Gaviria[1], Verónica Botero-Fernández***

** Institución Universitaria Colegio Mayor de Antioquia*

*** Universidad Nacional de Colombia*

[1] Carrera 78 # 65 - 46, 57-3113332063, edna.rodriguez@colmayor.edu.co

KEYWORDS: floods, vulnerability, risk, urban planning

ABSTRACT

Colombian norms and laws establish the requirements and scale to incorporate risk management into municipal development plans, and territorial land use planning. These norms and laws are far from the reality that urban areas with less than 100 thousand inhabitants live, since they cannot evaluate risk due to the lack of economical, technical, human, and technological capacities. These urban areas suffer frequently the impact of flooding, considering their disorderly and unplanned sprawl, exposing them more, and increasing their vulnerability and risk. We propose a methodology to evaluate flood risk at local level. This methodology was tested in an urban area historically affected by slow flooding. The results of this research are comparable to detailed technical assessments required by current laws, therefore becoming especially useful to small municipalities in Colombia or Latin America, where municipal capacities are similar.

Sustainable approaches to flood risk management

44. Overcoming barriers to Blue-Green infrastructure through multiple benefit evaluation
Dr Richard Fenner, University of Cambridge, United Kingdom

103. Interagency Approaches to Study and Develop Adaptive Strategies for Addressing Rising Sea Levels in South Florida
Mr David Apple U.S. Army Corps of Engineers, Jacksonville District, United States

180. Assessment of long-term performance of blue-green infrastructure in the urban catchment
Dr Sangaralingam Ahilan, University of Leeds, United Kingdom

184. Storm water management and flood control in sponge city construction of Beijing
Dr Shuhan Zhang, Beijing Water Science and Technology Institute, China

187. "Sponge City" in China – a breakthrough of flood risk management and land use planning in the urban context?
Dr Faith Chan University of Nottingham Ningbo China, China

212. The Evolution of Natured-Based Solutions in an Urban Context: GI, LID, Ecological Engineering, Building with Nature
Ms Yen-Yu Chiu, UNESCO-IHE Institute for Water Education, Netherlands

222. Increasing Urban Flood Risks in China: Challenges and Coping Strategies
Dr Xiaotao Cheng, China Institute of Water Resources and Hydropower Research（IWHR), China

287. Chinese Sponge City: theory and practices learned for flood management in Brazil
Prof Newton Moura, Universidade de Fortaleza, Brazil

334. Challenges in green infrastructure planning
Prof Chris Zevenbergen, UNESCO-IHE Institute for Water Education, Netherlands

326. The resilience of nature-based solutions: insights from literature and case studies
Dr Grazia Di Giovanni Gran Sasso, Science Institute, Italy

44. Overcoming barriers to Blue-Green infrastructure through multiple benefit evaluation

Emily O'Donnell[1] and Richard Fenner***

** University of Nottingham*

***University of Cambridge*

[1] *University Park, University of Nottingham, NG7 2RD. Tel: 0115 8468137. Email: Emily.O'Donnell@nottingham.ac.uk*

KEYWORDS: Blue-Green infrastructrue; Benefits; Barriers; Multifunctionality

EXTENDED ABSTRACT

Approaches to flood and water management that centre on 'living with and making space for water' are increasingly adopted internationally to better integrate the water cycle with urban design and development needs. Nonetheless, widespread implementation of Sustainable Drainage Systems (SuDS) utilising forms of Blue-Green infrastructure (BGI) is currently hampered by barriers that impede uptake and innovation. This includes uncertainties regarding hydrological performance and service delivery; funding, adoption and maintenance, and; lack of confidence that communities and decision makers will accept, support, and take ownership of BGI (Thorne et al., 2015).

Barriers to the widespread implementation of BGI were investigated in Newcastle, UK, through a series of semi-structured interviews with professional stakeholders (O'Donnell et al., 2017a). 17 types of barriers were identified, including a reluctance to support 'novel' approaches, a lack of knowledge, education and awareness, and challenges around partnership working to deliver multifunctional assets (Figure 10). Overall, the socio-institutional barriers posed the greatest hindrance to implementation of sustainable water management schemes and exerted a greater influence on the chosen solution when compared with purely hydrological, physical science or engineering considerations. A range of strategies to overcome the barriers were also identified, including the promotion of multifunctional space and identification, quantification and (where possible) monetisation of the multiple benefits (Figure 11).

Figure 10 Barriers to the implementation of BGI in Newcastle. Red = socio-political barriers, black = biophysical barriers, blue = barriers that are both socio-political and biophysical (O'Donnell et al., 2017a).

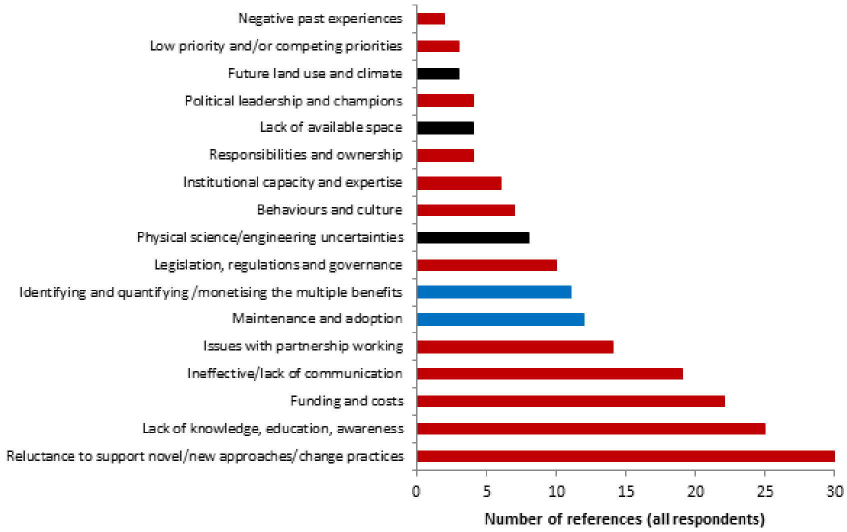
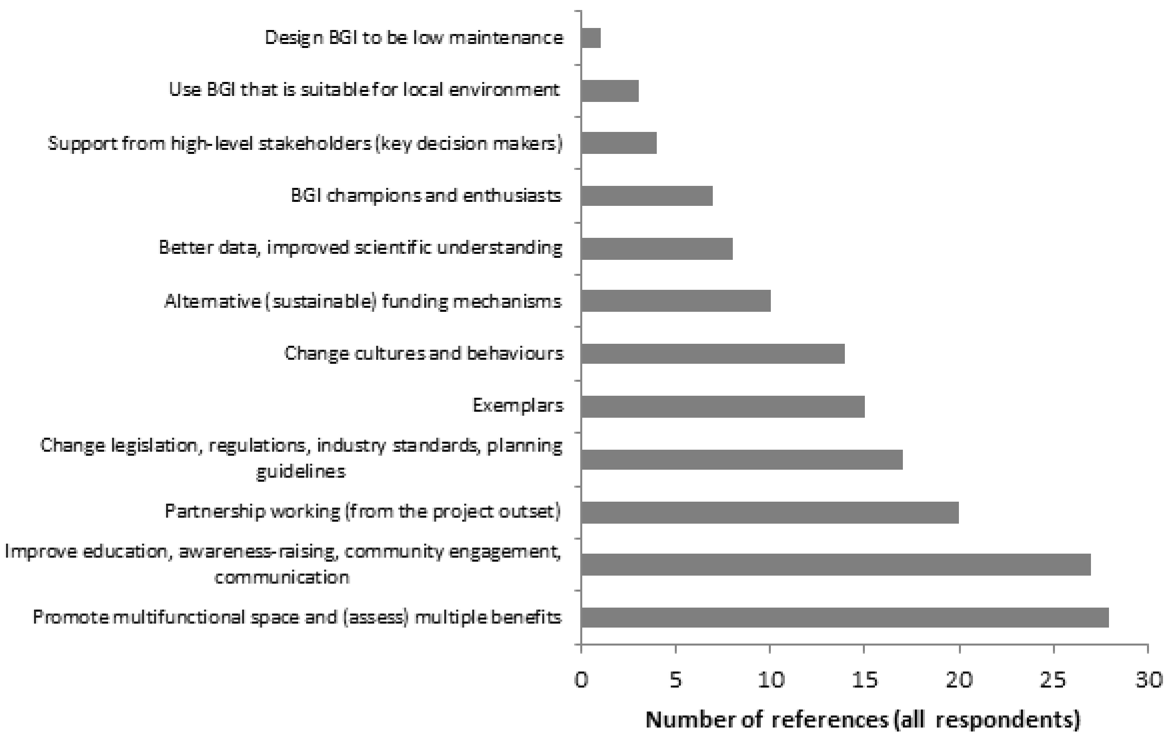


Figure 11 Strategies to overcome barriers to the implementation of BGI in Newcastle (O'Donnell et al., 2017a).



Responding to the need to robustly establish and compare the benefits of SuDS/BGI, we present a new GIS method that demonstrates the intensity and spatial distribution of the diverse impacts that accrue from these types of stormwater management interventions (Morgan and Fenner, 2017, *in press*). The method provides location-specific evaluations of the spatial distribution of benefits that are referenced against the pre-existing environmental conditions. To develop and demonstrate this new approach six biophysical benefit categories were evaluated in a number of sites in Newcastle, UK. These include flood damage reduction, noise attenuation, air pollution reduction, carbon sequestration, habitat size improvement, and access to greenspace as a representative (though not exhaustive) set of benefit categories frequently associated with SuDS/BGI assets. This approach complements existing methods for evaluating the performance of SuDS and BGI (e.g. CIRIA, 2015) by addressing three key issues:

1. Spatial: the method recognises that each benefit will have a specific spatial distribution and may potentially accrue to different stakeholder groups than the asset owner;
2. Context sensitive: the benefit evaluation depends on the existing context of the location. Thus, the same intervention in two different locations may have different results;
3. Normalised: different types of benefit can be compared against each other as they are normalised to a common scale.

Four case studies were evaluated in Newcastle, each representing a different type of urban form and BGI/SuDS (O'Donnell et al., 2017b; Morgan and Fenner, 2017, *in press*). In each case, a before (current condition) and after (BGI condition, whether hypothetical or implemented) scenario were modelled and compared. The multiple benefits of the intervention were calculated by combining the outputs of single benefit layers into a cumulative benefit intensity map, illustrating where the scheme creates the most improvement and where the dominant benefits can be co-optimised. The GIS method was also used to calculate the *potential benefits* and the *effectiveness* of the modelled interventions. Effectiveness assesses whether the scheme could make a significant difference to the area when compared with the benefits that the area provides under the reference scenario. Potential benefit scores evaluate where the best opportunities for improvements are within an area, demonstrating where interventions might generate the most single and multiple benefits.

Here, we report on the first case study, Wingrove, which comprise a residential neighbourhood characterised by densely packed terraced houses and high proportions of impermeable surfaces. The current condition was compared with a hypothetical greening scenario (where all gardens had natural surfaces and small additional green areas were inserted into public areas as proposed by a group of local stakeholders). Significant benefits from the hypothetical greening programme were observed in Wingrove due to the original lack of greenspace, and radiated out from the site of intervention (Figure

3). The benefit profile, which compares the relative performance of each benefit category both in terms of the magnitude of the benefit achieved, and the area over which this benefit has influence, shows that access to greenspace and the increase in habitat size are the most significant benefits (Figure 4). The large size of the “Access” bubble in Figure 4 demonstrates that the intervention was effective and achieved a high proportion of the total potential benefit realisable in this location. The analysis illustrates that there is a relatively high potential for beneficial interventions along highways and pavements, suggesting that transportation departments would be a key stakeholder to involve in discussions about BGI in residential areas.

Figure 3 Wingrove benefit intensity maps (unweighted accumulation of total benefits)

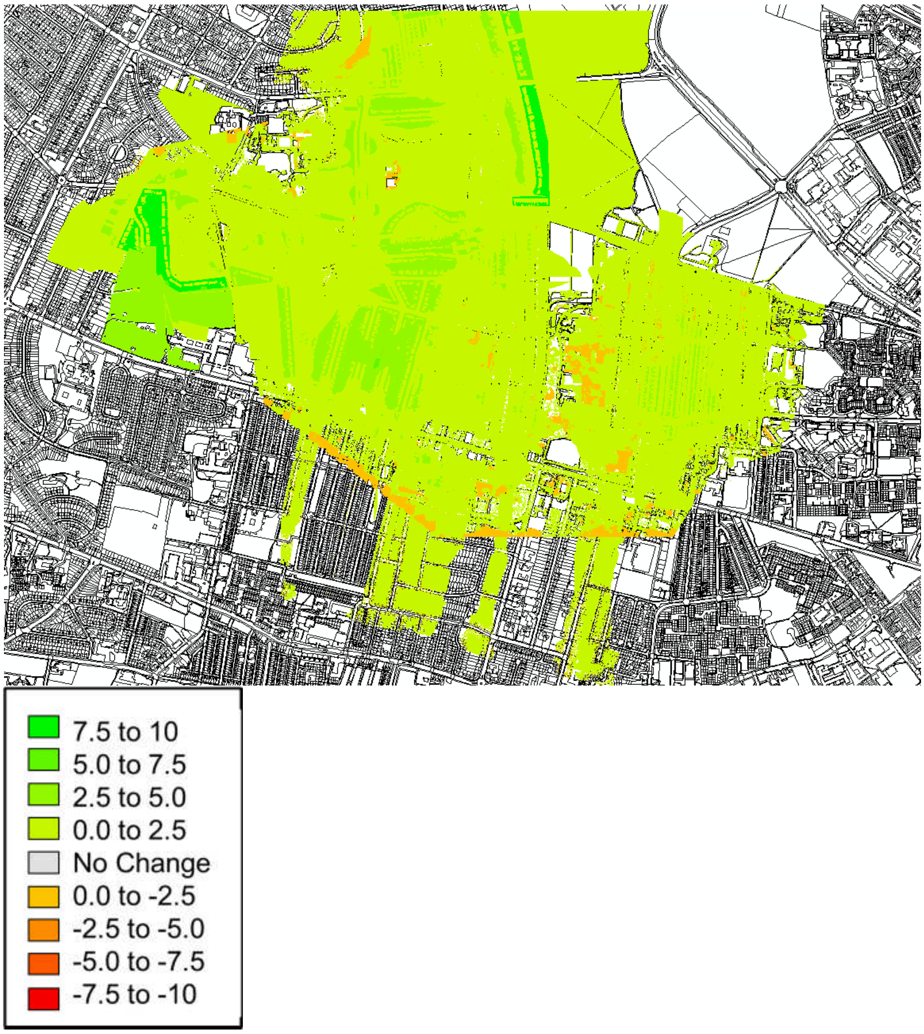
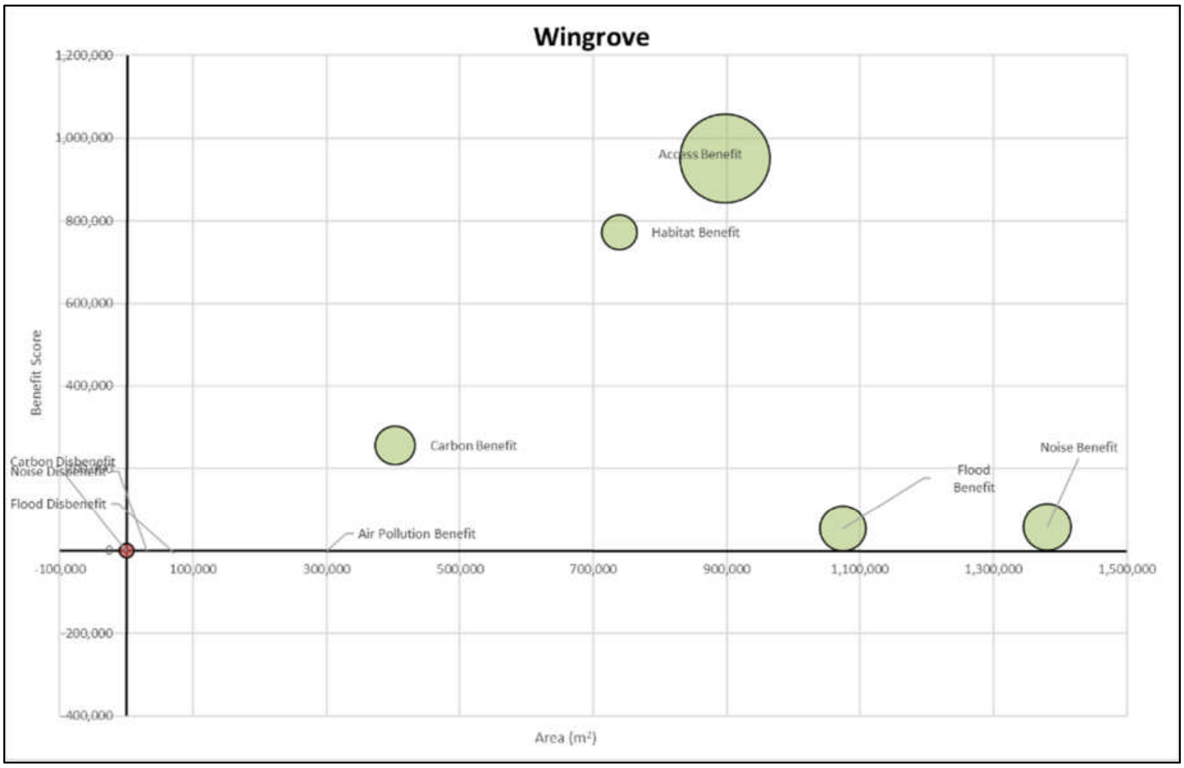


Figure 4: Example benefit profile for Wingrove



We conclude that the compilation of quantitative evidence of the multiple benefits may support business cases for SuDS and BGI schemes and help overcome some of the socio-institutional barriers to widespread implementation. The GIS based approach provides a useful method for evaluating multiple benefits, potential benefits, and benefit efficiency, and compliments other recent tools, such as CIRIA's Benefits of SuDS Tool (BeST), an Excel-based decision-support tool that provides a robust economic appraisal of the multiple benefits of different SuDS options (CIRIA, 2015). The method is most applicable in the early stages of design, to examine the selection of the scheme location, potential options, and to ensure that the most desired benefits are co-optimised with the primary drainage and flood management function of each drainage asset. The effective spatial visualisation capability of the benefit intensity and benefit profile makes it highly suitable for learning and communication activities across organisational boundaries, facilitating partnership working towards greater implementation of multifunctional BGI. The Multiple Benefits GIS approach is available to download from the Blue-Green Cities website (www.bluegreencities.ac.uk/publications/multiple-benefit-toolbox.aspx). This approach was trialled in Newcastle and can be adopted for the evaluation of BGI and SuDS in other cities and catchments.

REFERENCES

- CIRIA, (2015). W045a Benefits of SuDS Tool - BeST. London, UK.
- Morgan M, Fenner R. (2017, *in press*). A spatial evaluation of the multiple benefits of SuDS using blue-green infrastructure. Proceedings of the Institution of Civil Engineers – Water Management. DOI: 10.1680/jwama.16.00048.
- O'Donnell E, Lamond J, Thorne C. (2017a). Recognising barriers to implementation of Blue-Green Infrastructure: a Newcastle case study. Urban Water Journal. DOI: 10.1080/1573062X.2017.1279190.
- O'Donnell E, Woodhouse R, Thorne C. (2017b). Evaluating the multiple benefits of a Newcastle surface water management scheme. Proceedings of the ICE – Water Management, 2017. DOI: 10.1680/jwama.16.00103.
- Thorne C, Lawson E, Ozawa C, Hamlin S, Smith L. (2015). Overcoming uncertainty and barriers to adoption of blue-green infrastructure for urban flood risk management. Journal of Flood Risk Management. DOI: 10.1111/jfr3.12218.

103. Interagency Approaches to Study and Develop Adaptive Strategies for Addressing Rising Sea Levels in

South Florida

David Apple[1], Susan Lucas**, Patrick Vogler†*

** U.S. Army Corps of Engineers, Jacksonville District*

*** U.S. Army Corps of Engineers, Jacksonville District*

† U.S. Army Corps of Engineers, Jacksonville District

[1] 701 San Marco Blvd., Jacksonville, FL 32207, (904) 232-1757, E-mail david.p.apple@usace.army.mil

KEYWORDS: Sea Level Rise Adaptive Strategies

ABSTRACT

Objectives

The Southeast Florida coastline and inland areas are one of this nation's most densely populated and urbanized regions vulnerable to coastal flooding and storm damage due to abnormal high tides, storm surges and intense rainfalls from severe storm events (hurricanes, tropical storms and thunderstorms), and sea level rise (SLR). Since the 1950s, the Central and South Florida Flood Control (C&SF) system made up of numerous canals and water control structures provided flood protection to the urbanized areas of Central and South Florida. Unfortunately, the original C&SF system design did not account for the impacts of future SLR. Rising sea levels along South Florida's coastlines have raised coastal communities' awareness of increasing coastal flooding problems resulting from unusual high tides and storm surge that also contribute to failure of critical infrastructure services (transportation, power, and communications) and reduce stormwater drainage capacities of current flood protection systems. Low topography and recent sea level changes of 5 to 6 inches are endangering coastal drainage structures, resulting in losses of system flowage capacity. Some coastal water control structures are being closed twice daily (during two epochs of high tide) to prevent inland flooding due to ocean water levels being higher than inland canal water levels. Although coastal communities are making changes to growth management policies, considering the effects of sea level rise and climate change, this is only a starting point in addressing the larger issue.

Method

To accomplish this, partnering agencies are dedicating their time, data, and resources, using an interagency approach to study and develop adaptive strategies to address flood damage reduction, coastal erosion, and saltwater intrusion associated with the effects of SLR. The use of existing numerical modelling tools will assist in developing the hydrologic information needed to model historic and synthetic storm surge scenarios along the Miami-Dade County coastline to investigate the effectiveness of non-structural flood control measures (dune restoration, vegetation management, land use changes, etc.) to protect structures from damaging storm surges and reduce coastal flooding. Additionally, this information is useful in developing operating rules for the pre-storm operation of

the system. The development and implementation of a Decision Support System tool will enable community officials to better prepare the region for pre-storm operations by providing probabilistic projections of storm surge scenarios and hydrologic responses of the regional system to assist in pre-storm operation decisions.

Results

If implemented, these non-structural measures will result in decreased structural damage, and lowered loss of life. Furthermore, application of these tools offer a comprehensive approach in improving flood risk management by leveraging modelling results that will: determine the extent of saltwater intrusion, and improve analyses of SLR effects on coastal and inland wetland areas and in the Everglades.

Conclusion

Disseminating information to flood risk stakeholders (resident and business owners) requires training for state and local government staff (Counties, municipalities along the coastline) to understand and apply this information. Therefore, conducting educational outreach opportunities (workshops, webinars, and public meetings) is the next step in interpreting/utilizing this information in addressing future SLR impacts.

180. Assessment of long-term performance of blue-green infrastructures in the urban catchment

S. Ahilan†[1], M. Guan**, A. Sleigh* and N. Wright****

** water@leeds, School of Civil Engineering, University of Leeds*

† College of Engineering, Mathematics and Physical Sciences, University of Exeter

*** Department of Geography, Loughborough University*

**** School of Engineering and Sustainable Development, De Montfort University*

[1] *Dr Sangaralingam Ahilan, Collge of Engineering, Mathematics and Physical Sciences, University of Exeter.*

Tel. (01392) 723730. E-mail: s.ahilan@exeter.ac.uk

KEYWORDS: Floodplain, Flood attenuation, Long-term peformance, Stormwater pond, Sediment dynamics.

Objectives

The blue-green infrastructure (B-GI) and sustainable draiange systems (SuDS), such as floodplain restoration, stormwater ponds, wetlands, bio-swales, etc., are increasingly regarded as an emerging concept for sustainable urban water management in the UK and many other countries. Nonetheless, the adaptation of the B-GI infrastructures has been slow, predominately due to lack of empirical data, evidence and dominant technical uncertainties in its long-term hydrological performance. Thus it is essential to evaluate the long-term performance of the B-GI so as to bridge the gap between hard engineering approaches and natural systems. This study assesses the long-term performance of a floodplain and stormwater pond on flow and suspended sediment dynamics in two urban catchments through detailed hydrological and two-dimensional hydro-morphodynamic modelling.

Data & Methods

Two case studies have been undertaken to explore the long-term performance of the B-GI in urban catchments. The first case study is based on Johnson Creek, Portland, USA and the later is based on the Ouseburn catchment, Newcastle upon Tyne, UK. To improve downstream fluvial flood resilience in Johnson Creek, the East Lents floodplain on a 0.26 km^2 site has been reconfigured to reconnect to the river (Figure 1).

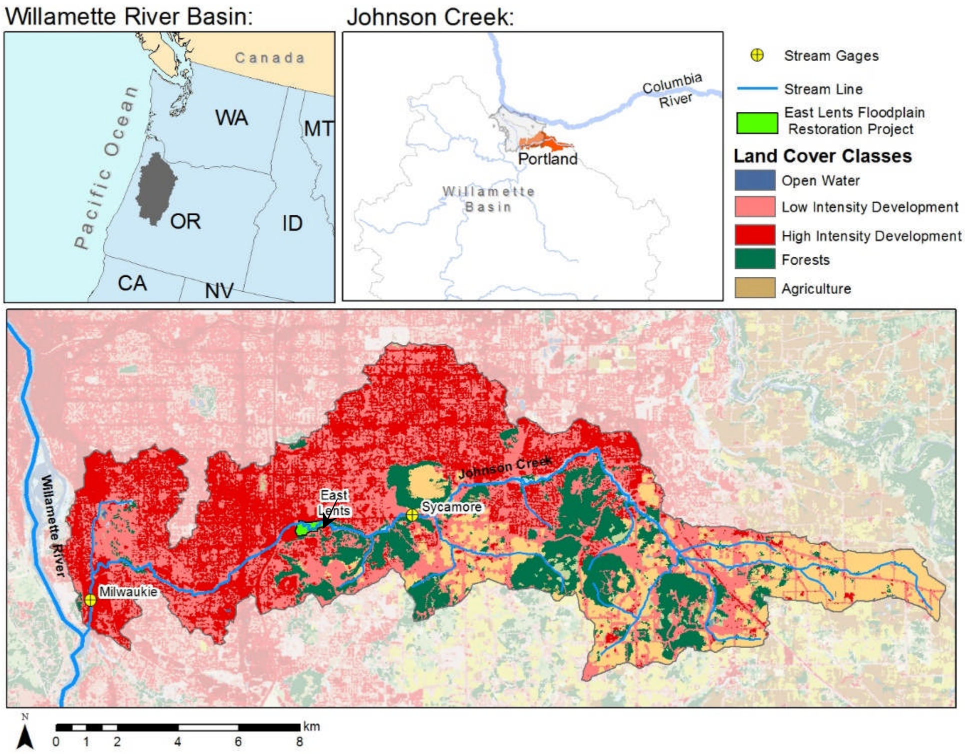


Figure 1 Johnson Creek watershed

In Ouseburn catchment, a number of stormwater ponds are in place to offset additional runoff from the proposed Newcastle Great Park urban development on the greenfield site within the greenbelt. This study focus on flow and sediment dynamics in Pond 2 (Figure 2).

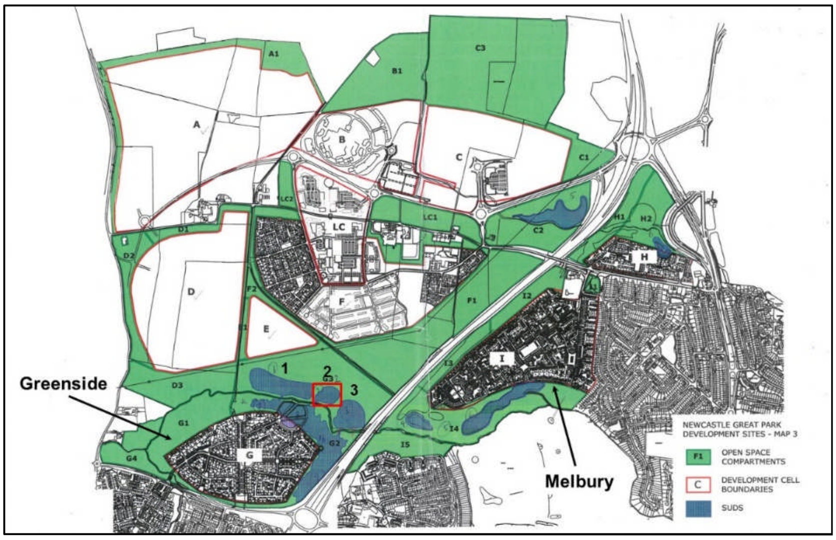


Figure 2 Newcastle Great Park development

The layer based hydro-morphodynamic model (Guan *et al.*, 2014) has been adopted to evaluate both short and long-term flow and suspended sediment dynamics in the above mentioned blue-green infrastructure. In the long term simulation, 64 historical flow events between 1941 and 2014 are considered for Johnson Creek, whereas 3896 rainfall events between 1982 and 2015 are considered for Ouseburn catchment.

Results & Disscussions

Simulation results indicate that East Lents floodplain provides a flood attenuation up to 25% at the downstream and the effects are more pronounced for larger flood event (e.g., 500-year). The temporal and spatial changes of the floodplain topography as a result of cumulative sediment deposition at regular intervals is shown in Figure 3.

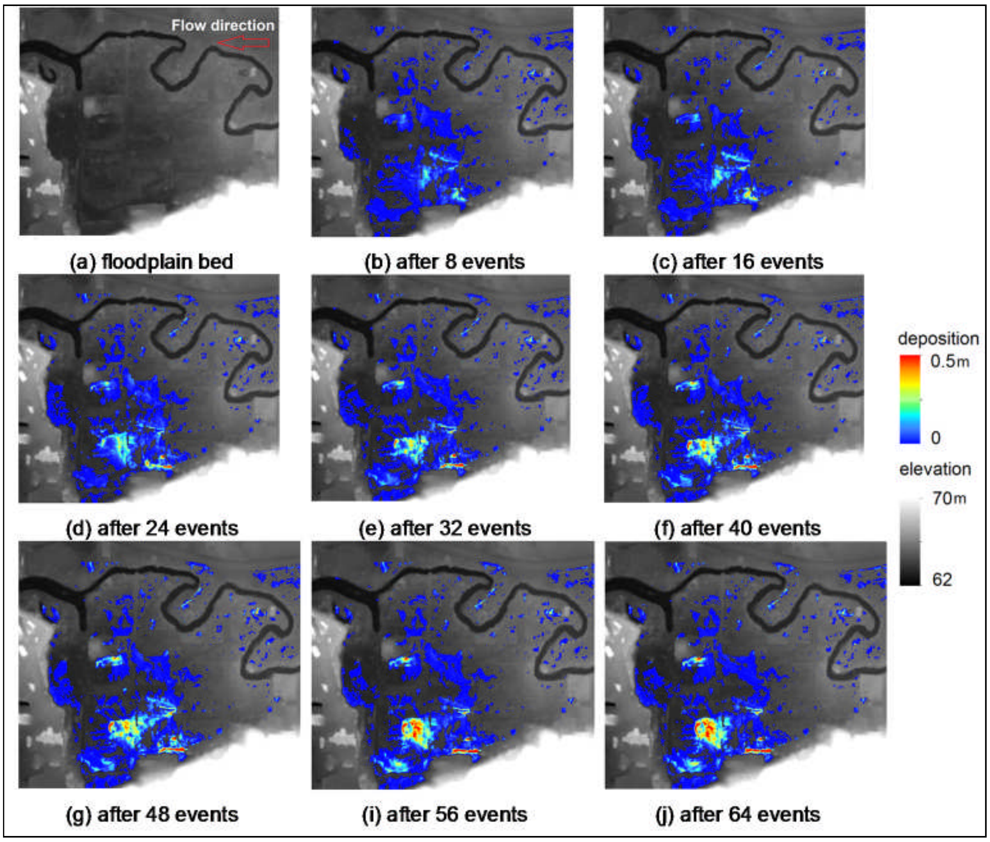


Figure 3 Cumulative sediment depositions after 8, 16, 24, 32, 40, 48, 56 and 64 events

As expected, the amount of sediment accumulated in the flood basin gradually increases with subsequent flooding. Results also show that 20% - 30% of suspended sediment from upstream is deposited on the floodplain and consequently reduces the annual sediment loading of Johnson Creek by 1% at the confluence with Willamette river. More details description of the East Lents study can be obtained from (Ahilan *et al.*, 2015).

The stormwater pond attenuates the flood peak by up to 85% at the pond outlet for more frequent smaller flood events (e.g., 5-year). Simulation results indicate that 25% - 60% suspended sediments from the Newcastle Great Park development are deposited in the pond. The flood attenuation and sediment trapping effects by the pond are more pronounced for more frequent smaller and medium flood events. Figure 4 shows the simulated temporal and spatial variation of the sediment deposition in the pond over the 32 year study period (1984-2015).

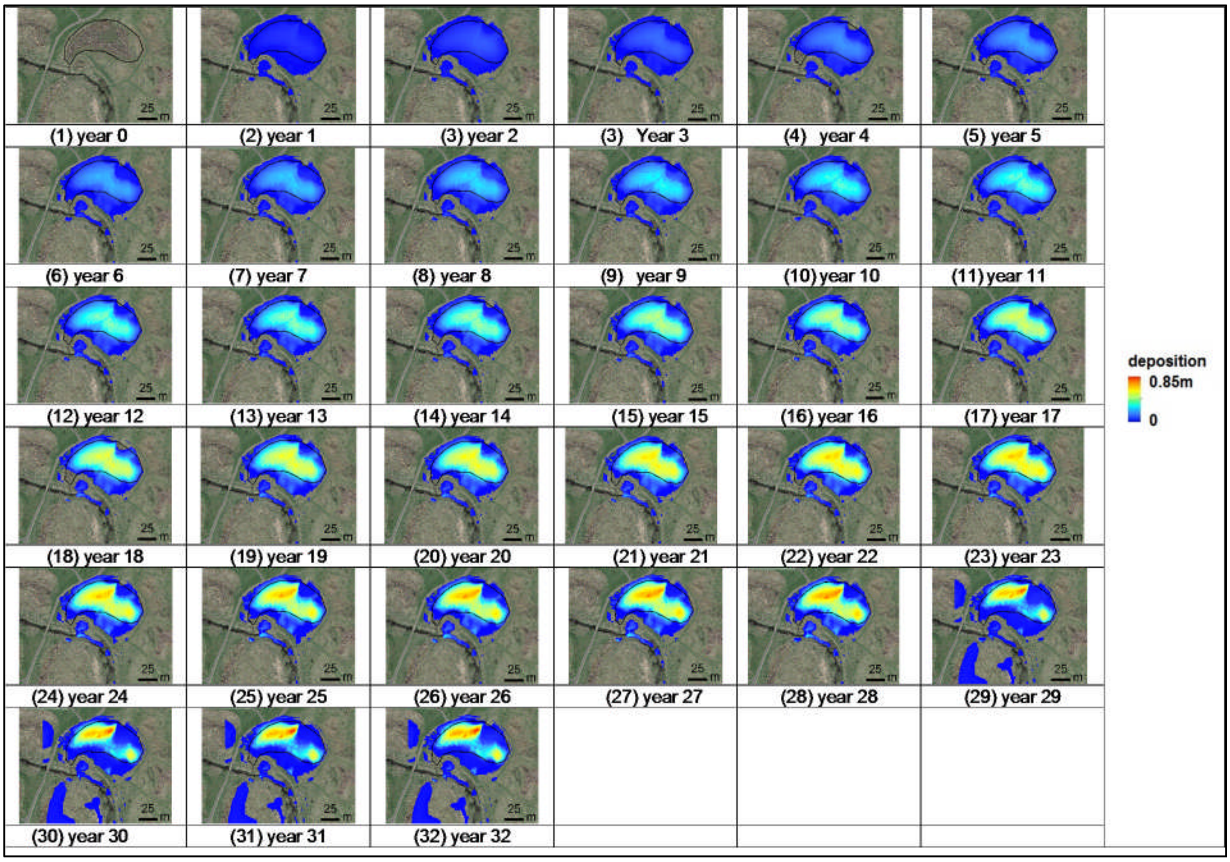


Figure 4 Cumulative annual sediment deposition from 1984 to 2015

Most of the historical events with small and medium magnitude lead to temporary sediment detention and sediment aggradation in the pond. However there are a few extreme rainfall events in Year 16 (1999), Year 24 (2007), Year 25 (2008) and Year 29 (2012), that resulted in flood events. These events strongly influence the overall sediment budget by flushing out the accumulated sediment as a shock load to the river system. On the one hand, this process considerably reduces the sedimentation, enabling the pond volume and flood resilience capacity to re-establish. On the other hand, the shock load could lead to elevated concentrations of sediment and pollutants, resulting in dissolved oxygen depressions due to oxidation of contaminants.

Simulation results also indicate that the major proportion of rainfall events cause sediment accumulation with an average rate of 0.01 m year^{-1}. It indicates that over time, sediment deposition nonlinearly increases and moves towards the pond outlet direction. According to the model prediction at the end of the 32 years long-term simulation, 993m^3 of sediment was deposited in the pond which is equivalent to 18% of the total sediment input. This resulted in a 12% loss in the pond's volume which is equivalent to a sedimentation depth of 0.26m throughout the pond. More details of the Newcastle Great Park study can be obtained from Ahilan *et al*. ( ).

Conclusions

This study provides the first numerical simulation linking the long-term performance of a floodplain and stormwater pond on sediment trapping and flood resilience. Based on the two case studies undertaken, hydro-morphodynamic modelling and long-term simulation shows that the B-GI and SuDS offer a considerable means of providing both improved water quality and flood resilience further downstream.

References

Ahilan, S., Guan, M., Sleigh, A., Wright, N. and Chang, H. (2016). The Influence of Floodplain Restoration on Flow and Sediment Dynamics in an Urban River. J Flood Risk Management. doi:10.1111/jfr3.12251.

Ahilan, S., Guan, M., Wright, N., Sleigh, A., Allen, D., Arthur, S. and Haynes, H. (in review). Modelling the long-term performance of a stormwater pond in an urban catchment. Advances in Water Resources.

Guan, M., Wright, N. G., and Sleigh, P. A. (2014). 2D process-based morphodynamic model for flooding by noncohesive dyke breach. Journal of Hydraulic Engineering, 140(7), 04014022.

184. Storm water management and flood control in sponge city construction of Beijing

*Zhang Shuhan *[1], Song Ruining*, Chen Jiangang**

** Beijing Water Science and Technology Institute, Beijing 100048*

[1] Beijing Water Science and Technology Institute, 21 CheGongZhuang West Road, Haidian District, Beijing, China, 100048, Tel: +86-10-68731921, Fax: +86-10-88423808, Mobile: +86-13910603735, Email:bjzhangshuhan@126.com

KEYWORDS: Sponge City, Water ecology, Storm water management, Flood control; Resilience

ABSTRACT

In order to solve the problems of the increased local flooding, water shortage and water pollution caused by the traditional model of urban development, the Chinese government proposed a new model of urban development——the Sponge City. Beijing, as the capital of China, has begun to research on storm water management in urban areas since 1989, and put forward the concept of urban storm water harvesting and flood control. The further research and demonstration application started in 2000. So far a series of policies and technology standards on storm water management have been formulated, promoting the application of technologies on urban storm water harvesting and flood control comprehensively. Beijing has built a lot of storm water harvesting and flood control projects, which are now playing important roles in runoff reduction, local flood control, non-point source pollution reduction and storm water utilization. It, however， still doesn't solve the problem mentioned above completely. Therefore, Beijing needs to strengthen storm water management and flood control further. In order to make the “Sponge City”, the traditional ideas of storm water management and city development should be changed, that means that city should be built with the natural and ecology law, such as storm water should be managed with natural infiltration, natural retention and detention, and natural cleaning facilities. Based on the in-deep analysis of the connotation, characteristics and construction paths of the “Sponge City”, in the paper, the technique development and application statue of urban storm water harvesting and flood control, the policy and engineering statue in Beijing is summarized, the general idea and approach of sponge city construction is introduced. It can provide a reference for similar cities in Sponge City construction.

187. "Sponge City" in China – a breakthrough of flood risk management and land use planning in the urban context?

FKS Chan[1], James Griffiths*,David Higgitt*, Xiaotao Cheng ** and Yangbo Chen†*

** School of Geographical Sciences, University of Nottingham Ningbo China*

*** Institute of Water Resources and Hydropower Research, Beijing, China*

† School of Geography and Planning, Sun Yat-Sen University, Guangzhou, China

1 Dr FKS Chan (School of Geographical Sciences, University of Nottingham Ningbo China Ningbo 315100, China, +8618867859622, faith.chan@nottingham.edu.cn)

KEYWORDS: Sponge City, Urban flood management, urbanisation, flood resilience, Planning.

ABSTRACT

Urban floods are becoming a national scandal in China, evidently some severe events have been occurred, for example in Beijing 2012 that caused 79 deaths, and in Guangzhou during 2014 and 2015 caused costly financial impacts. Lately, the Chinese National Government has promoted "Sponge City" concept that has initiated and applied to 17 cities (including some megacities such as Tianjin, Guangzhou, Ningbo, etc.). It is still yet to know whether the current Sponge City approach in China is an effective way to mitigate severe urban surface flooding in China.

Objectives

The aim of this study is to provide a better understanding of current "Sponge City" concept in urban China context, by following some specific objectives: (i) To investigate the Sponge City policy background of and how it formulise? (ii) To understand how this practice to transform the current water/flood risk management and urban planning. (iii) To understand how this policy particularly influence on the landuse policy and planning of the Chinese megacities (with massive population such as Guangzhou, Shenzhen, Ningbo, etc.).

This study are based on the empirical case study in Ningbo Sponge city project, and combined with substantial secondary data analysis on latest governmental documents and grey literatures.

Results

In this study, we have found the current drainage system that have not been equipped and prepared against the recent intensive rainstorm events for relieving the acute discharges. Urban surface water flooding now occurred as regularly to urbanised and populated megacities during the annual monsoon season. Rapid urbanisation and the landuse changes that might have not fully considered and addressed water infiltration on concrete landscape, Shenzhen is the city has got massive urbanisation percentage on flood prone area reached 98 per cent has largely increased 12.9% to

urban discharge due to urbanisation from 1987 to 2007, which reflects the current drainage system is highly overloaded from the rapid landuse changes. Current urban drainage design can at most withstand a 1-in-1 year to 1-in-5 year rainstorms in Shenzhen, Ningbo, Guangzhou and other Chinese cities. We have also found that the sponge city approach is an alternative solution to achieve stormwater and surface water flooding issues despite it is important to address that the practice is unlikely addressing the climate extreme events (e.g. rainstorm of 100mm/hr). This approach provides an opportunity for a better sustainable landuse and urban planning, as sponge city infrastructure (e.g. swales, artificial wetland and stormwater storage retention areas) requires more urban land areas. Collaborative efforts from several municipal governmental institutions from Planning, Construction and Building and Water Bureaus are required.

Conclusion

Hard-engineering flood protection approach (e.g. channelisation, banks and floodgates) has been favourable for a long time from the ancient Chinese history. In this study from the empirical case study at Ningbo and secondary data, it shows good opportunities for undertaking more strategic urban planning through the Sponge City project for achieving a range of sustainability goals and targets (e.g. socio-economic and ecological benefits) other than managing urban flood risks in most of urbanised Chinese cities. (499 words)

212. The Evolution of Natured-based Solutions: Green Infrastructure, Low Impact Development, Ecological Engineering and Building with Nature

Yen-Yu Chiu#1, Nidhi Raina*, Grazia Di Giovanni**, Richard Ashley† and Chris Zevenbergen*, ****

** UNESCO-IHE Institute for Water Education, The Netherlands*

 # National Chiao-Tung University, Taiwan

**** Gran Sasso Science Institute, Italy*

† University of Sheffield, Sheffield, UK

***** TuDelft, The Netherlands*

[1] *Details for contact author (Address: Westvest 7 2611AX Delft, The Netherlands, Telephone: +31616976758, E-mail: ciu0519.cv98g@g2.nctu.edu.tw)*

KEYWORDS: Nature-based Solution, Green Infrastructure, Building with Nature, Ecological Engineering

INTRODUCTION

Resilience is an important attribute of sustainable development and this has been a key objective for flood management strategies over the past decades, albeit implicitly (Chocat et al., 2001; Fletcher et al., 2014). Stormwater and storm surges are the two most common causes of flooding. Stormwater management is using terms like ‘Green Infrastructure’ and ‘Low Impact Development’; whereas in the Netherlands, ‘Building with Nature’ has emerged as an approach for integrated coastal management and policy. In this paper, we collectively called these approaches ‘Nature-based solutions’(NbS), which not only offer a solution for flood management issues, but also provides other benefits to both humans and ecosystems.

OBJECTIVES

This paper aims to briefly review the evolution and relationships between several NbS used in flood management, specifically: ‘Ecological Engineering’ (EE); ‘Low Impact Development’ (LID); ‘Green Infrastructure’ (GI)[13]; and ‘Building with Nature’ (BwN). Based on this temporal review, we try to describe the progression of different approaches.

METHODOLOGY

We first describe the historical evolution of each approach, and then compare the various NbS using multiple criteria. Consequently, we use the number of citations to analyse the popular trend of these concepts to identify the changing growth in awareness. Finally, we outline the evolution of human needs of water since ancient times using a hierarchy of water-use needs & planning based on water-related historical events (in a macro perspective).

---

[3] Green infrastructure for stormwater management is also commonly referred to as Green Stormwater Infrastructure (GSI) by the US-EPA

RESULTS

A. Temporal Transformation of NbS

The current definitions and applications of the various approaches has changed substantially from when they were first used. EE focused more on waste clean-up and management from the earliest definition that came from Odum (as cited in Mitsch & Jørgensen, 2003), but the term has evolved over time (by 1990s) to describe the design of sustainable ecosystems (Mitsch, 1996). Similarly, the term GI was widely popularized during 1990s to identify, protect and restore interconnected urban green-spaces (Florida Greenways Commission, 1994), however, the concept was further developed by the USEPA for management of stormwater and polluted runoff (US-EPA, 2007) using natural or engineered systems to mimic natural systems. GI & LID are increasingly used in combination for stormwater management e.g. by the USEPA (Fletcher et al., 2014). Similarly, the original intent of BwN emphasized coastal spatial optimization (Waterman 2008), however, today, the primary objective is flood safety and application has also expanded to encompass rivers and cities.

B. Evolutionary Timeline

EE principles provide a backbone to the design of all the other NbS, for creating, protecting and enhancing natural systems. The timeline of some important milestones for these approaches is illustrated in Figure 1. The emergence of EE was a turning point in flood management and engineering. Recent literature (Matlock and Morgan, 2011) also emphasizes that recently emergent urban design approaches (GI and LID) are the future of EE for water and flood management. BwN has also been identified as a type of EE application (van den Hoek et al., 2012).

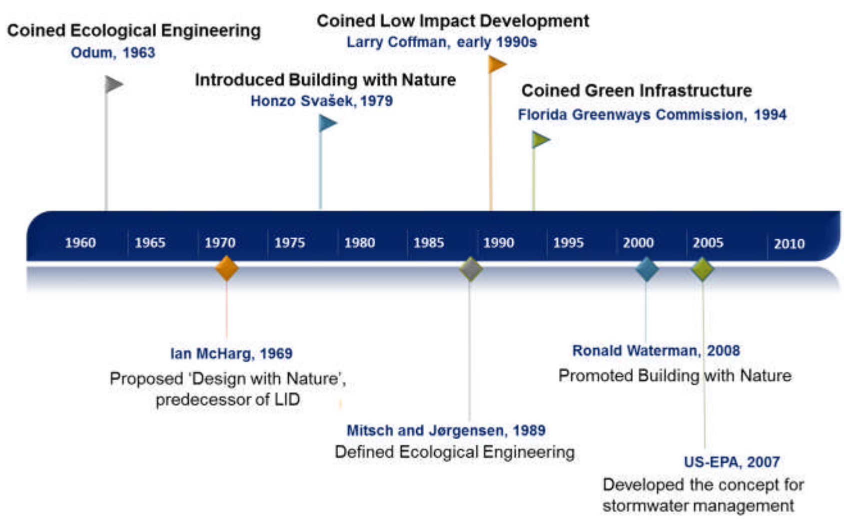


Figure 12: Timeline of different NbS

C. The Interconnecting Relationship

Reviewing each term, we list the realms, objectives, approaches, etc. of different NbS (Table 1) and although there are some exceptions, the resulting classification broadly aligns with current applications.

Table 1: Comparison of GI, LID, EE in different aspects

	EE	GI	LID	BWN
Realm	Ecology	Urban ecosystem services/ Stormwater	Stormwate r	Hydraulic engineering
Primary objective	Ecosystem preservation & Ecosystem utilization	Flood Safety; Reduce nuisance from floods;		
Approach	1. Use or imitate ecosystems to reduce pollution or disturbance. 2. Use engineering to restore ecosystems.	Use vegetation and soil for managing.	Mimic a site's natural hydrology	Use nature materials and natural dynamics in the layout
Target domain	Urban & Nature environment	Urban: Coordinated effort to employ these practices to a community	Urban: The site-level to control stormwater	Coastal & Fluvial Regions
Additional benefits	Human health and wellbeing, biological habitat, landscape, urban amenity			

In Figure 2, we classify various management approaches based on the causes of the flood: Stormwater management, such as GI & LID, act as a system or practice that focus on preserving, enhancing or re-creating the natural functionality of an area being developed (EPA, 2015). For example, by using natural systems to capture, clean and infiltrate stormwater to reduce surface flood volume. Whereas BwN principles promote the use of natural materials and dynamics to create effective flood management in coastal (e.g. coastal development through Sand Motor Delfland Coast) and fluvial areas (e.g. Riverbank realignment through Room for the River project).

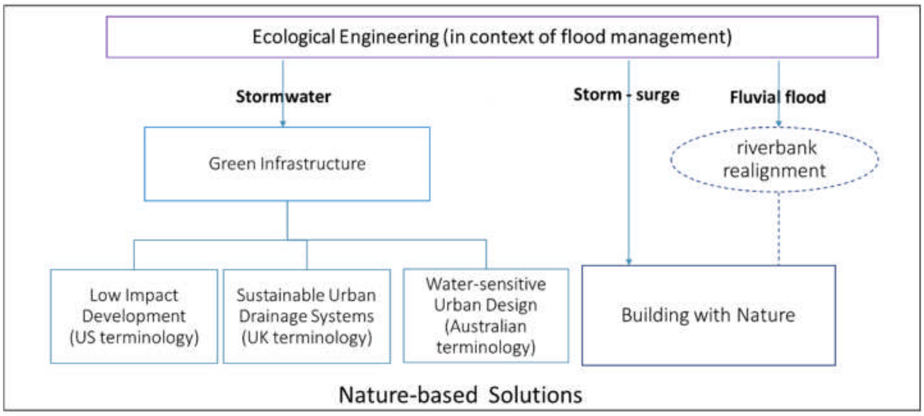


Figure 2: The inter-relationship between flood-related NbS

D. Citation Trends

The trend in the number of citations found in Google Scholar (Figure 3) clearly indicates an increase in the scientific and engineering interests to adopt NbS for economic, environmental and social benefits. EE appeared around 50 years ago and has already developed as a major discipline. The use of other terms and subtly different approaches, such as GI, LID and BwN, have been growing rapidly for the past 20 years.

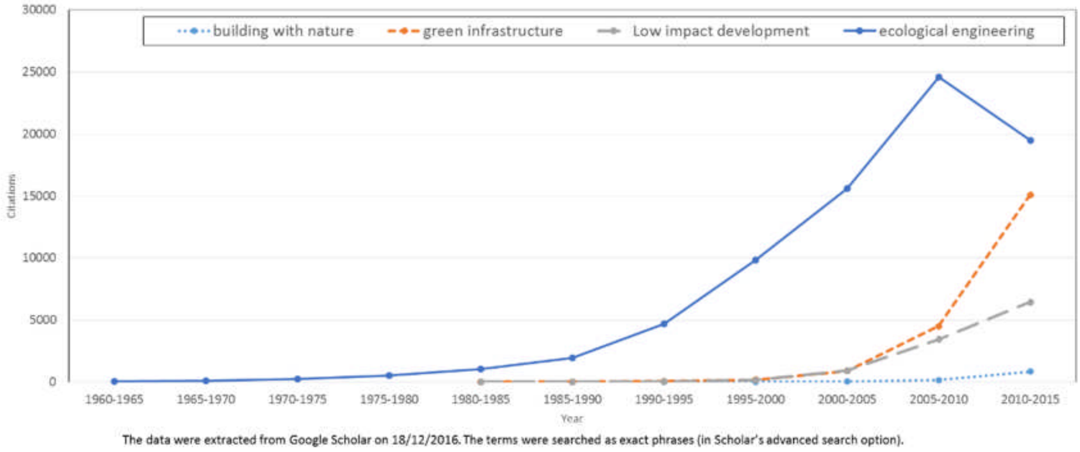


Figure 3 The number of citations of flood-related NbSs (incl. EE, LID, GI & BwN)

E. The Hierarchy of Water Use & Planning

The evolution and hierarchy of human needs, use & planning of water resources since primeval times may be mapped using Maslow's concept of human needs. We illustrate the hierarchy of water-use needs & planning (Figure 4) based on historical records such as the locations and advancement of planning from early villages or dams, to devices like screw pumps, hydro powered water supply system, the first hydroelectric power plant, and the first UN Water conference and further to harmonising with nature through nature based solutions.

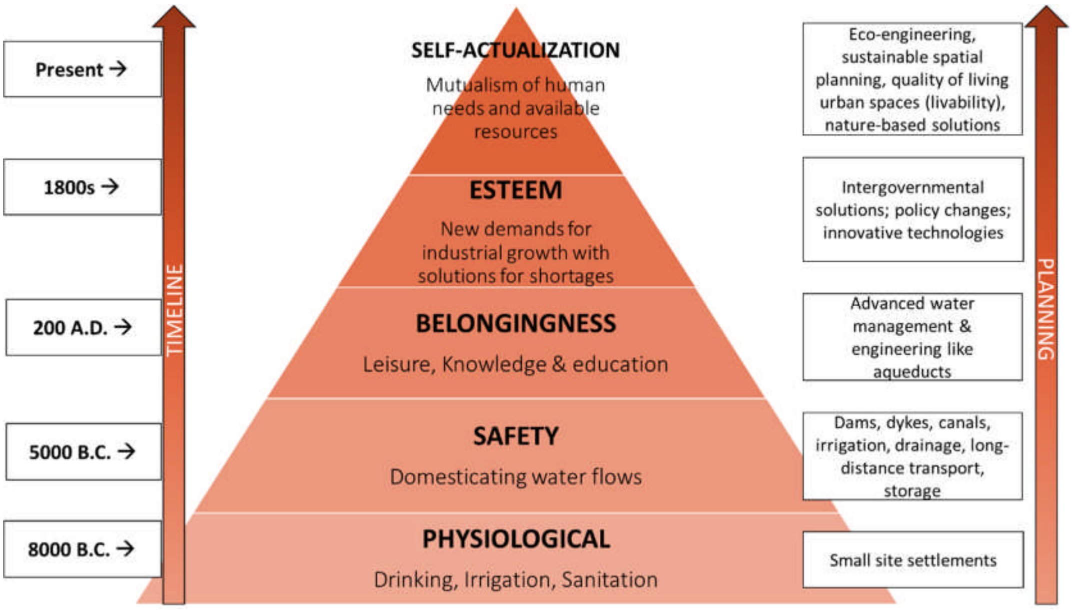


Figure 4: Hierarchy of water-use needs & planning

CONCLUSIONS

Examining the trend of emergence, application and popularity of the various terms and approaches like EE, GI, LID, and BwN, the rise of NbS in the recent decades reflects the growing needs to deliver more resilient and effective flood-risk management approaches. These approaches spanning multiple realms indicate the importance of integrated management aiming at multi-objectives, and infrastructures that deliver multiple functions to satisfy the many needs of society and nature at affordable cost. The emergence of NbS is piloting transformation of some of the hard measures to soft measures for flood management and in other cases has led to combined grey-green measures. As a result, we continue to see significant changes in flood management technologies, concepts, and policies over time.We can expect that the adoption and application of more resilient and effective solutions across multiple domains will keep increasing in the future. Consequently, all NbS have evolved in their terminologies and practice over time.

ACKNOWLEDGMENTS

This research is partially supported by the “Graduate Students Study Abroad Program” of Ministry of Science and Technology, Taiwan, R.O.C. under Grant no. MOST 106-2917-I-009-013.

REFERENCES

Chocat, B., Krebs, P., Marsalek, J., Rauch, W., and Schilling, W. (2001). Urban drainage redefined; from stormwater removal to integrated management. Water Science and Technology, 43 (5), 61–68.

Davies, C., Hansen, R., Rall, E., Pauleit, S., Lafortezza, R., De Bellis, Y., … Tosics, I. (2015). Green infrastructure planning and implementation, (March 2015), 134.

De Vriend, H. J., & Van Koningsveld, M. (2012). Building with Nature: Thinking, acting and interacting differently. Ecoshape. Dordrecht, the Netherlands: EcoShape, Building with Nature. https://doi.org/10.1080/02513625.2014.925714

European Commission. (2015). Towards an EU Research and Innovation policy agenda for Nature-Based Solutions & Re-Naturing Cities. https://doi.org/10.2777/765301

Nesshöver, C., Assmuth, T., Irvine, K. N., Rusch, G. M., Waylen, K. A., Delbaere, B., Wittmer, H. (2017). The science, policy and practice of nature-based solutions: An interdisciplinary perspective. Science of the Total Environment, 579, 1215–1227.

Fletcher, T.D.; Shuster, W.; Hunt, W.F.; Ashley, R.; Butler, D.; Arthur, S.; Trowsdale, S.; Barraud, S.; Semadeni-Davies, A.; Bertrand-Krajewski, J.L.; et al. (2014). SUDS, LID, BMPs, WSUD and more—The evolution and application of terminology surrounding urban drainage. Urban Water J.,12, 525-542.

Matlock, M. D., & Morgan, R. A. (2011). Ecological Engineering Design Ecological Engineering Design Restoring and Conserving Ecosystem Services and. John Wiley & Sons, Inc.

Mitsch, W. J., & Jørgensen, S. E. (2003). Ecological engineering: A field whose time has come. Ecological Engineering, 20(5), 363–377.

Mitsch, W.J. (1996). Ecological engineering: a new paradigm for engineers and ecologists. In: Schulze, P.C. (Ed.), Engineering within Ecological Constraints. National Academy Press, Washington, DC, pp. 114–132.

Waterman, R.E. (2008). Towards an integrated coastal policy via Building with Nature.

Florida Greenways Commission, 1994. Creating a Statewide Greenways System. For People. . . for Wildlife. . .for Florida. Report to the Governor. Florida Greenways Commission, Tallahassee

US-EPA. (2007). Using Green Infrastructure to Protect Water Quality in Stormwater, CSO, Nonpoint Source and other Water Programs.

Van den Hoek, R. E., Brugnach, M., & Hoekstra, A. Y. (2012). Shifting to ecological engineering in flood management: Introducing new uncertainties in the development of a Building with Nature pilot project. Environmental Science and Policy, 22, 85–99.

222. Increasing Urban Flood Risks in China: Challenges and Coping Strategies

Xiaotao CHENG[1], Gaohu SUN**, Hong WANG* and Chaochao LI**

** China Institute of Water Resources and Hydropower Research （IWHR）*

*** IAHR Beijing Office*

[1] *A-1 Fuxing Road, IWHR, Beijing 100038, China. +86-10-6878 1693, chengxt@iwhr.com*

KEYWORDS: urbanization; urban flood; flood risk management; sponge city

ABSTRACT

Across country in China, many urban cities are facing challenges of flood risks, which cause increasing severe damages. In order to effectively mitigate the flood risks during the unprecedented urbanization, it is necessary to explore the integrated coping strategies proper for the developing phases and the local conditions. The status quo and challenges of urban floods prevention in China were studied through typical case investigations in recent years, statistic data analyses and secenario simulations, as well as comparison of domestic and international experiences and lessons. The results show that the significant rise of flood damages in China since 2010 is primarily caused by the rapid expansion of newly urbanized areas to low lying and flood prone areas, and by the deterioration of drainage facilities in old towns. The heavy reliance on lifeline infrastructure systems in mega-metropolis triggered the mutation of flood damages once the rainstorm intensity exceeds capacities of flood prevention and drainage systems. The construction of "pilot sponge city", which imitate natural functions of storage, infiltration and purification, has been initiated in 30 cities in the past two years as a new model of low impact urban development. However, it is facing tremendous challenges in uneven distribution of rainstorm with extreme high intensity, unbalanced economic development and continuous increasing pressure from rapid urbanization and environmental pollution. Some major policy adjustments are reviewed in this paper, and it is concluded that some unsuitable modes in practices should be further adjusted. Promoting a positive interaction between man and nature by integrated approach is of importance to rebuild new balance gradually for sustainable development and urban safety.

287. The Chinese Sponge City: theory and practice learned for flood management in Brazil

N.C. B. Moura[1], V. P.Araujo*, P.R.M. Pellegrino**, J. R. S. Martins****

** Universidade de Fortaleza, Technological Center - UNIFOR*

*** Universidade de São Paulo, Facultuy of Architecture and Urbanism - FAUUSP*

****Universidade de São Paulo, Polytechnic School - EPUSP*

[1] *Av. Washington Soares, 1321, 60.811-905, Fortaleza-CE, Brazil*

arqnewton@yahoo.com

KEYWORDS: Sponge City, Brazil, China, Turenscape, São Paulo, flood management

EXTENDED ABSTRACT

INTRODUCTION

Turenscape, the largest landscape architecture firm in China, has won several awards for its unique and resilient waterscape projects. Visiting some of Turenscape´s most emblematic projects and meeting the firm´s founder and principal designer, Dr. Kongjian Yu, has prompted an inquiry about the theory behind Turenscape´s accomplishments: the Sponge City. Conceptually, it addresses a multi-scale hydroecological infrastructure to provide an integrated solution to the prominent water problems in China. In regard to flood control, strategies for stormwater management and treatment must be more comprehensive and integrated to regulation of urban microclimates, groundwater recharge and restoration of degraded areas (YU, 2016).

As an ambitious nationwide program that ranges from planning to design, Sponge City´s strategies resonate with the Western concept of Green Infrastructure. Given the successful cases that have attracted world attention, this paper examines the suitability of China's Sponge City to Brazil in two steps. First, it analyzes the statistical data related to urbanization and water in both countries, highlighting their common aspects. Second, it presents a comparative study between an emblematic Turenscape´s project, the Yanweizhou Park, in Jinhua City, China, and a revitalization proposal for a pilot area of the Jaguaré Creek, in São Paulo City, Brazil.

COMPARATIVE ANALYSIS OF FLOOD SCENARIOS BETWEEN CHINA AND BRAZIL

China's environment and water issues, especially related to flooding, have defined the strategies of Sponge City. The fast rural-urban transition has enhanced the already challenging problems caused by uneven distribution of water and rainfall, severe monsoons and climatic variations. From 1949 to 2014, Chinese urbanization rate rose from 10.6% to 54.6% (YU apud NSO, 2015). In Brazil, rates increased from 31.24% to 84.36% (IBGE, 2010) at the same period. The accelerated growth of large urban centers resulted in a greater loss of natural resources and landscapes, disappearance of aquatic ecosystems and pollution. The decline of naturally drained areas and disruptions to the hydrological cycle have increased the risk of flooding and the socio-environmental damages in cities. In 2010, floods in China caused a direct economic loss of 176.5 billion yuan, and affected a population of 1.34 million (YU apud SFDH). In Brazil, between 1900 and 2006, 150 disasters of great severity occurred, with damages of approximately 10 billion dollars (EM-DAT, 2007).

SPONGE CITY PRACTICAL APPLICABILITY FOR BRAZIL: CASE STUDIES

Yanweizhou Park – Jinhua City, China

Crowned as Landscape of the Year at the World Architecture Festival in 2015, Yanweizhou Park is a representative of modern flood-resilient design. The awarded Turenscape´s project consists of a 26ha area located where the Wuyi River and Yiwu River converge to form Jinhua River (Fig. 01), which used to divide the densely populated communities of the region, resulting in underutilization and inaccessibility of the adjacent cultural facilities. According to the designers, the challenges at

Fig. 01: Location and situation of the places of intervention. Source: own elaboration.

Yanweizhou were both ecological and cultural: to preserve the remaining riverside habitat, proposing a new approach to resilient flood management, and to integrate the existing environment to its surroundings, finally reconnecting districts once detached to the natural landscape in order to strengthen the community and the cultural identity of Jinhua City (YU, 2016).

Jaguaré Creek Revitalization Project – São Paulo City, Brazil

Jaguaré Creek watershed corresponds to only 1/10 of the total 270km^2 drainage area of Pinheiros River, one of the two main watercourses crossing Greater São Paulo. Its waters carry significant load of domestic and industrial sewage and other non-point sources as well. Reversing this scenario requires innovation and an integrated system of coordinated actions based on technology, urban planning and advocacy. In order to restore this pilot watershed, the Jaguaré Project has been developed by a multidisciplinary team acting in two complementary fronts: 1. Interception and combined treatment of stormwater and sewage illegally discharged into underground drainage system; 2. Non-source point pollution control and runoff management through a Green Stormwater Infrastructure. As a design approach, a prototype of retention reservoir with 72,000 m^3 has been proposed to a critical flooding area where the Jaguaré Creek flows channelized between heavy traffic roads (Fig. 02).

ANALOGOUS STRATEGIES BETWEEN CASE STUDIES

Fig. 02: The Jaguaré Channel and the current prototype area for flood management. Source: USP.

Adaptation to Preservation and Restoration

In order to adapt to monsoon flooding, the main strategy at Yanweizhou Park was to make full use of the existing land with minimal intervention, seeking the preservation of natural vegetation, allowing various habitats to evolve (YU, 2016). In Jaguaré, the adjustment for flooding demanded the restoration of the available land to recover the braided channel pattern, modifying the topography to decrease water flow speed as retention, infiltration and purification increase. In both cases, preservation or recovery attempt to restore biodiversity and urban dynamics.

Resilience

At Yanweizhou, not only the terrain is suitable to monsoon floods. Pedestrian paths, green terraces, elevated bridges and pavilions are also adaptive to extreme rainfalls from a 200-year return period (YU, 2016). As to Jaguaré, the recovery of floodplains and creek meanders requested more room for water, considering a retention capacity compatible with a 100-year rainfall event. Since the intense traffic on the roads along the river could not be compromised by this change on the waterscape, the road system has been suspended and adapted in high causeways, also adding new routes for cyclists and pedestrians on walkways and floodable tracks (Fig. 03).

Appropriation and Aesthetics

The curves are the basic formal language at Yanweizhou. They are in waving bridges, terraces, concentric pavements and winding paths, defining planting areas and activity spaces. Aided by digital parametric tools, the same aesthetic concept has been adopted in the pilot project of Jaguaré, creating a unifying design approach that integrates and braids the restored environment and the city into a harmonious whole (Fig. 04). The curves reflect the weaving of the flows of water, people and material objects that together create a pleasant and functional spaces in both projects, pointing to Sponge City's influence not only in storm water management strategies, but also to propose a new aesthetic and landscape dynamics for cities adapted to floods.

Fig. 03: Retention park at Jaguaré – São Paulo (
/ Turenscape.

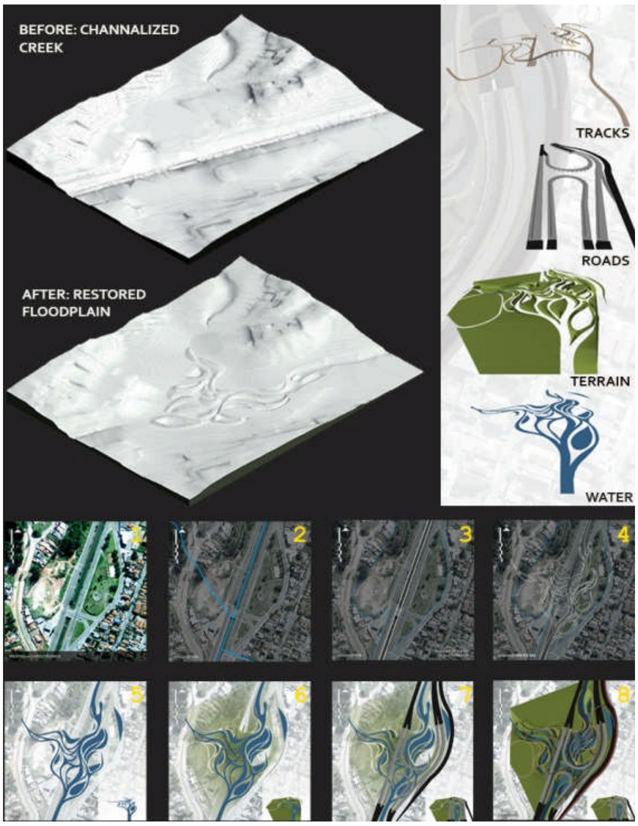


Fig. 3: Design process for the Jaguaré proposal. Source: own

CONCLUSION

Even in different scenarios, the similarities between the hydrological features of China and Brazil and between the technical solutions for flood management in the case studies attest a synergy bonded by the theories that supported the projects of Yanweizhou Park and Jaguaré. Respectively Sponge City and Green Infrastructure, both reinforce that whether in China or Brazil, adaptive systems for flood control depend on a project which combines aesthetics and efficiency to achieve balance among cultural, historical, environmental and infrastructural urban landscape.

REFERENCES

EM-DAT – Emergency Events Database. (2007). The OFDA/CRED International Disaster Database. (Accessed November 2016).

Instituto Brasileiro de Geografia e Estatística - IBGE. Séries Históricas e Estatísticas: Taxa de urbanização. Available in<http://seriesestatisticas.ibge.gov.br /series.aspx?vcodigo=POP122> (Accessed November 2016).

YU, Kongjian. Sponge City: Theory and Practice. NFAPST. Beijing, 2016.

SWISS REINSURANCE COMPANY. Flood Risk in Brazil. Report. 2011.

334. Challenges in green infrastructure planning

Chris Zevenbergen.,***[1], Grazia Di Giovanni**, Richard Ashley†, Taneha Bacchin*** and Yen-Yu Chiu*[#]*

** UNESCO-IHE Institute for Water Education, Netherlands*

*** Gran Sasso Science Institute, Italy*

† University of Sheffield, Sheffield, UK

**** TuDelft, The Netherlands*

[#]National Chiao-Tung University, Taiwan

[1] Details for contact author (Address: Westvest 7 2611AX Delft, The Netherlands, Telephone: +31616976758, E-mail: c.zevenbergen@unesco-ihe.org)

KEYWORDS: urban flooding, adaptive planning, extreme events, green infrastructure

ABSTRACT

Introduction: Contemporary urban flood risk management approaches typically involve two levels of planning. The first level concerns *short-term planning* for operational purposes encompassing maintenance and upgrading activities (incremental adjustments) of the urban drainage system and management activities to reduce the impacts that extreme weather events may have on people and property. This level also includes activities mostly addressing non-structural mitigation measures such as evacuation plans and building resilience to manage flows that exceed the design standard of the drainage system. The second level involves *long-term planning* for capital expenditure plans. This requires projections of the underlying socio-economic trends and climate change in order to identify interventions which are robust enough to meet plausible futures. These may involve a single intervention sometimes leading to a transformational (system) change or adaptation pathways entailing a range of interventions to be implemented sequentially over time to adapt the system for the short and long-term futures. Green Infrastructure has potentials to play a crucial role in this adaptive planning process to foster both short-term and long-term flood resilience.

Despite the growing recognition of its value for mitigating the adverse impacts of climate change in cities, green infrastructure measures are often implemented with a single, short-term objective in mind. Their benefits are generally associated with their ability to moderate the impacts of extreme weather events (rainfall or temperature), whereas they often take some time to develop before they can provide these benefits.

Objectives: In this paper we argue that there is a need for new valuation tools to support green infrastructure approaches in cities to achieve long-term, planning objectives such as water conservation, flood prevention and storm-surge protection, which can be gradually implemented and be adapted to changing conditions as these occur. These adaptive approaches consist of a portfolio of “green” infrastructure and technologies combined with traditional “grey” infrastructure to achieve greater flexibility and thus resilience.

Conclusions: A framework will be presented which aims to support green infrastructure planning to maximise the inclusion of green space hubs and corridors in cities. The framework attempts to identify the benefits of such green spaces, both on the short and long-term.

326. The resilience of nature-based solutions: insights from literature and case studies

Grazia Di Giovanni[1], Yen-Yu Chiu** #, Lorenzo Chelleri*, Sebastian Van Heerk° and Chris Zevenbergen**, ****

** Gran Sasso Science Institute, Italy*

**** UNESCO-IHE Institute for Water Education, The Netherlands*

 # National Chiao-Tung University, Taiwan

° Bax & Company, Spain

****** TuDelft, The Netherlands*

[1] *Details for contact author (Address: Viale Francesco Crispi 7, L'Aquila, Italy, Telephone: +393470409519, E-mail: grazia.digiovanni@gssi.infn.it)*

KEYWORDS: resilience; nature-based solutions; adaptation; flood risk; coastal erosion

ABSTRACT

Introduction: Nature-based solutions (NBS) have been recently defined as "actions inspired by, supported by or copied from nature" – intended mainly as its features, capital and complex system processes – to address several "environmental, social and economic challenges in sustainable ways" (European Union, 2015). Their design and implementation require a multidisciplinary and multi-systemic approach, and the involvement of broad groups of stakeholders in innovative governance, providing multiple functions and co-benefits. Consequently, NBS are defined as "ideally resilient to change, and energy and resource efficient" (ibid.) *per se* and expected to be no-regret and more cost-effective solutions (Naumann et al., 2014). The growing debate focused on NBS highlights knowledge gaps and a lack of grounded evidence related to their performance, efficiency, long-term benefits, and also compared with traditional solutions and in terms of measurability and evaluation (Kabisch et al., 2016). A selection of key resilience properties and related indicators (e.g.: De Bruijn, 2005; Tyler & Moench, 2012) have been interpreted here as a lens to further investigate NBS design and implementation.

Objectives. The study investigated NBS dedicated to flood risk and coastal erosion reduction with the aims of: a. gaining evidence about NBS performance in tackling nature-related risks whilst enhancing ecosystem services and providing multiple benefits; b. understanding the rationale and the governance processes supporting these experimentations, since the planning phase; c. identifying specific challenges and enabling factors characterizing the implementation of NBS.

Methods. Moving from the different bodies of literature addressing resilience indicators and NBS, the research proposes a framework of indicators to investigate NBS, applied to case studies in the European North Sea Region and being tested in ongoing research. The study is based on document analysis and semi-structured interviews with key stakeholders involved in pilot projects.

Results. The expected results are: 1. the definition of a potential tailored framework of resilience indicators dedicated to NBS for risk reduction and adaptation, derived from the literature and enriched by the exploration of case studies; 2. A contribution to current research on NBS, in particular about their performance (also compared with conventional approaches to risk reduction), challenges in implementation and possible upscaling processes, through evidence-based information.

REFERENCES

De Bruijn, K. M. (2005). *Resilience and flood risk management: a systems approach applied to lowland rivers.* Delft University Press.

European Union. (2015). *Towards an EU Research and Innovation policy agenda for Nature-Based Solutions&Re-Naturing Cities. Final Report of the Horizon 2020 Expert Group on 'Nature-Based Solutions and Re-Naturing Cities'.* European Commission.

Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., . . . Bonn, A. (2016). Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action. *Ecology and Society, 21*(2).

Naumann, S., Kaphengst, T., McFarland, K., & Stadler, J. (2014). *Nature-based approaches for climate change mitigation and adaptation*. Bonn, Germany: German Federal Agency for Nature Conservation.

Tyler, S., & Moench, M. (2012). A framework for urban climate resilience. *Climate and Development, 4*(4), 311-326.

Governance (i)

50. Compensation for spatial flood measures in Austria, Germany, and the Netherlands: A social justice perspective
Dr Thomas Hartmann, Utrecht University, Netherlands

75. Organizational Learning to Unleash Creative Capacity of Contractors
Mrs Ellen Tromp, Deltares/ Delft University of Technology, Netherlands

88. How to cope with uncertainty in river management?
Dr Ralph Schielen, Ministry of Infrastructure and the Environment-Rijkswaterstaat, Netherlands

100. Quantifying Flood Resilience – A Case Study
Mr Doug Bellomo, US Army Corps of Engineers, United States

121. Decision-making in the case of a flood threat: implementing the new risk approach
Dr Lex Veerhuis, HKV consultants, Netherlands

124. Building international collaboration in and improving flood forecasting and warning services in Australia and England
Mr Craig Woolhouse, Environment Agency, United Kingdom

129. Methodological approach to flood risk diagnosis at a national level in areas with scarcedata. Study case: Algeria
Mr Pedro García De Mendoza, INCLAM, S.A., Spain

50. Compensation for spatial flood measures in Austria, Germany, and the Netherlands: A social justice perspective

Neelke Doorn[1], Thomas Hartmann** and Thomas Thaler*[†]

** Delft University of Technology, Department of Technology, Policy and Management*

*** Utrecht University, Faculty of Geosciences, Dept. Human Geography & Planning*

† University of Natural Ressources and Life Sciences, Institute of Mountain Risk Engineering, Vienna

[1] PO Box 5015, 2600 GA Delft, The Netherlands, email: N.Doorn@tudelft.nl

KEYWORDS: regulatory taking, loss, compensation, spatial measures

ABSTRACT

In view of the anticipated climate change, many countries face increasing risks of flooding. In many countries, flood protection measures will need to be taken in the coming years to protect flood prone areas from the increased risk of flooding. Since the end of the 20th century, the traditional hard flood protection measures are increasingly complemented with land use and spatial instruments.

Spatial measures taken in the context of water management are in the public interest—and as such benefit many people—but it is almost inevitable that certain citizens will be adversely affected by these measures. Examples of this may include decreases in property values as a result of changes to zoning plans, as well as the obligation to tolerate certain acts related to the construction or maintenance of water defence structures. As such, spatial flood risk measures prompt concerns of distributive justice.

Some national law systems provide for compensation for loss as a result of lawful administrative acts like regulatory taking and the imposition to tolerate the use of one's property, if and to the extent that it is considered unreasonable for this loss to be the full responsibility of the affected party. In this paper, we compare the legal compensation system in three different countries: Austria, Germany and the Netherlands. On the basis of a comparative analysis, we discuss how these different compensation schemes affect justice, both in terms of substantive distributions but also in terms of procedural justice.

75. Organizational Learning to Unleash Creative Capacity of Contractors

Ellen Tromp†[1],Pieter Bots*,*

** TUDelft*

† Deltares

[1] *Delft University of Technology, PO Box 5015, 2600GA, Delft, +31883357340, ellen.tromp@deltares.nl*

KEYWORDS: Organizational learning, Innovations, Flood Defences

ABSTRACT

In the Netherlands, technical innovations for dike strengthening rarely become mainstream. A case study of the redesign process of the dike between Kinderdijk and Schoonhovenseveer suggests that benefitting from the creative capacity of contractors requires organizational learning.

In 2001, the Dutch National Water Authority *Rijkswaterstaat* stimulated the development of innovations to improve dike stability with minimal impact on the physical environment. By means of a competition aimed at stimulating creativity of contractors, three techniques were selected for further development: *soil anchoring* (SA), *dike core blunging* (DCB) and *expanding columns* (EC). During a six-year period, *Rijkswaterstaat* largely subsidized the R&D of the involved private parties. An independent committee advised that, after small and medium scale tests, full scale testing was required to gain experience.

All three techniques were expected to become best practices after an experimental application in a full scale test. However, strong institutions delay the uptake of innovative techniques: Dutch regional water authorities (RWAs) normally publish their call for tenders with a detailed technical design (including estimates of required materials and construction time), projects are subject to formal review, and contractors bear all risks.

In 2008, severe vibrations felt during a conventional dike reconstruction project led RWA *Rivierenland* to pilot-test DCB and EC in two 100 meter dike segments, hoping that the experience gained in these pilots would warrant full-scale application to 10 km of dikes needing reconstruction, between Kinderdijk and Schoonhovenseveer. To better understand how knowledge transfer and uptake took place during the pilots, we analysed both processes using a fine-grained sender-receiver framework (Tromp & Bots, 2016).

In the DCB pilot, consortium X was contracted under a best-endeavours obligation. The DCB technique had already been applied successfully in the construction sector, and procedures and mechanisms to ensure safety had been validated there. The contractor worked in close concert with the RWA and the formal reviewer. The parties trusted each other, collaborated as equals, and brought the innovation as far as project constraints permitted. This meant that the dike core blunges were constructed in a different manner due to field experiences. Despite caution, this caused damage to the surroundings and required further improvement of the technique. The DCB technique is currently successfully applied in with different project characteristics.

In the EC pilot, consortium Y was contracted under a performance obligation. They also interacted closely with RWA and reviewer, but the process was quite different. For the relatively more innovative EC technique, no validated safety approach existed yet. Elaborating this approach led to an iterative knowledge development cycle in which answers induced new questions and knowledge needs. In view of the performance obligation contract, consortium Y became very apprehensive about time and budget constraints and expected deliverables. Not knowing where and when the knowledge development process would end, they felt that RWA and the formal reviewers behaved like Eric Carle's 'very hungry caterpillar', and would be insatiable in their knowledge need. This loss of trust led consortium Y to take a reactive stance, which made the other parties – feeling that they had to do all the work – lose trust in consortium Y.

Despite this loss of trust, all three parties had strong incentives to carry on with the pilot. Consortium Y remained optimistic about the applicability of EC and the potential returns on their own investments in developing this technique. The RWA still believed in the additional benefits of the EC technique. Moreover, they knew that their financial risk was covered by guarantees from the National Water Authority. The reviewer felt that the knowledge developed so far warranted the risk. Eventually, the contracted target of expanding columns set in the dike segment was reached. Although here, too, damage to the neighbouring houses was greater than expected, the experience gained allowed consortium Y to upgrade the EC technique. Although Y decided not to tender for the full-scale project between Kinderdijk-Schoonhovenseveer, they later performed a second pilot – again in collaboration with the RWA, but on a different site – to test the refined EC technique. More recently, consortium Y successfully applied it to another dike under the RWA's jurisdiction. The technique is presently considered almost best practice.

If we interpret our observations on knowledge development, transfer and uptake in the two pilots in terms of team learning and organisational learning (Easterby-Smith & Lyles, 2011), we see a lot of substantive team learning, both within and among contractor, RWA and reviewer.

Organizational learning occurred mainly during the ex-post process evaluation of the pilots. This made the RWA realize that the type of contract does matter when the aim is to stimulate innovation. After reviewing alternatives developed for road infrastructure, the RWA adopted as policy to tender for projects using Design-and-Construct contracts, favouring consortia that can provide the RWA and its formal reviewer detailed information on their innovations. The linked stages in D&C contracts allow contractors to develop knowledge early on, reducing the uncertainty that clashes with performance obligation.

Adopting this policy meant that the RWA had to develop the competence needed to tender on the basis of functional requirements instead of technical specifications. The policy also leads the RWA to periodically consult the private sector to discuss risk allocation, and gain support for new types of procurement guidelines. When tender documents for a particular dike strengthening project comprise innovations, the RWA also installs a special committee that is to advise the RWA on whether the innovation is applicable to this project.

The experience gained with this new variant of integrated contracts lead to application of several integrated contracts at other dike reinforcement projects, while further unleashing the creative capacity of contractors.

During project implementation between Kinderdijk and Schoonhovenseveer, the RWA learned that widening the scope for dike reconstruction projects can help discover synergies between dikes and their surroundings, and also that public participation can help improve the overall quality of an area, and provide opportunities to develop more sustainable solutions. The RWA is more open-minded and therefore continues its organizational learning efforts, resulting in different contracting and public engagement approaches in their current projects.

REFERENCES

Easterby-Smith, M. and Lyles, M.A. eds., 2011. Handbook of organizational learning and knowledge management. John Wiley & Sons.

Tromp, E. & Bots, P.W.G., (2016), *Knowledge transfer and uptake in Design Process of Flood Defences: Case of Kinderdijk-Schoonhovenseveer*, 17th European Conference on Knowledge Management, Belfast, Northern Ireland, UK, 1-2 September 2016.

88. How to cope with uncertainty in river management?

Warmink J.J.[1], Vinke-de Kruijf J.**, Brugnach M.*, Schielen R.M.J.*,† and Augustijn D.C.M.**

** Department of Water Engineering and Management, University of Twente, Enschede, The Netherlands*

*** Institute of Environmental Systems Research, University of Osnabrück, Germany*

† Ministry of Infrastructure and the Environment - Rijkswaterstaat, Utrecht, The Netherlands

[1] Corresponding author: P.O. Box 217, 7500 AE Enschede, The Netherlands, Tel: +31 53 489 2831, j.j.warmink@utwente.nl

KEYWORDS: Policy making, Uncertainty, Ambiguity, River management, Adaptive management

ABSTRACT

Policy makers often perceive uncertainty as a complicating factor in the development of river management plans. Yet, they need to cope with it on a daily basis. The aim of this paper is to assist policy makers in their struggle with uncertainty by presenting a holistic, adaptive management perspective on coping with uncertainty. We integrate insights about uncertainties from the natural and social sciences domains and learning and translate them into concrete action perspectives for policy makers . The main focus of this paper is on river flood management, but we describe several, successful and unsuccesful, examples from other environmental management challenges.

Based on a review of the literature on uncertainty concepts, strategies to cope with uncertainty and learning concepts, we identify three challenges in current river management: 1) paying too much or too little attention to uncertainty, 2) being conservative and 3) reaching a lock-in situation. We illustrate these and other issues using case study examples from the Netherlands, Spain and Romania. We show that a proper identification of uncertainties is essential in policy making to raise awareness and support for policy plans, thereby reducing ncertainty in the social system. In addition, striving for certainty by gathering more and better knowledge is not always the optimal strategy to cope with uncertainty. Inspired by the multi-loop learning concept, we show that learning in the form of changing organizations, paradigms and governance structures can be essential when coping with uncertainties. The successfull implementation of an adaptive management policy requires flexibility from the side of policy makers, being reflective about organisational processes, and changing perspectives of scientists. We conclude that coping with uncertainty may require paradigm shifts that can only be achieved through organisational learning.

100. Quantifying Flood Resilience - A Case Study

Doug Bellomo[1],Michael Deegan*[1], Rolf Olsen*[1]*

** United States Army Corps of Engineers, Institute for Water Resources*

[1] 7701 Telegraph Road, Casey Bldg., Alexandria VA 22315 Douglas.A.Bellomo@usace.army.mil

KEYWORDS: Risk, Resilience, Measurement, Framework, Management

ABSTRACT

In 2012 a general framework for measuring resilience through the use of common definitions and a straight forward equation for risk was developed. This effort was built on general definitions of risk and demonstrated how four orders of resilience could be calculated for anything whose value could be measured over time. First order resilience was identified as an object's or system's ability to withstand a stress and by definition did not include any time for recovery. Second order resilience was proposed as a measure of both the system's deformation and its ability to recover to a pre-stress state. Third order resilience was proposed as the integral of various second order resilience values over a single hazard of various magnitudes and fourth order resilience was proposed as a measure of the system's or object's ability to withstand and recover from a variety of different hazards. Use of a this common framework for measuring resilience across a wide variety of fields was proposed to inform planning and investment decisions, provide meaningful comparisons, track performance over time, and ultimately help aid government officials, business owners, and the broader public in making more informed risk management decisions.

Following up on that effort, the U.S. Army Corps of Engineers Institute for Water Resources applied the proposed framework in a specific flood risk case study. One purpose of the effort was to identify gaps in the proposed framework and potential ways to address them. Another purpose was to evaluate available data and the assumptions needed to calculate a quantitative measure of flood resilience including a look at various sectors within a community and the connections between people, resources, and infrastructure. This presentation will overview the proposed resilience framework and share findings from its application in a flood context.

121. Decision-making in the case of a flood-threat

*L.M.S. Veerhuis *,** B. Kolen*,** *1 M. Kok*,** * D. Riedstra ****

** HKV consultants. Botter 11-29, 8232 JN Lelystad, the Netherlands, info@hkv.nl, +31 320 294242*

*** Delft University of Technology, HKV Consultants.*

*** Rijkswaterstaat*

INTRODUCTION

Design-criteria for flood-defences have a legal character in the Netherlands. Formerly, these flood protection standards were based on design-waterlevels, where a flood defence was implicitly supposed not to fail below this waterlevel. Since knowledge regarding dike-failure improved, a new risk approach has been developed based on a social cost-benefit analysis which addresses a monetary value to a (prevented) fatality. Also, loss of life is part of the risk analysis. The main improvement of the new approach is the explicit inclusion of failure probabilities in flood-risk calculations. A recent floodrisk study showed the risk of flooding for some regions in the Netherlands is larger than previously thought [Rijkswaterstaat 2015].

In the case of a flood-threat, safety protocols are conducted for crisis-managers and decision-makers. These protocols use design-waterlevels as up-scaling criteria to indicate a degree of alertness. The green scale represents a normal life situation, whereas scale red indicates the most extreme situation where evacuation is considered. Regarding evacuation, the measure has the opportunity to prevent loss of life but enormous costs are involved. Two problems can be noticed related to the evacuation-decision. First, the moment of up-scaling represents the start of communication. It does not indicate a moment to start the evacuation-process. Second, scales are developed by history and have a limited scientific substantion.

Because of high (economic) impact and uncertainties, decision-makers tend to wait to call for evacuation. Accordingly, decision-makers requested additional information to support this decision [Kolen, 2013]. Research question is whether an alarm waterlevel for evacuation can be developed, based on the risk-management approach as used to define the new flood protection standards.

Decision-method

The main objective is a decision-method to find an alarm-waterlevel to call for evacuation. The method uses a social cost-benefit analysis to support a decision on a rational basis. Additionally, waterlevel-forecasts and conditional dike-strength are required as input. The costs of evacuation are defined as:

- Loss of life (LoL): Expressed in monetary units as is done in the new safety standards. It relates to the percentage of evacuated people (a), a mortality rate (r), the number of inhabitants (I) and the value for loss of life (V), after [Bockarjova et al. 2010, Bockarjova et al. 2012].

$F1 = r \times I \times V$

Value of LoL if no evacuation called, given a flood. (1)

$F2 = r \times a \times I \times V$

Value of LoL if evacuation called, given a flood.

(2)

- Some loss of life can occur due to the evacuation-process itself [Kolen, 2013]. This value is expressed as a fraction b of the number of inhabitants.

$F3 = b \times I \times V$ Value of LoL due to evacuation-process.

(3)

- Business interruption (B.I.): Due to evacuation, inhabitants are not able to contribute to economy for a while.

$C = m \times GDP$

Costs of B.I. if evacuation called.

(4)

- Goods: Damage can be partly saved by moving goods. This factor is expressed as a fraction k of all damage D.

$M = k \times D$ Value of goods saved by evacuation, given a flood.

(5)

Benefits of evacuation (prevented loss of life) are related to the uncertain event of flooding, since time is needed for decision-making, preparation and transportation [Barendregt and van Noortwijk

2004]. Accordingly, more people can be evacuated if more time is available until the critical event (Figure 13). If no flooding occurred, the measure evacuation only incurred costs.

Forecasts of waterlevels are used as indicator to call for evacuation. The method uses a representative waterlevel-development over time to mimic waterlevel-forecasting (Figure 14). For every day t = i, forecasts of waterlevels are made for days t = i+k. A maximum time-frame of four days k = [1 : 4] is considered as enough time to evacuate all inhabitants from the threatened area. Every day in the design-wave an evacuation-decision will be made based on forecasts of that day.

Figure 15 presents a decision-tree for day t = i. Seven cost-scenarios can be conducted when the evacuation- process is assumed to be irreversible. If one decides for no evacuation and no flooding occurred, the next day a new decision can be made with updated information. A decision for evacuation for day t = i is made if the expected costs of evacuation are smaller than the expected costs of no evacuation, i.e.:

$$P_{t=i,k=1} \times \text{Scenario } 1 + (1 - P_{t=i,k=1}) P_{t=i,k=2} \times \text{Scenario } 2 + \ldots + (1 - P_{t=i,k=1})(1 - P_{t=i,k=2})(1 - P_{t=i,k=3})(1 - P_{t=i,k=4}) \times \text{Scenario } 5 < P_{t=i,k=1} \times \text{Scenario } 6 + (1 - P_{t=i,k=1}) \times \text{Scenario } 7 \tag{6}$$

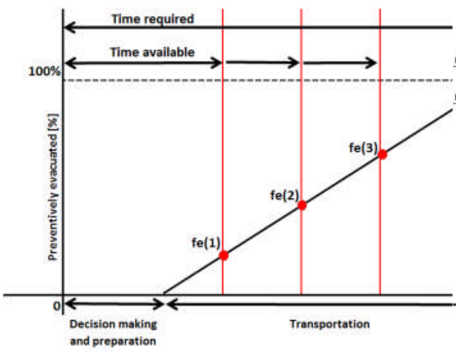


Figure 13: Representation of available and required time for evacuation [Wojciechowska, 2015] after [Barendregt and van Noortwijk, 2004].

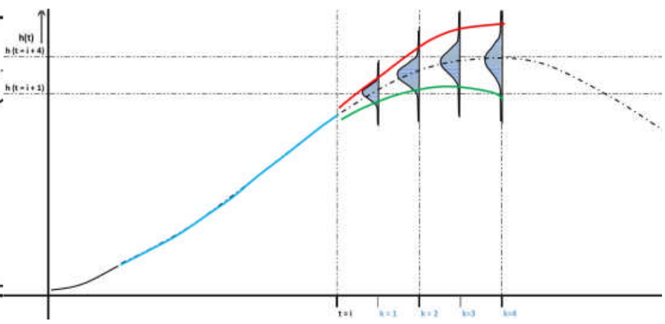


Figure 14: Representation of waterlevel forecasts for days t = i + k with k = [1 : 4], using a representative waterlevel-development over time.

The decision-method uses fragility curves of dike-sections to calculate flooding-probabilities Pt,k using waterlevel-forecasts (Figure 16). These curves represent the conditional failure-probability for a given failure- mechanism as a function of the waterlevel.

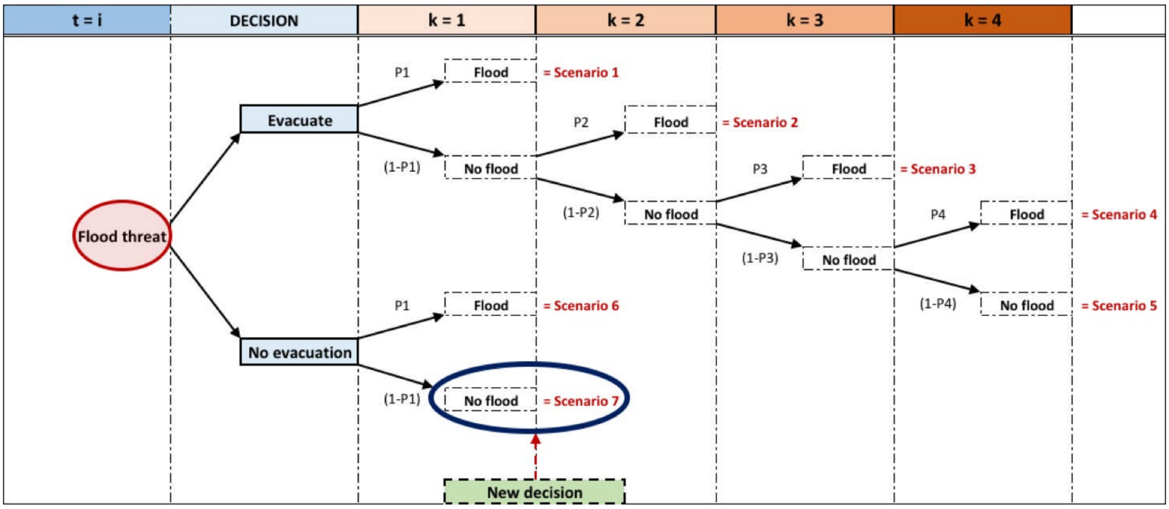


Figure 15: Decision-tree for evacuation-decision on day t = i, using waterlevel-forecasts of days t = i + k with k = [1 : 4].

Every day t = i according to the representative waterlevel-development over time, expected costs for the measures evacuation and no evacuation can be compared. If this ratio becomes smaller than one, deciding

for evacuation is satisfied. Figure 17 shows the development of $\frac{\textit{Expected costs Evacuation}}{\text{Expected costs No Evacuation}}$ over time, relative to a given waterlevel-development over time. An alarm-waterlevel can be found using the corresponding failure-probability with given fragility-curve. This alarm-waterlevel can be compared with current emergency- protocols to check if the evacuation-decision is still considered in time.

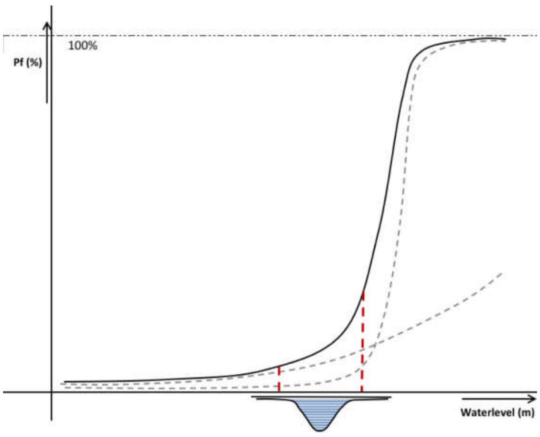


Figure 16: Calculating flooding-probabilities: integrating forecast-distributions under the fragility-curve.

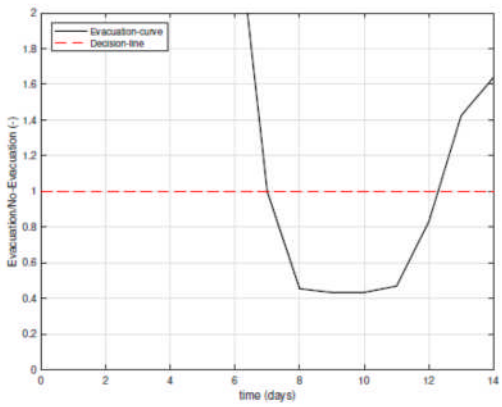


Figure 17: Representation of the development of an evacuation-decision over time, relative to a representative waterlevel-development over time.

Results case-study

The decision-method finally is applied to dikering-area 43 in the Netherlands, which is surrounded by branches of the river Rhine. The study focused on emergency-procedures on national and local level, using evacuation estimates of [Kolen et al., 2013] and actual dike-strength information of

[Rijkswaterstaat VNK Project, 2015] to calculate a well-considered alarm-waterlevel to call for evacuation. Figure 18 shows a representative waterlevel-development over time for this region during an extreme high- water event. The colours represent scales as stated in the national emergency-protocol.

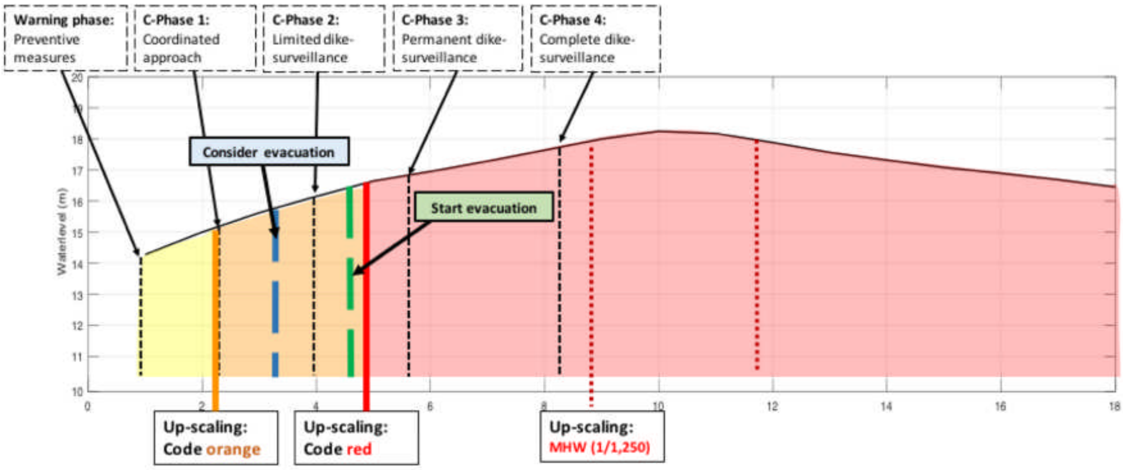


Figure 18: Comparison of current emergency-procedures with the calculated alarm-waterlevel to call for evacuation (MHW is defined as the water level with a return period of 1250 years.

The analysis of dikering-area 43 makes clear that the cost-benefit ratio of evacuation is already favorable in scale orange. This scale currently corresponds with the consideration of flood-prevention measures instead of evacuation. Accordingly, it is wise to make a clear distinction between the first moment of considering evacuation and the start of the evacuation-process itself, since time is needed for decision-making and preparation.

Conclusions and discussion

The study focused on the development of a decision-method to find an alarm-waterlevel to call for evacuation in the case of a flood-threat, for dikering-areas in the Netherlands. A sensitivity-study resulted in two main conclusions. First, an alarm-waterlevel to call for evacuation relies on the performance of the evacuation-process. If more people can be saved within the same amount of time, the possible benefits of an evacuation increase. This puts more favour to the decision evacuation over no evacuation for the same loading- and strength-conditions. Concluding, if the performance of evacuation improves, a lower alarm-waterlevel is economically satisfied. Second, strength of a dike influences an evacuation-decision positively. If strength of the dikering is in- creased by reducing the contribution of a failure-mechanism as piping, conditional failure-probabilities become less significant for the same waterlevels. Therefore, if the same waterlevel-forecasts are expected for a stronger dike, failure will be less likely to occur. As a result, a worthwhile decision for evacuation can be found for an increased alarm-waterlevel. The decision-method is finally applied to dikering 43 in the Netherlands. The analysis used dike-strength information of [Rijkswaterstaat VNK Project, 2015] and evacuation-estimates of [Kolen et al., 2013] to quan- tify the possible benefits of evacuation in this area. The analysis made clear that an evacuation-consideration can be made sooner than currently stated in the emergency-protocols. Accordingly, it is advised to revise current emergency-protocols and explicitly include uncertainties as strength and evacuation-performance to the evacuation-consideration. Finally, the same method can be applied to a broader variety of emergency- measures, which can provide insights for optimal decision-making in the case of a flood-threat.

References

[Barendregt and van Noortwijk, 2004] Barendregt, A. and van Noortwijk, J. (2004). Bepalen beschikbare en benodigde tijd voor evacuatie bij dreigende overstromingen. Technical report, HKV.

[Bockarjova et al., 2010] Bockarjova, M., Rietveld, P., and Verhoef, E. (2010). Instruments for decision-making: Immaterial damage valuation in flood risk context.

[Bockarjova et al., 2012] Bockarjova, M., Rietveld, P., and Verhoef, E. (2012). Composite valuation of im-material damage in flooding: value of statistical life, value of statistical evacuation and value of statistical injury. Tinbergen institute discussion paper.

[Kolen, 2013] Kolen, B. (2013). Certainty of uncertainty in evacuation for threat driven response. Nijmegen. [Kolen et al., 2013] Kolen, B., Maaskant, B., and Terpstra, T. (2013). Evacuatieschattingen Nederland. Technical report.

[Rijkswaterstaat VNK Project, 2015] Rijkswaterstaat VNK Project (2015). The National Flood Risk Analysis for the Netherlands.

[Wojciechowska, 2015] Wojciechowska, K. A. (2015). Advances in operational flood risk management in the Netherlands. Delft.

124. Building international collaboration and improving flood forecasting and warning services in Australia and England

Alex Cornish.[1], Jeff Perkins. *, Dr Dasarath Jayasuriya*, Mark Russell** Oliver Harmar***

** Flood Forecasting and Warning, Bureau of Meteorology*

*** United Kingdom Environment Agency*

[1] *Details for contact author: alex.cornish@bom.gov.au telephone: +61 88366 2667*

KEYWORDS: Memorandum of Understanding, international collaboration, Australia, England, improvements, flood forecasting services.

ABSTRACT

The Australian Bureau of Meteorology and the Environment Agency in England both deliver forecasting and warning services for flooding from rivers and seas. Both organisations have moved to a national operational model and high level meetings between the two organisations in recent years have shown that there are many areas of mutual interest. Both organisations are keen to collaborate and will formalise arrangements through a Memorandum of Understanding.

In Particular, the Bureau and the Environment Agency are looking to co-operate in a wide range of areas, including

- Technology and innovation; flood monitoring, forecasting and warning systems development, maintenance and performance;
- Developing our people including; skills, accreditation, training;
- Service development including; operational standards, service process, research and development, learning and operational response;
- Customer and partner engagement including; warning and informing services, infrastructure operators, communication channels and embedding effective actions.

The benefits of international collaboration are well documented, as well as many of the pitfalls. Both organisations are keen to get the most from working together and are putting in place governance arrangements, strategic and annual plans, but the key to success is for the relationship to grow formally and organically with many touch points and not rely on the commitment of a few critical people.

This paper will discuss the journey and experiences of both organisations.

REFERENCES (if applicable)

129. Methodological approach to flood risk diagnosis at a national level in areas with scarce data. Study case: Algeria.

García de Mendoza, P.[1], Ciancio, J.*, Martínez-Bravo, E.* & Arrabal, M.A.**

* INCLAM Group

[1] Consell de Cent, 333. 4th floor. Barcelona 08007. Phone: +34 93.238.95.20
pere.garciademendoza@inclam.com

KEYWORDS: flood risk, diagnosis, scarce data, prioritisation, governance

Algeria is very prone and vulnerable to flooding. In fact, floods regularly cause severe material damage and human losses (e.g. Bab el Oued in 2001, where 757 people died; or Ghardaia in 2008, with a death toll of 33 and significant damages).

Consequently, the People's Democratic Republic of Algeria, through its Ministry of Water Resources (MRE) and in collaboration with the European Union (EU), promoted in 2013 the elaboration of a **National Strategy against Floods**. The goals were to gain knowledge on flood risk throughout the country and, based on that, to draw up a Program of Measures to better cope with this kind of disasters minimizing their devastating consequences and reinforcing resilience.

The study was entrusted to a Spanish-Dutch Consortium comprising: OFITECO, who led; INCLAM; DELTARES and the Dutch Government Service for Land and Water Management (DLG). The work, concluded in April 2016, was organised in four missions: (M1) Diagnostic and analysis of the current situation; (M2) Field visit and diagnosis of sites most exposed to floods; (M3) Action plan and strategy; and (M4) Capacity building.

INCLAM led M2, assisted by OFITECO. The objective was to establish a methodology for the qualitative prioritisation of those sites most exposed to flooding. Up to 689 of them were pre-identified by the Algerian authorities through historical records. Such a prioritisation was to be a reference for the implementation of various structural and non-structural actions to be proposed in M3. To this end, M2 was structured into three sub-missions or steps, namely:

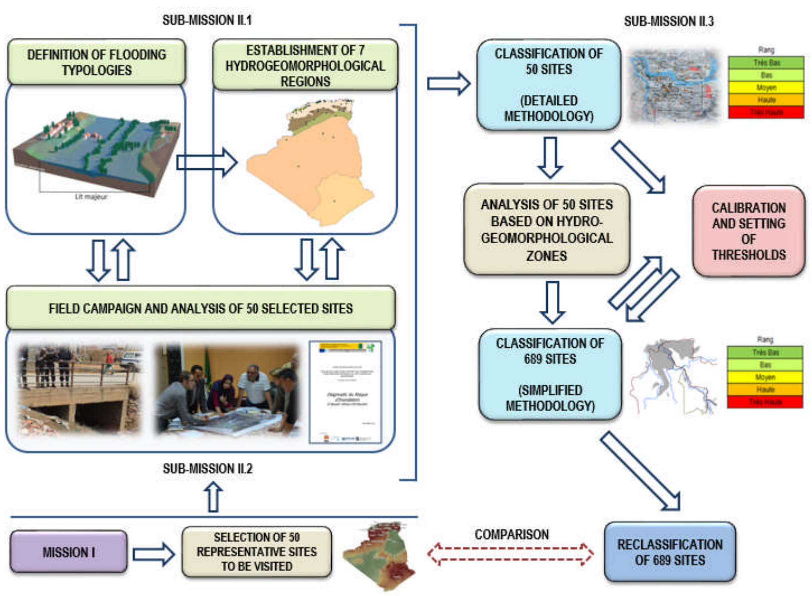


Figure 19: Schematic of the methodological approach proposed to achieve the objectives set in Mission II (M2). Source: Courtesy of MRE (Government of Algeria).

- Definition of flooding typologies in Algeria based on the country characteristics. As a result, **seven hydrogeomorphological zones were delimited**, depending on the predominance of typologies with common general characteristics and similar magnitudes.
- Field visit to 50 sites (previously selected in M1, out of a total of 689) representative of the flood and flooding problems within the country. A **diagnosis of the existing situation** in each visited site was made, considering several aspects observed and/or collected in a survey: flood and flooding typology, their causes and consequences, damages, measures implemented (if any), governance, capacity building and communication, early warning, crisis management, regulations, coordination and risk culture.
- Development and implementation of a qualitative methodology to assess flood risks nationwide, capitalising on the knowledge gained from the 50 sites visited, and its subsequent **extrapolation to the whole country** (689 sites).

Among the activities conducted, characterization and diagnosis faced a significant challenge: the need of a huge amount of information, which in most cases had a serious lack of homogeneous and quality data.

At this point, it must be stressed that in EU countries, as those of the Consortium's partners, flood risk assessment follows the EU Floods Directive 2007/60/EC. A huge amount of (climate, hydrometeorological, topographic, hydrologic, hydraulic and so forth) quality data is demanded, which feeds complex modelling to produce accurate hazard and risk maps. However, these studies become a hard work where this information is not available or it is not homogeneous. That was the case of Algeria where, depending on the region, information ranged from accurate digital information and detailed models to ancient historical hard-copy records, if any. Hence, it was necessary to both devise ways to overcome this situation and prevent results from being useless. A two-fold strategy was adopted.

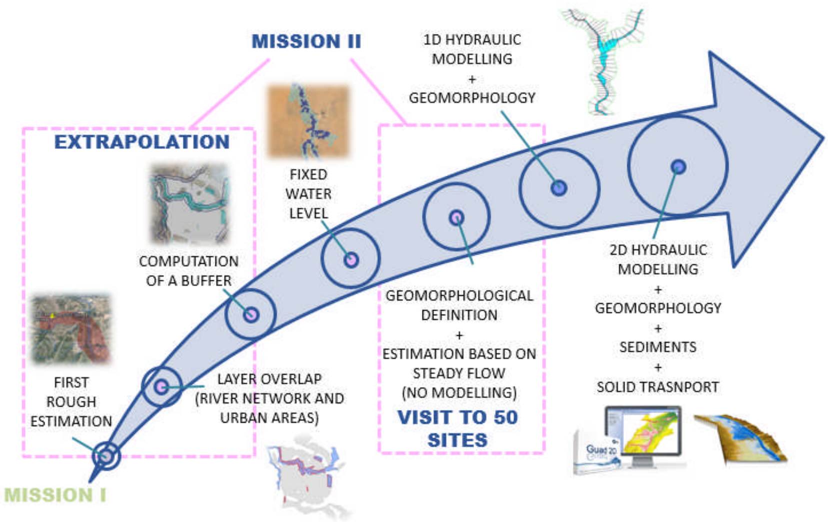


Figure 20: Successive stages in a diagnosis process, showing the framework where Mission II (M2) fits. Source: Courtesy of MRE (Government of Algeria).

On the one hand, field visits were key to make up for the lack of homogeneous and quality data. The deployment of an expert team along with a comprehensive survey (taking into account the view of local authorities, who really know their territory) were essential to achieve a clear understanding of local characteristics and flood-related problems. The result was a complete and useful knowledge of the flood and flooding problems in Algeria through 50 representative sites, including a rough hydraulic analysis based on either simple models using low-resolution cartography or just landmarks, geomorphology and expert criteria.

In any case, upscaling to a national level was probably the process most influenced by **low quality and scarce datasets**, since their homogeneity is essential to achieve a sound analysis. This issue was solved by means of a risk qualitative analysis using a limited set of available factors adapted to the country's reality (namely urban areas, river networks and road and railroad networks) which made possible a risk hierarchy of sites. Then, differentiating parameters were regionally defined and the outcomes of the 50-site analysis were extrapolated to the 689 sites. This required a significant effort in digitising, with the support of freely available satellite imagery.

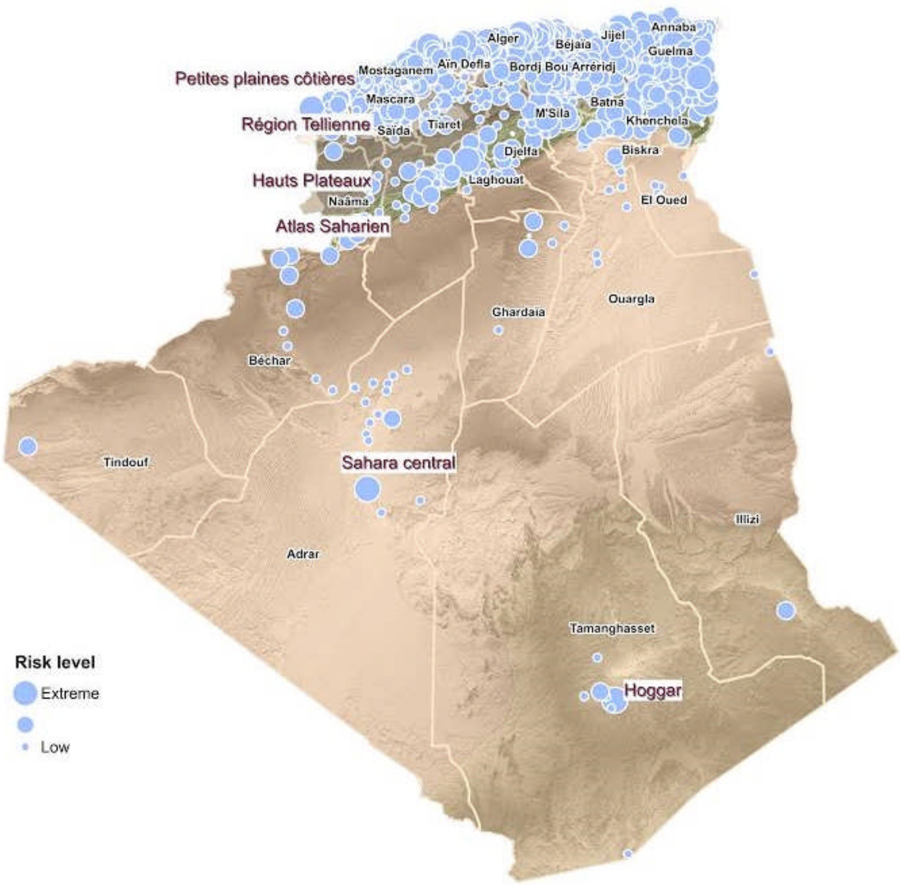


Figure 21: Characterization of flood risks in Algeria, according to the methodology devised. The larger the circle depicted, the higher its risk. Source: Courtesy of MRE (Government of Algeria).

On the other hand, a **multidisciplinary approach** through field campaigns and regular interaction with stakeholders allowed not only to focus on the technical aspects of the situation, but also internalise the social, economic, legislative, political and institutional background which have strong influence on how flood risk happens and is managed in Algeria. In this regard, among several others, the following aspects are highlighted:

- The **occupation of flood-prone areas** around big cities, due to the imperative dwelling construction during the political turmoil the country went through some decades ago;
- The **need to complement with non-structural measures** the great effort the Algerian Government had deployed with the structural ones, since these latter could gave a false security perception and lead to play down residual risk.
- The importance of mapping the **organisational framework** of public administration, which allows accessing not only a deep understanding of the country's reality, but also different sources of data, whenever available. In this sense, the collaboration of the Algerian administration, especially the MRE and their technical assistance, was outstanding;

In conclusion, **adaptability and flexibility to existing conditions** in regions where very developed standards are not met yet, are essential to face limitations vis-à-vis the lack of quality information. In this sense, a good knowledge of the country's idiosyncrasy and its governance structures as well as the devising of simplified and adapted (but reliable and useful) methodologies based on experience, clear criteria, sound judgement and available means turn out to be key factors to overcome those issues.

REFERENCES

Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks.

García de Mendoza, P.; Ciancio, J.; Arrabal, M.A. & Martínez-Bravo, E. (2015). Final Report of Mission II: "Réalisation d'une étude portant sur l'élaboration d'une stratégie nationale de lutte contre les inondations" (Study for the elaboration of a national strategy against floods). Sercice Contract ENPI/2013/327-588 (EuropeAid/133151/D/SER/DZ).

Modelling and hydroinformatics (i)

19. Safety Assessment on Flood Control of Urban River Channel: a Case Study
Dr Xinlei Guo, China Institute of Water Resources and Hydropower Research, China

42. Flood forecasting in the Netherlands for lakes shores
Mr Robert Slomp, Rijkswatestaat, Netherlands

76. Flood forecasting and warning for river basins in Malaysia: non-structural measures for flood mitigation
Mrs Emma Brown, HR Wallingford Ltd United Kingdom

107. Flood Forecasting in Australia – developing better systems for better services
Mr Chris Leahy, Bureau of Meteorology, Australia

144. Application of the Independent Subsection Method to Compound Channel having Non-Prismatic Floodplains
Mr Bhabani Shankar Das, National Institute of Technology, Rourkela Odisha, India

154. Evaluation of open global Digital Elevation Models for urban flood modelling
Mr Laurent Courty, Universidad Nacional Autónoma de México, Mexico

164. Testing resilience of distributed natural flood risk management measures
Dr Barry Hankin, JBA Consulting, United Kingdom

19. Safety Assessment on Flood Control of Urban River Channel: a Case Study

Xinlei Guo, Jiazhen Li**, Tao Wang**, Yongxin Guo** and Hui Fu***

** State Key Laboratory of Simulation and Regulation of Water Cycle in River Basin, China Institute of Water Resources and Hydropower Research*

*** Department of Hydraulics, China Institute of Water Resources and Hydropower Research*

[1] Professor of Engineering, State Key Laboratory of Simulation and Regulation of Water Cycle in River Basin, China Institute of Water Resources and Hydropower Research, Fuxing Road No.1, Beijing, China. Tel: 86 (10)68781725/68538685, E-mail:guoxinlei@163.com

KEYWORDS: Flood control; urban river; roughness coefficient; LSPIV; backwater

ABSTRACT

The uncertainties such as the roughness coefficient of the river bed, section morphometry parameters and the local resistance characteristics of backwater for bridge piers have great influence on river channel flood discharge capacity. Taking the flood control and regulating engineering of Hunchun urban river as a case study, the physical model experiments were carried out to investigate the hydraulic performance of the river. A method to roughen the bed surface by slotting and using plastic grass with different space and height is presented. Different depth measurements were made using point gauge which velocity measurements were taking using Large-Scale Particle Image Velocimetry (LSPIV) and electromagnetic current metre over a grid defined throughout the region in experimental test. The distribution of the water level and velocity were obtained and the uncertainties of the typical parameters which affect the flood discharge capacity have been analyzed. The experiments show that the roughen method is effective for the experimental simulation of the flow resistance and LSPIV has proven to be a flexible and inexpensive tool to obtain velocity measurements. Several existing prediction models for bridge backwater have been examined and results show that the measured maximum backwater is bigger than the above models due to complexity character of the piers. Finally, the recommended flood control plans were tested and proved that it can fulfil the design requirements.

42. Flood forecasting in the Netherlands for lakes shores

Dollee, Aad, Hartholt, H, Slomp, R *[1]*

** Rijkswaterstaat, Ministry of Infrastructure and the Environment*

[1] Details for contact author (Robert Slomp, Robert.slomp@rws.nl, +31320298532, ..Lelystad the Netherlands

KEYWORDS: Flood forecasts, uncertainty, ensembles, coastal flooding along lakes

ABSTRACT

This article is written from the perspective of the user. Rijkswaterstaat, the National Water Authority provides flood forecasts for the whole of the Netherlands through the water management centre of the Netherlands (WMCN). WMCN is an organization with many participants, regional water authorities, the national water authority and the national meteorological service (KNMI). The WMCN has different teams. Storm surge warning service for lakes WMCN-meren /coast (formally WDIJM) is a recent service Netherlands. It was founded 1985 after an assessment of the flood defences, many flood defences did not comply with the standards. The most important issue is a cost-efficient and reliable forecasting and warning system. This always involves trade-offs. Reliability and redundancy are important issues. Older systems, databases are always available as backup. The costs are for hardware, software and training and availability of staff 24/7 365 days a year. A full model train is currently used. This model train consists of an automated system, a model train which provides a forecast every 6 hours. It starts with an wind forecast from a global model, HIRLAM downscaling for the lake areas. This provides input for a hydro-dynamical model, a wave forecasting model and finishes with a wave run up model. Corrections are automatically carried out based on measurements in the system. A complicating issue is accounting for the river discharges from three rivers into both large lakes. Storm surges and river flooding can take place simultaneously but are not correlated.

Major issues to resolve are

-the trajectory of the storm. This information is often sufficiently reliable 24 to 48 hours before the storm

Not everything fits in the model train. Additional information is passed on to the users of the flood forecasts and warnings by phone and email.

Users of flood alerts need references and information on uncertainty. More information is available, results from the 6 yearly assessment of flood defences and information on potential damages and casualties comes from policy studies as VNK (Flood Risk in the Netherlands) and WV21 (Flood Risk in the 21st century). This information helps in determining the consequences of a breach in the flood defences.

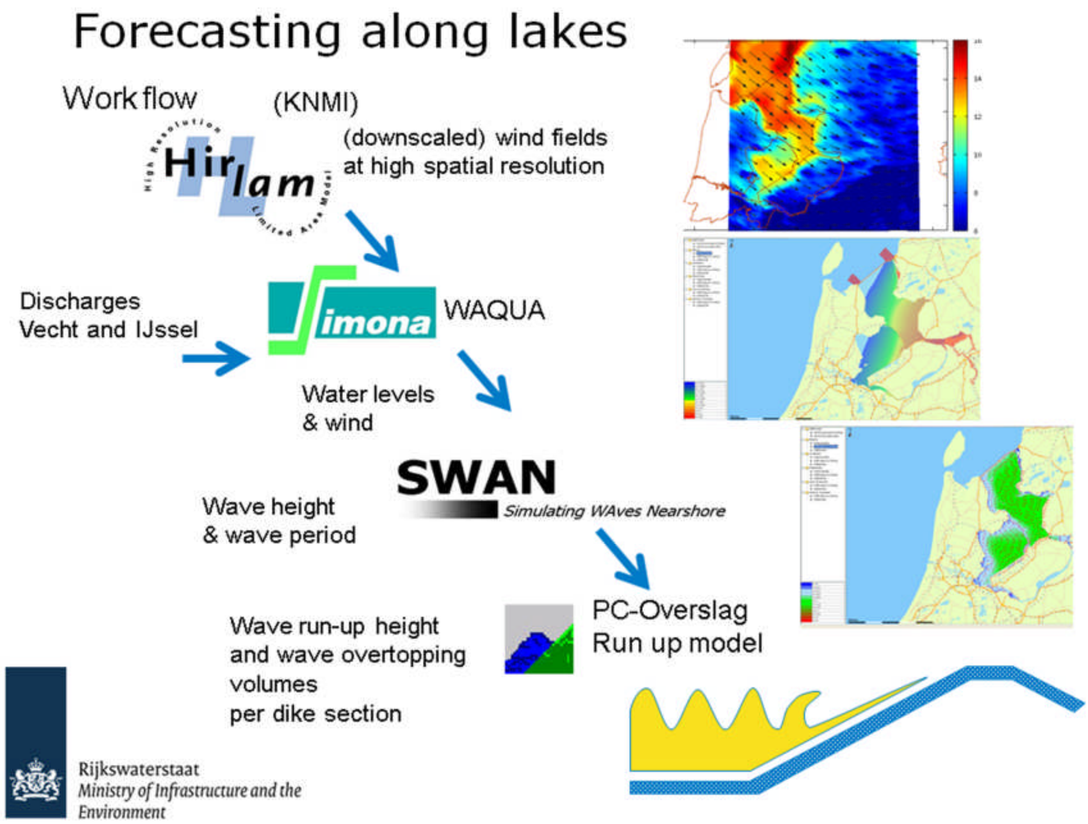
Information on uncertainty is provided by using the ensembles from the meteorological office.

Challenges or the future are

- giving more information on uncertainties.

- new references based on the new standards for flood defences in the Netherlands

- using wave information in flood forecasts



76. Flood forecasting and warning for river basins in Malaysia: non-structural measures for flood mitigation

Brown E.L.[1] and Hassan A.J.***

** HR Wallingford Ltd*

*** HR Wallingford Asia Sdn Bhd*

[1] HR Wallingford Ltd, Howbery Park, Wallingford, Oxfordshire, OX10 8BA, UK. Tel: (01491) 835381. Email: e.brown@hrwallingford.com

KEYWORDS: non-structural measures; flood forecasting; dissemination; communication; flood warning.

ABSTRACT

The Department of Irrigation and Drainage (JPS) of the Malaysian government has adopted an integrated approach to river basin development and flood management across the country. The major rivers of Peninsular Malaysia have their sources in the band of hills running along the centre of the peninsula. The country has a humid tropical climate; Average Annual Rainfall is 2500 mm, although seasonal distribution of rainfall varies widely from place to place. Many of the river basins have repeatedly suffered prolonged, significant flood events which have caused widespread disruption and impacts to residents, businesses and infrastructure. The impacts of flood events have been exacerbated by considerable rapid development over the past decade, which has modified the flow regimes and flooding mechanisms. To help prepare for, and mitigate, the effects of future floods, the Malaysian government, via JPS, is implementing a range of flood management projects, which will provide an integrated approach based on structural and non-structural measures.

Flood forecasting and warning systems are currently being developed for key river basins. These systems are characterised by a need for flexibility in their handling of sources of incoming data, combining spatial and gauged observations, along with Numerical Weather Prediction (NWP) forecasts, as well as techniques for providing robustness to missing or poor quality inputs. The fully automated end-to-end systems are designed to ingest data, run simulations, and post-process results to provide flood managers and the general public with relevant information in a timely manner. Flexible dissemination routes via dedicated interfaces for operational staff, and websites, SMS messaging and smart phone applications for the general public, are designed to ensure that warnings reach stakeholders in time for action to be taken, so that the widely used government slogan 'Rakyat didahulukan, pencapaian diutamakan' ('People first, performance now') is key to resilient flood management.

154. Evaluation of open global Digital Elevation Models for urban flood modelling

Julio C. Soriano-Monzalvo†1, Laurent G. Courty*† and Adrián Pedrozo-Acuña**

** Instituto de Ingeniería, Universidad Nacional Autónoma de México.*

† Programa de Maestría y Doctorado en Ingeniería, Universidad Nacional Autónoma de México.

[1] Circuito Escolar S/N, Edificio 5, Ciudad Universitaria, Del. Coyoacán, Ciudad de México, México. C.P. 04510, JSorianoM@iingen.unam.mx

KEYWORDS: Computer modelling, Digital Elevation Models

ABSTRACT

The quality of Digital Elevation Model (DEM) is widely acknowledged to be the most determinant factor in the accuracy of computer flood modelling. Nowadays, the Light Detection And Ranging (LiDAR) data has become a common way of rapidly collecting accurate elevation data with 5 meters resolution or lower. However, in many regions of the world, especially in developing countries, still lack this type of information and therefore relies on globally available datasets. For hydrologic modelling, the Shuttle Radar Topography Mission (SRTM) DEM, created by data collected by the Space Shuttle in the year 2000, might be the most widely used dataset today. Until recently, the global SRTM DEM was available at 3 arc seconds horizontal resolution, or roughly 90m. It is not until 2015 that the 30 meters global version was publicly released by the United States government. In May 2016, the Japan Aerospace Exploration Agency (JAXA) released a global DEM at 30m resolution called AW3D30, that has been generated with the data collected between 2006 and 2011 by the Advanced Land Observing Satellite (ALOS) (Tadono et al., 2014) .

The objective of this study is to evaluate SRTM and AW3D30 DEM applied to urban flood modelling. To achieve this goal, computer simulations will be run with the same synthetic rainfall over those two datasets. The same event will be again simulated using a 5 meters LiDAR DEM downscaled to 30 meters to serve as a baseline. The resulting flood maps of the two assessed DEM will then be compared to the one obtained with the use of the LiDAR DEM, in order to calculate the differences between them. The area chosen for this study is the city of Río Bravo, located in the Mexican state of Tamaulipas, close to the border with Texas, where LiDAR DEM is available. The simulations will be carried out using Itzï, a GIS computer model resolving a simple-inertia, explicit version of the Shallow Water Equations (Courty & Pedrozo-Acuña, 2016) .

It is expected that the results of this work will help other researchers and practitioners to choose the adequate DEM for their computer simulation needs, mainly in regions of the world where high quality information is not yet available.

REFERENCES

Courty, L. G., & Pedrozo-Acuña, A. (2016). A GRASS GIS module for 2D superficial flow simulations. In *Proceedings of the 12th International Conference on Hydroinformatics*. http://doi.org/10.5281/zenodo.159617

Tadono, T., Ishida, H., Oda, F., Naito, S., Minakawa, K., & Iwamoto, H. (2014). Precise Global DEM Generation by ALOS PRISM. *ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences*, *II-4*(May), 71–76. http://doi.org/10.5194/isprsannals-II-4-71-2014

164. Testing resilience of distributed natural flood risk management measures

Barry Hankin[1], Rob Lamb*, Iain Craigen*, Nick Chappell**, Trevor Page**, Peter Metcalfe***

** JBA Consulting*

*** LEC*

[1] JBA Consulting, Bank Quay House, Sankey Street, WARRINGTON,WA1 1NN

KEYWORDS: Natural Flood Risk Management. Resilience. Spatial Joint Probability.

ABSTRACT

This paper brings together advances in the modelling, mapping and assessment of opportunities for better working with natural processes in the Eden catchment, Cumbria, that has been impacted severly on three occasions in recent history (2005, 2009, 2015). We explore further the modelling approaches behind JBA's winning entry to the Defra Cumbria Flood Modelling Competition, and the Life-IP funded modelling undertaken for the Rivers Trust to help prioritise NFM measures strategically over a wide area.

The NFM measures that were modelled take the form of: (1) small scale distributed runoff attenuation features, taken from techniques for data mining the updated surface water flood map; and (2) tree-planting opportunities identified in the Forest Research 'Woodlands for Water' dataset. Both of these datasets were refined following catchment engagement workshops facilitated by the Rivers Trust, so that the opportunities were modified to some extent using local knowledge as constraints, such as land ownership issues.

In our Defra entry, we argued that to build in resilience, modelling the catchment response to multiple events, or complex-peaked events would give a more reliable measure of performance than modelling the typical single peaked design event typically undertaaken for scheme appraisal. We demostrated how this could be undertaken by combining ensemble modelling of extreme event-sets with a fully distributed 2d overland flow model of the whole of the Eden, with and without NFM measures. We explored how it was more useful to look at the *average* response given all the interactions from tributaries change depending on the rainfall event. The rainfall events were based on the spatial joint probability work developed at JBA and Lancaster over the last 10 years. This involved fitting joint probability funtions to the extremes in the long-term timeseries foir the 7 available rainfall gauges around the Eden using the Hefferman and Tawn approach. In this way it was possible to generate extreme events having the right spatial characteristics.

Since this work, a more detailed Dynamic Topmodel model of the upper 200km^2 of the Eden catchment has been built and calibrated in an uncertainty framework using the period Nov-Dec 2015 to capture a range of catchment conditions and the extreme Desmond event. This has also been set up with and without NFM measures, using credible parameter ranges.

The paper will explore the similarities and differences between the management advice that could be given on the siting of distributed NFM measures using outputs from both the ensemble 2d surface water model, and the Dynamic Topmodel approach calibrated in an uncertainty framework. Both approaches bring something new to help us understand the catchment behaviour and take into account modelling uncertainties, policy options and forcing conditions to test the resilience of NFM.

Community and social resilience

54. Disaster Adaptiveness, Resilience, and Capacity Building by Accounting for People's Perception: A Canadian Case Study
Dr Niru Nirupama, York University, Canada

63. Resilient Recovery: How Can Gender and Diversity Perspective be Reflected in Recovery Programs following the Great East Japan Earthquake and Tsunami?
Dr Mikio Ishiwatari, Japan International Cooperation Agency, Japan

74. Identification of Interchangeable Elements to Enhance the Implementation of EU-FRM Programs:Lessons Learned From UK and NL
Mrs Ellen Tromp, Deltares / Dutch Flood Protection Programme, Netherlands

96. Multi-dimensional perspectives of flood risk – using a participatory framework to develop new approaches to flood risk communication
Mr Edward Rollason, Durham University, United Kingdom

99. Mayors and "their" land: considering options for municipal flood risk reduction in post socialist setting
Prof Lenka Slavikova, J. E. Purkyne University, Czech Republic

139. Identifying tipping points in flood resilience and anticipatory governance: an Alpine case study
Prof Marco Borga, University of Padova Italy

159. Modelling human decision-making in agent-based models of flood events
Mr Nicholas Roxburgh, University of Leeds, United Kingdom

373. Residents and flood risk management in Flanders (Belgium): two worlds apart?
Dr Barbara Tempels Centre for Mobility and Spatial Planning, Ghent University, Belgium

54. Disaster Adaptiveness, Resilience, and Capacity Building by Accounting for People's Perception: A Canadian Case Study

N. Nirupama[1], *Slobodan P Simonovic***, *and Mark Elliott****

** Associate Professor, Disaster & Emergency Management Program, York University, Canada*

*** Professor, Department of Civil & Environmental Engineering, Western University, Canada*

**** Candidate, Master of Environmental Studies, York University, Canada*

[1] *nirupama@yorku.ca*

KEYWORDS: Disaster Resilience, Adaptability, Capacity Building, Canada, Natural Disaster.

ABSTRACT

Canada's vast regions are unpredictably reacting to climate change in recent years. Understanding of local disaster risks and knowledge of underlying causes for negative impacts of disasters are key factors to working toward resilient environment across the social, economic, and the built sectors. Historically, floods have caused the most economic and social damage in Canada than other types of natural disasters. The recent flood events of 2013 in Toronto, Ontario and Calgary, Alberta raised some compelling questions, namely, how communities can be educated with relevant knowledge on flood resilience so they would want to contribute to the discussion; how can people make a difference in minimizing damage from flood disasters for themselves; and is the role of people's perception important in building coping and adaptive capacity and how to incorporate it. Main *objectives* of this study include addressing these issues and to debate if a unified strategy for disaster resilience would be possible in Canada.

A resilient community is one where people take proactive steps to engage with local leaders and community networks. In order to help communities enhance their adaptability, coping capacity, and overall resilience for natural disasters, it is important that people understand the risks that may affect them so they can be prepared to protect their assets and livelihoods.

Method: relationships between the makeup of the communities, their general vulnerabilities, the geomorphology of the region, and people's perception are explored using the 2013 flood event in the GTA as case-in-point. The datasets used include, flood inundation in the 2013 flood event, 2011 census for demographic information, property values, historic rainfall and temperature pattern, slopes and terrain, and landuse, especially for critical infrastructure and facilities. The component of people's perception is being incorporated using a survey data collected from a few different locations in the GTA. This data reflects how people perceive risks from natural hazards, how they would cope in emergencies, and what their thoughts are on building resilience. These perceptions are treated as representative of the entire City in which they were collected for the purpose of developing the methodology of the assessment of people's resilience. The GIS is used to carry out data processing and analysis.

Results: although the idea that people's perception should be incorporated in the assessment of community resilience and coping capacity had caught attention of experts in the field for its importance and relevance, due to various practical difficulties, the concept hadn't been applied in practice. This study is able to achieve that.

63. Resilient Recovery: How Can Gender and Diversity Perspective be Reflected in Recovery Programs following the Great East Japan Earthquake and Tsunami?

Mikio Ishiwatari[1], Akiko Domoto **, and Yumiko Tanaka†*

** Senior Advisor, Japan International Cooperation Agency (JICA), 5-25 Nibancho, Chiyodaku, Tokyo 102-8012 Japan, TEL: +81-3-5226-9368 FAX:+81-3-5226-638, ishiwatari.mikio@jica.go.jp*
***President, Japan Women's Network for Disaster Risk Reduction*
†Senior Gender Advisor, JICA

KEYWORDS: Disaster recovery, Coastal dyke, Relocation, Great East Japan Earthquake and Tsunami

ABSTRACT

Objectives: Recovery efforts following disasters should encompass the needs and vision of various groups including women, the elderly, or people with disability. This study aims at proposing planning methods of recovery programs through considering diverse needs of affected communities and establishing consensus in local communities.

Methods: The Great East Japan Earthquake and Tsunami in 2011 left over 20,000 people dead or missing, and economic damage is estimated at JPY 16.9 trillion, or some USD 150 billion (Ranghieri and Ishiwatari 2014). Local governments are responsible for implementing recovery programs that cover relocation of affected people from areas at risk to higher grounds and construction of coastal dykes against tsunamis. Government organizations concerned, however, have faced difficulties in reflecting diverse perspectives into recovery programs. This is mainly because the local governments have limited capacity and experience to implement enormous number of recovery programs under severe time constrain.

The study reviews process of two recovery programs in Miyagi Prefecture: (a) coastal dyke program in Oya District in Kesennuma City and (b) relocation program in Kitakami District in Ishinomaki City. Semi-structured interviews were conducted to local governments, civil society organizations (CSOs), experts, and affected people in August and October 2016. Government officers, experts, CSO staff, and researchers discussed these practices at a symposium held in Tokyo, October 2016. Project documents and studies were reviewed.

Results: Two programs are the best practices to incorporate diverse perspectives into program planing.

(a) Coastal dyke program in Oya District, Kesennuma City

While government organizations have led construction of coastal dykes against tsunamis in Tohoku region, local communities were engaged in planning process of dyke construction in Kesennuma City. Since the local communities have different views on the plans formulated by the government organizations, the communities established a study group in July 2012 to examine the plans from a wide range of perspectives, such as disaster

management, environment, scenery, and livelihoods. The group carried out a serious of workshops in which experts, practitioners, CSOs, and academia provided advice on these plans. Some 2,500 people participated in the workshops in total. The local communities requested the government organizations concerned in 2012 to (a) construct the dykes based on local conditions, (b) involve the local communities in decision making, (c) examine multiple alternatives, (d) share information with the public, and (e) develop comprehensive disaster management.

Local communities in Oya District succeeded in revising the plan of a coastal dyke to preserve environment in the Oya coast. The government organizations proposed the dyke with 10 meter height and 40 meter width. The communities were concerned that the dyke would make adverse effects on natural environment of the coast. The sand beach with one kilometre length was famous as sea bathing, and attracted tourists from other districts before the tsunami. The communities requested Kesennuma Mayor in 2012 to suspend the project and conduct consultations with the communities. The communities established a study group, examined alternatives at town planning committee, and conducted interview surveys to community members. The communities proposed to revise the plan in 2015 to setback the dyke to remain sand beach, coastal environment, and recreation places. Finally the government organizations accepted the revised plan in 2016.

(b) Relocation program in Kitakami District, Ishinomaki City

Local communities took the initiative of planning relocation programs in Kitakami District. The Kitakami District Office lost 54 members among 57 staff members as well as buildings and equipment by the tsunami. The office could not promote response and recovery efforts without local communities' involvement and support from outside the affected areas. A nongovernment organization (NGO) based in Tokyo, architect association in Sendai City, and academia experts outside Tohoku region supported the recovery efforts. The architect association provided professional knowledge to plan and design a relocation site and houses. Academic experts who conducted research works in society structures, environment, culture, and daily lives in Kitakami District before the disaster supported the communities to include cultural aspects in the recovery programs. NGO facilitated workshops to build consensus of the relocation program.

A women group played a leading role in formulating the relocation program at Nikkori site, which is the largest relocation site in district. As the first step the group conducted interview survey to the affected people in their communities in December 2011 to examine people's concerns and needs of reconstructing houses. The women group continued to facilitate consultation between the local communities and the government organizations to promote the relocation program. The views of the elderly and women were properly reflected in planning of the housing complex and layout of houses. The town planning committee formulated the concept of the relocation program as "sustaining rich nature and harmonizing town building with nature" through incorporating these activities' outputs. Japanese style single story row houses were proposed for the elderly people living alone so that community members can watch over and help each other.

The local communities have historically maintained social bonds of supporting each other in communities. The strong relationship among community members contributed to consensus building of the relocation program (Hirakawa 2015).

Conclusion: Two practices show that recovery programs need consensus building of various groups including women and the elderly; and integration among multi-sectors, such as environment, ecosystem, and town planning. Local communities are expected to lead planning recovery programs under support from experts and CSOs outside.

Reference

Hirakawa Z. (2015) Relocation program at high ground and people's time In *Considering rehabilitation of livelihoods and local communities: Case study in Kitakami District in Ishinomaki City, Miyagi Prefecture* (in Japanese), Tokyo, Kojinnotomo Sya.

Ranghieri F. Ishiwatari M. (2014) *Learning from mega-disasters: Lessons from the Great East Japan Earthquake*, Washington DC, World Bank.

74. Identification of Interchangeable Elements to Enhance the Implementation of EU-FRM Programs:Lessons Learned From UK and NL

Ellen Tromp† [1],Ruth Allin**,Jasper Luiten**

** Dutch Flood Protection Programme*

*** Environment Agency*

† Deltares

[1] *Dutch Flood Protection Programme PO Box 2232,3500GE, Utrecht, +31883357340, ellen.tromp@deltares.nl*

KEYWORDS: Cross country analysis, Flood Risk Management.

ABSTRACT

European countries, especially urban areas, face increasing flood risks due to urbanisation and the effects of climate change. Of all the natural hazards in Europe, flooding is the most common, and accounts for the largest number of casualties and highest economic damage. Unlike other natural hazards, no European country is free from the risk of flooding. Between 2000 and 2005, Europe suffered nine major flood disasters, which caused 155 casualties and economic losses of more than € 35 billion.

Flood risks will increase due to climate change, population growth and urbanisation. To respond to these pressures, further action is required. Under the framework of the Floods Directive(2007/60/EC), EU Member States are currently reflecting on their approaches, aiming to improve and integrate their Flood Risk Management Strategies and enhance societal resilience.

In this paper we focus on possible interchangeable elements across programs between England and the Netherlands. In the Netherlands, the Dutch Flood Protection Programme (DFPP) is an alliance of the regional water authorities (RWAs) and Ministry based upon joint responsibility and financing of flood protection measures along the coast, rivers and lakes. RWAs are responsible for the realization of the majority of the projects.

In England, the Flood and Coastal Erosion Risk Management Capital Programme runs from April 2015 to March 2021. The government will invest £2.3 billion in over 1,500 projects to reduce the risks of flooding or coastal erosion across the country. The programme is administered by the Environment Agency (EA) and schemes are developed by local authorities, internal drainage boards and the EA.

Our research showed two elements, namely funding (risk-based approach), and stakeholder engagement approaches, where the countries can learn from eachother.

We considered two dimensions of participation, based on Berry et al.(1993), namely width and depth of

participation, which together determine the strength of participation in the policy process.

The English funding model seeks to use “partnership funding” – contributions from other public or private organisations to increase the overall budget by 15% so more houses can be protected. In contrast the DFPP funds 100% of the flood protection work, which aims to bring defences in line with statutory levels of protection. However, it does seek additional contributions for additional benefits that can be incorporated in the re-design of flood defences.

Participation varies by scheme. In the English case early engagement, contributions from individual businesses and a community centred approach to maintenance ensured that the participation was wide and deep. The Dutch case showed that the participants were consulted. The identification of the interchangeable elements across English and Dutch programs enhance the implementation of the different schemes.

REFERENCES

Berry, J.M., K.E. Portney & K. Thomson (1993) The Rebirth of Urban Democracy, The Brookings Institution, Washington DC.

96. Multi-dimensional perspectives of flood risk – using a participatory framework to develop new approaches to flood risk communication

Rollason E.[1], Bracken, LJ.*, Hardy R. * and Large A.***

** Department of Geography, Durham University*

*** Department of Geography, Newcastle University*

[1] *Post: Department of Geography, Durham University, Science Laboratories, Durham University, South Rd, Durham DH1 3LE, Email: e.d.rollason@durham.ac.uk, Phone: 07508 740524*

KEYWORDS: flood risk, resilience, communication, community, participation.

ABSTRACT

Flooding is a major hazard in England, potentially affecting over 5 million properties. Climate change is predicted to increase the risks posed by flooding in the future. The effective communication of flood risk information plays a major role in allowing those at risk to make decisions about flood risk and prepare for floods. Hence, there is an urgent need to integrate people living at risk from flooding into flood management approaches, encouraging flood resilience and the up-take of resilient activities.

Objectives

The research presented explores current approaches to flood risk communication and the effectiveness of these methods in encouraging resilient actions before and during flooding events. The research also investigates how flood risk communications could be undertaken more effectively, using a novel participatory framework to integrate the perspectives of those living at risk.

Methods

The research uses co-production between local communities and researchers in the environmental sciences, using a participatory framework to bring together local knowledge of flood risk and flood communications. Using a local competency group, the research explores what those living at risk from flooding want from flood communications in order to develop new approaches to help those at risk understand and respond to floods. Suggestions for practice are refined by the communities to co-produce recommendations.

Results

The research finds that current approaches to real-time flood risk communication fail to forecast the significance of predicted floods, whilst flood maps lack detailed information about how floods occur, or use

scientific terminology which people at risk find confusing or lacking in realistic grounding. This means users do not have information they find useful to make informed decisions about how to prepare for and respond to floods. Working together with at-risk participants, the research has developed new approaches for communicating flood risk. These approaches focus on understanding flood mechanisms and dynamics, to help participants imagine their flood risk and link potential scenarios to reality, and provide forecasts of predicted flooding at a variety of scales, allowing participants to assess the significance of predicted flooding and make more informed judgments on what action to take in response.

Conclusions

The findings presented have significant implications for the way in which flood risk is communicated, changing the focus of mapping from probabilistic future scenarios to understanding flood dynamics and mechanisms. Such ways of communicating flood risk embrace how people would like to see risk communicated, and help those at risk grow their resilience. Communicating in such a way has wider implications for flood modelling and data collection. However, these represent potential opportunities to build more effective local partnerships for assessing and managing flood risks.

99. Mayors and "their" land: considering options for municipal flood risk reduction in post socialist setting

Slavíková L., Raška P.**, Kopáček M.†*

** Faculty of Social and Economic Studies, J.E. Purkyně University, Moskevská 54, 400 96, Ústí nad Labem, Czech Republic, +420 475 284 910, lenka.slavikova@ujep.cz*

*** Faculty of Science, J. E. Purkyně University, České mládeže 8, 400 96, Ústí nad Labem, Czech Republic, +420 475 283 300, pavel.raska@ujep.cz*

† Faculty of Social and Economic Studies, J.E. Purkyně University, Moskevská 54, 400 96, Ústí nad Labem, Czech Republic, +420 475 284 912, miroslav.kopacek@ujep.cz

KEYWORDS: flood, municipalities, risk reduction measures, land management

ABSTRACT

A flood occurrence is always followed by discussions of the extent of public relief provisions, issues of responsibility and liability for damages (particularly public versus private risk-sharing) and innovations of mitigation strategies (Hartmann and Albrecht 2014). Despite considerable decentralisation and participatory effort Europe-wide (e.g., Thaler and Levin-Keitel 2016), central governments play the most important role in flood risk management. This is even more obvious in post socialist countries (Raška 2015), and may (under some circumstances) crowd out the initiative of local actors (cf. Raschky and Weck-Hannemann 2007, Slavíková 2016).

Our objective is to analyse what are the potentials and barriers for the flood risk reduction measures in small and medium-size municipalities (less than 20 thousand inhabitants) viewed by their Mayors (as key municipal representatives). The Czech Republic is used as a case study. Since Czech Mayors possess strong competencies regarding land-use planning, the focus is on so-called natural water retention measures (renaturalization of streams, floodplains conservation, buy-outs, etc.) that require access to land.

For this purpose, more than 20 municipalities was selected based on the share of buildings situated in 100-year floodplains. The selection of municipalities with more than 30 % of buildings located in floodplain was made by spatial analyses in GIS by integrating modelled floodplain extent and official digital geodatabase for the Czech Republic. Than a qualitative research design was adopted: face-to-face interviews with semi-structured questions with all mayors have been undertaken, recorded and transcribed. The collected texts were coded with the use of Atlas.ti and keywords clustered and interpreted within the analysed context. The results provide first wider empirical evidence for perceived barriers and potentials of the individual flood risk reduction measures as viewed and experienced by mayors in the Czech Republic.

REFERENCES:

Hartmann T. and Albrecht J. (2014) From Flood Protection to Flood Risk Management: Condition-Based and Performance-Based Regulations in German Water Law. J Environ Law, 26(2), 243–268.

Raschky P.A. and Weck-Hannemann,H. (2007) Charity Hazard – A Real Hazard to Natural Disaster Insurance? Environ Hazards, 7 (4), 321–329.

Raška, P. (2015) Flood risk perception in Central-Eastern European members states of the EU: a review. Natural Hazards 79(3), 2163–2179.

Slavíková L. (2016) Effects of government flood expenditures: the problem of crowding-out. Journal of Flood Risk Management, DOI:10.1111/jfr3.12265.

Thaler T. and Levin-Keitel M. (2016) Multi-level stakeholder engagement in flood risk management – A question of roles and power: Lessons from England. Environ Sci Policy, 55, 292-301.

139. Identifying tipping points in flood resilience and anticipatory governance: an Alpine case study

Marco Borga[1], Roberto Poli**, Rocco Scolozzi**, Ruggero Valentinotti†, Stefan Fait†*

** Department of Land, Environment, Agriculture and Forestry, University of Padova, Italy,*

*** Department of Sociology and Social Research, University of Trento, Italy*

† Servizio Bacini Montani, Autonomous Province of Trento, Italy

[1] AGRIPOLIS, via dell'Università, 16, Legnaro (PD), IT-35020 Italy, e-mail: marco.borga@unipd.it

KEYWORDS: Flood risk management, climate change, community resilience, anticipatory governance.

ABSTRACT

Dealing with possible changes in future climate, as well as in population, economy and society is one of the biggest challenges in flood risk management. Addressing this challenge requires a new way of planning and management, termed here anticipatory governance, which is capable to enhance adaptive potential, keeping options open and avoiding lock-in. An emerging method termed adaptation tipping point – opportunity assesses a system's climate-incurred tipping points and uses opportunities arising from social developments to introduce adaptation strategies while reducing investment costs. In this work we extend the method to examine changes related to economy and society. The method is based on the examination of the flood system and how much change (due to climate change) it can handle, given the thresholds that are modified taking into account the prospected changes in economy and society. A tipping point depends solely on the magnitude of change and on the threshold selection, and not on time.

Prospected changes in economy and society are examined by considering different strategic scenarios, which are prepared working together with different groups of stakeholder and addressing different aspects of flood risk management and anticipation. Scenarios development and discussion is meant to help actors to better understand the nature and magnitude of the challenges, whether customary habits have to be modified and how, and the choices that should be implemented.

The study is developed in the frame of the LIFE FRANCA project, and will focus on three social communities in the Eastern Italian Alps, characterised by different flood risks and varying spatial and organisational complexities. The practical objective is to explore i) whether adaptation tipping points are a useful concept for assessing and communicating the implications of climate change, as well as changes in economy and society, and ii) how these concepts can help decision makers in developing and prioritising adaptation strategies and developing anticipatory governance.

159. Modelling human decision-making in agent-based models of flood events

Roxburgh N.[1]*

** School of Earth & Environment, University of Leeds*

[1] Email: ee12nr@leeds.ac.uk; Address: School of Earth and Environment, University of Leeds, Leeds, LS2 9JT; Phone: +44 7895 309781

KEYWORDS: agent-based modelling; decision-making; behaviour

ABSTRACT

While agent-based models have been used to study a range of issues around disaster management, application to the particular sub-field of flood management is still in the nascent stages. Nonetheless, agent-based modelling offers huge potential for exploring questions related to population readiness, response, and recovery in respect to flood events. One of the most significant challenges would-be modellers face within the field is to imbue virtual human agents and organisational actors with suitable decision-making capabilities. Deterministic “if-then” behavioural rules can be adequate in certain cases, but many research questions will require modelling of more sophisticated decision-making processes and recognition of heterogeneity in agent thinking. For example, agents might need to anticipate how flood events could develop going forward and appraise the merits of various behavioural options on this basis, factoring in their particular needs, capabilities, risk tolerances, and so forth. This paper surveys the decision-making architectures that have thus far been employed in agent-based models of flood and disaster events and categorises them by the nature of the research questions being addressed in order to identify the practices that currently prevail. The extent to which modelling choices have been guided by behavioural theories or empirical evidence is also assessed, as are the efforts that have been made to validate model outcomes. The survey found that a wide range of approaches to modelling agent decision-making have been used, most of them being chosen on an ad hoc basis. Due to differences between research questions and difference between geographical contexts, different models also tend to place emphasis on different decision domains and decision-making mechanisms. It is apparent that certain aspects of agent decision-making relevant to potential flood management studies remain underdeveloped, though practices used in other fields where agent-based models have been applied could be drawn upon to address this. While recognising that most models require a bespoke set of design choices be made, this paper identifies a set of features, capabilities, and practices that would-be modellers should at least consider when determining the design of the agent decision-making architectures that they employ. Cases where these features, capabilities, and practices have already been implemented are provided.

373. Residents and flood risk management in Flanders (Belgium): two worlds apart?

Barbara Tempels, Kobe Boussauw**, Luuk Boelens**

** Centre for Mobility and Spatial Planning, Ghent University, Belgium*

*** Cosmopolis, Vrije Universiteit Brussel, Belgium*

[1] *Vrijdagmarkt 10/301, 9000 Gent, BELGIUM, barbara.tempels@ugent.be, +32 9 331 32 55*

KEYWORDS: responsibility; governance; residents; survey; property level protection

ABSTRACT

The flooding issue is usually framed as a physical problem. When conflicts arise between the physical system (water) and the socio-spatial system (land), solutions are often restricted within the confines of the water system. However, flood risks have an important socio-spatial component, such as urbanization in floodplains, the increasing share of sealed land, or the development of real estate values. These spatial developments are influenced by a large number of individual decisions, such as location choice, or private flood protection measures.

Due to challenges such as climate change, flood risk management is shifting towards including spatial development through responsibilization of spatial planners and civil society. However, socio-spatial aspects such as existing properties and land use rights and the lack of the private sense of responsibility impede the inclusion of spatial development in managing flood risks. Since flood risk management research has mainly focused on the isolated study of (mostly technical) systems, there is little knowledge available on how to overcome this.

To gain insight in the socio-spatial aspect of flooding, this paper analyzes the point of view of residents of flood-prone areas, based on a survey (n=183) in the Dender basin (Flanders, Belgium). The paper first discusses three themes: the relation of residents to their residence and their willingness to move, their sense of responsibility, and potential seeds of self-initiative. The survey shows that residents are very much attached to their homes, but at the same time take very little action. Remarkable is that even though Belgium has a relatively weak tradition in spatial planning, they place responsibility for living in flood-prone areas on the government, and therefore they feel entitled to public protection. The paper then reflects on how formal flood risk management and society interact, and how this reciprocal relation can be more fruitful.

Climate change impacts (i)

34. Dynamic Resilience to Climate Change Caused Natural Disasters in the Greater Vancouver, Canada
Prof Slobodan Simonovic, The University of Western Ontario, Canada

37. Rewilding in a managed landscape – a case study from the Lake District
Mr Lee Schofield, The RSPB, United Kingdom

68. Transferring Research knowledge of Climate Change Uncertainty in Flood Risk Management in Scotland
Dr Lila Collet, Heriot Watt University, United Kingdom

131. Rainfall intensity-duration-frequency curves in a city of Brazilian coast under climate change
Ms Daniela Martins, Instituto Tecnológico da Aeronáutica – São José dos Campos, SP – Brazil Brazil

165. Changes in flooding inferred from centennial length streamflow data records
Dr Paul Whitfield, University of Saskatchewan, Canada

34. Dynamic Resilience to Climate Change Caused Natural Disasters in the Greater Vancouver, Canada

Simonovic, S.P.[1], and Peck, A.**

** Department of Civil and Environmental Engineering, The University of Western Ontario, London, Ontario, Canada*

[1] simonovic@uwo.ca, +1(519)661-4075

KEYWORDS: resilience, flooding, systems approach, adaptation, climate change

ABSTRACT

Objectives: The framework is designed to provide (i) for better understanding of factors contributing to urban resilience; and (ii) for comparison of climate change adaptation options. Its implementation in the Greater Vancouver is presented.

Methods: Disasters occur at the intersection of hazards and vulnerabilities. As the climate changes, so do the patterns of climate hazards. Coastal megacities, like Greater Vancouver are faced with many challenges including (i) increased exposure to natural hazards such as hurricanes, typhoons, storm surges, sea-level rise and riverine flooding; (ii) pressures of increasing urbanization and population growth; and (iii) increased complexity of interacting subsystems. An original method for quantification of resilience is provided through spatial system dynamics simulation. The quantitative resilience framework combines economic, social, health and physical impacts of climate change caused natural disasters on coastal megacities. The developed measure defines resilience as a function of time and location in space. The framework is being implemented through the system dynamics simulation model in an integrated computational environment.

Results: Data collection for the Coastal Megacity Resilience Simulator (CMRS) model input and discussions with local decision makers were the basis for model development for the primary case study coastal city of Greater Vancouver, British Columbia, Canada. Three policy driven adaptation scenarios are compared using the resilience metric and two climate change scenarios.

37. Rewilding in a managed landscape – a case study from the Lake District

Lee Schofield[1], George Heritage***

** RSPB*

*** AECOM*

[1] *Lee Schofield, RSPB Haweswater, Naddle Farm, Bampton, Penrith, Cumbria CA10 2RP, 01931 713376, lee.schofield@rpsb.org.uk*

KEYWORDS: river restoration, geomorphology, farming, biodiversity, water quality

ABSTRACT

OBJECTIVES

Climate change increases the likelihood and potential severity of flooding. Following the devastating floods affecting Cumbria, there is considerable local and national interest in measures that could help to reduce the impacts of flooding. The RSPB in partnership with EA, UU & NE have completed the restoration of over 1km of the Swindale Beck, within their RSPB Haweswater reserve. The project aims to provide information on the compatibility of river restoration and the reinstatement of natural processes with farming. It is anticipated that restoring sinuosity to the Swindale Beck will increase salmonid spawning habitat and invertebrate diversity and abundance, improve raw drinking water quality through increased sediment deposition, demonstrate natural flood management measures. This project is a microcosm of the trial management RSPB and UU are undertaking in the Haweswater drinking water catchment to see how improved biodiversity, raw water quality and other public benefits can be integrated within an extensive sheep farming operation (RSPB, 2015).

METHODS

A restored sinuous course was excavated following designs based on a DEM and the locations of paleochannels. A relatively basic channel was created with the expectation that natural processes would create the desired in-river features after connection. Work was challenging due to the sensitive nature of the surrounding land and weather typical of upland environments. In order to enhance the surrounding hay meadow habitat, seed was harvested and spread onto the old river channel after in-filling. The new channel was created in an area of meadow which was permanently waterlogged and species poor, with the aim of increasing the extent of species-rich hay meadow habitat, in addition to improving river habitats.

RESULTS

The restored channel is 140m longer and 2m wider than the corresponding section of straightened river (now in-filled) and better connected to the surrounding flood plain. Following connection the restored channel rapidly demonstrated the desired natural processes with the formation of new gravel bars, riffle sections and pools developing rapidly following high flows. The new channel is considerably more morphologically diverse

that the old channel and ecological diversity is anticipated to follow. Hay meadow habitat will take some time to fully recover and establish.

CONCLUSIONS

Monitoring of how the restored Swindale Beck interacts with surrounding land over the course of the channel's first winter (2016/17) will provide valuable insight into morphological aspects of river restoration and how compatible this type of 'rewilding' project is with the management of anthropogenic habitats such as hay meadows. A series of aerial photographs will describe the evolution of the new channel and its relationship with surrounding land. The intention is to have a hands-off approach to the restored channel, avoiding further management intervention unless deemed absolutely necessary.

REFERENCES

RSPB. (2015). Farming with Nature at RSPB Haweswater (online). Available at: http://www.rspb.org.uk/Images/HWR-0629-15-16%20Haweswater%20management%20plan%2016pp%20low%20res_tcm9-412269.pdf (accessed 18th Nov 2016)

68. Transferring Research knowledge of Climate Change Uncertainty in Flood Risk Management in Scotland

Collet L.[1], Beevers L.* and Stewart M.D.***

** Heriot-Watt University, Edinburgh Campus, Edinburgh EH14 4AS, UK*

*** Kaya Consulting, Phoenix House, Phoenix Cres, Bellshill ML4 3NJ, UK*

[1] *Corresponding author: Lila Collet, l.f.collet@hw.ac.uk, +44 (0) 131 451 4549*

KEYWORDS: Climate Change impact; Cluster Analysis; Decision Trees; Extreme Value Theory; Regionalization anaysis.

EXTENDED ABSTRACT

Objectives: Climate change impact research is continually evolving, particularly regarding flood hazard. Recent research looks to account for the uncertainties related to climate change projections, moving from deterministic to probabilistic approaches. However, the outcomes of such research are rarely adopted by stakeholders, leading to little impact on society. This work aims to address this gap using a transdisciplinary approach to transfer research knowledge of climate change impact and uncertainty to flood risk management (FRM) practitioners.

Methods: First, an analysis of the Future Flow Hydrology (FFH) database (Prudhomme et al., 2013) for 95 gauging stations in Scotland was performed to assess probabilistic changes in extreme flows and the related uncertainties for different return periods on the baseline (1961-1990) and the 2080s (2069-2098). Two probabilistic distributions, the Generalized Extreme Value (Coles, 2001) and the Generalized Logistic (Hosking & Wallis, 1997) were fitted to the 11 ensemble members which constitute the FFH database, and Climate Model and Probabilistic Distribution function uncertainties were computed (following Collet et al,. 2017). Second, the future return period flows were analysed to answer the stakeholders' question: What would be the probability of future lower return period flows (1:10, 30, 50 and 100 years) to become higher than the current return period flow (1:200 years) used within national (Scottish) planning guidance? The key issue being to what extent will design standards in present day development be eroded over time due to climate change. Third, a regionalization analysis was performed to apply the probabilistic analysis and uncertainty assessment to ungauged catchments in Scotland using: (i) a cluster analysis to gather the catchments into homogeneous groups, (ii) catchment characteristics were extracted from the FEH (Flood Estimation Handbook) database and a selection was made to determine the ones that could explain the most differences between clusters following Chiverton et al. (2015), and (iii) decision trees were built based on the selected catchment characteristics for use in ungauged catchments as shown by Kay et al. (2011).

Results: For each gauging station a database was developed which gathers the assessment of peak flows and associated uncertainties for the 1:2, 5, 10, 20, 50, 100, and 200 year return periods for the baseline (1961-1990) and the future (2069-2098). Flood Frequency and Growth Factors curves were plotted for each ensemble-member and the associated 95% confidence intervals. For the median 1:200-year return period peak

flow (Fig. 1), there is an east-west gradient across Scotland with the highest values on the west and the highest increase from the baseline to the 2080s for catchments on the east part of Scotland (up to +80%). The Climate Model Uncertainty (CMU) is higher on the baseline for catchments in the northeast and southeast of Scotland, and shows a significant increase in CMU the 2080s for 40% of the catchments in the north of Scotland and across the Central Belt the change (up to +150%). The Probabilistic Distribution Uncertainty (PDU) is higher on the baseline for catchments on the north and southeast of Scotland, and shows a significant increase in the future for 30% of the catchments, particularly on the east coast (up to +30%).

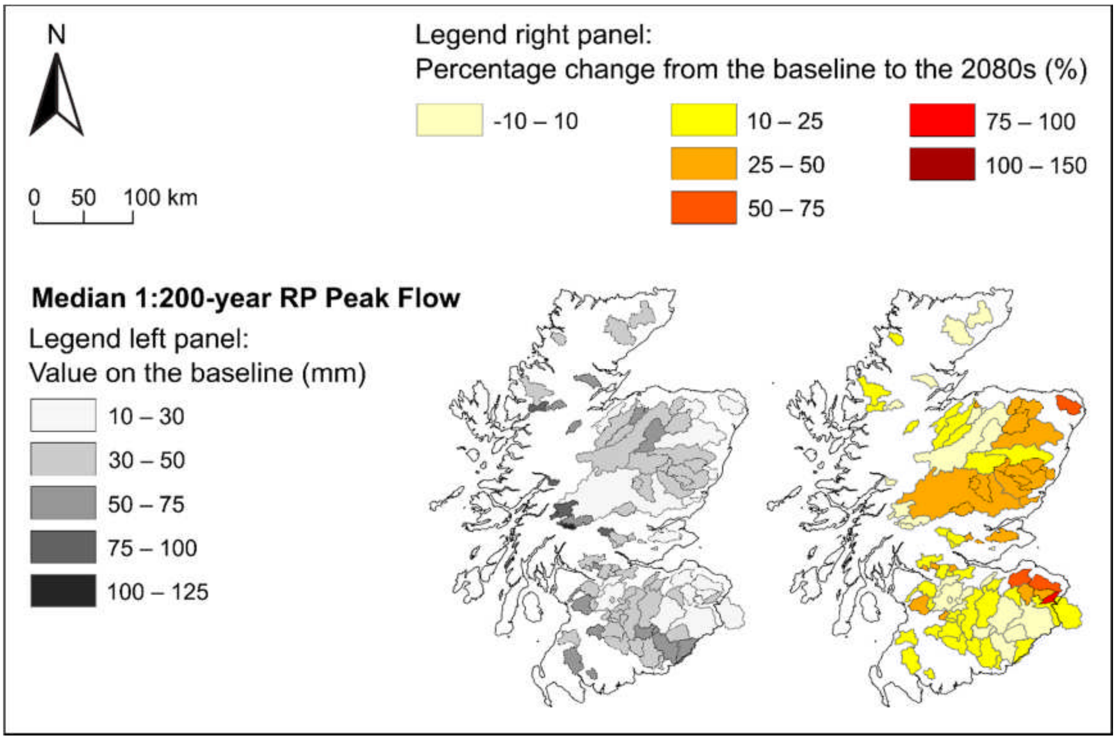


Fig. 1 Results across Scotland on the baseline (left panel) and percentage change to the 2080s (right panel) for the median 1:200-year return period peak flow

Secondly, the 1:10- and 1:30-year floods in Figure 2 show a majority of catchments with very low (0-20%) to low (20-40%) probability to exceed the baseline 1:200-year flood (see Fig. 1). However, the 1:50-year flood shows a high (60-80%) to very high (80-100%) probability of exceeding the baseline 1:200-year flood in east and central Scotland, and this trend spreads to the 1:100-year flood for catchments in the west and south of Scotland.

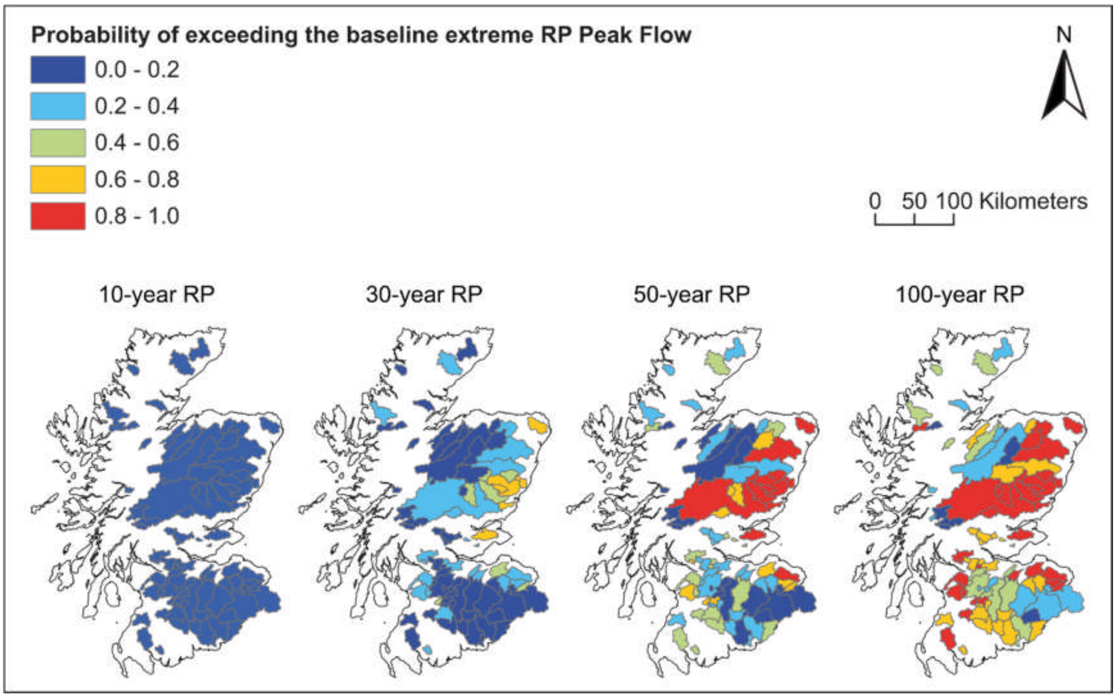


Fig. 2 Probabilistic maps of low-return period floods to become higher in the 2080s than the medium baseline 1:200-year flood

Finally, the Cluster analysis reflects three categories of percentage change in extreme peak flow: no significant trend, a small increase, and a larger increase (Fig. 3). Nine catchment characteristics explain the discrimination between these three clusters: the baseflow index, flood attenuation from reservoirs, the centroid coordinate, mean drainage path length, average annual rainfall, standard percentage runoff, soil wetness, mean altitude, and urban extent. Similar regionalization analysis was performed on the percentage change of the Climate Model and the Probabilistic Distribution uncertainties with respectively four and seven catchment characteristics discriminating the corresponding catchment clusters.

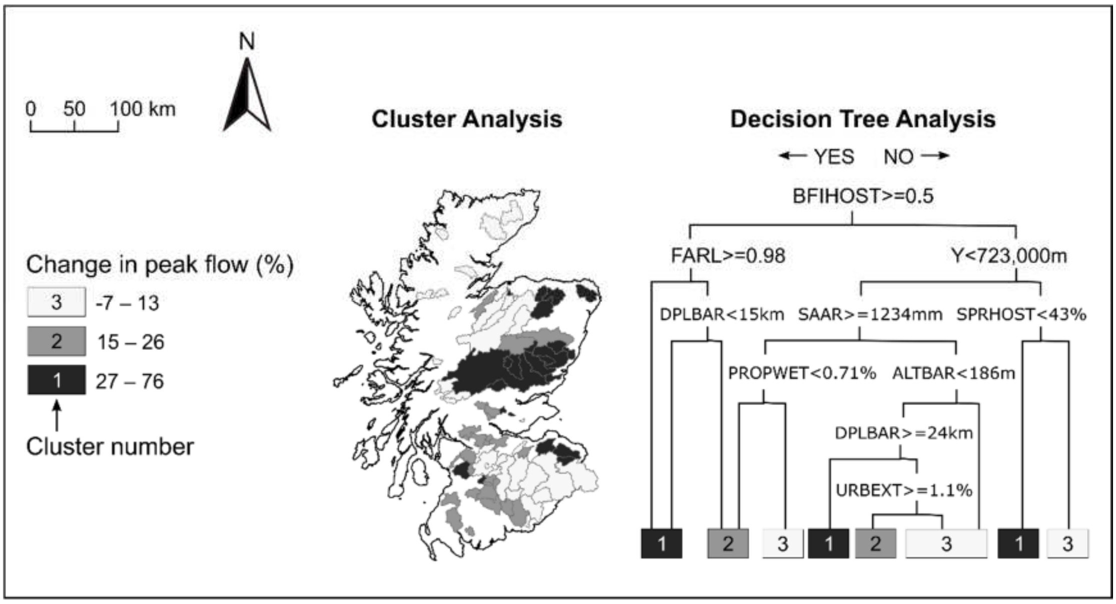


Fig. 3 Cluster analysis and Decision Tree analysis across Scotland on the percentage change from the baseline to the 2080s in the median 1:200-year return period peak flow

Conclusions: Further work is proposed where the results of the analysis can be used to test the applicability of local and national planning guidance in terms of flow increases due to climate change and freeboards for Finished Floor Levels within development.

References:

Chiverton, A., Hannaford, J., Holman, I., Corstanje, R., Prudhomme, C., Bloomfield, J., and Hess, T.H. Which catchment characteristics control the temporal dependence structure of daily river flows? Hydrol. Process. 2015, 29, 1353–1369, doi: 10.1002/hyp.10252.

Coles, S. (2001) An Introduction to Statistical Modelling of Extreme Values. Springer-Verlag, London.

Collet, L., Beevers, L., Prudhomme, C. Assessing the Impact of Climate Change and Extreme Value Uncertainty to Extreme Flows across Great Britain. Water 2017, 9, 103; doi:10.3390/w9010103

Hosking, J.R.M. & Wallis, J.R. Regional Frequency analysis: an approach based on L-moments. Cambridge University Press, 1997; 224 pp.

Kay, A.L., Crooks, S.M., Davies, H.N. and Reynard, N.S. An assessment of the vulnerability of Scotland’s river catchments and coasts to the impacts of climate change - Work Package 1 Report. Centre for Ecology and Hydrology report, Wallingford, UK, 2011; 140 pp.

Prudhomme, C.; Haxton, T.; Crooks, S.; Jackson, C.; Barkwith, A.; Williamson, J.; Kelvin, J.; Mackay, J.; Wang, L.; Young, A.; et al. Future Flows Hydrology: An ensemble of daily river flow and monthly groundwater levels for use for climate change impact assessment across Great Britain. Earth Syst. Sci. Data 2013, 5, 101–107.

131. Rainfall intensity-duration-frequency curves in a city of Brazilian coast under climate change

Martins, D. [1], *Queiroz, P. I. B.* [2], *Smaha, N. K.* [3] *and Gandini, M. L. T.* [4]

[1]*Instituto Tecnológico da Aeronáutica – São José dos Campos, SP - Brasil. Doctoral student. E-mail: engdanimartins@gmail.com*

[2]*Instituto Tecnológico da Aeronáutica – São José dos Campos, SP - Brasil. Professor at Geotechnics Department. E-mail: pi@ita.br*

[3]*Instituto Tecnológico da Aeronáutica – São José dos Campos, SP - Brasil. Professor at Water Resources and Environmental Sanitation Department. E-mail: nadiane@ita.br*

[4]*Instituto Tecnológico da Aeronáutica – São José dos Campos, SP - Brasil. Doctoral student. E-mail: mltgandini@gmail.com*

ABSTRACT

Drainage systems are dimensioned for a design storm based on intensity-duration-frequency (IDF) curves of extreme precipitation, established for a given location because they vary with hydrological conditions. These curves may also vary with time, and should be updated with recent data. Climate models are useful in assessment of the impact of climate changes on drainage systems, through precipitation forecasts.

The aim of this work is to present and validate future IDF curves under the climate changes to design drainage systems. The IDF curves are obtained from Eta regional climate model (RCM) data. These curves are validated by comparison with IDF curves obtained from several years of rainfall gauge data.

KEYWORDS: IDF curves, urban drainage, regional climate model, bias correction, climate changes.

INTRODUCTION

Urban drainage systems are design using IDF equation based in past rainfall data. These IDF curves may change under climate change and these changes may arise as the size of hydraulics structures. According to Willems (2013), oscillations in climate and related rainfall extremes may lead to several complications in hydrology and these complications affect rainfall design statistics.

According to Nahar et al. (2017), Global Climate Models (GCM) are the main tools for estimating changes in the climate for the future. In order to get better scale results, this work uses Eta regional climate model (RCM) data with 20km of resolution. Spatial resolution of global climate models is still insufficient to adequately describe many regional climate processes (Christensen et al., 2008). The RCM (Eta) was nested in two GCM: HadGEM2-ES (Collins et al.,2011 and Martin et al., 2011) and MIROC5S (Watanabe et al., 2010).

Nahar et al. (2017) also complete that the imperfect representation of these models introduces biases in their simulations that need to be corrected prior to their use for impact assessment. The bias correction methods usually assume that the bias calculated over the historical period does not change and they can be applied to the future. This methodology was done in this work and replied to the future based on the gamma distribution (Vlček and Huth, 2009) for the extreme values of the series (Wilks, 2011), which reads.

$$f(x) = \frac{\left({}^{x}/_{\beta}\right)^{\alpha-1}\exp(-\frac{x}{\beta})}{\beta\Gamma(\alpha)}\ , x, \alpha, \beta > 0, \qquad [1]$$

This distribution function has two parameters: α, shape parameter and β scale parameter and x is the random variable. It should be stressed that both the simulated and the observed distributions of rainfall intensities used in this work have their adherences to gamma distribution verified by the Lilliefors test (Wilks, 2011).

MATERIAL AND METHODS

The region of study is the northern coast of São Paulo state, in Brazil. Precipitation data series from rain gauge E2-046 (latitude 23°38'00"S and longitude 45°26'00"W) were provided and used in order to construct partial duration series made of the 31 annual largest observations during the period from 1971 to 2001.

The Eta Regional Climate Model (RCM) was forced by two global climate models, the HadGEM2-ES and the MIROC5 run at 100-km resolution which were simulated for the period 1961-2005.

The RCM were used to downscale future daily precipitation extremes at the rain gauge station E2-046, at the same coordinate under two IPCC (IPCC, 2013 and 2014) climate change scenarios, RCP4.5 and RCP8.5.

RESULTS

Figure 1 shows the comparison between rain gauge data series (1974-2001) for different return periods (10, 25, 50 and 100 years). It is remarkable that while Eta-HadGEM2-ES results have better adjust to rain gauge data for longer precipitation durations, Eta-MIROC5S results are closer for 10-minute duration.

For future precipitations, Eta-MIROC5S always tends to underestimate the results in comparison to past data, that is, this model predicts extreme rainfalls lower than past rainfall data. On the other hand, the future IDF curves from Eta-HadGEM2-ES almost overlapped the observed data series.

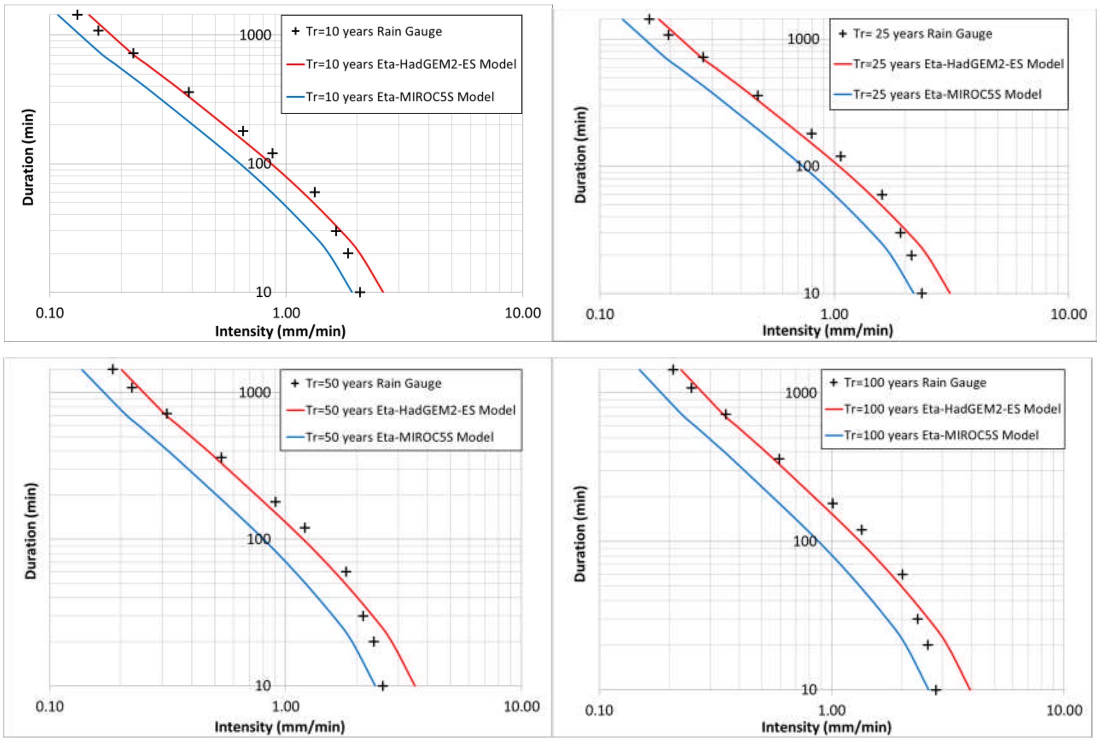


Figure 1: IDF curve generated by rain gauge from data series from 1971 to 2001 and future IDF's curve of RCM Models from future data base (from 2007 to 2099).

CONCLUSIONS

This paper presents comparisons of IDF curves from rain gage data and a regional climate model nested in global models, Eta-HadGEM2-ES and Eta-MIROC5S.

IDF curves generated are practically identical for RCM Eta-HadGEM2-ES and rain gauge E2-046, but when the duration is short (10 minutes), the IDF curves of RCM Eta-MIROC5S tend to be closer of the observed data, based on 31 years of data series. Future IDF curve generated from Eta-HadGEM2-ES presents higher extremes values when compared to Eta-MIROC5. Nevertheless, both prediction curves present good correlation with observed data.

It should be remarked that bias correction techniques are fundamental for climate forecasting application to hydraulic design, because these methods reduces systematic errors produced by global climate models. Furthermore, the technique presented in this work for extreme rainfall predictions seems to be very useful for drainage projects, in order to take into account climate changes over design calculations.

ACKNOWLEDGEMENT

The E2-046 rain gauge data series was made available by Department of Water and Electric Energy of São Paulo State (DAEE). The Eta RCM precipitation data series from Eta regional model was provided by Center for Weather Forecasting and Climate Studies (CPTEC) in the person of Chou Sin Chan, to whom all the authors are very grateful.

REFERENCES

Collins, W. J., et al. (2011) Development and Evaluation of an Earth-System Model—HadGEM2. Geoscientific Model Development, 4, 1051-1075, http://dx.doi.org/10.5194/gmd-4-1051-2011

Christensen, J. H. et al., (2008). On the need for bias correction of regional climate change projections of temperature and precipitation. Geophysical Research Letters, 35, L20709.

IPCC, 2013: Climate Change 2013: The Physical Science Basis. Constribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York.

IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Martin, G. M. et al., (2011) The HadGEM2 Family of Met Office Unified Model Climate Configurations. Geoscientific Model Development, 4, 723-757, http://dx.doi.org/10.5194/gmd-4-723-2011

Nahar, J. et al (2017) Assessing the extent of non-stationary biases in GCMs. Journal of Hydrology, 549, 148-162. http://dx.doi.org/10.1016/j.jhydrol.2017.03.045

Vlček, O. ; Huth, R. Is daily precipitation Gamma-distributed? Adverse effects of an incorrect application of the Kolmogorov-Smirnov test. Atmospheric Research, v.93, p. 759-766, 2009.

Willems, P. (2013) Adjustment of extreme rainfall statistics accounting for multidecadal climate oscillations. Journal of Hydrology, 490, 126-133. http://dx.doi.org/10.1016/j.jhydrol.2013.03.034

Watanabe, M., et al. (2010) Improved Climate Simulation by MIROC5: Mean States, Variability, and Climate Sensitivity. Journal of Climate, 23, 6312-6335. http://dx.doi.org/10.1175/2010JCLI3679.1

Wilks, D.S. Statistical methods in the atmospheric sciences. 3ª ed. New York:Elsevier, 2011. 669p. (International Geophysics Series, v.100)

Willems, P. (2013) Adjustment of extreme rainfall statistics accounting for multidecadal climate oscillations. Journal of Hydrology, 490, 126-133. http://dx.doi.org/10.1016/j.jhydrol.2013.03.034

165. Changes in flooding inferred from centennial length streamflow data records

Burn D.H.[1] and Whitfield P.H.***

** Civil and Environmental Engineering, Univeristy of Waterloo*

*** Centre for Hydrology, University of Saskatchewan*

[1] 200 Univeristy Avenue West, Waterloo, ON Canada, N2L 3G1, +1 519 888-4567 Ext 33338, dhburn@civmail.uwaterloo.ca

KEYWORDS: floods, climate change, flood regimes, flood generating processes.

ABSTRACT

This research seeks to determine ways in which climate change may alter the risk of flooding in cold regions. The research focusses on changes in the flood regimes at the selected watersheds and explores changes and shifts in the dominant flood generating processes at the watersheds.

Changes in flood regimes are examined using data from long term hydrometric reference streamflow gauging stations for flood regimes from natural watersheds in Canada as well as adjacent areas in the United States. We examine a collection of 27 gauging stations, whose data record spans most of the past century; 18 stations are from the Canadian Reference Hydrometric Basin Network (RHBN) and nine stations are from the U.S. Geological Survey (USGS) Hydro-Climatic Data Network (HCDN). These reference hydrologic networks were specifically developed to assist in the identification of the impacts of climate change; stations included are considered to have good quality data and were screened to avoid the influences of regulation, diversions, or land use change. Changes in flood regimes are complex and require a multifaceted approach to properly characterize the types of changes that have occurred and are likely to occur in the future. Choosing stations with nearly 100 years of data allows for the investigation of changes that span several phases of some of the atmospheric drivers influencing flood behaviour. Peaks over threshold (POT) data are extracted from daily flow data for each watershed and changes to the magnitude, timing, volume and duration of threshold exceedences are investigated. Seasonal statistics are used as a basis to explore changes in the nature of the flood regime based on changes in the timing of flood threshold exceedences. A variety of measures are developed to infer flood regime shifts including from a nival regime to a mixed regime and a mixed regime to a more pluvial-dominated regime.

All flood regimes show an increased number of events. Nival sites in general show increases in quantile estimates for longer return periods. The flood regime at many of the subject watersheds demonstrates an increased prevalence of rainfall flood responses, as events occur more often during the rainfall dominated portion of the seasonal cycle resulting in a shift from a nival to a more mixed regime, and for mixed regime stations to transition towards a more pluvial regime. The results support viewing hydrologic regime as a continuum from nival to pluvial with several stations demonstrating a move towards the pluvial end of this continuum.

Governance (ii)

138. Implementation of EU Floods Directive in Finland – lessons learned and steps towards resilient planning
Mr Juha Aaltonen, Finnish Environment Institute, Finland

174. Outcomes Achieved Through Interagency Flood Risk Management Efforts
Ms Elizabeth Bourget, US Army Corps of Engineers, United States

186. Woodland Creation – Implementing Best Practice
Mr Andrew Vaughan, Tilhill Forestry, United Kingdom

306. A national policy statement for flood defences: A route-map to ensure critical projects can be consented and delivered
Mr Gordon McCreath, Pinsent Masons LLP, United Kingdom

310. Asset management framework for flood protection, with baseline data for North Sea Region countries
Dr Berry Gersonius, UNESCO-IHE Institute for Water Education, Netherlands

313. Asset management for flood protection infrastructure; a review of the barriers for implementation and a way forward
Mr Jeroen Rijke, HAN University of Applied Sciences, Netherlands

138. Implementation of EU Floods Directive in Finland – lessons learned and steps towards resilient planning

Juha Aaltonen[1], Antti Parjanne, Mikko Sane and Mikko Huokuna

Finnish Environment Institute, Water Centre, P. O. Box 140, FI-00251 Helsinki, Finland

[1] contact author juha.aaltonen@environment.fi @jkaalton +358 295 251 051

KEYWORDS: Flood risk management, Floods Directive, governance, lessons learned

European Union Floods Directive required member states to prepare preliminary flood risk assessment, flood maps and flood risk management plans by the end of 2015. The process will be reviewed every six years. The first cycle was a good learning experience and it is good to document, review and develop the planning process before the next cycle.

In order to find out the most important development needs for governance, tools and guidance, national flood risk coordination group launched questionnaire and round-up discussions in the beginning of 2016. Questionnaire was targeted to all stakeholders involved in the planning process, for example regional environment authorities, regional councils, municipalities, rescue services and consultants. Feedback was discussed further in a workshop and formulated in to a lessons learned document.

The preliminary flood risk assessment was done with a nationwide automatized general fluvial flood mapping tool. The tool utilized an accurate elevation model, building register and probability analysis for flood levels. Risk squares defined by the rescue authority were produced based on the mapping results (Figure 1). The final decision of significant flood risk areas was made by using preliminary maps together with other available data. Pluvial floods were not covered in this detail on the first cycle, but a method to cover them is now under development. No significant flood risk areas were named on due to pluvial flood risk. In future, preliminary surface water flood maps for population centres will give all municipalities a better and equal starting point for pluvial flood risk assessment. In Finnish legislation pluvial and coastal flood risk management are for regional governmental authorities whereas fluvial floods are for municipalities.

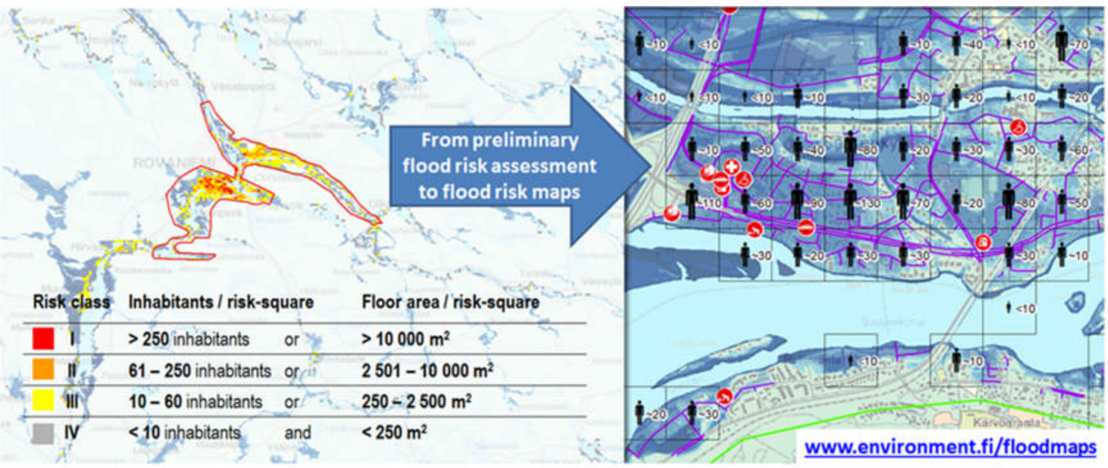


Figure 1. Criteria for risk-squares and an example about the flood risk map.

Based on the preliminary flood risk assessment by 13 regional Centres for Economic Development, Transport and Environment, the Ministry of Agriculture and Forestry named 21 areas of potential significant flood risk and regional flood risk management groups. Groups were formed by regional councils. Key authorities of the Finnish flood risk management are presented in Figure 3.

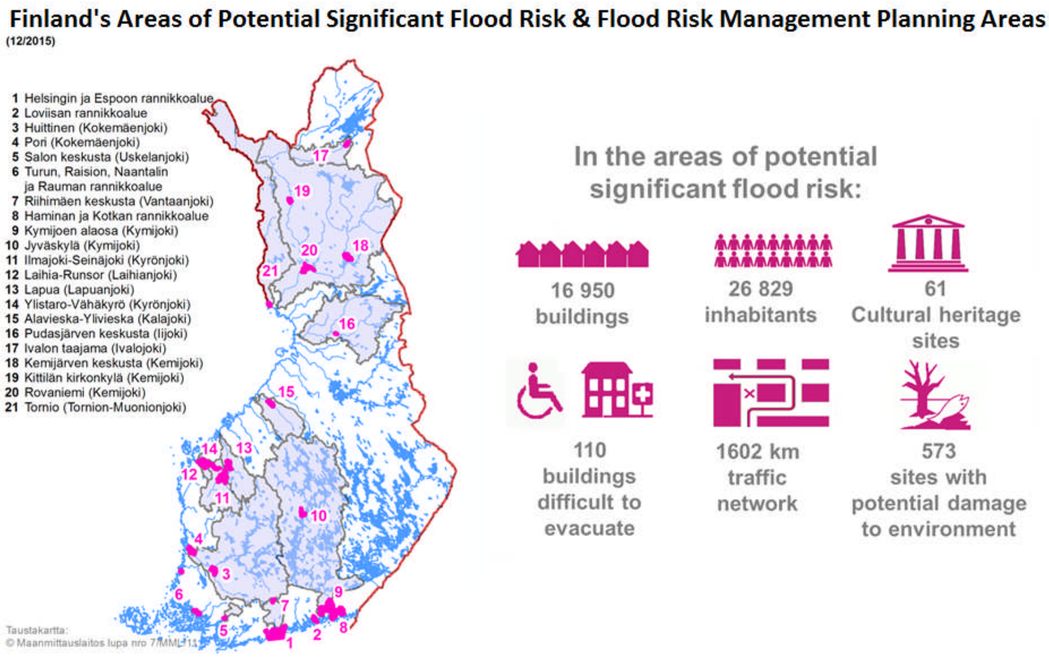


Figure 2. Finland's areas of potential significant flood risk, flood risk management planning areas and combined key figures. Figures are based on the estimation of the consequences of an extreme flood.

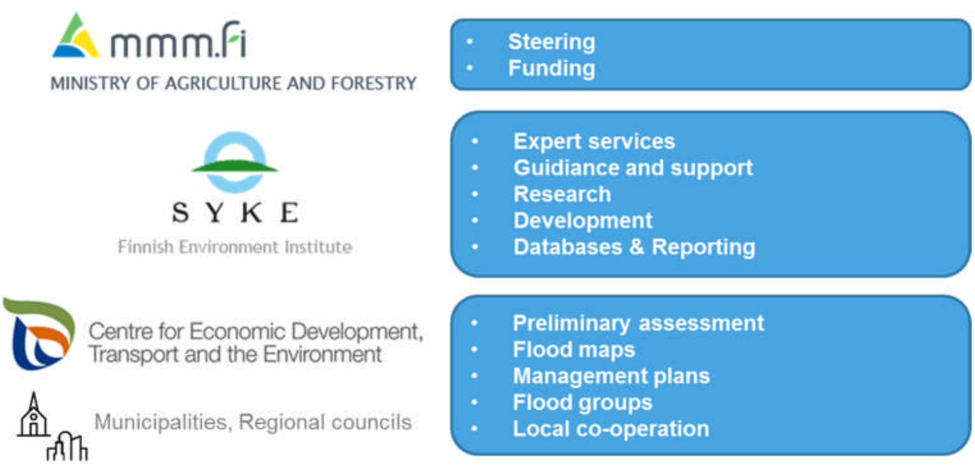


Figure 3. Key authorities and their roles in the Finnish flood risk management planning

Flood mapping was done with detailed elevation model (a 2m LiDAR elevation model is freely available for 90

% of Finland's area) and hydraulic modelling was used for rivers. Perceiving uncertainties, climate change impacts and special scenarios like ice break up jams and levee failures will be covered more closely on the next cycle. Pluvial flood modelling and risk mapping procedure must be created. Outsourcing the flood mapping and risk management plan writing is ought to increase according to past experiences and estimated governance resources available, so emphasis must be put on documentation, criteria and instruction. Maps will be delivered to Finnish Environment Institute which will publish them on the Flood map service and report them further to EU. Stakeholder feedback indicated, that there might be a need for simplified flood maps for public while the current maps could be used for planning. Finalising all maps in Finnish Environment Insitute could save resources.

There was a common framework for **flood risk management plans** consisting of table of context and general texts. This divided opinions, as some experienced this straightforward and easy while others considered this restricting and heavy. Plans became quite extensive as they were supposed to be up-to-date compilations of all flood plans in the river basin area. An effort has to be made to lighten the plan while keeping all the required content. One option is to screen out nationwide parts and process descriptions. Another solution could be compressing the essential to a public-friendly summary and attach else as appendices.

It was realised early that plans were not any good for public hearing in terms of promoting flood awareness and individual preparedness. For this purpose a joint effort was made together with river basin management planning and marine planning. Public hearing was done simultaneously under a common slogan, #vaikutavesiin ("act for waters") and a webpage which had popularised language together with map service and links to plans and feedback forms. As this didn't lead to significant amount of public feedback, news threshold was however exceeded. This good co-operation is going to be continued.

Joint planning between river basin management was limited to information exchange, cross-evaluation of the measures and simultaneous public hearing. These planning frameworks will most likely remain separate, as river basin management plans are even more comprehensive plans. Finnish flood risk management plans are quite locally concentrated and detailed, so flood issues would lose their weight on river basin management plans.

Perhaps the greatest needs for development and guidance are in setting objectives and assessing the effects and cost of proposed measures. Setting objectives for flood risk management was an iterative process as new information emerged when various accounts were completed. Some considered flood risk objects were identified too late whereas some felt lack of flood expertise and politicking hampered the work. Flood groups received a guideline document for objective setting from the national coordination group, which was found very useful. All the objectives should be connected to adverse consequences defined in the national flood risk management act and be detailed and measurable.

To assess the measures, flood groups were provided multi-criteria decision analysis frameworks which wereas used by the majority. They were found to improve understanding and ease comparison between different alternatives. It is very important to have a transparent assessment process. For the next cycle, measures must be climate proofed and they must be reflected against different flood probabilities and uncertainties.

For the cost estimation of the measures there will be more information based on the first cycle. A cost estimation tool should be expanded to include non-structural measures and indirect costs.

Table 1 summarises development needs for the next cycle.

Table 2. Summary of development needs for the next cycle.

General pluvial flood map product for preliminary flood risk assessment (PFRA)

- municipalities are responsible for pluvial PFRA, but they do no necessary have resources or equal starting points for this
- pluvial floods cause more and more adverse consequences, while municipalities often don't have methods and knowledge to prepare for those

Assessment of climate change, future land use planning and uncertainties throughout the planning process

- as flood risk management consist of consecutive analyses from historical observations to future projections, decision-making process should be aware of uncertainties

Improvement of flood maps

- pluvial flood hazard and risk map development and guidance
- dealing and visualising uncertainties
- mapping of indirect/economic consequences
- special scenarios (ice jam, levee overtopping)
- more simple layout for public flood awareness
- review of other communication methods than maps
- common flood map for entire coast with dense intervals (10-20cm)

Development of hydraulic modelling and flood mapping guidance

- use of consultants might increase, varying expertise within consultants
- proper and common modelling criteria is not available at the moment

Improving flood risk management plan outline and guidance

- current plans are too heavy, they need focus locally and to objects and measures

More understandable flood risk management (FRM) objectives

- connecting FRM objectives to adverse consequences and local flood risk

Development of evaluation methods for measures

- transparent and neural multi-criteria decision analysis framework
- improvement of cost-benefit and impact analysis (review of unit costs – also for non-structural and continuous measures)
- development of explicit prioritisation framework for measures

Early attention to river basin management planning (RBMP)

- Flood group should have a permanent RBMP member
- joint method and planning framework development
- joint communication

More effective knowledge sharing and support to regional level

- flood groups may have members with limited flood expertise
- information sharing increase understanding and mutual trust
- centralized preparation of common materials and information

Public hearing

- search of ways to communicate FRM interestingly and promote especially public awareness and preparedness
- deepening of co-operation with RBMP and marine planning
- consulting communication experts (no engineer talk, clear and uniform message)

Promoting flood risk management in areas not identified as significant

- floods may occur anywhere and this concept is applicable for all FRM

174. Outcomes Achieved Through Interagency Flood Risk Management Efforts

*Lisa Bourget**

** United States Army Corps of Engineers, Institute for Water Resources*

[1] 7701 Telegraph Road, Casey Bldg., Alexandria VA 22315

KEYWORDS: Indicators, benefits, outcomes, interagency, flood risk management

ABSTRACT

Flood risk management responsibilities in the United States are broadly shared among various levels of government, myriad public and private non-governmental organizations, and individuals. At the federal level, 14 agencies are members of or advisors to a Federal Interagency Floodplain Management Task Force that encourages programs and policies to reduce flood losses. Fifty states have multiple agencies that address flood risk management issues, working with local governments and other entities.

Within this overarching framework, the U.S. Army Corps of Engineers (USACE) provides a wide variety of floodplain management services nationwide. Although USACE can provide such services directly, sometimes it can leverage its investment or achieve expanded outcomes by delivering those services collaboratively with others. Recently, USACE has apportioned funds specifically to interagency work, with particular focus on nonstructural approaches to managing and reducing flood risks. Conducted jointly with other partners as special studies, the efforts provide USACE technical and planning assistance in support of solutions to state and local flood risk management issues across the nation. These interagency efforts pair USACE authorities, expertise, and resources with partners' authorities, expertise, and/or resources in order to pursue more comprehensive solutions and achieve flood risk management benefits together that could not be achieved by any one party alone. Over 250 such efforts have been funded to date, reflecting a wide variety of diverse approaches.

Documenting the benefits and outcomes achieved by these interagency efforts is seen as a critical aspect for conveying the value of the overall effort at the program level, including to those outside the flood risk management field. Estimating the time, expertise, and sometimes resources provided by other flood risk management partners acknowledges their contributions and shows how USACE apportioned funds are leveraged to achieve a greater whole. Documenting efforts' contributions toward reduced or better managed flood risk is a greater challenge. For each effort undertaken, USACE team members provide information on outcomes achieved.

Each effort's outcomes are considered along a flood risk management continuum that progresses from raising awareness, to prompting action, to achieving reduced or better managed flood risk. In addition, outcomes that achieve non-monetary social benefits and/or improve environmental function are reflected. In order to acknowledge all contributions and better capture the full scope of achievement in true partnership fashion,

outcomes are considered regardless of who achieves them as long as they are directly related to the effort undertaken.

Documenting outcomes in this manner provides a means of indicating an effort's contribution to overarching programmatic goals; this contribution is in addition to achievement of a specific effort's objectives. Placing outcomes in a continuum encourages consideration of how to progress further in that continuum, which may require partnership with others to achieve. The resulting information supports communication of successes achieved, what they mean, and and why they matter.

186. Woodland Creation - implementing best practice

Gallacher J., Vaughan A.

Tilhill Forestry, Duckburn Park, Stirling Road, Dunblane. FK15 0EW.

KEYWORDS: Woodland Creation, Diffuse Pollution, Natural Flood Management, Groundwater Dependent Habitat.

ABSTRACT

The Scottish Government have committed to a target of establishing 10,000ha per annum of new woodland to mitigate climate change, to secure an expansion of the productive timber resource to sustain the £1Bn per annum forest industry, and to provide a range of other benefits, including sustainable flood management.

This will entail a significant increase in woodland creation not seen since the 1980’s, but within the context of a much more complex strata of policy, grant scheme and stakeholder interests to negotiate. In addition, the practical experience of practitioners and stakeholders required to deliver significant woodland creation schemes is proving to be limited, and current policies and practices are having to be rapidly updated to reflect this.

Tilhill Forestry manage over 120,000ha of productive forests and over the past 10 years have delivered 5,000ha of new, mainly productive, woodland creation projects. The company’s Senior Ecologist, John Gallacher, has been responsible for managing grant approval for the projects, often involving Environmental Impact Assessments, scoped and consulted with stakeholders. Andrew Vaughan, has led a District forest management team in Central Scotland to deliver many of the projects.

The process of planning, delivering, consulting and delivering woodland creation projects typically involves a process of due diligence. This starts with an understanding of the UK Forest Standards minimum legal requirements and standards of good practice, reviewing the often conflicting site constraints, drafting a design compatible with the owner’s objectives and then consulting and resolving stakeholder interests – which may be site or constraint specific.

The authors, through direct practical experience from current projects, have recently developed and contributed to key areas of policy and will present three case studies:-

- Forest Hydrology - consideration of the impact of woody debris and runoff at the Jerah woodland creation site, which lies immediately upstream of a flood prone community;

- Diffuse Pollution – developing company and UK wide guidance and training to understand and manage the risks of diffuse pollution from forestry operations;

- Groundwater Dependent Habitats (GDH) – developing new industry guidance to identify and protect important GDH on proposed woodland creation sites.

Common issues encountered include: client/stakeholder expectations; policies being out of date; stakeholders lacking industry knowledge/experience; seeking consensus not adversity; and analysis-paralysis.

Andrew Vaughan FICFor,

District Manager

Tilhill Forestry

E: andrew.vaughan@tilhill.com

T: 01786 821666

306. A national policy statement for flood defences: A route-map to ensure critical projects can be consented and delivered

Gordon McCreath and George Wilson*[1]*

** Pinsent Masons LLP*

[1] Pinsent Masons LLP, 30 Crown Place, Earl Street, London, EC2A 4ES

KEYWORDS: Planning, Consenting, Flood Defences, Development Consent Order

ABSTRACT

Under the Planning Act 2008, projects that meet certain thresholds are classed as Nationally Significant Infrastructure Projects ("NSIPs") which must be consented by way of a Development Consent Order ("DCO"). Large-scale transport and energy projects are routinely consented this way.

However, as it stands, significant flood defence projects are not explicitly included within the NSIP regime. Our presentation would consider the advantages that would flow from bringing them into the regime, concentrating on two in particular.

Firstly, bringing significant flood defence schemes into the regime would enable a 'national policy statement' to be designated for these schemes, which would support a national, joined up planning approach in terms of flood risk.

Secondly, and flowing from this, DCOs, the means by which NSIPs are consented, have successfully enabled large scale infrastructure to be delivered with unparalleled certainty and in relatively short and certain time-frames – a 'must' for significant flood defence projects. DCOs comprise a 'unified' consent for NSIPs, as a number of separate consents and permissions are either not needed (e.g. planning permission) or can be included 'within' a DCO (e.g. compulsory purchase powers).

In a time of critical need for effective, deliverable flood defence schemes, bringing such schemes into the NSIP regime would be, we consider, a key piece in the puzzle of dealing with increasing flood risk.

310. Asset management framework for flood protection, with baseline data for North Sea Region countries

Gersonius B.[1], Den Heijer F.**, Klerk W.J.**, Rijke J.†, Sayers P.†† and Vlad D.*,*

** UNESCO-IHE*

*** Deltares*

† HAN University of Applied Sciences

†† Sayers&Partners

[1] Westvest 7, 2611AX Delft, Netherlands, 0031152151744, b.gersonius@unesco-ihe.org

KEYWORDS: Asset management; Flood protection; Investment planning; North Sea Region.

INTRODUCTION

North Sea Region (NSR) countries depend heavily on flood protection infrastructure, such as dykes, dams, sluices and flood gates. Many of these structures will reach their end-of-life between 2020 and 2050. Currently in all NSR countries, policies aim to maintain, renovate and adapt the existing infrastructure. This has lead to large-scale investment programmes, such as the UK flood and coastal erosion risk management investment programme and the Dutch flood protection programme.

Knowledge on where, when and how much to invest is of crucial importance for asset owners. They need to make best use of (shrinking) budgets for flood protection: e.g. the Dutch flood protection programme needs to reinforce primary defences 50km/y faster and 6M€/km cheaper than to date. This requires improved and innovative approaches, such as using Life-Cycle-Costing to substantiate choices between maintenance, renovation and adaptation. It also requires looking for opportunities to connect with other complementary investments, such as for transportation, recreation and ecosystem restoration. The overall objective of the Interreg NSR FAIR project is to demonstrate improved approaches for investment planning. Initially, the project will analyse approaches in use and emerging across NSR countries, indicating the differences, advantages and disadvantages.

METHOD

From a desk study (e.g. CIRIA 2013, Klerk and den Heijer 2016) we have developed a comprehensive framework for asset management of flood protection infrastructure. The framework is comprehensive in that it incoporates and connects maintenance (object-level / short-term) investment planning with strategic (network-level / long-term) investment planning. We used the framework to analyse and compare the approaches (incl. input data and performance indicators) applied by various asset owners; especially comparing on how they support climate adaptation across spatio-temporal scales. The analysis was carried out in collaboration with the FAIR partners that own or operate assets, plan investments and set policies (e.g. RWS, LSBG).

RESULTS AND CONCLUSION

The result of the analysis is a methodological baseline for each NSR countries in terms of current approaches. These baselines will be used to identify the optimisation potential in the current approaches used by the asset owners, together with the preceived barriers for improved asset management. It is concluded from the analysis that there is ample potential in further mainstreaming asset management at the object-level and the network-level. Furthermore, we have observed that there is a clear difference in approach per country, which means that in the Interreg NSR FAIR project there is opportunity to share knowledge in a meaningful way, so as to enhance practice in the various NSR countries.

REFERENCES

CIRIA. (2013) The International Levee Handbook. C731. RP957. ISBN: 978-0-86017-734-0.

Klerk W.J. and den Heijer F. (2016) A framework for life-cycle management of public infrastructure. Proceedings of IALCCE.

313. Asset management for flood protection infrastructure; a review of the barriers for implementation and a way forward

Vlad, D. Rijke, J.**,†1, Gersonius, B.***, Schrijver, R. ††*

** Utrecht University*

***HAN University of Applied Sciences*

****UNESCO-IHE*

† Van Hall Larenstein University of Applied Sciences

†† Rijkswaterstaat

[1] *HAN Institute Built Environment, Ruitenberglaan 26, Arnhem, Netherlands, j.rijke@han.nl, +31615086275*

KEYWORDS: Asset Management, barriers, flood protection infrastructure, Interreg NSR project FAIR, North Sea region.

ABSTRACT

Introduction:

In the context of flood management, asset management (AM) stands for a proactive planning and management approach that aims to optimise the performance of flood protection infrastructure at the lowest total cost of ownership. However, in reality, a more reactive approach is often employed, including sub-optimal performance or cost-effectiveness due to insufficient inclusion of long-term planning.

In this paper, we present the outcomes of a review of AM for flood protection in the North Sea Region (NSR). We focus on the governance barriers for implementation of 'proactive' AM and ways to overcome these. We draw from the insights that were generated through the Interreg NSR project FAIR, in which flood protection asset managers from the Netherlands, Germany, Denmark, Sweden, Norway, Flanders and the UK exchange knowledge and experiences about flood protection infrastructure AM.

Methods:

The research approach consists of a literature review and a qualitative case study comparison of all the NSR countries mentioned above. Based on a literature review of best practices for AM, an assessment framework for proactive AM has been designed against which current AM approaches of a selected group of flood protection asset managers in the NSR are evaluated. This has provided a baseline for what asset managers can improve in current AM practices.

Subsequently, barriers to the implementation of proactive AM are determined via a literature review and qualitative case study comparison. As a result of the literature review, several categories of governance barriers were identified: institutional, participation, information, cognitive, and resources. These categories were subsequently used to structure interviews with the selected group of asset managers in order to

determine the specific barriers they face to implement proactive AM.
Finally, the results were discussed in a series of workshops with all the interviewed asset managers to verify the preliminary findings and explore practical ways to overcome the barriers.

Preliminary results and conclusions:
It was found that in none of the NSR countries the framework for proactive AM is fully implemented. Significant differences were identified between the countries investigated, ranging from lack of knowledge about the location and ownership of flood protection assets to uncertainties about the soil conditions around flood infrastructures. For each country, examples are given for all of the categories of barriers. In the workshops that will be held in February and March 2017, we will evaluate the barriers to proactive AM identified and discuss ways to overcome them in order to be able to provide the asset managers with recommendations for improvements that they desire and need.

Modelling and hydroinformatics (ii)

176. Development and case study of the real-time river stage prediction model using deep neural network
Dr Masayuki Hitokoto, Nippon Koei CO., LTD., Japan

183. Design and Development of Community Flash Flood Risk Assessment System
Dr Minglei Ren China, Institute of Water Resources and Hydropower Research, China

207. Flood mapping in the near future land use and climate change scenarios for ungauged basin that experiences rapid urbanisation
Ms Nithila Devi Nallasamy, Indian Institute of Technology Madras, India

208. A Novel combined cell- and node-centered finite volume method (CNCFVM) for efficient flood inundation mapping
Mr Sridharan Balakrishnan, Indian Institute of Technology. Madras, India

114. Scenario-free Simulation of Flood Risk for Multiple Drivers
Dr Roland Loewe, Technical University of Denmark, DTU Environment Denmark

148. Prediction of calibrating coefficients for rough compound channel flow
Ms Kamalini Devi, National Institute of Technology Rourkela Odisha, India

176. Development and case study of the real-time river stage prediction model using deep neural network

*Masayuki H. *[1], Masaaki S.**

** Research and Development Center, Nippon Koei CO., LTD.*

[1] 2304, Inarihara, Tsukuba, Ibaraki, 300-1259, Japan, +81-29-871-2034,
hitokoto-ms@n-koei.jp

KEYWORDS: Deep learning, Neural network, Flood prediction, River stage prediction.

ABSTRACT

Objectives

To reduce the damage of the flood disasters, improvement of the accuracy and the lead time of flood forecasting is important. Conceptual or physically based rainfall-runoff models have been widely studied as forecasting method. However, these models inevitably contain various errors. On the other hand, data-driven model, especially artificial neural networks (ANN), is one of the most potent alternatives. Due to the limitation of the learning ability of ANN model, it is undesirable to use too many input data into the model. Thus, selection of appropriate model inputs is extremely important. We have to select a few strongly correlated data among the many available time series of the observing stations. However, to improve the river-stage prediction, it is desirable to take advantage of as many observation data as possible. As a new learning method of ANN, deep learning is said to have an excellent ability of learning, and is able to handle huge input data. In this study, we developed the real-time river stage prediction model using deep learning based ANN. We executed the case studies of the various hyper-parameters and condition setting of the learning processes, and looked at the prediction accuracy compared to the conventional ANN model.

Methods

The study area is the Ooyodo River, in the Kyushu Island, Japan. 14 rain-gauge stations and 5 water level gauging stations were installed in this basin. The basin area is 861 km^2 and the length of main stream is 52 km. The prediction point in this study is Hiwatashi, located in the lowest point of the study area. The number of objective flood and is 24, which exceeded the flood warning level (6.0m) during the period of 1990–2014. The top 4 event without the missing data was selected as the validation event. The model was composed of 4 layer feed-forward network. Output of the network was the change of water level from current time to the prediction time. Input of the network was the antecedent water level of prediction point itself, hourly rainfall of all the rain-gauge stations, and hourly change of water level of all the water level gauging stations. In the deep ANN, learning processes become difficult owing to the vanishing gradient problem. To overcome this problem, the denoising autoencoder was applied as the pre-training method. To avoid over-fitting, the drop-

out method was applied. To clarify the suitable configuration of the model, case study was executed. The prediction accuracy was evaluated by leave-one-out cross validation method through the 4 superior flood events.

Result and Conclusions

Prediction accuracy of the developed model was compared to the conventional ANN model and other prediction models, and the developed model showed the best performance among these models. As the result of the case studies, the number of learning iteration, the number of neurons, and dropout rate were very important for the prediction accuracy.

183. Design and Development of Community Flash Flood Risk Assessment System

Ren Minglei[1,], He Xiaoyan[1],Huang Jinchi[1],Wang Fan[1],and Bi Xiaodong[2]*

(1.China Institute of Water Resources and Hydropower Research, Beijing 100038;

2. Beijing Aero Img Info Technology Ltd, Beijing 100038)

KEYWORDS: Community flash flood; Risk assessment system; Storm flood simulation; GIS technology; Submerged area; Submerged depth

ABSTRACT

With the development of social economy, the town, which is the political, economic, cultural, financial and technical centre in a region, has highly concentrated population, and high economic value of unit land. Communities, as the basic units of towns, are the foundation of urban flood defence. The area, where flash flood is liable to occur, is usually backward in economic level and weak in the capacity of disaster prevention and reduction. The community flash flood risk assessment system (CFFRSAS) that introduced in this paper, is established on the .net framework platform, and developed by using C# language. In the CFFRSAS, firstly, the storm flood simulation technology in mountainous area was combined with GIS technology; secondly, the storm flood analysis model in mountainous area was taken as the core module, and storm flood in mountainous area of designed scheme was analyzed and calculated by using the storm flood analysis model; thirdly, submerged area and submerged depth of community flash flood were visualized intuitively by using GIS technology to superimpose basic electronic map of community, and the community flash flood risk map were produced quickly. The CFFRSAS could provide important technology support for improving the capacity of disaster prevention and mitigation in community, enhancing the consciousness of community residents of flood prevention, and reducing the casualties and economic losses caused by flash flood disaster.

207. Flood mapping in the near future land use and climate change scenarios for ungauged basin that experiences rapid urbanisation.

Nithila Devi.N[1] Sridharan Balakrishnan.* * and Soumendra Nath Kuiry†*

***** *Research Scholar, Hydraulics and Water Resources Engineering Division, Department of Civil Engineering, IIT Madras, Chennai – 600 036, E-mail- nithiladevi.n@gmail.com*

****** *Research Scholar, Hydraulics and Water Resources Engineering Division, Department of Civil Engineering, IIT Madras, Chennai – 600 036, E-mail- krishstee@gmail.com*

† *Assistant Professor, Hydraulics and Water Resources Engineering Division, Department of Civil Engineering, IIT Madras, Chennai – 600 036.*

KEYWORDS: Flood mapping, land use and climate change scenario, ungauged basin.

ABSTRACT

The Adyar and the Cooum are the two major rivers that bring floods to the Chennai Metropolitan Area (CMA) in the state of Tamil nadu, India. The history of flooding in the CMA dates back to the years: 1903, 1918, 1943, 2005 and 2015. These floods had disrupted normal life and had incurred considerable loss to life and property. The observed rapid urbanisation in CMA also poses great threat by disrupting a huge proportion of storm water retention. However, the in-situ and routine measurements of river cross-sections, flood plain mapping, river discharges at various sections over the time that are required for simulating the floods and preparing emergency action plans (EAP) are still at their infancy. Therefore, we propose a framework to model the flooding extent in the near future land-use and climate change scenarios for an ungauged basin like that of CMA. The framework operates by incorporating valuable satellite derived terrain information into the physical model HEC-HMS and HEC-RAS that have been proven to be successful for flood modelling with minimal calibration parameters. The land use land cover (LULC) information is acquired by performing Google Earth assisted unsupervised classification on Landsat satellite data. The historical LULC and other GIS derived factors (distance from road, railways, city core, urbanised pixels in the neighbourhood and water bodies) that drive urbanisation is again used to train Artificial Neural Network (ANN) in order to predict the near future LULC scenarios. The Soil data is obtained from the World Soil Information repository. River network and basin delineation is carried out using elevation data from Shuttle Radar Topography Mission (SRTM). Future projections of extreme precipiation can be obtained from ensemble of available Regional Climate Models (RCM). The HEC-HMS model uses the above said information as input to simulate the lateral flows to the Adyar and Cooum rivers. The lateral inflows to the rivers and the upstream inflows from the reservoirs are used as the boundary conditions to the HEC-RAS model to simulate the extent of flooding in the near future LULC and climate change scenarios. It is observed that due to change in LULC and climate condition, the lateral inflows to the rivers increase and hence the inundation extents. Therefore, it is suggested that the CMA must have

EAP to deal with the future floods.

REFERENCES

Pijanowski, B. C., Brown, D. G., Shellito, B. A. & Manik, G. A (2002). Using neural networks and GIS to forecast land use changes : a Land Transformation Model. 26**,** 553–575.

208. A Novel combined cell- and node-centered finite volume method (CNCFVM) for efficient flood inundation mapping

Sridharan Balakrishnan.* 1 and Soumendra Nath Kuiry**

* Research Scholar, Hydraulics and Water Resources Engineering Division, Department of Civil Engineering, IIT Madras, Chennai – 600 036, E-mail- krishstee@gmail.com

** Assistant Professor, Hydraulics and Water Resources Engineering Division, Department of Civil Engineering, IIT Madras, Chennai – 600 036.

KEYWORDS: Shallow Water Equations (SWEs), finite volume method, flood inundation, combined cell- and node-centered finite volume method.

ABSTRACT

All over the world, settling near large water bodies have always been an important factor governing economic and demographic growth of cities. Such cities also tend to be the largest cities in the world. It is in this context, accurate and efficient modeling of flood inundation becomes quintessential to issue early warning message in order to avoid heavy loss to the economy. Therefore, this paper presents a novel flood model that uses a combined cell- and node-centered finite volume method (CNCFVM) to solve the two-dimensional depth-averaged shallow water equations. Among all available numerical methods, the finite volume method (FVM) is the most popular in the recent time because it uses the integral form of the governing equations and maintains excellent mass conservation both at local and domain levels. Also, the Riemann solver based flux calculation schemes within the finite volume method are able to handle shocks, discontinuity and multiple flow regimes common to disastrous flood events. In general, the FVM can be broadly classified into two categories: the Cell-Centered Finite Volume Method (CCFVM) (Barth and Jespersen, 1989) and the Node-Centered Finite Volume Method (NCFVM) (Delis et al., 2011). The CCFVM uses the primary cell as its control volume and the flow variables are specified at the centroid. On highly orthogonal meshes, the CCFVM takes low memory power and less computation time and hence it is efficient. However, it is not robust on the non-orthogonal mesh, which may contain highly distorted grids and suffers from convergence problem (Croft 1989; Delis et al. 2011). The control volume for the NCFVM is obtained by connecting the centroids of the surrounding cells and the midpoints of the edges connected to the corresponding node. Since the number of edges involved in mass flux calculation in the NCFVM is more, the size of the control volume is relatively large and hence this allows the use of larger time step size. On the contrary, the NCFVM involves more computations for solving the momentum equation. However, the NCFVM is capable of providing better accuracy on highly distorted meshes (Prakash and Patankar 1985). Therefore, a combined model CNCFVM is

proposed in this study that takes advantages of both the approaches CCFVM and NCFVM. The combined approach is achieved by using NCFVM for solving the continuity equation using relatively larger time step size and CCFVM for solving the momentum equations by reducing number of computations. The two different control volumes exchange information by transferring the conserved variables from one to another using a suitable interpolation method. Finally, the combined model has shown to have advantages such as the use of larger time step resulted from the dual mesh, and improved accuracy in the regions of distorted. The performance of the model is evaluated through suitable examples and experimental observations. Also, the model is applied to simulate a flood event to confirm the ability of the model to handle variety of field conditions that may arise in real world scenario.

REFERENCES

Barth, T. J., and Jespersen, D. C. (1989). The design and application of upwind schemes on unstructured meshes.

Croft, T. N. (1998). Unstructured mesh-finite volume algorithms for swirling, turbulent, reacting flows (Doctoral dissertation, University of Greenwich).

Delis, A. I., Nikolos, I. K., and Kazolea, M. (2011). Performance and comparison of cell-centered and node-centered unstructured finite volume discretizations for shallow water free surface flows. Archives of Computational Methods in Engineering, 18(1), 57-118.

Prakash, C. and Patankar, S. V. (1985). A control volume-based finite-element method for solving the Navier-Stokes equations using equal-order velocity-pressure interpolation. Numerical Heat Transfer , 8(3), 259-280.

114. Scenario-free Simulation of Flood Risk for Multiple Drivers

Löwe, R.,#1, Urich, C.**,#, Radhakrishnan, M.†,#, Deletic, A.** and Arnbjerg-Nielsen, K.**

** DTU Environment, Technical University of Denmark*

*** Monash University, Faculty of Civil Engineering, Australia*

† UNESCO-IHE Institute for Water Education, The Netherlands

[1] *Miljøvej B115, 2800 Kgs. Lyngby, rolo@env.dtu.dk*

KEYWORDS: Flood risk, experimental design, kriging, urban redevelopment, scenario planning

ABSTRACT

Objectives

Evaluation of Expected Annual Damage (EAD) due to flooding for various climate and population growth scenarios is computationally expensive. In an area subject to coastal and pluvial risk, the computation of EAD requires a minimum of 15 to 20 hydraulic simulations at each time point and for each scenario and adaptation measure, leading to thousands of simulations when exploring several scenarios and adaptation measures. We present a setup to evaluate economic flood damages for an urban catchment with a limited number of hydraulic simulations. The purpose is to be able to assess flood risk reliably for a multitude of climate and population growth scenarios by interpolating between damage values derived from hydraulic simulations for only few selected combinations of the input variables rainfall, sea level, and number of households in the catchment.

Methods

We derived flood damages for different rainfall depths and sea levels based on 1D-2D hydraulic simulations in MIKE FLOOD for a 50km^2 urban catchment. The hydrological model part and the surface mesh of the hydraulic model were modified based on building layers simulated by the urban development model DAnCE4Water for a given number of households in the catchment. Starting of with 16 hydraulic simulations for randomly selected combinations of the input variables, we applied kriging surrogates to interpolate flood damages for input variable values in between those simulated. Subsequently, we used cross validation to identify for which combinations of input variables the kriging results were least determined and performed a new hydraulic simulation in this location. The process was repeated and the dataset extended sequentially until the surrogates could describe flood damages with satisfactory accuracy.

Results

We demonstrate that kriging models are suitable surrogates to describe the variation of flood damages in a catchment depending on the input variables rainfall, sea level and number of households. Using ~50 hydraulic

simulations, we were able to identify estimates of EAD for a variety of climate and population growth scenarios that deviated only few percent from the EAD estimates derived in a reference case with 1000 simulations. This is a significant reduction of computational effort compared to the scenario-based approach, as the kriging surrogates can be used to flexibly evaluate EAD for any climate and population growth scenario within the physical ranges considered in the simulations.

Conclusions

The application of an experimental design involving hydraulic modelling, urban development modelling and kriging surrogates is a powerful tool to quantify flood damages for a variety of climate and population growth scenarios with a limited number of hydraulic simulations. Our approach enhances the ability to evaluate flood adaptation measures for a variety of scenarios by decreasing the needed computations by one to two orders of magnitude.

148. Prediction of calibrating coefficients for rough compound channel flow

Devi K. [1], Khatua K.K.**, Das B.S.* and Khuntia J.R.**

** Ph.D. Scholars, N.I.T, Rourkela*

*** Associate Professor, N.I.T, Rourkela*

[1]Civil Engineering Department, National Institute of Technology, Rourkela, Odisha, India, Ph: +91-8763866544, email: kamalinidevi1@gmail.com

KEYWORDS: Momentum exchange, empirical model, Shiono and Knight Method, depth averaged velocity.

ABSTRACT

The transverse momentum exchange occurred at mixing layer region of a compound channel for a smooth bed case is significantly different for the case of rough boundary. As a result the transverse shear stress and secondary flow will considerably vary for the whole compound channel. So this research mostly focuses the calibrating coefficients needed for solving the analytical method of SKM due to the existence of non homogenous roughness. These calibrating coefficients are eddy viscosity coefficient, friction factor and secondary flow coefficient appraising the lateral shear, bed friction and secondary flow. The chief aim is to investigate the influence of existing roughness on these calibrating coefficients and empirical expressions for them are developed to predict depth averaged velocity distribution and boundary shear distribution. The strength of the current approach has also been tested against large channel FCF data, experimental data sets and the field data sets.

Objectives

To predict boundary shear stress distribution and depth averaged velocity distribution by deriving new expressions for the three indispensible coefficients needed in Shiono and Knight Method more significantly for compound channels having non homogenous roughness. To validate the current prophecy with the most preferred experimental data set of flood channel facility and with the natural river.

Methods

The simplification of the Reynolds average Navier- Stokes equation has been done in SKM and the final equation is

$$\rho\frac{\partial H(\overline{u}\overline{v})_d}{\partial y} = \rho H g S_0 + \frac{\partial}{\partial y}\left(\rho\lambda H^2\left(\frac{f}{8}\right)^{\frac{1}{2}} U\frac{\partial U}{\partial y}\right) - \frac{f}{8}\rho U^2\sqrt{1+\frac{1}{s^2}} \qquad (1)$$

Where ρ the density of the water, S_0 the longitudinal bed slope, g the acceleration due to gravity, $\overline{u}$ and $\overline{v}$ are the component of the mean velocity, f is the friction factor, λ is the eddy viscosity coefficients and U is the depth averaged velocity.

The turbulent shear stress of SKM is simplified like the equation (1)

$$\tau_{yx} = \rho\lambda H^2 \left(\frac{f}{8}\right)^{\frac{1}{2}} U \frac{\partial U}{\partial y} \tag{2}$$

For assessing the friction factor *f*, experimental depth-averaged velocity distribution and boundary shear stress data sets are necessary, from which the friction factors can be back-calculated as

$$\tau = \frac{f}{8}\rho U^2 \tag{3}$$

The term λ and f manifested in equation (2) and (3) has been modelled in this paper considering a wide channel data sets.

Results

The existing calibrating coefficients models for smooth channels have not performed well for non-homogenous roughness as noticed from various investigations. Especially for these channels, a remarkable velocity gradients and strong secondary flow appeared at junction as stated by other investigators. So the new models have been applied in SKM in order to find better results for depth averaged velocity distribution and boundary shear distribution.

Conclusions

Calibrating coefficients required in SKM have been developed distinctly for rough compound channels. This modified models have been derived to account the turbulent shear and secondary flow and friction factor generated due roughness. It has been applied to the depth averaged momentum equation for predicting flow variables for a rough compound channel with reasonable accuracy.

Urban flood risk management (ii)

230. Achieving Urban Flood Resilience in an Uncertain Future
Dr Scott Arthur, Heriot Watt University, United Kingdom

252. Floods in arid and semi arid regions in recent decades
Mr Mosbah Ben Said, Scientific and Technical Research Center on Arid Regions -CRSTRA -Biskra, Algeria Algeria

256. Analysis of 1582 and 1890 flash floods in Carslbad, Czech Republic
Mr Jan Daňhelka, Czech Hydrometeorological Institute, Czech Republic

324. Assessment of Future Flood Inundations under Climate and Landuse Change Scenarios in Rapidly Growing Cities
Dr Binaya Kumar Mishra, United Nations University Institute for Advanced Study of Sustainability (UNU-IAS) Japan

361. The costs of adaptation- a Life cycle costing framework to assess sea dikes
Dr Oliver Heidrich, Newcastle University, United Kingdom

403. Urban and Basement Flood Risk in Canada: Critical Issues and Practical Risk Reduction Resources
Mr Dan Sandink, Institute for Catastrophic Loss Reduction, Canada

230. Achieving Urban Flood Resilience in an Uncertain Future

Colin R. Thorne[*1], Emily O'Donnell[1], N. Wright[2], R. Fenner[3], S. Arthur[4], H. Haynes[4], J. Lamond[5], C. Kilsby[6], K. Potter[7], D. Butler[8], Z. Kapelan[8], D. Dawson[9], L. Kapetas[3], D. Allen[4], G. Everett[5], V. Glenis[6], G. O'Donnell[6], T. Vilcan[7], S. Ahilan[8]*

1. School of Geography, University of Nottingham

2. PVC Research and Innovation, De Montford University

3. Centre for Sustainable Development, Cambridge University

4. School of the Built Environment, Heriot-Watt University

5. Department of Architecture and the Built Environment, UWE

6. School of Civil Engineering and Geosciences, Newcastle University

7. Department for Public Leadership and Social Enterprise, Open University, UK

8. Department of Engineering, Exeter University

9. School of Civil Engineering, Leeds University

[*]*University Park, Nottingham NG72RD, 0115-9515431,* colin.thorne@nottingham.ac.uk

KEYWORDS: Blue-Green Cities Climate change adaptation Future Floods Flood Resilience Inter-operable systems Sponge City

ABSTRACT submitted for consideration for session 'Urban Flood Management and Mitigation' proposed by Professor Xiaotao Chen

This presentation introduces initial research findings of the EPSRC-funded Urban Flood Resilience research consortium (www.urbanfloodresilience.ac.uk). Our intent is to work out and then demonstrate how resilience to future floods and droughts can be achieved using integrated systems of Blue-Green and Grey assets, no matter how climate change unfolds. This is essential to manage urban flood risk sustainably while assuring continuous urban water service delivery that is adapatable and reliable.

The project uses physics-based models to investigate how stormwater cascades through a city's drainage system, accounting for the dynamics of not only water, but also sediment, debris, natural solutes and contaminants. We then investigate how the performance of grey systems (i.e. lined drainage conduits/ditches, pipes and detention tanks/ponds) can be improved by adding Sustainable Drainage System (SuDS) and more extensive Blue-Green Infrastructure, to create integrated treatment trains that simulatneously manage both the *quantity* and *quality*. Models and design solutions will be developed, tested and (where appropriate) implemented in the contexts of both retro-fit and new build through case studies in UK core city of Newcastle-upon-Tyne and the 'garden city' of Ebbsfleet, Kent.

We adopt a whole systems perspective that recognises interdependencies between water and other urban systems, including transport, energy and land-use, identifying opportunities for managing stormwater as a

resource as well as a hazard to lever the multi-functional benefits of using Blue-Green FRM infrastructure to increase water security. Possibilities range from non-potable uses in homes and commercial buildings (based on RainWater Harvesting) to irrigating green infrastructure (e.g. street trees), managing subsidence, soil moisture enhancement and groundwater recharge. Wider benefits may extend to local energy generation (i.e. micro-hydropower) and wider enhancement of urban watercourses and ecosystems. New models/protocols will form the basis for assessment of the potential for the optimised combinations of B/G+Grey and smart infrastructure to deliver multiple-benefits in UK core cities, nationwide.

Engineered solutions must be better informed and explicitly accounted for in urban planning and development at all spatial scales. Also, optimal urban flood and water management is only deliverable in practice when founded on a deep understanding of the real lives of citizens and community preferences for management of water and public spaces. Consequently, research will investigate the planning, development and organisational systems that govern urban flood risk management, using Participatory Action Research, and Social Practice Theory will be used to evaluate the attitudes and responses of citizens and communities to innovation in flood and water management.

The primary mechanism for bringing together engineering, social and planning components of the project is co-location research in Newcastle-upon-Tyne and Ebbsfleet, Kent. Work in these case study cities will establish how barriers to innovation associated with uncertainties in future urban climates, land-use, development and political leadership can be overcome. Critical engagement with planners, developers and land-owners will be feed back and to inform and help steer the engineering research , building on the current trend towards the development of urban infrastructure observatories to explore responses to the innovative changes needed to achieve urban flood resilience.

252. Floods in arid and semi arid regions in recent decades

*Mosbah Ben Said. *, Mohammed Amin Hafnaoui. *, Ali Hachemi. *, Mohammed Madi. *, Abderrahmane Noui. *, Halime Mghezzi. *, Nora Bouchahm.* and Yacine Farhi. **

(*) *Scientific and Technical Research Center on Arid Regions -CRSTRA -Biskra, Algeria.*

bensaid.mosbah@crstra.dz

Tel: +213 670026673

Fax: 0021333522092

KEYWORDS : Floods, principal factors, arid and semi-aride regions, Algeria.

ABSTRACT

Nowadays, flooding is a prominent issue in many countries around the world, especially for areas with high annual rainfall. However, the floods are not specific to humid region but also reach the arid regions. Most of the Algerian's land surface is classified as arid and semi-arid lands. In the recent decades, this region has been affected by several floods that caused a significant human and material damages. Severe flooding has been reported namely those of Adrar (October 2004 and January 2009), Ghardaia (October 2008), Bechar (October 2008) Biskra (September 2009) and El-bayadh (October 2008 and 2011).

A better understanding of the processes causing of floods and determination of the main factors amplifying this phenomena in these regions are becoming real issue.

Three areas in the southern of Algeria are considering as case study, Biskra, Bechar and El-bayadh. The first results from the investigation have shown that, the climate variability, lack of reliable measurement data regarding rainfall and runoff, lack of information about stream flow, the insufficient capacity of structures and land use evolution are the main factors influencing flooding susceptibility. Investigations once again warned us to the need for integrated planning that takes into account regional specificities and the natural factors in particular. in order to develop reliable and valid measures to minimize adverse flood effects, especially, in the arid and semi-arid regions.

256. Analysis of 1582 and 1890 flash floods in Carslbad, Czech Republic

Daňhelka J.[1], Elleder, L. *, Kurka, D. *, Augustin M**, Šírová J. **

** Czech Hydrometeorological Institute*

*** State District Archive in Karlovy Vary*

[1] Na Šabatce 2050/17, Praha, 15521, Czech Republic, +420 244032300, danhelka@chmi.cz

KEYWORDS: Historical Floods, Flash Flood, Carlsbad, Flood Hazard Analysis

ABSTRACT

Understanding and analysis of flood risk at particular area is usually based on data on observed floods. However, available instrumental records are not sufficient to provide robust information on probability of extreme “black swan” events. Therefore reconstruction of historical (pre-instrumental) floods might provide valuable information for nowadays flood risk analysis.

Objectives

We analysed two extreme floods (1582 and 1890) of Tepla River in the spa city of Carlsbad in western Bohemia based on contemporary sources and documents. The main objective is to estimate peak flows of these floods and discus implications for flood risk under current conditions of flood protection (including effect of reservoirs).

Methods

While for the 1890 flood many contemporary documents exists including geodetic documentation and peak flow estimates, spare written description of flood 1582 were available. We reviewed the 1890 data to provide new estimate of peak flow for 1890 flood using a current knowledge of hydraulics and software. Using contemporary written sources and old drawings, we reconstructed the settlement in the Carlsbad valley and channel conditions in 16th century. Relative flood levels of 1582 were estimated based on description of damages caused by the flood and other information. In particular, the hot spring elevation and known changes of the valey cross-section at the locality of the hot spring enabled the comparison fof both studied floods.

Results

While contemporary estimate of peak flow in 1890 was 400 $m^3.s^{-1}$, we concluded that flow velocities were over estimated by these calculations. We propose alternative estimate of 250 to 300 $m^3.s^{-1}$. Absolute flood level was higher in 1890 than in 1582. However due to construction of buildings and river banks in early 19th century, the crossection area changed significantly and thus we concluded that the peak flow of 1582 was likely same or greater than that of 1890, most likely between 250 and 400 $m^3.s^{-1}$.

Conclusions

Brezova Reservoir was constructed in 1930s to protect Carlsbad from flood risk, Stanovice reservoir for drinking water supply provides additional flood control storage at Lomnicky potor River (tributary to the Tepla River). However a critical location, a modern Hot spring collonade that bridges the river channel in the city center, discharge capacity is estimated only to 100 $m^3.s^{-1}$. Comparison of estimated flood volumes of 1890 and 1582 suggests that the available flood control storage of reservoirs wouldn't be sufficient to transform flood sufficiently to protect city center.

REFERENCES

Summer J. (1609). Narratio illius Cataclysmi, qui anno Superiore 82. easdem Thermas obruit. In: Fabian Summer: De inventione, descriptione, temperie, viribus, et inprimis usu Thermarum D.Caroli IIII. Imperatoris libellus, 3rd Edition, Lipsae, 1609

Stephani C. (1582). Erbärmliche und erschröckliche Neue Zeitung der vor unerhörte sämerlichen Wassersnoth so sich dises 1582.Jar den 9.May in Keiser Carls Bad…. Nürnberg, 1582.

Stastgemeide Karlsbad. (1898). Das Hochwasser in Karlsbad vom 24. November 1890, Im Selbstveriage der Stadtgemeide Karlsbad

324. Assessment of Future Flood Inundations under Climate and Landuse Change Scenarios in Rapidly Growing Cities

Mishra B.K.[1], Mohamed, K., Masago, Y. and Kumar, P.

United Nations University Institute for Advanced Study of Sustainability (UNU-IAS)
[1] 5-53-70 Jingumae, Shibuya-ku, Tokyo 150-8925,

Tel : +81-3-5467-1212, Fax : +81-3-3499-2828, Email : mishra@unu.edu

KEYWORDS: Climate change; flood inundation; FLO-2D; GCM bias correction; HEC-HMS

ABSTRACT
In recent decades, the increasing frequency of disaster events, particularly hydro-meteorological disasters, have threatened human lives and infrastructure. Changes in climate and land use patterns are two of the major reasons which greatly affect water runoff resulting frequent urban floods. The flood hazard and risk mapping require a detailed understanding of flood inundation characteristics at various locations within the target area. This study evaluated flood inundations under rapid urbanization and climate change in Jakarta, Hanoi and Manila towards improving urban water environment sustainably.

HEC-HMS model was used to simulate the impact of climate and land use change on the peak discharge. FLO-2D, a two-dimensional flood routing model, was used to simulate flood inundations for current and future climate conditions. MRI-CGCM3, MIROC5, HadGEM-ES and GFDL-ESM2M precipitation output for RCP45 and RCP85 were used for the climate change impact assessment. Quantile-quantile bias correction, a statistical downscaling technique, were applied for correcting the GCM rainfall output. An increase of 37% inundation area/depths were found despite of extended 90 m3/s from the existing 45 m3/s pump in Hanoi. Southwest and south area of the Hanoi city need greater attention as these area are expected to be severely affected by flood with deeply inundated areas. Similary, in Jakarta case, the flood inundation extent and depths under the future conditions were found significantly higher than those under the current condition.

361. The costs of adaptation- a Life cycle costing framework to assess sea dikes

KEYWORDS: flooding, sea-level rise, adaptation

ABSTRACT

Motivation and aim

In contrast to climate change mitigation, there are no established frameworks for evaluating the effectiveness of different adaptation options over time [1]. Across countries and cities only limited evidence of the actual costs of installing the various infrastructure components is available, which indicates a gap between global adaptation needs and the funds available for adaptation. Although a range of studies have calculated the cost benefit ratio to protect for example megacities [2] or the value of providing coastal defence systems [3] the recent IPCC report [4] states that current studies that estimate the cost of adaptation are characterised by shortcomings in data, methods, and coverage and there is a need for a better assessment of global adaptation costs, funding, and investment [4]. As highlighted by Watkiss [5] there are 6 principal approaches (from cost-benefit to portfolio analysis) to support economic decision that are resource intensive and technically complex. Such complexity prevents the formal application to large investment decisions or major risks [5]. An emerging, although equally complex and resource intensive approach is Life Cycle Costing (LCC), however we argue that this standardised approach will support decision making processes.

Methodology

Adaptation generally assumed that early investments will be likely to be more cost-effective and bring bigger benefits in the long run, compared to a responsive approach. One widely used method to assess the effectiveness of adaptation strategies is to adopt a cost-benefit analysis and we compare such an approach with LCC. The objective of LCC is to provide decision-makers with the ability to select the most appropriate alternative options at any time throughout the life cycle of an item [6]. We utilise the BS draft method on Life cycle costing to illustrate its applicability for sea dike constructions. Conducting the LCC will reduce a potential uncertainty on the protection costs, which can remove potential barriers in decision making [7]. Importantly for this study LCC does provide important data and guidance information enabling decision-makers to evaluate available options. We position our findings in the wider context of dike costing and uncertainty estimates for dikes in the Netherlands, Canada and the UK [8]. The study advances a “best practice” approach to understand how the cost of adaptation strategies can be measured, alongside the assessment of risk reduction methods.

Results and conclusion

The research represents an effort to provide a framework for policy-makers to prioritize adaptation options and to allocate financial resources, in a context of increasing climate pressures. Recommendation are drawn how to improve costs estimation in order to support adaptation and to consider life costing methods. In future research, a range of factors could be considered before underlying drivers of costs can be estimated worldwide, like climate or socio-economic conditions.

1. Linnenluecke, M.K., J. Birt, and A. Griffiths, *The role of accounting in supporting adaptation to climate change.* Accounting and Finance, 2015. **55**(3): p. 607-625.
2. Aerts, J.C.J.H., et al., *Climate adaptation: Evaluating flood resilience strategies for coastal megacities.* Science, 2014. **344**(6183): p. 473-475.
3. Jonkman, S.N., et al., *Costs of adapting coastal defences to sea-level rise - New estimates and their implications.* Journal of Coastal Research, 2013. **29**(5): p. 1212-1226.
4. IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects.* , in *Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* V.R.B. C.B. Field, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R.

Mastrandrea, and L.L. White, Editor. 2014: Cambridge, United Kingdom and New York, NY, USA. p. 1132.

5. Watkiss, P., et al., *The use of new economic decision support tools for adaptation assessment: A review of methods and applications, towards guidance on applicability.* Climatic Change, 2015. **132**(3): p. 401-416.
6. Draft BS EN 60300-3, *Dependability management- Part 3-3: Application guide - Life cycle costing*, Mrs Philippa Younas (BSI), Editor. 2015, BSI: Brussels, Belgium.
7. Heidrich, O., et al., *National climate policies across Europe and their impacts on cities strategies.* Journal of Environmental Management, 2016. **168**: p. 36-45.
8. Lenk, S., et al., *Costs of sea dikes – regressions and uncertainty estimates.* Nat. Hazards Earth Syst. Sci. Discuss., 2016. **2016**: p. 1-21.
1. Linnenluecke, M.K., J. Birt, and A. Griffiths, *The role of accounting in supporting adaptation to climate change.* Accounting and Finance, 2015. **55**(3): p. 607-625.
2. Aerts, J.C.J.H., et al., *Climate adaptation: Evaluating flood resilience strategies for coastal megacities.* Science, 2014. **344**(6183): p. 473-475.
3. Jonkman, S.N., et al., *Costs of adapting coastal defences to sea-level rise - New estimates and their implications.* Journal of Coastal Research, 2013. **29**(5): p. 1212-1226.
4. IPCC, *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects.* , in *Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* V.R.B. C.B. Field, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White, Editor. 2014: Cambridge, United Kingdom and New York, NY, USA. p. 1132.
5. Watkiss, P., et al., *The use of new economic decision support tools for adaptation assessment: A review of methods and applications, towards guidance on applicability.* Climatic Change, 2015. **132**(3): p. 401-416.
6. Draft BS EN 60300-3, *Dependability management- Part 3-3: Application guide - Life cycle costing*, Mrs Philippa Younas (BSI), Editor. 2015, BSI: Brussels, Belgium.
7. Heidrich, O., et al., *National climate policies across Europe and their impacts on cities strategies.* Journal of Environmental Management, 2016. **168**: p. 36-45.
8. Lenk, S., et al., *Costs of sea dikes – regressions and uncertainty estimates.* Nat. Hazards Earth Syst. Sci. Discuss., 2016. **2016**: p. 1-21.

403. Urban and Basement Flood Risk in Canada: Critical Issues and Practical Risk Reduction Resources

Dan Sandink

Institute for Catastrophic Loss Reduction

210-20 Richmond St. E

Toronto, ON

dsandink@iclr.org

Phone: 416-364-8677 x3212

Fax: 416-364-5889

ICFM 7 Abstract – May 8, 2017

Keywords: Urban Flood; Basement Flood; Inflow/Infiltration; Backflow Protection; Construction Codes.

Urban and basement flooding has emerged as one of the most important causes of disaster loss in Canada. Notably, an extreme rainfall event in the Greater Toronto Area in July 2013 resulted in more than $1 billion in insured losses alone. The event was associated with extremely high intensity rainfall (total accumulation reaching 126 mm in isolated areas, most of which fell in ~2 hr period) centred over one of the most highly urbanized areas of the country. Over 60% of the insured losses experienced during this event were attributed to sewer backup in private residences.

Many other Canadian urban centres have been affected by similar urban flood events, resulting in $billions of insured and uninsured losses. Typically, the majority of losses experienced during these events are associated with a combination of stormwater/overland flow, infiltration and sewer backup basement flooding in private, ground-related homes.

Aside from insured and uninsured property damage, homeowners face reduced home livability, loss of irreplaceable items, exposure to contaminated floodwaters, and impacts on insurance coverage terms and conditions. The Institute for Catastrophic Loss Reduction (ICLR) has been working with academic, insurance, municipal and consulting partners to identify and address a number of critical urban and basement flooding issues that have historically received limited attention from decision makers in Canada. These critical issues include:

- High rates of excess groundwater and rainwater entering sanitary sewer systems (referred to as Inflow/Infiltration or I/I) in new residential subdivisions,
- Residential construction code issues affecting risk of basement flooding, including construction and inspection factors affecting I/I, building design and site drainage factors, and installation of private-side flood risk reduction measures,
- Low involvement of homeowners in private-side flood risk reduction retrofit programs and programs oriented toward limiting private-side I/I,
- Long-term efficacy and reliability of private-side basement flood protection technologies (including private-side sewer backflow protection), and
- Retrofit practices that have the potential to affect reliability of private-side flood protection technologies.

ICLR has developed, or is currently developing tools and resources to help key stakeholders, including insurers and municipalities, address the above list of critical urban and basement flood risk reduction issues.

This presentation will provide an overview of the impacts of urban and basement flood events in Canada, with a focus on losses and impacts on individual households. The presentation will then review ICLR tools, resources and initiatives aimed at reducing risk associated with sewer backup, stormwater and infiltration flooding in new and existing development, with a focus on residential private-side measures that affect urban and basement flood risk.

Climate change impacts (ii)

263. Facilitating integration of working with natural processes into Scottish flood risk management planning
Dr Heather Forbes, Scottish Environment Protection Agency (SEPA), United Kingdom

279. Analysis of the Most Catastrophic Flood Events in Turkey (1960-2014): Triggering Mechanisms of the Flood Events
Ms Gamze Koc, University of Potsdam, Germany

302. Impact of SUDS on urban heat managed – Case studies from Colombo, Sri Laka & Tainan, Taiwan
Dr Hung-En Chen, UNESCO-IHE, Institute for Water Education, Netherlands

325. Translating weather extremes into the future – a case for Norway
Dr Nathalie Schaller, CICERO, Norway

328. The role of human influence on climate in recent UK winter floods and their impacts
Dr Nathalie Schaller, CICERO, Norway

341. Testing the climatic resilience to floods on the Ourthe river, Belgium
Mr Benjamin Grelier, LOTERR – Université de Lorraine, France

363. Climate Change Impact on Flood Control Measures for Highly Populated Urban Watershed
Dr. Andre Schardong, University of Western Ontario, Canada

263. Facilitating integration of working with natural processes into Scottish flood risk management planning

Heather E. Forbes

Scottish Environment Protection Agency

Silvan House, 231 Corstorphine Road, Edinburgh, EH12 7AT, 0131 2737262, heather.forbes@sepa.org.uk

KEYWORDS: natural flood management, flood risk management planning

ABSTRACT

There has been increasing awareness in recent years of the potential for land management activities to help manage the risk from flooding - a concept frequently termed natural flood management or NFM. The central tenet of this approach is that by restoring or enhancing natural features of a catchment or coastline it is possible to slow and/or store flood waters thus reducing the level of impact downstream. In addition to benefits to flooding, NFM can also often easily contribute to improvements in biodiversity, water quality, carbon storage, and recreation.

In Scotland, the Flood Risk Management (Scotland) Act 2009 specifically requires flood risk management authorities to consider where working with natural processes may benefit flood risk. A total of 106 NFM actions, ranging from scoping studies through to works on the ground, have now been identified for delivery in Scotland's Flood Risk Management Strategies and Plans. Implementation of these actions will seek to integrate with other drivers, such as river basin management planning, forestry and climate change targets.

Since the implementation of the FRM Act in 2009, SEPA has been working with Scottish Government and partners on a variety of activities to support delivery of NFM. These include the development of opportunity maps for NFM, modelling guidance and advice on the compensation mechanisms that might be used to support the land managers that undertake NFM works. SEPA has also produced a Natural Flood Management Handbook outlining the elements involved in facilitating delivery on the ground. By working with partners, both locally on projects such as the Eddleston Water Project and internationally on the EU INTERREG Building with Nature project, we will continue to seek improvements to the evidence base for NFM that informs the policy, understanding and justification for this approach. This will include improving our understanding of the role of NFM in providing resilience to the effects of climate and land use change on future flood risk.

REFERENCES

Risk and Policy Analysts (2015). Assessing the mechanisms for compensating land managers. Report to Scottish Government. Available online: http://www.gov.scot/Resource/0048/00487805.pdf

Scottish Environment Protection Agency (2013). Identifying opportunities for natural flood management. Available online: https://www.sepa.org.uk/media/163412/natural_flood_management_guidance.pdf

Scottish Environment Protection Agency (2015). Natural Flood Management Handbook. Available online:

https://www.sepa.org.uk/media/163560/sepa-natural-flood-management-handbook1.pdf

Scottish Environment Protection Agency (2016). Flood modelling guidance for responsible authorities. Available online: https://www.sepa.org.uk/media/219653/flood_model_guidance_v2.pdf

279. Analysis of the Most Catastrophic Flood Events in Turkey (1960-2014): Triggering Mechanisms of the Flood Events

Gamze Koç[1] , Theresia Petrow* and Annegret H. Thieken**

** University of Potsdam, Institute of Earth and Environmental Science, Karl-Liebknecht-Straße 24–25, 14476 Potsdam, Germany*

[1] *E-Mail: gamze.koc@uni-potsdam.de , Telefon: +49 331 977 2595, Fax: +49 331 977 2761*

KEYWORDS: Precipitation pattern, Turkey, flood hazards, atmospheric circulation types, triggering factors

ABSTRACT

Turkey has been seriously affected by numerous flood events especially in the last fifty years. The Turkish Disaster Database (TABB) reported 1,076 flood events which caused 795 fatalities and $800 million economic losses between the years 1960-2014. In Turkey, most of the flood events were analysed as case studies with regard to their meteorological characteristics including atmospheric conditions and their influences on precipitation patterns. However, up to now, there is no study that reflects the control mechanisms of severe flood events in the aggregate of atmospheric circulation patterns, catchment properties and human activities on the country scale. Therefore, it is aimed to analyse typical mechanisms that trigger catastrophic flood events in Turkey as a whole between the years 1960-2014. For this, the 25 most severe flood events in Turkey were identified considering human losses, affected people and economic losses as main indicators. Triggering mechanism of these events are being analysed in terms of atmospheric conditions (circulation pattern), precipitation pattern, catchment properties (topography, catchment size, land use types, soil properties) and human activities.

With this study, direct or indirect relevance of atmospheric circulation, precipitation pattern, catchment properties and human activities on the severe flood events in Turkey between 1960-2014 will be investigated. This study could provide beneficial information on flood mechanism in different regions of Turkey in terms of flood producing factors.

302. Impact of SUDS on urban heat management – Case studies from Colombo, Sri Laka & Tainan, Taiwan

H. E. Chen[1], H. R. A. Ducton Ishara*, Assela Pathirana*, and Chris Zevenbergen**

** UNESCO-IHE, Institution for Water Education*

[1] *Details for contact author (Address: Westvest 7 2611 AX Delft, The Netherlands, Telephone: +31682684555, E-mail: h.chen@unesco-ihe.org)*

KEYWORDS: urban heat island (UHI), sustainable drainage systems (SUDS), urban climate model, temperature increasing

ABSTRACT

Introduction

In the evolution of cities, the urbanization and industrialization of human civilization has caused a significant amount of heat to become concentrated in cities. Because the densification of urban areas reduces the space available for green areas, ambient city temperatures are often higher than surrounding suburban areas. This is known as the Urban Heat Island (UHI) effect (Rosenfeld et al. 1998). In order to maintain thermal comfort, additional energy is consumed to operate cooling systems, including air conditioning, refrigerators, and fans. An increase the green areas in city planning for development or in urban renewal can help to address the problems brought by UHI.

Objectives

This study is collecting and analyzing the influence on heat managed by sustainable urban drainage (SuDS) in Colombo, Sri Lanka and Tainan, Taiwan.

Methodology

The UrbClim model has been used to analyze the effect of SuDS on UHI. UrbClim is an urban climate model (Ridder et al. 2015), which is suitable for a few hundred metres resolution. This model is composed of a land surface scheme coupling simplified urban physics to a 3-D atmospheric boundary layer module. The model is of equivalent accuracy to more sophisticated models and also faster to run than high-resolution mesoscale climate models by at least two orders of magnitude. The data required to use UrbClim include the terrain (DEM), surface land use and meteorological data such as wind speed, rainfall and surface temperature.

Discussion

Historical records for the cities have been used to help understand the relationship between temperature and urban development. This phenomenon provides evidence for the existence of an UHI, which can be simulated and quantified by using UrbClim., Test cases, with increasing green areas of SUDS have been analyzed via model simulation to assess their effectiveness at reducing urban heat.

REFERENCES

Rosenfeld AHR, Akbari H, Romm JJ, Pomerantz H (1998). 'Cool communities': strategies of urban heat island mitigation and smog reduction. Energ Tech 28:51–62.

De Ridder, K.; Lauwaet, D.; Maiheu, B. UrbClim—A fast urban boundary layer climate model. Urban Clim. 2015, 12, 21–48.

325. Translating weather extremes into the future – a case for Norway

Jana Sillmann, Malte Mueller†, Nathalie Schaller*[1], Uta Gjersten**, Rein Haarsma# and Wilco Hazeleger^*

** CICERO, Norway*
† Norwegian Meteorological Institute, Norway
*** Statkraft, Norway*
 # KNMI, The Nethderlands
^ Netherlands eScience center, The Netherlands

[1] CICERO, Gaustadalleen 21, 0349 Oslo, Norway
nathalie.schaller@cicero.oslo.no, *+4722004731*

KEYWORDS: hydroclimatic extremes, high-impact floods, atmospheric rivers.

ABSTRACT

We will present the first results of a new project, "Translating weather extremes into the future – a case for Norway" (TWEX - http://www.cicero.uio.no/en/twex). In TWEX, we take a novel "Tales of future weather" (Hazeleger et al., 2015) approach in which we use future scenarios tailored to a specific region and stakeholder in order to gain a more realistic picture of what future weather extremes might look like in a particular context. We focus on hydroclimatic extremes associated with a particular circulation pattern (so-called "Atmospheric River") leading to heavy rainfall in fall and winter along the West Coast of Norway and causing high-impact floods in Norwegian communities. We translate selected past events into the future (e.g., 2090) using an approach very similar to what is used today for weather prediction. The data will be distributed by standard (weather prediction) communication channels of the Norwegian Meteorological Institute and thus, will be easily accessible by end-users for analyzing the impact of the events in the future and support decision-making on hazard prevention and control.

REFERENCES

Hazeleger, W. et al. (2015), Tales of future weather. Nature Climate Change, 5(2), 107-113, doi : 10.1038/nclimate2450.

328. The role of human influence on climate in recent UK winter floods and their impacts

Nathalie Schaller[1,2], Alison L. Kay[3], Rob Lamb[4,9], Neil R. Massey[2], Geert Jan van Oldenborgh[5], Friederike E. L. Otto[2], Sarah N. Sparrow[7], Robert Vautard[6], Pascal Yiou[6], Andy Bowery[7], Karsten Haustein[2], Chris Huntingford[3], William Ingram[8], Richard Jones[2,8], Tim Legg[8], David Wallom[7], Simon Wilson[8] & Myles R. Allen[2]

1: CICERO, Norway
2: Environmental Change Institute, University of Oxford, UK
3: Centre for Ecology and Hydrology, UK
4: JBA Trust, UK
5: KNMI, Netherlands
6: LCSE/IPSL, France
7: Oxford e-Research Center, UK
8: Met Office Hadley Centre, UK
9: Lancaster Environment Centre, Lancaster University, LA1 4YQ

[1] 1 CICERO, Gaustadalleen 21, 0349 Oslo, Norway nathalie.schaller@cicero.oslo.no, +4722004731

KEYWORDS: Probabilistic event attribution, 2013/2014 UK winter floods, large ensembles, hydrological modelling

ABSTRACT

The whole winter of 2013/2014 was characterized by a near-continuous succession of westerly storms. Accumulated rainfall during January 2014 was the largest ever recorded for that month across much of southern England, including the Radcliffe Observatory record in Oxford that begins in 1767. Severe floods resulted, causing major disruption. So far, quantifying any contribution from human influence on climate to such weather events and resulting floods has been difficult due to the large natural variability of winter precipitation in the North Atlantic and European regions. The emerging science of probabilistic event attribution however increasingly allows us to evaluate the extent to which human-induced climate change is affecting localised weather events. Under the project “EUropean CLimate and weather Events: Interpretation and Attribution” (EUCLEIA), an end-to-end attribution study is performed for the first time. An ensemble of 134,354 general circulation model simulations is run using the citizen science project weather@home. We find that the frequency of days in January in zonal flows increases jointly with increases in precipitation as a result of anthropogenic climate change. The best estimate of the change in risk of extreme (1-in-100-year in pre-industrial conditions) precipitation for January in southern England is an increase by around 40%, but the uncertainty range includes no change or an increase by over 160% due to uncertainty in the pattern of anthropogenic warming. Hydrological modelling indicates this increased extreme 30-day-average Thames river flows, and slightly increased daily peak flows, consistent with the understanding of the catchment’s sensitivity to longer-duration precipitation and changes in the role of snowmelt. Consequently, flood risk mapping shows a small increase in properties in the Thames catchment potentially at risk of riverine flooding, with a substantial range of uncertainty, demonstrating the importance of explicit modelling of impacts and relatively subtle changes in weather-related risks when quantifying present-day effects of human influence on climate. Our study provides for the first time an estimate of the scale of precipitation-related damages in a specific region due to the effects of anthropogenic changes in the composition of the atmosphere on climate.

341. Testing the climatic resilience to floods on the Ourthe River, Belgium.

Grelier B.[1], Drogue G., Pirotton M.** and Archambeau P.***

** LOTERR, Centre de Recherches en géographie, Université de Lorraine, Metz, France*

*** Hydraulic in Environmental and Civil Engineering (HECE), Université de Liège, Liège, Belgium*

[1] *benjamin.grelier@univ-lorraine.fr*

KEYWORDS: climate change scenarios, climatic resilience, hydraulic modelling, flooding discharge, soft river planning measure.

ABSTRACT

Objectives

Climate changes are now recognized as one of the main issue of the societies and are expected to bring disturbances in many fields including floods. However, as future is unknown, and climate models projections still own a wide range of uncertainties, adaptation measures are confronted to large uncertainties, that can lead decision-makers to inaction due to the high risk to mistake when designing. Furthermore, adaptation measures usually yield from deterministic, or top-down climate change impact studies, which restricts them to only few potential climate scenarios. The position of this study is to follow an alternative approach to assess the potential impacts of climate change on floods in the Ourthe catchment, Belgium. Grelier et al (2016) elaborated a transfer function method to assess long-term climate risk from mesoscale atmospheric circulation using a paleoclimate reconstruction and many climate models projections. They produced more than 2000 monthly anomalies with which they perturbed a baseline series to run a hydrological model. Based on these results we propose to use the hydraulic modelling to assess the impact of climate change on floods.

Methods

In a first step, a statistical sampling aims at selecting climate change reference scenarios (and corresponding hydrological scenarios) considered as representative of different atmospheric conditions. A 1D bin hydraulic model is calibrated and used to simulate the hydrological scenarios (of 30 years each) on a reach of the Ourthe river in order to detect sequences of overflowing at each bin. Two parameters have been retained: the first discharge and the duration of the overflowing sequences, which are then examined via a frequency analysis procedure to assess the impacts of climate change on floods.

Finally, a simple planning measure is tested with the hydraulic model: implementation of hedge in the flood plain. Results will provide information of the flood resilient nature of such a “soft” measure.

Conclusions

To summarize, our approach can contribute to consider the unexpected in the flood assessment and management: as climate change uncertainties still remains large, the resilience concept represents a promising way to better consider the potential climate change impacts on flood risk. Our work fits into this frame of resilience and besides testing a simple river planning measure, it may serve for example the elaboration of climate security margins or impulse the integration of a climate change component in the flood risk management documents and plans.

REFERENCES

Grelier B., Drogue G., Pirotton M. and Archambeau P. (2016). An alternate approach for assessing impacts of climate change on water resources: combining hazard likelihood and catchment sensitivity. Presented at 4th IAHR Europe congress, Liège Belgium, 2016. London, UK: CRC Press/Balkema.

363. CLIMATE CHANGE IMPACT ON FLOOD CONTROL MEASURES FOR HIGLHY POPULATATED URBAN WATERSHED

Carla Voltarelli Franco da Silva, Andre Schardong**, Cristiano de Padua Milagres Oliveira* and Joaquin I. B. Garcia*

** LabSid, Escola Politécnica, Universidade de Sao Paulo (USP). Sao Paulo, SP, Brazil*
*** University of Western Ontario – UWO, London, Ontario – Canada (email: aschardo@uwo.ca, +1 226 272 0040)*

KEYWORDS: Climate Change, Urban Flooding, Hydraulic modeling, IDF Updating

ABSTRACT

Flooding and overflows are recurring problems in several Brazilian cities, which usually undergo disorderly development. Their causes vary from increased impervious surface areas, deficiency/inefficiency of drainage structures and their maintenance, siltation of rivers, channel obstructions, and climatic factors. This situation is aggravated in the major cities. The Anhangabau Watershed is located in the central portion of Sao Paulo – Brazil and covers a drainage area of 5.4 km². The region is densely urbanized and crossed by a major north-south road connection. During the wet season, very often the portions of this interconnection passage become compromised due to rainstorms events, disrupting the flow of vehicles and creating a chaotic situation for the population in additional to the local effects of the flooding.

Observed rainfall records and an existing IDF (intensity duration frequency) curve for the region are used to obtain design storms. To account for climate change, a well know procedure, the equidistance quantile matching method for updating IDF curves under climate change, was applied to the existing historical data. Several different global climate models (GCM) and one regional model were applied to obtain and update rainfall design storm. The GCMs and future scenarios used were from the IPCC Assessment Report 5 (AR5) and two future projections: RCP (representative concentration pathway) 4.5 and 8.5.

Alternatives previously proposed to solve to flooding issue are briefly reviewed. On one of the latest studies (Silva et al. 2014), a few modern concepts of water resources management are presented and the linear retention measure was found to offer higher potential to mitigate the flooding problem in the lower valley of the Watershed. Therefore, this alternative was used to evaluate different design storms scenarios combined with return periods of 25 and 100-years as well as the updated IDF under climate change for RCP 4.5 and RCP 8.5. To model the complex network, representing both road and drainage systems and their interconnections, PCSWMM/SWMM software was applied.

Results are presented as flooding maps and show the impacts of the proposed linear retention measure based on: i) the existing IDF; ii) an observed rainfall event and iii) the updated IDF curves under climate change.

Community and social resilience (ii)

172. Silver Jackets Program: Ten Years of Progress
Mr Doug Bellomo, US Army Corps of Engineers, United States

188. Are there lessons that can be learnt from Bangladesh and Cuba that can increase American coastal communities' resilience to flooding?
Mr Darren Lumbroso, HR Wallingford Ltd, United Kingdom

209. Diverging flood risk subcultures in public institutions and local communities: Implications for flood risk management. The case of Itteren and Borgharen, The Netherlands.
Mr Douwe de Voogt, Vrije Universiteit Amsterdam, Netherlands

215. Flood Groups and Flood Resilience: Before, during and after the 2015 Boxing Day Floods in The Upper Calder Valley
Mr Steven Forrest, University of Groningen, Netherlands

285. "Making an impact": Improving response and resilience through innovation in flood warning and forecast communications
Dr Jacqui Cotton, Environment Agency, United Kingdom

332. Agent-based models: How can they reduce the risk posed to people by extreme flood events?
Mr Andrew Tagg, HR Wallingford Ltd, United Kingdom

340. Involving communities in flood risk management: a comparative approach
Ms Corinne Larrue, University of Paris Est Créteil, Lab'Urba France

386. Social justice: Towards flood resilience in vulnerable communities
Mr Paul Sayers, Sayers and Partners, United Kingdom

172. Silver Jackets Program: Ten Years of Progress

Jennifer Dunn

United States Army Corps of Engineers

7701 Telegraph Road, Alexandria VA

(571)236-1816

Jennifer.K.Dunn@usace.army.mil

KEYWORDS: interagency, flood risk management, team, outcomes

ABSTRACT

This presentation will examine a decade of achievements of the U.S. Silver Jackets program, a significant voluntary organizational effort that has resulted in more effective and efficient delivery of integrated governmental flood risk management through state-led teams.

By applying their shared knowledge and leveraging resources among agencies, the teams enhance flood mitigation, response and recovery. No single agency has all the answers, but leveraging multiple programs and perspectives can provide a cohesive solution.

Flood risk management responsibilities are shared among an extensive myriad of federal, state, tribal, and local governments, as well as other private groups and individuals. Within this context of such broadly distributed responsibilities, authorities, and programs, Silver Jackets teams provides an innovative and crucial link at the federal-state level. Participation in the program is voluntary; the success of the program is reflected in the participation in almost every state. There are presently 48 active teams in 47 states and the District of Columbia.

Although each state Silver Jackets team is unique, common agency participants include state agencies with mission areas of hazard mitigation, emergency management, floodplain management, natural resources management or conservation. Federal participation typically includes the U.S. Army Corps of Engineers and the Federal Emergency Management Agency and often others such as the National Weather Service and the U.S. Geological Survey.

The USACE, as a committed and active member of all state-led Silver Jackets teams, provides institutional support to promote collaboration and coordination within and among teams. The agency also provides technical assistance, leveraging existing programs to contribute to interagency projects that advance nonstructural flood risk management solutions. Engaging in flood risk management as an interagency team enables the agency to better track the outcomes of its programs; interagency team members often lead risk communication outreach efforts and take specific actions to reduce risk.

This presentation will provide a brief overview of the current status of the Silver Jackets program, point to examples of Silver Jackets teams in action, reference best practices in developing these diverse teams, and outline future directions.

188. Are there lessons that can be learnt from Bangladesh and Cuba that can increase American coastal communities' resilience to flooding?

Darren M. Lumbroso[1], Natalie R. Suckall[2], Robert J. Nicholls[3] and Kathleen D. White[4]

[1]HR Wallingford, Howbery Park, Wallingford, Oxfordshire OX10 8BA, UK
[2]Geography and Environment, University of Southampton, University Road, Southampton SO17 1BJ, UK
[3]Engineering and Environment, University of Southampton, University Road, Southampton SO17 1BJ, UK
[4]US Army Corps of Engineers, Institute for Water Resources, National Capital Region (NCR), 7701 Telegraph Road (Casey Building), Alexandria, Virginia 22315, USA
[1] Darren Lumbroso, HR Wallingford, Howbery Park, Wallingford, Oxfordshire OX10 8BA, UK, telephone: +44 (0)1491 822383, email: d.lumbroso@hrwallingford.com

KEYWORDS: Bangladesh; coastal flooding; Cuba; resilience; USA

ABSTRACT
Over the past decade, the US Gulf Coast has been hit by a series of major hurricanes, including Ivan, Katrina, Rita, Ike and Sandy which have led to coastal flooding and fatalities, as well as significant economic losses. In the USA over the past 60 years the disparity between the rich and poor has increased, with the poorest people becoming increasing physically and socially isolated. These isolated households often have limited social networks to call upon in times of emergency reducing their resilience to natural hazards such as coastal floods. In many coastal states, such as Florida and Georgia, it is expected that coastal populations will have increased by up to 20% by 2020. This increase, which will mainly comprise people of retirement age, coupled with increasing sea-levels, will make American coastal communities increasingly vulnerable to coastal flood events. Some states, such as Georgia, have not experienced an extreme coastal surge for more than 100 years. A recent survey found that less than one quarter of Georgians living on the coast were very concerned about hurricanes and many people living in low lying areas did not believe their homes could flood.

Despite their relative lack of resources the resilience of communities to coastal floods in Cuba and Bangladesh has increased via a range of measures including: improving the comprehensibility and effectiveness of warnings; building social capital; increasing the levels of trust in organisations responsible for issuing warnings and coordinating the emergency response; and methods of providing education in disaster risk reduction at primary through to tertiary level institutions. Despite financial challenges, both Cuba and Bangladesh have been made significant progress in reducing deaths, as well as ensuring that people are able to maintain their livelihoods following tropical cyclones and coastal flood events.

This paper looks at how the resilience of disadvantaged and isolated American coastal communities to floods could be increased based on the success of strategies and measures employed in Bangladesh and Cuba, where governments face significant financial constraints in providing infrastructure to protect populations from severe storms. Between 2003 and 2011, there were almost 20 times fewer deaths per million people at risk in

in Cuba than in the USA as a result of hurricanes and coastal floods and in Bangladesh the number of fatalities from cyclones has reduced by two orders of magnitude over the past 25 years. This paper will investigate if the lessons learnt in Bangladesh and Cuba can be applied in the USA. It will also discuss why there needs to be a recognition of the importance of social capital and community self-sufficiency and how these can be encouraged and measures can be designed to leverage it in the context of future coastal flood events.

209. Diverging flood risk subcultures in public institutions and local communities: Implications for flood risk management. The case of Itteren and Borgharen, The Netherlands.

Stefania Munaretto[1], Douwe de Voogt*, Kees Boersma**, and Jeroen Warner****

** Institute for Environmental Studies (IVM), Vrije Universiteit Amsterdam, The Netherlands.*

*** Faculty of Social Sciences, Vrije Universiteit Amsterdam, The Netherlands.*

****Department of Social Sciences, Wageningen University, The Netherlands.*

[1] *email: stefania.munaretto@vu.nl*

address: De Boelelaan 1087, 1081 HV Amsterdam

telephone: +31 6 25400974

KEYWORDS: disaster subcultures; risk perception; community resilience; risk communication; safety paradox

1. Introduction

Floods affect the livelihoods of many societies. Yet the understanding and perception of flood risk differ among cultures, levels of governance, geographical regions, institutions and academics. In the endeavour to grasp how individuals, communities and institutions understand disaster risk, disaster studies have proposed numerous analytical frameworks. In particular, using culture as an explanatory factor, scholars have elaborated on the emergence of disaster subcultures in communities affected by a potentially harmful 'disaster agent' (see e.g. Moore 1964; Anderson 1965; Wenger and Weller 1972; 1973; Granot 1996; also Marín et al. 2010).

A key element of disaster subcultures is the perception of risk. Studies in this field typically understand risk perception as an experience of the individual, and accordingly investigate aspects such as rationality, emotions, communication, and interpretation (e.g. Renn 2008; Pennings & Grossman 2008). However, the literature remains underdeveloped on risk perception as an experience of a collective of individuals, such as communities or organizations.

Drawing from disaster subculture theory and risk perception theory, this paper addresses flood risk starting from two key hypotheses: 1) flood risk subcultures can be identified in different societal groups (e.g. communities, public organizations, private organizations); 2) there may be a gap between the "flood risk subculture" of public organisations (professionals) and the flood risk subculture of local communities (see e.g. Luna 2003: 137). This gap originates in the premise that risk perception for these two groups is based on different sources of knowledge. The way public authorities address flood risk is typically underpinned by 'factual' knowledge derived from continuous monitoring, measuring, and modelling work, whereas the lay person usually understands risk more on an emotional level as product of flood event experiences. We argue the difference in flood perception is attributable to the lack of access of communities to factual knowledge and knowledge about implemented flood risk measures. Communication is herein a key factor as diverging flood risk subcultures may develop when there is little communication between authorities and communities about knowledge.

2. Analytical framework and methodology

This paper presents a novel analytical framework that integrates the concepts of individual flood risk perception and collective disaster subculture to illustrate how three key factors contribute to the development of flood risk subcultures: 1) (the last) flood event experience; 2) flood risk factual knowledge based on data and models; and 3) actions or interventions implemented to mitigate flood risk. We propose four ideal scenarios based on two factors: the frequency and last occurrence of flood events; and the quality of the communication regarding flood risk knowledge and measures. Communication about flood risk determines to what extent the flood risk subcultures of institutions and those of communities may diverge.

The methodological approach of this research revolved around a single in-depth case study (Yin 2009) regarding Itteren and Borgharen, two parishes in the municipality of Maastricht in the Netherlands. Itteren and Borgharen were severely flooded twice in the 1990s, and prior research has identified 'disaster subcultures' in these parishes (Engel et al. 2014). The case study involved a mixed methods approach, including semi-structured interviews with public organizations in charge of flood management and the local communities, a survey, and informal chats with local inhabitants.

3. Some preliminary observations

The absence of floods in the past twenty years, coupled with the development of flood infrastructure, have altered the perception of flood risk in communities as well as in authorities. Citizens feel safe behind the dikes. However, because the new flood infrastructure has altered flood dynamics, community knowledge of flood effects has partially become obsolete. For instance, whereas the water used to raise slowly and leave quickly during a flood event, if a flood had to occur now, the dynamic would be reversed with a sudden and quick rise of water and a slow water withdrawal. As for authorities, their perception of flood risk in Itteren and Borgharen has also changed as result of the flood protection measures. Itteren and Borgharen are now relatively well protected in comparison to other surrounding inhabited areas. Due to limited resources public authorities need to prioritize action, which implies that if a flood had to occur now, Itteren and Borgharen would receive less or delayed support. However, the communities are less resilient than in the past, and authorities as well as communities do not appear to be aware of that. The 2003 and 2011 high water events which got close to overflowing the dikes, may have reinforced the perception of a low flood risk, as our results show that both communities and authorities tend to downplay current flood risks. This perception of low risk coupled with a lack of awareness of the changed flood dynamics undermines local resilience.

Activities aimed at raising awareness and improving communication about the effects of the infrastructure on flood dynamics may help restore local resilience. More results and conclusions will be addressed at the conference.

References

Anderson W. A. (1965). *Some observations on a disaster subculture: The organizational response of Cincinnati, Ohio, to the 1964 flood*. Research Note No. 6. Disaster Research Center, The Ohio State University:

Columbus.

Engel, K., Frerks, G., Velotti, L., Warner, J., and Weijs, B. (2014). Flood disaster subcultures in The Netherlands: The parishes of Borgharen and Itteren. *Natural Hazards*, 73(2): 859-882.

Granot, H. (1996). Disaster subcultures. *Disaster Prevention and Management: An International Journal*, 5(4): 36-40.

Luna, E. M. (2011). Endogenous system of response to river flooding as a disaster subculture: A case study of Bula, Camarines Sur. *Philippine Sociological Review*, 51: 135-153.

Marín, A., Gelcich, S., Araya, G., Olea, G., Espíndola, M., and Castilla, J. C. (2010). The 2010 tsunami in Chile: Devastation and survival of coastal small-scale fishing communities. *Marine Policy*, 35(6): 1381-1384.

Moore, H. E. (1964). *And the winds blew*. Austin, Hogg Foundation for Mental Health, University of Texas.

Pennings, J. M. E. and Grossman, D. B. (2008). Responding to crises and disasters: the role of risk attitudes and risk perceptions. *Disasters*, 32: 434–448.

Renn, O. (2008). *Risk governance: Coping with uncertainty in a complex world*. London, UK: Earthscan.

Wenger D. E., and Weller J. M. (1972). *Some observations on the concept of disaster subculture*. Disaster Research Center Working Paper #48. Disaster Resarch Center, Ohio State University, Columbus, Ohio.

Wenger D. E., and Weller J. M. (1973). *Disaster subcultures: the cultural residue of community disasters*. Disaster Research Center Preliminary Paper #9. Disaster Research Center, Ohio State University, Columbus.

Yin, R.K. 2009. *Case study research: Design and methods* [fourth edition]. Thousand Oaks, CA: SAGE Publications.

215. Flood Groups and Flood Resilience: Before, during and after the 2015 Boxing Day Floods in The Upper Calder Valley

Forrest, S.[1], Trell, E.M.* and Woltjer, J.***

** University of Groningen, The Netherlands*

*** University of Westminster, England*

[1] *Faculty of Spatial Sciences, Department of Planning, The University of Groningen, The Netherlands;*s.a.forrest@rug.nl

KEYWORDS: Flood Resilience; Flood Groups; Civil Society

ABSTRACT

Objectives: To understand the changing role and contribution of flood groups (understood as voluntary-run civil society groups focusing on flooding) to local level flood resilience before, during and after the severe December 2015 floods in the Upper Calder Valley (England) using data collected from May 2015 and January 2017. To contribute to the analysis and deconstruction of local level flood resilience.

Methods: Semi-structured interviews were carried out in May 2015 (8 months before the flood) in Todmorden, Hebden Bridge and Mytholmroyd in the Upper Calder Valley. Interviews were with the three flood groups present in order to understand their governance arrangements and contributions to local level flood resilience. Local actors were also interviewed to understand their interactions with the flood groups. In January 2017, 13 months after the floods, interviews were carried out with the same flood group members and local actors to identify and analyse governance changes in the flood groups and how they influenced local level flood resilience during this time period.

Results: The data is still in the process of being analysed. Two areas were inaccessible to local authorities and emergency responders in the immediate aftermath (estimated to be 36 hours) of the flood. Therefore, these areas were heavily dependent upon the actions of local citizens acting as volunteers to address their immediate needs. Initial results suggest that the three flood groups contributed to local level flood resilience either before the flood by creating flood stores, which were then used during the flood response and recovery; or by developing an advocacy platform for citizens after the floods. During the flood itself, it was emerging volunteers (not attached to the flood groups) that were most active in contributing to local level flood resilience. Flood group member participation was limited by being away from the area at the time or because they themselves had been flooded and needed to take care of their own homes.

Conclusions: This research addresses existing literature gaps by analysing the contribution of civil society groups to local level flood resilience before, during and after a flood. Initial conclusions suggest that the flood groups were most active before and after the flooding event, but the event itself acted as a ‘window of

opportunity’ for flood groups and citizen-led initiatives. The floods increased the levels of awareness of these flood groups, and their activities, by local actors and also led to citizen-led governance changes in existing flood groups and civil society initiatives (e.g. The Mytholmroyd Flood Wardens) and the development of new civil society groups (e.g. The Flood Studies Group; Slow the Flow Calderdale). However, it is unclear how sustainable this will be in the longer-term.

285. "Making an impact": Improving response and resilience through innovation in flood warning and forecast communications.

Dr Jacqui Cotton, Dr Sally Priest**, Dr Simon McCarthy**, Murray Dale†, Helen Rukin†, Neil Blazey†, Dr John Wicks† and Melissa Stannard**

** Environment Agency*

*** Flood Hazard Research Centre, Middlesex University*

† CH2M Hill

[1] Jacqui Cotton, Lateral, 8 City Walk, Leeds, LS119AT. Email jacqui.cotton@environment-agency.gov.uk . Telephone 07825754924

KEYWORDS: flood warning forecasting risk communication.

ABSTRACT

Internationally, a key challenge to improving community resilience to flood risk is the extent to which the public are aware of flood risk and are able to respond effectively during a flood to mitigate the impacts. Awareness, and flood resilience, is often low for those with no previous flood experience. Knowing how to interpret information and how to respond is often challenging for those with and without prior experience.

Previous research has indicated that an understanding of the impacts of a flood enables the public to respond more effectively. The term impact refers to the timing and description of the hazard; how deep and fast flowing the water will be; and the consequences of these hazards to people. Impacts can also refer to the effect of a flood on buildings, key locations, roads, networks and infrastructure.

The challenge for flood risk authorities is to understand which impacts are most significant for those affected and how to best disseminate that information in real time; through which routes and using what language or visuals.

This paper reports on research to develop ways of enabling flood forecasting and alerting services (warnings, forecasts, social media, and traditional media) to convey the impact of a flood and make messages more meaningful to the at-risk public and first responders.

The research reviewed available evidence on public and responders' needs for describing impacts. It used that evidence to co-create and test with the at-risk public and responders innovative and effective approaches to describing and embedding impacts across flood forecasting, alerting and warning services. The paper will report on recommended ways of expressing impacts which encourage behaviour change in those taking action.

332. Agent-based models: How can they reduce the risk posed to people by extreme flood events?

Andrew F. Tagg[1], Darren M. Lumbroso* and Mark Davison**

** HR Wallingford*

[1] *Howbery Park, Wallingford, Oxfordshire, OX10 8BA, UK, 01491 822332, 07918 652035,*

a.tagg@hrwallingford.com.

KEYWORDS: Agent-based modelling, emergency management, evacuation, loss of life.

ABSTRACT

As the effects of major flood events continues to increase around the world, driven at least in part by climate change, the importance of considering a wide range of response measures has never been more pressing. Over the past 10 to 20 years there has been a paradigm shift from flood defence to flood risk management, and that use of non-structural measures can be more cost-effective, particularly when dealing with residual flood risk. One management response is to plan for evacuation of affected communities so as to reduce risk to people and with it loss of life. For this to be effective and safe, emergency plans need to be based on realistic assumptions of human behaviour, and to have been tested for a range of event scenarios.

Agent-based modelling of human responses before and during flood events is a powerful tool for considering risk to people, and its use has grown in the past couple of decades. This paper describes the application of the Life Safety Model in many countries and for different flood types, including dam failure in Malaysia, river flooding in Australia and coastal surges in the eastern USA. The paper considers how the model attempts to capture the physical and behavioural rules that may apply during evacuation, and the uncertainty inherent in any modelling approach.

The LSM software combines a widely-used transport module with physical and behavioural rules that are in part informed by limited observations. So the impact of floodwater on loss of life and injury, in terms of its depth and velocity, is derived from laboratory experiments that tested human stability over a range of conditions. Even so, this testing does not cover all age groups or physical characteristics, and so there remains uncertainty in the LSM simulations. Similarly, the model can specify the behaviour of people during major floods, such as time taken to start the evacuation and mode of evacuation. The model is therefore a powerful tool in being able to consider how such assumptions affect loss of life and evacuation times. But further research and experiential evidence would help in informing such behaviour to include in the model.

The LSM is currently being used in several flood applications for emergency management planning, to assess risks to people and to try and impose a response on the affected communities to minimise fatalities and injuries. The paper will provide examples to illustrate this. Key issues are the assumptions on response times to the warnings, and the effect this has on the road usage. The case studies will illustrate how the location of warning centres and safe havens affects the loss of life.

The LSM is an established and powerful agent-based tool that permits the simulation of behaviour before and during a flood, that can be used in emergency management. It uses standard physical rules on the stability of people, and allows a range of behavioural decisions to be tested.

340. Involving communities in flood risk management: a comparative approach

Corinne Larrue, Lila Oriard***

** Lab'Urba, Ecole d'Urbanisme de Paris, Univesité Paris Est Créteil, France, 14-20 boulevard Newton, Cité Descartes - Champs sur Marne, 77454 Marne La Vallée Cedex 2, Corinne.larrue@u-pec.fr, +33 171408041*
*** Lab'Urba, Univesité Paris Est Créteil, France, lila.oriard@gmail.com*

KEYWORDS: Communityand institution involvement, flood management

ABSTRACT

The involvement of communities, and more generally the involvement of inhabitants, is more and more considered as a key element of territorial flood risk resilience. Even if in most cases, inhabitants are mostly considered as people who have to be sensitized and informed, they are able to play an important proactive role in the implementation of collective actions for flood mitigation.

The communication will propose a comparative analysis of community involvement in five case studies[4], located in different river stretches across Europe with relevant past flood events. Moreover, in those five cases, local and/or regional institutions are aware or are implementing actions towards the affected population.

For each case study, the involvement of the communities in local flood management has been analyzed through an assessment of the social and civic capacities. The capacities assessment takes into account five different dimensions: knowledge, motivation, network, finance and participation. The assessment grid was applied to both: the communities at local scale and the flood risk management institutions linked to them at different territorial scales.

The five cases present a contrasted situation as regards community involvement. The main findings are: Most cases show that communities have a certain level of knowledge on flood risks, especially those confronted regularly to flood events. Only a few have motivation to mitigate flood risk, especially those confronted regularly to floods. In other cases, low levels of mitigation are related to over-trust of the population in infrastructure such as dikes which makes them feel secure without knowing the limits. Only two cases have developed participation capacities, in one case these capacities were developed during the implementation of a green space, flood friendly urban project and the other due to the motivation of the municipality to implement a participatory process. In the five case studies, network capacities as well as finance resources are

[4]These cases have been studied within the CAPFLO Research project on local resilience capacity building for flood mitigation coordinated by the Institute of Government and Public Policy (University of Barcelona, Spain), and which involves four other European teams (Lab'Urba of the University of Paris-Est, France; Institute for Environmental Studies of University of Amsterdam, The Netherlands; Institute for Social Research, Italy; and Institute of Sustainability Governance University of Luneburg, Germany)

varying and depends on the specific context. In all the cases, an important gap was observed between the level of capacities of the flood risk management institutions, in general higher, in contrast with those of the communities, which in most cases are low and only expressed during the flood event.

The communication presents in the first part the framework and the methods used to assess the involvement of communities/inhabitants in flood risk management. Then, it will describe and explain the main traits of this involvement in the five areas under study: Ribera Alta (Spain), Meuse river near Maastricht (The Netherlands), Vitry-sur-Seine (France), Trebbia river (Italy), Iller river (Germany). Lastly, it will point out the dialectic, interdependent relationships between the capacities of the flood risk management structure and that of the communities.

REFERENCES

Ballester A., Fernandez Ch., Pares M. (2016) “Social and civic capacity assessment, Ribera Alta del Ebro, Ebro River basin (Spain)” CAPFLO Project, Institut de Govern i Politiques Publiques, Universitat Autonoma de Barcelona, Barcelona.

Kochskamper E., Schutze N., “Task C1-C3, Case study description and application of assessment tool, the Iller River in Baden-Wurttemberg and Bavaria, Germany” CAPFLO Project, Leuphana Universitat Luneburg, Luneburg.

Larrue C., Oriard L. (2016) “Task C4: Cases comparative analysis” CAPFLO Project, Lab Urba, Ecole d'Urbanisme de Paris, Marne la Vallée.

Munaretto S., Van der Kaap M., de Voogt D., (2016) “C1-C2-C3 Social and civic for flood mitigation, the Meuse River in South Limburg, the Netherlands” CAPFLO Project, Faculty of Earth and Life Sciences, IVM Institute for Environmental Studies, Amsterdam.

Oriard L., Hubert G., Larrue C., Ballif F. (2016) “Task C1-C3 French case study, Action C” CAPFLO Project, Lab Urba, Ecole d'Urbanisme de Paris, Marne la Vallée.

Vasilescu C., Meloni E., (2016) “Task C1, C2, C3: Case study description, Trebbia River Italy” CAPFLO Project, Area Politiche Amministrative e Istituzionali, Istituto per la ricerca sociale, Milan

386. Social justice: Towards flood resilience in vulnerable communities

Paul Sayers[1,a], Matt Horritt[2], Edmund Penning-Rowsell[3], Katharine Knox[4], Jessie Fieth[5]

[1] Partner, Sayers and Partners, Associate WWF-UK and Senior Visiting Fellow, Environmental Change Institute, University of Oxford. Email: paul.sayers@sayersandpartners.co.uk
[2] Horritt Consulting
[3] Flood Hazard Research Centre, Middlesex University
[4] Joseph Rowntree Foundation (JRF)
[5] Sayers and Partners LLP
Keywords:

social justice, flood risk, Future Flood Explorer, adaptation policy

Summary of presentation:

Developing a better understanding of flood resilience in vulnerable communities is a prerequisite, we believe, to delivering a socially just or "fair" approach to prioritising flood risk management efforts within national policy and funding structures. Such an approach emphasizes Rawlsian principles of preferentially targeting risk reduction for the most vulnerable, and avoids a process of prioritisation based upon strict utilitarian or purely egalitarian principles.

Achieving this in practice however raises two central questions. The first is geographic; what are the inherent characteristics of a community that influence its vulnerability to a flood should it occur, and where are the most vulnerable communities located and what is their current exposure to flooding. The second is systemic; how successful is current flood risk management (FRM) policy in reducing risk in the most vulnerable communities as compared to less vulnerable communities.

The analysis presented seeks to understand both of these aspects and how they may change in the future in response exogenous influences (e.g. climate change and population) and endogenous influences (e.g. flood management policy and its broader impacts on issues such as insurance). In doing so the paper identifies those neighbourhoods at greatest flood disadvantage now and in the future (through to the 2020s, 2050s and 2080s) and, secondly, assesses the degree to which current flood risk management policy can be considered successful in delivering socially just outcomes. Based on this analysis the papers explores policy gaps and recommend policy changes to improve flood disadvantage and hence enhance flood resilience of vulnerable communities.

Modelling and hydroinformatics (iii)

223. An Integrated Approach for Maximizing Multi-Platform Data for Enhancing Water Related Disaster Early Warning and Management in Developing Countries
Dr Mohamed Rasmy Abdul Wahid, International Centre for Water Hazard and Risk Management (ICHARM), Public Works Research Institute (PWRI), Japan

255. Application of Particle Filter as Data Assimilation Method to Flood Predicting Model
Dr Kohji Tanaka, CTI Engineering Co., Ltd., Japan

264. The use of palehydrology for runoff estimation after flash floods in a torrential basin
Mr José David del Moral Erencia, University of Jaén, Spain

274. Opportunity mapping for natural flood management
Dr Kate Kipling, Environment Agency, United Kingdom

289. Tidal Basin Management for sediment management
Mr Rocky Talchabhadel, Kyoto University, Japan

294. Influence of Spatial Resolution of Rainfall Data on Flood Forecasting
Dr Mamoru Miyamoto International Centre for Water Hazard and Risk Management (ICHARM), Public Works Research Institute (PWRI), Japan

316. Flood Quantile Estimation from a Generalized Pareto Mixture Distribution
Prof Carlos Lima, University of Brasilia, Brazil

382. RMS pan-Europe Flood HD Models
Mr Maurizio Savina, Risk Management Solution, Switzerland

223. **An Integrated Approach for Maximizing Multi-Platform Data for Enhancing Water Related Disaster Early Warning and Management in Developing Countries**

Rasmy M. †1, Iwami Y.**1, Yamazaki Y.†, Tsuda M., Koike T.**

** International center for water hazard and risk management (ICHARM)*

† The National Graduate Institute for Policy Studies (GRIPS), Tokyo, Japan

[1] Mohamed Rasmy, 1-6, Minamihara, TsukubaIbaraki-Ken, Japan, Tel: +81 29 879 6779; abdul@pwri.go.jp

KEYWORDS: water related disasters, rainfall, satellite data, data integration, information dissemnination

ABSTRACT

There is an increasing need for obtaining reliable information on water related disaster events as early as possible, because the frequency and intensity of these events keep increasing and causing devastating damages to lives and properties around the world. In this research, we develop an integrated approach for maximizing the muti-platform data for enhancing water related disaster early warning and for better managing pre- and post- the disasters activities. The approach consists of three primary components such as a) real-time data collecting, archiving, and integration system, b) state of the art modeling, and c) information dissemination system.

Rainfall data is primary input for forecasting and early warning models, however, availability of reliable and timely (real-time) insitu observations are very limited in many developing countries, and hence effective early warning and counter measure against water related disasters cannot be realized. As a result, we have established rainfall data network in Kalu river basin, Sri Lanka and collecting the data in real time. To fill gap from the unobserved in-situ area, Near real-time satellite information was utilized. Japan Aerospace Exploration Agency (JAXA) is providing Global Satellite Mapping of Precipitation (GSMaP) Nowcast (GSMaP-Now) and Near Real time (GSMaP-NRT) products in 30 minutes and 4 hours latency from the satellite observation, respectively. However, the satellite data is biased mainly due to indirect measurements and interpolation of microwave data to the un-observed regions using cloud moving vectors estimated from infrared (IR) images. We employ several statistical bias correction methods to better calibrate the satellite rainfall products using the limited real-time ground gauges. The merged real-time insitu-satellite rainfall products were used for simulating river discharges, flood inundation, and the potential land slide information within the study region. In addition, we also forecast the rainfall using Weather Research and Forecasting (WRF) model and forecasted information were compared with the merged real-time insitu-satellite rainfall products for confirming the reliability of the forecast and its application for improving the lead time of the heavy rainfall and flood events. We utilize a platform from Data Integration and Analysis System (DIAS) of University of Tokyo for effective big-data management, processing, integration, and information dissemination. The proposed system will be applied in Pakistan and the Philippines in addition to Sri Lanka, and the effectiveness of approach will be demonstrated to national agencies, state holders, and policy makers in each country.

255. Application of Particle Filter as Data Assimilation Method to Flood Predicting Model

Kohji TANAKA[1], Hiroki TSUJIKURA***

** Dr.Eng., Water resources and plan management, Osaka Main Office, CTI Engineering Co., Ltd, JAPAN*

** Dr.Eng., Water resources and plan management, Osaka Main Office, CTI Engineering Co., Ltd, JAPAN*

[1] 1-6-7, Dosho-machi, Chuo-ku, Osaka 540-0045, JAPAN
Email: kj-tanak@ctie.co.jp
Phone: +81-6-6206-5923
Fax: +81-6-6206-6046

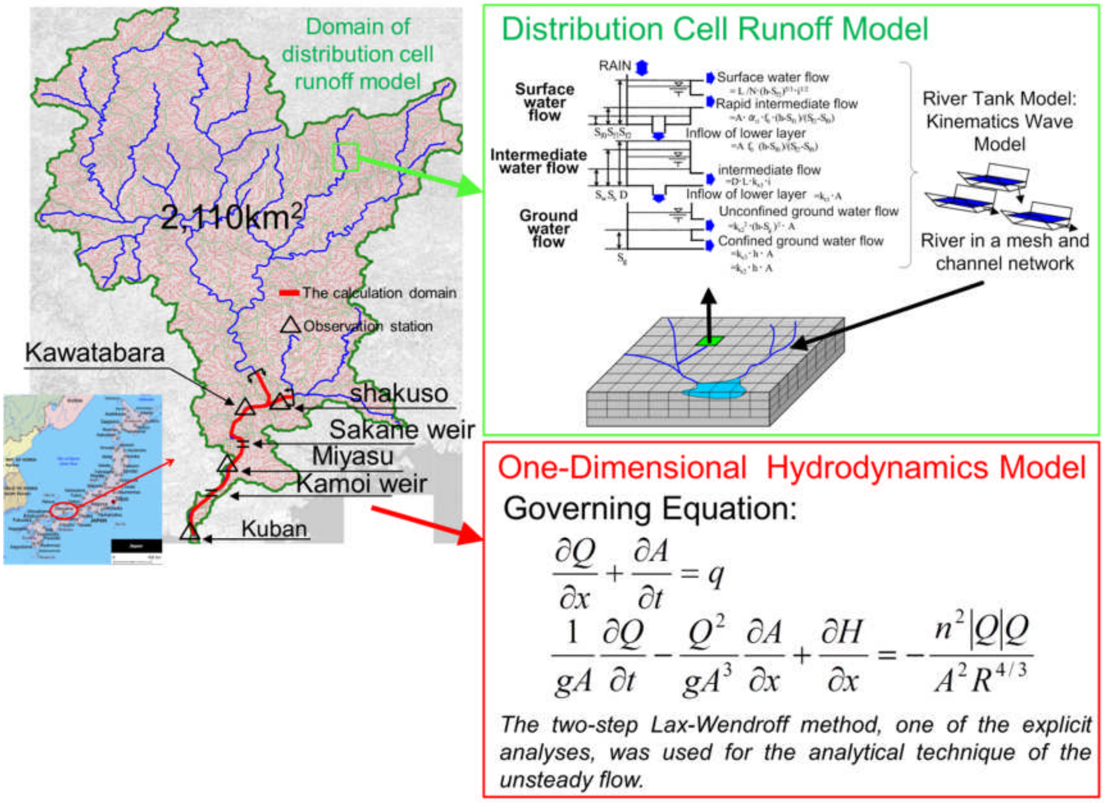
KEYWORDS: Particle Filter, Distributed cell runoff model, Flood prediction, Unsteady flow

ABSTRACT

The purpose of this study is to estimate the applicability of the Particle filter, which is one of methods that is used to optimise the values in governing equations in order to fit the temporal water surface level from past time to current time. The particle filter is a method that is used to optimise the state valuable by using static two order valuables of the observation and the system noise. In this study, we improved the accuracy of the water surface level forecast system, which are predicted at several water surface level gage stations in River Yoshii, Okayama prefecture in Japan.

Methodology

The object's reach has weirs, and it is difficult to predict the water level. Furthermore, the precision of the predicted water level will decrease by the HQ equation with the effects of the backwater and the weirs. Therefore, Particle filter was applied as a method to estimate the discharge for the water level. It is thought that the water level at several hours later, can be predicted by estimating the more suitable value of the discharge in the past conditions, which explain the changes in water level.



Results

These state variables were optimized by the Particle filter in order to fit the water surface level at the current time. Furthermore, computational predictions were performed with an optimized state variable as the initial condition. The temporary discharges by solving with the distributed runoff model was given to the boundary conditions at upstream. On the other hand, predicted water surface level before 6 hours was given to the boundary conditions at downstream. We estimated the accuracy of the water surface level at 1, 3, and 6 hours by comparing the predicted water surface level with the observed one. This technique was shown to be valid in its compatibility with the observations of the water levels, and it was applicable to the flood prediction system.

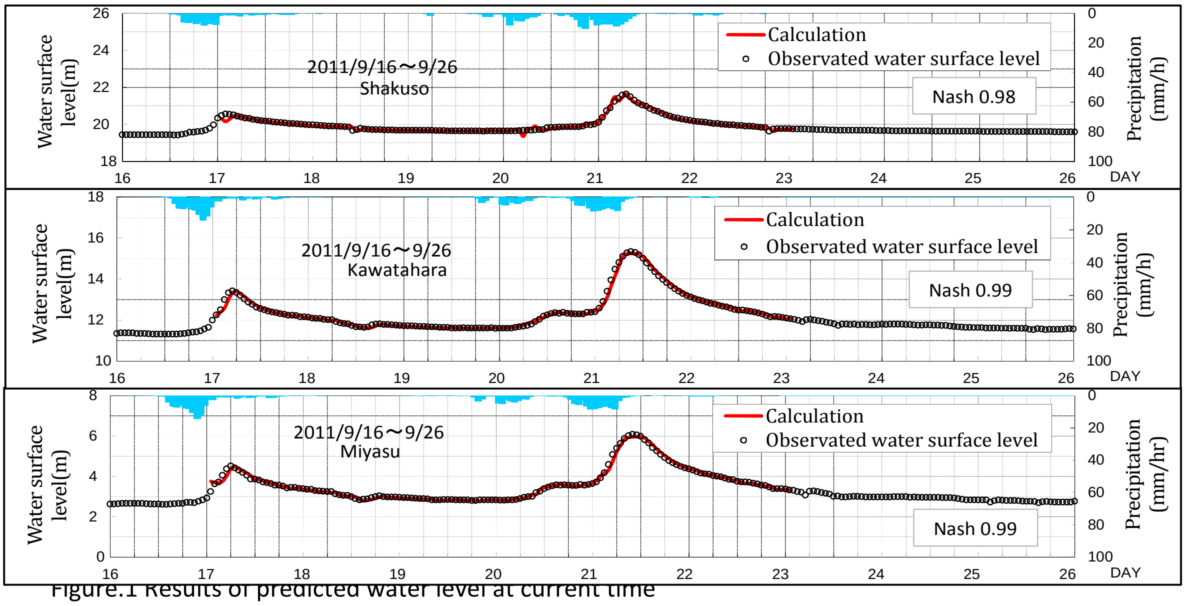


Figure.1 Results of predicted water level at current time

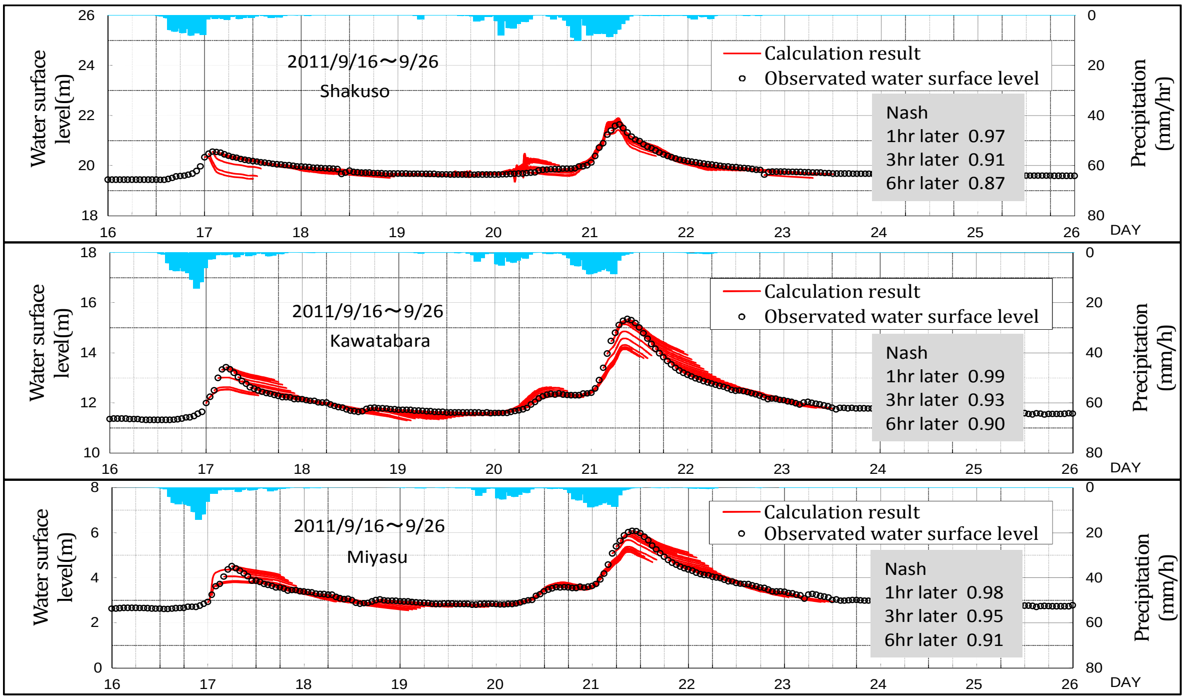


Figure.2 Results of predicted water level until 6 hours later

264. The use of paleohydrology for runoff estimation after flash floods in a torrential basin

Del Moral-Erencia J.D. [1] and Bohorquez P.* [2]*

** Área de Mecánica de Fluidos, Departamento de Ingeniería Mecánica y Minera, CEACTierra, Universidad de Jaén, Campus de las Lagunillas, 23071 Jaén*

[1] Email address: jdmoral@ujaen.es

[2] Email address: patricio.bohorquez@ujaen.es

KEYWORDS: flash flood; climate change; run-off; land-use change.

ABSTRACT

We propose a new methodology to infer the runoff and the peak water discharge of a flash flood event in an ungauged basin. The selected study area comprises the drainage basin of Ibros Torrent in southern Spain (Figure 1) which experienced an increase in the number of flash flood episodes between the years 1996 and 2013.

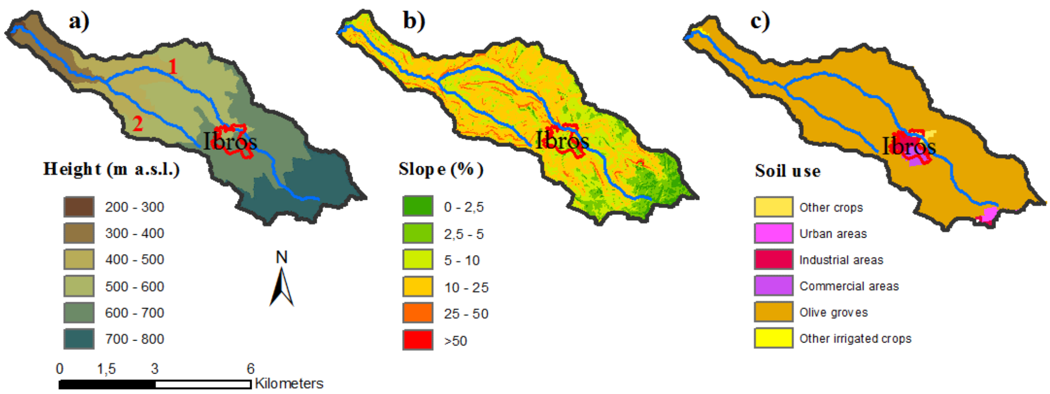


Figure 1. (a) Physical map, (b) local slope and (c) soil use classification of Ibros Basin. The two streams upstream of the confluence are (1) Moreras and (2) Ibros.

The catchment extends over an area of 25.6 km^2 and exhibits an average steep slope of about 12%. Soil management practises over 92% of the basin area focus on olive groves under conventional tillage, which leads to soil water repellency (Burguet et al., 2016). The increase in runoff provoked exceptional inundations in Ibros Village during the most recent floods (years 2009–2011), but the large magnitude of the event, the short duration and the damage of roads prevented the analysis of physical processes in situ.

To gain insight into geomorphologic and hydrologic processes, we studied morphological changes of the channel and soil use changes in the drainage basin using sequences of orthophotos during the period 1956–2013. We identified a nice collection of morphological changes and landslides across the basin related to the flash flood events between the years 2009 and 2013, but inexistent in the previous 50 years. For instance, Figure 2 shows the development and migration of a train of meanders that increased the channel width from

20 m (bankfull channel width) to 65 m (amplitude of new meander) and incised the channel approximately 3 m in depth.

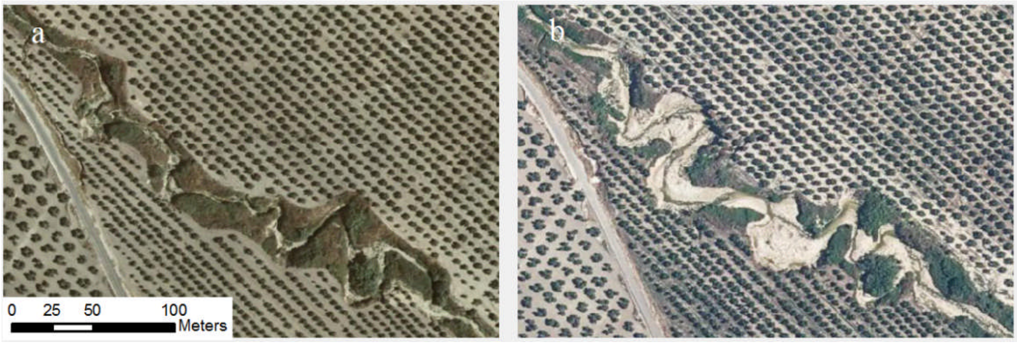


Figure 2. Orthophotos show the migration of meanders near the road to Ibros village between (a) July 2009 (pre-flood) and (b) May 2013 (post-flood).

We inferred the peak water discharges of the event along the most stable channel reach using high-resolution LiDAR (Light Detection and Ranging) elevations, paleostage indicators acquired after modern floods and two-dimensional numerical simulations based on IBER2D (Cea and Bladé, 2015), as proposed by Bohorquez (2016). The inferred peak flow on September 2009 flood was 170 $m^3 \cdot s^{-1}$. In the selected stretch (Figure 3), in-channel flow velocity achieved 6–7 $m \cdot s^{-1}$, flow depth was about 4.5 m, and the Froude number was supercritical (close to 3) due to the steep bottom slope.

Similarly, we retrieved the discharge values in Moreras and Ibros tributaries as well as in several gullies distributed over the basin. We were able to estimate the magnitude of the runoff by correlating the local water discharge with the draining area. The infiltration rate was neglected in our calculations due to the increase in water soil repellency observed in olive groves during the dry season at Mediterranean climate. Hence, the rainfall rate (RR) equals to the runoff in our study. Computed values of RR had a notorious geographical distribution, being higher in the northeast of the basin (114 $mm \cdot 3h^{-1}$ in a big gully) and lower in the south and west (29 $mm \cdot 3h^{-1}$ in Bancos stream). The mean value was 79 $mm \cdot 3h^{-1}$ and agreed with precipitation values from rain gauge observations, showing the same geographical distribution. Rainfall values obtained from rain gauges property of the Spanish Meteorology Agency (AEMET), and the Automatic Hydrologic Data Collection System (SAIH), were as high as 98.5 $l \cdot m^{-2}$ in Baeza and 80.6 $l \cdot m^{-2}$ in Canena on 16 September 2009. The frequency of the data was daily, but precipitation was concentrated in, approximately, three hours according to local newspapers.

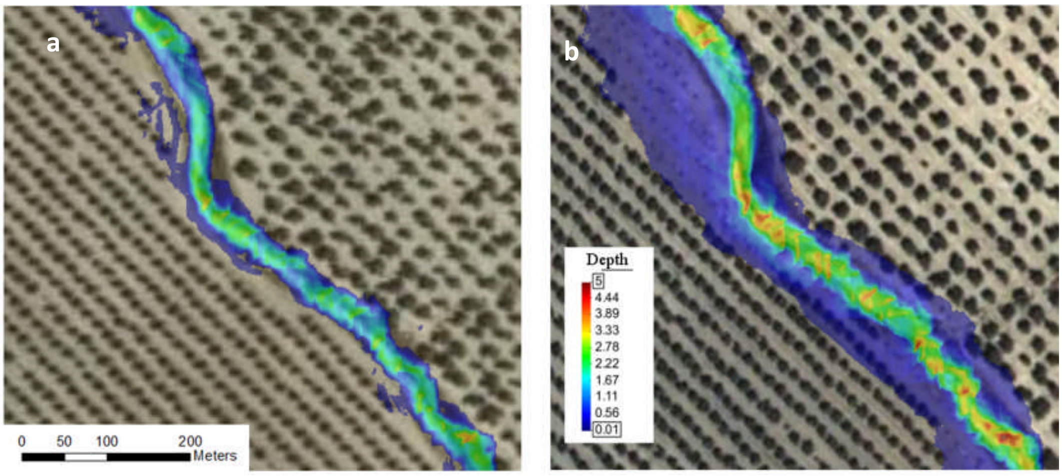


Figure 3. Flow depth for (a) 70 $m^3 \cdot s^{-1}$ bankfull streamflow and (b) September 2009 flood with peak river discharge of 170 $m^3 \cdot s^{-1}$. Orthophotos in (a) and (b) are pre- and post-event. Note the lack of three rows of olive trees washed out by the flow in the left upper corner of (b).

The exceptional activation of morphological processes was related to the effects of climate change (European Environmental Agency, 2017) and, also, to land-use changes (Table 1). Currently, traditional olive crops occupy the vast majority of the agricultural area (99%) and eliminate the natural vegetal cover. Climate change produced greater precipitation in a shorter time, while changes in land use induced an increase in runoff in the drainage basin. In particular, soil use change from cereal to olive grove during the last decades produced a decrease in infiltration rate and a huge increase in soil erosion rate with a potential factor of 200-300 (Cerdà & Doerr, 2007).

Soil use	1956		1984		2007	
	Area (km^2)	**Percent (%)**	**Area (km^2)**	**Percent (%)**	**Area (km^2)**	**Percent (%)**
Olive groves	16,897	66,00	19,476	76,08	23,318	**91,08**
Urban/industrial areas	0,300	1,17	0,614	2,40	1,041	4,07
Arable crops	8,021	31,33	5,098	19,91	0,649	2,54
Riverbed	0,333	1,30	0,333	1,30	0,333	1,30
Other	0,049	0,19	0,079	0,31	0,259	1,01

Table 1. Evolution of soil use in Ibros basin between 1956, 1984 and 2007.

Hence, there is a synergistic effect between climate and land-use changes that increase the risk of flooding in the study area. The combination of climate change and soil-use change triggered the activation of hydrologic and geomorphic processes that produced alterations in channel planform during the period 2009–2013 and the occurrence of extraordinary fast flood events in September 2009 and March 2011.

The factors described in this paper entail an increase of flood risk in non-regulated tributaries of the Guadalquivir River in Southern Spain during the last decades, with a rise in streamflow during storms with no necessary greater precipitation. The methodology presented in this work could be extrapolated to other regions affected by real climate change and soil degradation, particularly in small basins with steep slopes.

ACKNOWLEDGEMENTS

This work was supported by the Spanish Ministry of Economy and Competitiveness (MINECO/FEDER, UE) under Grant SEDRETO CGL2015-70736-R. J.D.d.M.E. was supported by the PhD scholarship BES-2016-079117 (MINECO/FSE, UE) from the Spanish National Programme for the Promotion of Talent and its Employability (call 2016).

REFERENCES

Bohorquez P. (2016) Paleohydraulic reconstruction of modern large floods at subcritical speed in a confined valley: proof of concept. Water, 8, 567.

Burguet M., Taguas E.V., Cerdà A. and Gómez J.A. (2016) Soil water repellency assessment in olive groves in Southern and Eastern Spain. Catena, 147, 187–195.

European Environment Agency (2017) Climate change, impacts and vulnerability in Europe 2016: An indicator-based report. EEA Report No 1/2017, doi:10.2800/534806.

Cea L. and Bladé E. (2015) A simple and efficient unstructured finite volume scheme for solving the shallow water equations in overland flow applications, Water Resour. Res., 51, 5464–5486.

Cerdà A. and Doerr S.H. (2007) Soil wettability, runoff and erodibility of major dry-Mediterranean land use types on calcareous soils. Hydrological Processes, 21(17), 2325–2336.

274. Opportunity mapping for Natural Flood Management

Objectives

This paper presents findings from ongoing work developing the evidence base for Natural Flood Management (NFM). The aim of this project is to create a toolbox of mapped data and methods which enable flood risk management (FRM) practitioners in England to identify potential locations for NFM. This will act as a supplement to local knowledge and a basis for discussions about NFM with catchment stakeholders. Much research has already been undertaken on this topic, including mapping of specific interventions (e.g. Broadmeadow et al., 2014), local maps and methodological guidance (Hankin et al., 2016). However, it has never been synthesised in one location nor presented in a manner that is widely accessible.

Method

The project is initially focussing on six priority NFM interventions and is aiming to be fully open under the terms of the Open Government License. We will create mapped layers by describing which landscape typology would permit each intervention, how to delimit those areas and which data sources to use. Data selection will focus on sources which are (i) the most openly licensable, (ii) have the best coverage and (iii) the most accurate. The resulting datasets will drive the creation of non-GIS based maps, index-linked to a range of boundaries. The maps enable users to explore NFM in different levels of detail – from large administrative areas to individual waterbodies. The accompanying user guide presents an adaptable set of tools which users can tailor to their area.

Results

The project will produce a nationally consistent set of data and maps, providing a framework which is adaptable to different contexts. Flood risk management authorities and other public bodies can employ this resource to plan both long-term catchment strategy and detailed implementation of NFM measures. It should provide an effective communication tool to challenge thinking around NFM interventions, and offer a different viewpoint to more established NFM programme areas. The indexed map library and technical guide will also enable users without specialism in GIS to access and use the maps. By releasing open data, we expect it to be reused, commercialised and improved. The bolt-on guide facilitates the addition of local, more accurate data to supplement the toolbox.

Conclusion

Finally, we highlight lessons learnt from our approach to opportunity mapping. Consultations with FRM practitioners revealed divided opinions over the utility of NFM, necessitating a flexible approach to take account of these opposing views. The requirement for open data to meet our aims meant prioritising accessibility above quality. As data increasingly moves into the public domain, future revisions could incorporate the latest developments to ensure that the opportunity maps remain fit for purpose. Further developments include expanding the range of interventions mapped, including urban and coastal NFM.

REFERENCES

Broadmeadow, S., Thomas, H. and Nisbet, T. (2014). Opportunity mapping for woodland creation to reduce diffuse water pollution and flood risk in England and Wales. Forest Research.

Hankin, B., Burgess-Gamble, L., Bentley, S. and Rose, S. (2016) How to model and map catchment processes when flood risk management planning. Environment Agency.

289. Tidal Basin Management for sediment management

Rocky Talchabhadel[1], Hajime Nakagawa** and Kenji Kawaike***

** Department of Civil and Earth Resources Engineering, Kyoto University, Japan*

*** Disaster Prevention Research Institute, Kyoto University, Kyoto, Japan*

[1] *Email: rocky@uh31.dpri.kyoto-u.ac.jp Phone : +81-80-4985-2043*

***Keywords**: Tidal Basin Management, Suspended Sediment Concentration, tidal movement, link canal, tidal basin, beel*

1. Introduction

Tidal rivers are characterised by the brackish water ecosystem combined with the tide-dominated rivers, streams and water-filled depressions. The river system is highly active, carrying large concentrations of sediment causing significant deposition of sediment and reduction in their drainage capacity. The series of polders constructed into encircled earthen embankments around depressions keeping the main tidal channel outside the polder are the response to the floods. But the obstructions by polder system led to accelerated silt deposition and sediment accumulation in the rivers and channels. The deposition of silt and clay on the riverbed for the longer time period alters the natural flow of such rivers. The resulting dearth of land formation leaves the floodplains inside the polders lower than the riverbanks outside the polders (Rezaie and Naveram, 2013). It causes the severe drainage congestion and water logging which adversely affects the homesteads and livelihood activities. Dredging and re-excavation are enormous tasks which are costly and again the river faces siltation every time. The sediment management has been most challenging.

De-poldering and then controlled flooding in a particular flooding plain as the tidal basin is not a new way of sediment management. But it involves taking full advantages of the natural tide movement in rivers. Tidal basin acts as tidal storage basin which allows natural tidal flows up and down in the river system (shown in figure 1). This sedimentation would occur into the riverbed if it is not utilized for storage as sedimentation trap (Ibne Amir *et al.*, 2013; Paul *et al.*, 2013; Rahman and Salehin, 2013). It is basically shifting the sedimentation from the riverbed to selected tidal basin. Moreover, the natural flow as low tides coming back to the river benefits in the river declination. In this regards, the system is effective to raise land for cultivation in the depression beel area, improve drainage performance, mitigate the water-logging crisis, and increase the navigability of tidal rivers and revival of river functionality. It involves the natural tide movement in rivers and taking full advantage of it (Ibne Amir *et al.*, 2013; Shampa and Pramanik, 2012; Talchabhadel *et al.*, 2016a). Such system has been practiced in South Western region of Bangladesh namely Tidal River Management (TRM).

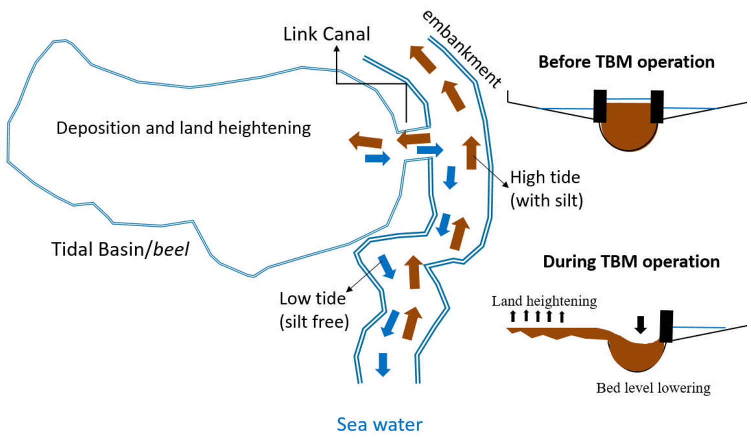


Figure 1 Conceptual model of Tidal Basin Management

The process is a participatory approach where people's participation is highly essential. The local people should be a vital player for the proper operation and management. The people of identified tidal basin have to sacrifice their land for intended period (few years), a proper compensation to the affected people should be ensured. The process is continued for several years (usually 3 to 4 years, the duration depends on the size of the tidal basin). Such tidal basins are to be rotated among various lowlands within the system so that farmers of one tidal basin do not have to suffer for a long time, the process known as Tidal Basin Management (TBM).

Some of the experiences of such systems in Bangladesh proved either an unsuccessful outcome or far beyond the expectation resulting in the discouragement among people to participate by providing their land. Even the process has been one of the integral parts of sediment management for the tidal rivers in Bangladesh, very few studies are realized based on the numerical simulations and almost nil is found based on the experimental studies. In this context, an attempt is made to assess the effectiveness of the system through experimental and numerical simulation.

2. Experimental and Numerical Study

One significant hydraulic fact is that the faster the flow is, the more sediment it can carry with it. Additionally, among the key governing factors of the flow, the appropriate design of the opening size of the link canal that connects the tidal basin and tidal river is crucial. For the establishment of the consistent relationship among tidal prism and minimum cross-sectional area, ample amount of field data of the tidal rivers are needed. An attempt is made to inspect the effectiveness of the process investigating the different opening sizes and to compare with available empirical relations, by conducting laboratory experiments (shown in figure 2). See (Talchabhadel *et al.*, 2017a, 2017c) for a detailed explanation of the experimental methodologies. Before incorporating the tidal condition, the sediment behaviour without tidal influence is explored as preliminary experiments. The preliminary experimental result carried out by (Talchabhadel *et al.*, 2016b, 2016c) shows that the SSCs towards the flow direction are higher.

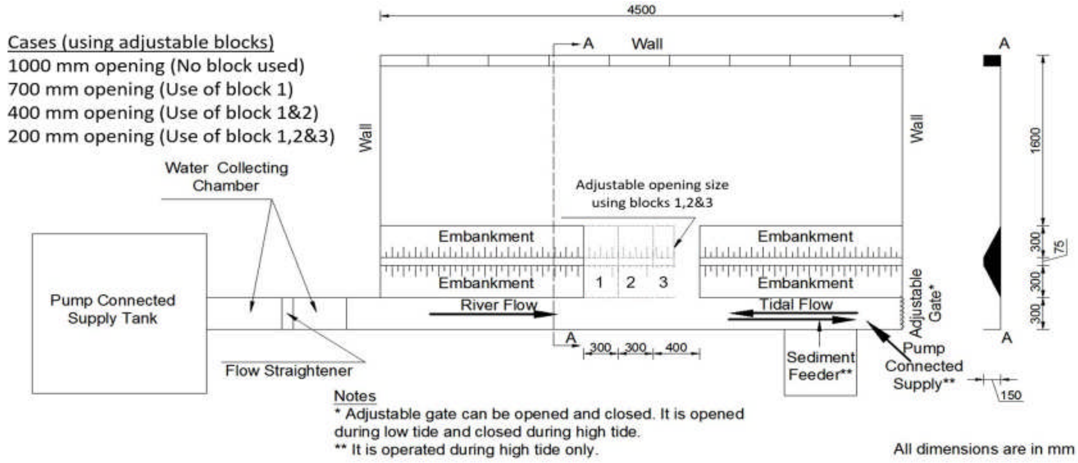


Figure 2 Schematic view of the experimental setup

The numerical simulation is developed reproducing reasonably similar results as that of the experiments (shown in figure 3). The developed numerical model is applied to explore the efficacy of the land heightening of the tidal basin with changing discharges and opening sizes. It is found that if the natural river is not intervened by human interactions and civil structures, the recommended size of the link canal is more or less equal to the natural width of the river. Additionally, if the upstream river flow is reduced or made nil, the attached side basin has better movement of up and down of the tidal movement resulting in more sedimentation (Talchabhadel *et al.*, 2017b). It suggests the crossing dam should be constructed during low flow period to allow maximum natural tidal movement in selected tidal basin. For this, a control structure to divert the upstream flow may be needed. The complex phenomena like vortex–like formation during the experiment is attempted to analyse by three-dimensional numerical simulation. The area that is influenced by high shear stress should be protected by using some mitigations like the use of concrete blocks. Finally, the model is considered to be applicable for real case.

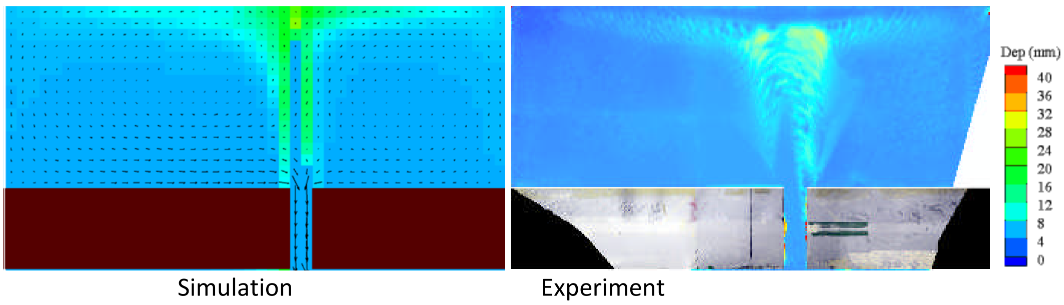


Figure 3 Sample comparison of simulated and experimental results of deposited sediment after repetitive tidal movement

The numerical model is applied to evaluate the TBM in the case of East *Beel* Khuksia. Uniformly raising the land inside a selected tidal basin and maintaining the proper river navigability are the two main objectives of TBM. The simulation is done for real storyline case and other options. The proposed size of the opening size and availability of crossing dam as recommended by experimental results and numerical simulations reproducing experiments have been used in the numerical simulation in an actual field to evaluate the land heightening during the dry period. The assessment of the TBM with single link canal, two link canals and simultaneous operated both link canals is performed.

It is recommended to operate one link canal in one tidal basin if the tidal equilibrium is fulfilled that by link canal's opening size. Moreover, to have additional benefits, the manual/mechanical dredging around the entrance of link canal can be done. Additionally, for the proper distribution of the deposited sediment, compartmentalization and channelization should be done. The numerical simulation can be used to evaluate the better position of link canal, suggest the appropriate number of link canals and to suggest the appropriate time to shift from one link canal to another. The developed model can be used in ongoing TBM basin and proposed basins to estimate the effectiveness of the options of the link canal, sequence of the operation of the link canals and ultimately the life span of the tidal basin.

3. Conclusion

TBM is very effective to manage sediment in the estuarine basin where the natural movement of tidal river is used. After the proper assessment of the available tidal prism, an equilibrium minimum cross-sectional area is to be designed and the area of selected tidal basin should be planned. Since the system strongly prerequisites the public participation, the stakeholder's consultation is necessary to finalize the acceptable options for sediment management inside the tidal basin. The blending of the utilization of natural tide movement with some level of engineering works and timely dredging/excavation of the deposited sediment around the entrance of the link canal would strongly provide better results.

Acknowledgement

The research is supported by JST/JICA SATREPS program on disaster prevention/mitigation measures against floods and storm surges in Bangladesh (PI: Dr. H. Nakagawa). The first author is pleased to acknowledge a Monbukagakusho scholarship for graduate students.

References

Ibne Amir MSI, Khan MSA, Kamal Khan MM, Golam Rasul M, Akram F. 2013. Tidal river sediment management - a case study in southwestern Bangladesh. *International Journal of Civil Science and Engineering* **7**(3).

Paul A, Nath B, Abbas MR. 2013. Tidal River Management (TRM) and its implication in disaster management : A geospatial study on Hari-Teka river basin , Jessore ,. *International Journal of Geomatics and Geosciencse* **4**(1): 125–135.

Rahman R, Salehin M. 2013. Disaster Risk Reduction Methods, Approaches and Practices. In: Shaw R, Mallick F and Islam A (eds) , 300.

Rezaie AM, Naveram UK. 2013. Tidal river management : An innovative approach for terminating drainage congestion and raising land through sedimentation in the Bhabodaho area , Bangladesh. *Advances in River*

Sediment Research. CRC Press 1363–1375.

Shampa, Pramanik MIM. 2012. Tidal River Management (TRM) for Selected Coastal Area of Bangladesh to Mitigate Drainage Congestion. *International Journal of Scientific & Technology Research* **1**(5): 1–6.

Talchabhadel R, Nakagawa H, Kawaike K. 2016a. Tidal River Management (TRM) and Tidal Basin Management (TBM): A case study on Bangladesh. *FLOODrisk 2016 - 3rd European Conference on Flood Risk Management*, 1–7. DOI: 10.1051/e3sconf/201 60712009.

Talchabhadel R, Nakagawa H, Kawaike K. 2016b. Experimental study on suspended sediment transport to represent Tidal Basin Management. *Journal of Japanese Society of Civil Engineers, Ser B1 (Hydraulic Engineering)* **60**: 847–852.

Talchabhadel R, Nakagawa H, Kawaike K. 2016c. Experimental Study on Transportation of Suspended Sediment on Side Basin. *Annuals of the Disaster Prevention Resesearch Institute, Kyoto University* **59**(B): 411–419.

Talchabhadel R, Nakagawa H, Kawaike K, Hashimoto M, Sahboun N. 2017a. Experimental investigation on opening size of tidal basin management: a case study in southwestern Bangladesh. *Journal of Japanese Society of Civil Engineers, Ser B1 (Hydraulic Engineering)* **61**: 781–786.

Talchabhadel R, Nakagawa H, Kawaike K, Ota K. 2017b. Experimental and Numerical Study of Tidal Basin Management around Link Canal : A Case Study of Bangladesh. *Annuals of Disas. Prev. Res. Inst., Kyoto Univ.,* **60**(B).

Talchabhadel R, Nakagawa H, Kawaike K, Sahboun N. 2017c. Experimental study on Tidal Basin Management : A case study of Bangladesh. *E-proceedings of the 37th IAHR World Congress*.

294. Influence of Spatial Resolution of Rainfall Data on Flood Forecasting

Mamoru Miyamoto.[1] Kazuhiro Matsumoto** and Yoichi Iwami.**

** International Centre for Water Hazard and Risk Management (ICHARM)*

*** Fujitsu Laboratories LTD.*

[1] Researcher, 1-6 Minamihara Tsukuba Ibaraki 305-8516, Japan, tel: +81-29-879-6779, fax: +81-29-879-6709, mmiyamoto@pwri.go.jp

KEYWORDS: IFAS, C-band radar, Parameter optimization

ABSTRACT

Reliability and usability of rainfall data are keys of flood foresasting and prevention activities. One of some kinds of rainfall data including ground gauge, radar and satellite-based is normally used in flood forecasting with consideration for availability. In general, ground gauge excels other types of rainfall data at accuracy of quantity, whereas grid-data such as radar and satellite-based can describe spatial distribution of rain area with higher resolution. For flood forecasting by distributed hydrological model, since basin-wide rainfall is applied to a forecasting model, authors focus on the reliability of basin-mean rainfall data during flood. In this study, firstly, error of the basin-mean rainfall data observed by ground gauge is quantitatively assessed on the basis of spatial representativeness. The result derives a relationship between desired error and necessary number of gauges in the basin. The gap between ground gauge and C-band radar as the basin-mean rainfall is also clarified in some flood events. Secondly, Integrated Flood Analysis System (IFAS), a distributed hydrological model developed by International Centre for Water Hazard and Risk Management (ICHARM), is applied to the Abe River basin with catchment area of 567km^2, applying rainfall data of ground gauge and C-band radar respectively. Hydrological parameters such as hydraulic conductivity, runoff coefficients and roughness are determined in each case by an optimization method developed collaboratively by ICHARM and Fujitsu Laboratories Ltd. Each time-series of simulated discharge is evaluated in terms of reproducible performance to the observed discharge. This evaluation brings that the gap of basin-mean rainfall data corresponds to the reproducibility of simulated discharge. As a result, this study finds the reliability of each rainfall data to the flood forecasting. Additionally, numerically optimized hydrological parameter sets with ground gauge and C-band radar are compared and verified from physical meaning of hydrological parameters.

REFERENCES

Mamoru MYAMOTO, Makoto ONO, Seishi NABESAKA, Toshio OKAZUMI, Yoichi IWAMI (2014) Applicability of a flood forecasting method utilizing global satellite information to an insufficiently-gauged river basin -a case of a river basin in the Philippines: proceedings of the 11th International Conference on Hydroinformatics, IWA IAHR, No. 1395

316. Flood Quantile Estimation from a Generalized Pareto Mixture Distribution

Carlos H. R. Lima[*1]

** Department of Civil and Environmental Engineering, University of Brasilia, Brazil*

[1] Campus Universitario Darcy Ribeiro, Brasilia, Brazil. chrlima@unb.br

KEYWORDS: Flood Generation Mechanisms, Flood Quantiles, Heterogeneous Distribution, Mixture of Distributions

ABSTRACT

Several studies have shown that some floods result from different climate mechanisms or are subject to temporal changes in the forcing mechanisms or surface conditions, which make the common homogeneity and stationary assumptions in traditional flood frequency analysis no more valid. In a previous study, I proposed a new methodology based on the ideas developed in the flood hydroclimatology field to identify the generation mechanisms and physical processes responsible for major floods across the 823,555 km^2 Upper Parana River Basin in Brazil. The findings of this work revealed heterogeneity in the type of storms responsible for major floods and resulted in a categorization of floods into four types, which were associated with tropical and extra-tropical processes (e.g. South America low-level jet, extra-tropical cyclones and the South Atlantic Convergence Zone) and with different distributions and regional scaling. Here we seek to advance the traditional flood frequency analysis (FFA) in the region by analyzing trends and attributing causing factors in flood maximum series, and estimating flood quantiles considering an heterogeneous distribution as a mixture of homogeneous distributions related to the identified, distinct climate mechanisms. Particularly, for each site I consider a mixture of Generalized Pareto distributions to fit partial duration series sorted into four categories. A Bayesian inference framework is adopted in order to better estimate and quantify parameter uncertainties. Preliminary results show significant differences in flood quantile estimates when compared with traditional methods of FFA which assume homogeneity. The proposed study provides also new conceptual ideas to deal with nonstationary flood series and a methodological framework to assess changes in the flood risk across the region resulting from future changes in the flood generation mechanisms. This is an important step forward to improve the flood risk management in the Upper Parana River Basin in terms of local and regional flood frequency analysis and flood risk prediction.

382. RMS pan-Europe Flood HD Models

Savina M.[1], Hilberts A.*, and Peiris N.**

** RMS, Risk Management Solution*

[1] *Stampfenbachstr. 85 8006 Zürich; T: +41.44.365.1512;* maurizio.savina@rms.com

KEYWORDS: Probabilistic, Flood, Hazard, Vulnerability, Loss.

ABSTRACT

This contribution provides an overview on the methodology used to develop the new RMS pan-Europe Flood HD Models. Particular focus will be given to the innovations within hazard and vulnerability components, and it will conclude by addressing open challenges for the scientific community dealing with flood modeling.

Precipitation-driven flooding poses a significant challenge for the re-insurance industry. Large events frequently impact river basins across Europe, resulting in major insured losses. But flood hazard is not confined to major rivers and their surrounding floodplains. Intense precipitation can occur anywhere and the associated flooding can pose an additional source of loss. These varying sources and scales of flood risk in Europe make this a challenging peril for re-insurers to manage. The new RMS pan-Europe flood HD models is designed to estimate flood risk across 13 countries in Europe.

The model is precipitation-driven, based on 50,000 years of simulated precipitation. Modeling precipitation is important because it ensures that the spatial correlation of flood hazard is explicitly represented and supports a realistic view of antecedent conditions, which can dramatically influence the flooding caused during an event. Simulated precipitation also enables the explicit modeling of both minor and major river fluvial flood risk, and pluvial flood risk, ensuring that the hazard is evaluated both on and off the floodplain. The development framework allows flexibility of analysis settings across various dimensions, as for instance supporting bespoke flood defenses and hours clause values, a key innovation in flood modeling.

Gaining a complete understanding of the risk requires an understanding of the exposure and its vulnerability to flood hazard. With hundreds of unique component-based vulnerability types defined, the models can represent information relating to the exposure type, its occupancy, construction and other characteristics that influence a risks vulnerability to flood damage, such as the presence of basements. Flood hazard is characterized by very high spatial gradients which are mainly driven by small scale topography and mitigations systems such as large scale flood defenses but also local protections as simple as sandbags. The modeled vulnerability is characterized by an innovative secondary uncertainty distribution that, thanks to a ground-up simulations framework allows users to have more realistic location level loss estimates.

RMS is the leading catastrophe risk management company developing Nat CAT models with the necessary tools to comprehensively understand and manage natural hazard risk.