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Book of Abstracts

Special Session Abstracts

Local scale approaches to community flood resilience (i)

168. Community-led actions supporting SMEs resilience to flooding
Dr Paola Sakai, University of Leeds, United Kingdom

203. How can community approaches to flood resilience add value. Slow the Flow : Calderdale – a Citizen Science approach to resilience
Mr Robin Gray, Pennine Prospects/ South Pennines Local Nature Partnership, United Kingdom

236. Re-configuring Local Governance for Community Resilience: social learning for flood adaptation under a changing climate
Prof Stewart Barr, University of Exeter, United Kingdom

243. 'Knowledges for resilience' and barriers and motivators to flood risk adaptation for small business owners in the UK
Prof Lindsey McEwen, University of the West of England, Bristol United Kingdom

168. Community-led actions supporting SMEs resilience to flooding

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KEYWORDS: Small businesses, community, insurance, flooding, resilience

ABSTRACT

Small and medium businesses (SMEs) represent 98% of the private sector in the UK, providing employment, goods, services, and contributing to GDP. Studies suggest that, within the private sector, SMEs are the most vulnerable to flooding, which is the main climate change impact in the UK. An aspect not well understood is how they can protect and recover from flooding events. Financial protection against flood risk is a way to safeguard livelihoods and assets. The UK Government has launched flood initiatives, like Flood Re, to help households in high-risk flood areas to afford flood insurance. SMEs, however, have been excluded. In the light of recent findings highlighting the unaffordability of insurance by SMEs (Sakai et al. 2016), the Government has urged the need to provide further evidence to substantiate the lack of flood protection for SMEs and their affordability of insurance (EAC 2016).

OBJECTIVE

The aim of this project is to gather evidence on the financial and practical means that SMEs possess to manage the impacts of flooding, and investigate alternative strategies that are available for them to reduce flood risk.

METHODS

A mixed-methods approach was adopted. Data from an online survey was analysed quantitatively to assess the costs of impacts and re-insurance needs of SMEs, as well as appraise the risk-reduction measures that have been undertaken. Interviews allowed a qualitative assessment of the barriers/opportunities and practical means that SMEs have to manage their flood risk.

RESULTS

We found that SMEs have signifcant problems to afford flood insurance. In some cases, this was crucial for business survival. A vital finding is that novel community-led recovery schemes have emerged to support SMEs in the absence of financial protection from the insurance market and government.

CONCLUSION

We need to better understand how to encourage the uptake of insurance and other risk reduction strategies by SMEs. Protecting themselves from flooding by having affordable insurance or other risk reduction measures is essential. Otherwise, economic impacts will escalate as climate change unfolds. However, if Flood Re, or any

other insurance scheme, is deemed relevant for SMEs, it must be accompanied by clear risk management strategies. Strong community action along with robust networks can thus play a strong role in increasing community resilience against the challenges of flooding. Existing efforts offer invaluable lessons that can inform more comprehensive and inclusive policies.

REFERENCES

Sakai, P., Holdford, A., Curry, S. (2016) Economic Impact Assessment of the Boxing Day Floods (2015) on SMEs in the Borough of Calderdale. University of Leeds, Calderdale Council, and Upper Calder Valley Renaissance. http://www.cccep.ac.uk/wp-content/uploads/2016/04/Economic-Impact-Assessment-of-Boxing-Day-floods.pdf

House of Commons Environmental Audit Committee (2016) Flooding: Cooperation across Government, Second Report of Session 2016–17. 9 June 2016, House of Commons. http://www.publications.parliament.uk/pa/cm201617/cmselect/cmenvaud/183/183.pdf

203. How can community approaches to flood resilience add value. Slow the Flow : Calderdale - a Citizen Science approach to resilience

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Keywords:
Community resilience, Natural Flood Management

Background
In December 2015, the Calder Valley suffered the most significant flooding event in recent times. 2,781 homes and 4,416 businesses were flooded causing unparalleled and significant damage. In the aftermath of these events there has been an emphasis on emergency response, recovery and resilience (Andrew, R.2015).

Citizen science has been seen as a way of increasing collective knowledge of historical flood events and also helping to predict future events both here and abroad (Le Coz, J et al , 2016) but there has been little research on the use of citizen science to increase resilience at the community level.

Slow The Flow Calderdale is an unincorporated charitable organisation founded in 2016. Volunteer-led including engineers, scientists and land managers/ specialists; the group works alongside statutory services to understand flood events and work on practical solutions. The group has

- Found willing landowners to implement small scale Natural Flood Management measures:
- Worked with schools and community groups to implement monitoring using simple single-board computers (i.e. Raspeberry Pi):
- Carried out river surveys with volunteers to help validate hydrological models;
- Created a volunteer workforce to assist in implementing Natural Flood Management measures:
- Raised awareness amongst residents, working with schools and universities to deliver a Science of Floods workshop and showing how residents can help themselves to 'slow the flow' through developing household projects including rain-gardens and reducing flow from individual properties.

Opportunities and challenges

A grass-roots approach can add value:

- A volunteer-led organisation can open doors that are not open to statutory services whether these are with landowners or funders;
- Support community cohesion and combat a feeling of helplessness in the aftermath of extreme events;
- Support existing initiatives supplying data, labour or know-how;

However such an approach also presents challenges to existing statutory agencies in terms of identifying roles/ responsibilities, accountability, sharing information and capacity?

Conclusions

From the experience in Calderdale success is achieved through

- developing simple tools for data collecting and processing
- communications at different levels for different audiences to advance public awareness of the issues
- engendering the support of local stakeholders
- making the results demonstrable and measurable

References

Andrew, R. (2012). Building Community Resilience. Proceedings of Institution of Civil Engineers, Vol 165 Issue CE6 pp 59 -64.

Le Coz,J.,Patalano,A., Collins,D.(2016) Lessons Learnt from recent Citizen Science Initiatives from France, Argentina & New Zealand, ES3 Web of Conferences, EDP Sciences, Volume 7

236. Re-configuring Local Governance for Community Resilience: social learning for flood adaptation under a changing climate

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Key words: Community Resilience, knowledge co-production, climate change, environmental governance

The last ten years have witnessed increasing levels of concern and public debate about the risks associated with environmental hazards in the UK, most notably flooding and the damage caused by high intensity storms. This paper suggests that there are three particular ways in which we can conceptualise this phenomenon and the implications for policy and practice. First, there is increasing concern surrounding the ways in which vulnerable communities practically prepare, respond to and recover from flooding in the UK. Second, the onset of anthropogenic climate change is leading to changes in the risks associated with many environmental hazards, rendering existing knowledges only partially useful in shaping responses to hazards like flooding. Third, placed alongside these environmental concerns is the wider context of the state's changing relationship with citizens and communities as austerity measures accelerate the rolling back of the local state and its role in providing support services during times of crisis. This has implications for the ways in which researchers, policy makers and communities view the relationship between local state provision of resilience 'services' to deal with emergencies like flood events and increasing demand for community-led, place-based approaches to resilience that rely less on the local state. The research reported in this paper aimed to assess the implications for these changing relationships between the local state and citizens in an age of anthropogenic climate change. In so doing, it explored a social learning approach in the market town of Crediton (Devon) to co-produce knowledges and strategies for adapting to future flood risk under a changing climate and new modes of local governance. The paper will examine both the process of knowledge co-production and the outcomes and outputs from the project, which has resulted in a new flood resilience group being established for the town.

243. 'Knowledges for resilience' and barriers and motivators to flood risk adaptation for small business owners in the UK

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KEYWORDS: adaptation, business, flood resilience, knowledge, learning

ABSTRACT

Objectives

Small businesses are critical for functioning of the UK economy and disproportionally affected by floods. This paper shares research that critically evaluates knowledges and knowledge networks that inform small businesses in their decision-making about flood adaptation, recognising this can take many forms (e.g. structural, behavioural). Initial assumptions were that 'local knowledge' may be accrued from, and situated within, wider knowledge networks and that adaptive decisions are made based on knowledge sources (expert, lay, experiential, situated) that business people trust and draw on, and how they perceive their local flood risk.

This paper reflects on key motivators/barriers that affect whether knowledge assimilated by small businesses becomes actionable knowledge for long-term adaptation/behaviour change in flood resilience building. It draws on thinking about knowledge hybridity, integration and controversies (Whatmore, 2009; Haughton et al., 2015), and sense-making (Weick et al., 2005), applying these in co-development of a prototype web-based learning tool to promote small business resilience.

Methods

Narrative interviews undertaken with business people with flood experience in four English case-study settings informed research and development processes of the e-tool (www.floodresilientbusiness.co.uk), co-produced with businesses in a UK town that floods, and national stakeholders that work with businesses to increase resilience. The approach reflects current ethics and practices of stakeholder research participation so that other equally valid forms of knowledge/competency are recognised.

Results

The results highlight diverse types of knowledge accessed by small businesses, and the high value given to business-to-business learning, tied strongly to place, and business owners' flood memories and linked experiential flood knowledge. Variable integration existed with other knowledge systems, depending e.g. on degrees of 'community embedding'. Links between flood knowledge, experiential learning and adaptation also varied, with incremental structural adjustments dominating. In these contexts, t he research then critically evaluates issues/opportunities identified by businesses/wider stakeholders in designing the e-learning tool to promote 'learning for resilience'.

Conclusions

The paper emphasises importance of multi-stakeholder understanding of small business knowledge systems and how businesses 'learn for resilience'. It proposes a framework for building, organising and sharing resilient knowledges integrated within wider knowledge systems. The e-tool is offered as 'living resource' to support developing communities of practice among small businesses so increasing resilience to changing risk.

REFERENCES

Haughton G., Bankoff G. and Coulthard T.J. (2015). In search of 'lost' knowledge and outsourced expertise in flood risk management. Transactions of Institute of British Geographers, 40, 375–386.

Whatmore S. (2009). Mapping knowledge controversies: science democracy and the redistribution of expertise. Progress in Human Geography, 33, 587-598.

Weick, K, Sutcliffe, K and Obstfeld D (2005). Organising and the process of sense making. Organization Science, 16, 409-421.

Towards a flood resilient yorkshire, a tale of two cities - ARUP special session

387. Leeds Flood Alleviation Scheme

Mr David Wilkes, Arup, United Kingdom

388. Sheffield Flood Alleviation Scheme – Upper Don and Sheaf Catchments

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387. Leeds Flood Alleviation Scheme

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ABSTRACT

The Leeds Flood Alleviation Scheme, in close partnership with Leeds City Council, the Environment Agency, Canal and River Trust and Yorkshire Water, principally aims to protect the city against flooding from the River Aire.

Phase 1 was specifically focused on the lower lengths of the river. Original designs prior to Arup's involvement were based on flood walls that would have needed to be over 8 feet high in places, thus impacting on the aesthetic value of the river for the city's waterfront. An alternative approach has been implemented, including the replacement of two main navigation weirs with innovative mechanical moving weirs. These maintain use for barges along the river, but in periods of dangerously high flood levels, the weirs progressively lower to reduce the flood height. The overarching design vision seeks to improve the corridor of the River Aire waterway for both wildlife and public amenity along with protecting the landscape character of the city waterfront. Work on this scheme, at a total cost of some £45 millions is expected to complete in Summer 2017 and has been built by BAM and with detailed design completed by their partners Mott MacDonald.

While Phase 1 in nearing completion, Arup are continuing to work for Leeds City Council and the Environment Agency on Leeds Flood Scheme Phase 2, with and with the BAM-Mott McDonald joint venture. Concept designs are currently progressing for Phase 2, which is taking a catchment-wide approach to reducing flood risk to areas upstream of the city centre such as Kirkstall and Stourton. Measures under consideration include the use of natural flood management.

388. Sheffield Flood Alleviation Scheme – Upper Don and Sheaf Catchments

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Sheffield City Council is working in close partnership with the Environment Agency considering the short, medium and long term future of the city, which is at risk from five separate river systems as well as from urban drainage sources. These sources, and the mechanisms responsible for flooding, are highly sensitive to the impacts of increases in peak river flows and rainfall intensity. So the Council's approach is necessarily long-term, with a focus on managed adaptation to address future climate change hazards. Over three months in summer 2016, the Council undertook a major public consultation programme seeking public views on potential options to manage flood risk over the coming century. The consultation included outline proposals for a wide range of large scale adaptations – flood storage reservoirs, flood defences and conveyance improvements – but also for natural measures to "slow the flow", build resilience and adapt. This paper will reflect on the outcomes of this consultation, how it informed the selection of a preferred approach and how the programme will integrate with wider public and private investment programmes, longer-term policies and socio-economic and environmental regeneration.

Future challenges in estimation of loss of life and evacuation

237. Building an event database for flood fatalities

Mrs Karin De Bruijn, Deltares, Netherlands

304. Flood hazard maps for vehicles and pedestrians

Dr Chiara Arrighi, University of Florence, Italy

358. Validation of Life Loss Modeling Against Historic Events

Mr Jason Needham, US Army Corps of Engineers – Risk Management Center, United States

237. Building an event database for flood fatalities

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KEYWORDS: Flood fatalities, flood risk to people, event database

ABSTRACT

Floods still cause significant disruption in many countries and result in high damages and fatalities. Due to population growth and increasing exposure in flood-prone areas the number of flood fatalities may increase in future, unless we are able to learn from past events .

Reliable knowledge on potential flood fatality numbers has become more important in the last decade, because they now are a more important criterion in flood risk management decisions in countries such as the Netherlands, UK, France and USA (De Bruijn et al., 2014), and the effectiveness of flood emergency management can be improved if we know more on the circumstances and factors which contribute to the loss of life of people. Research on these factors is in progress.

The knowledge on factors which contribute to fataility risks is captured in fatality functions and evacuation models (Di Mauro et al., 2012; Jonkman (2007), Kolen et al., 2014). However, the modeloutcomes are still highly uncertain. Lack of data is one of the causes of that uncertainty. Besides, the functions often consider only a few factors explicitly, and all others implicity. The Dutch mortality functions for example, relate flood parameters to mortality. Factors such as house type, warning and human are not considered explicity. This makes the functions difficult to use in other settings.

In order to advance research on flood fatalities we are developing a flood event database that will help to identify relevant factors and the way they relate to the occurcance of flood fatalities. By trying to capture as many factors as feasible, data of events may be used outside the area where they occurred. Differences in flood types, area characteristics and society need to be considered when doing so.

We aim to make an open and publicly available database which allow scientists to share knowledge. We plan to link to existing iniatives of for example CRED, Safelevee and the Floods Directive. We invite everyone to collaborate in this iniative.

REFERENCES

De Bruijn KM, Diermanse FLM, Beckers JVL (2014) An advanced method for flood risk analysis in river deltas, applied to societal flood fatality risk in the Netherlands. doi:http://dx.doi.org/10.5194/nhess-14-2767-2014

Di Mauro, M. and De Bruijn, K.M.(2012). Quantitative methods for estimating flood fatalities: towards the introduction of loss of life estimation in the assessment of flood risk. Nat. Hazards 52, DOI: 10.1007/s11069-012-0207-.

Jonkman S.N. (2007) Loss of life estimation in flood risk assessment. Theory and applications. Phd thesis Delft University (354 pag.).

Kolen B, Kok M, Helsloot I, Maaskant, B. (2013). EvacuAid: A Probabilistic Model to Determine the Expected Loss of Life for Different Mass Evacuation Strategies During Flood Threats. Risk Analysis, 33: 1312–1333.

304. Flood hazard maps for vehicles and pedestrians

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KEYWORDS: risk map, flooded vehicles, human stability

ABSTRACT

Floods are responsible of many casualties, which, in developed countries, are often caused by the attempt to wade flooded roads by car or on foot. Experimental activities and numerical models clarified, from the mechanical point of view, the occurrence of the phenomenon of instability for vehicles and pedestrians in floodwaters. However, putting into practice this knowledge is still a subject for research. This work aims at demonstrating the capabilities of flood hazard maps for vehicles and pedestrians as a support for risk assessment and management. Flood maps are implemented with a full 2D numerical model, whose mesh is refined enough to capture the urban roads/building pattern. The stability of parked vehicles and pedestrians is assessed through a dimensionless diagram, which allows the selection of a specific target receptor (Arrighi et al. 2015, 2016). The method is applied to a district of the city of Genoa (Italy) affected by a flood in 2014. The inundation model reproduces the actual flood event (Silvestro et al. 2015, 2016), whose water marks have been used for validation. Hazard maps for vehicles and pedestrians are compared to georeferenced images and videos taken during and immediately after the flood, showing a good agreement, although qualitative. This application allows the identification of particularly hazardous zones, which after the analysis of variuos scenarios, can support civil defence actions and citizens' education.

REFERENCES

Arrighi C., Alcèrreca-Huerta J. C., Oumeraci H. and Castelli F. (2015). Drag and Lift Contribution to the Incipient Motion of Partly Submerged Flooded Vehicles. Journal of Fluids and Structures 57, 170–84.

Arrighi C., Oumeraci H. and Castelli F. (2017). Hydrodynamics of Pedestrians' Instability in Floodwaters. Hydrology and Earth System Sciences 21, 615-531.

Silvestro, F., Rebora N., Giannoni F., Cavallo A., and L. Ferraris. 2015. The Flash Flood of the Bisagno Creek on 9th October 2014 (2015). An 'unfortunate' combination of Spatial and Temporal Scales. Journal of Hydrology 541, 50–62. Silvestro, Silvestro F., Rebora N., Rossi L., Dolia D., Gabellani S., Pignone F., Trasforini E., Rudari R., De Angeli S. and 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):1737–53.

358. Validation of Life Loss Modeling Against Historic Events

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KEYWORDS: Life loss modeling, Consequences assessment, Risk assessment, Validation, Calibration

ABSTRACT

The field of life loss estimation from flooding has progressed significantly over the past 15 years. Several groups have developed models for a better characterization of life loss in support of evaluating and managing flood risk as well as emergency management planning. While first methods were mainly based on general empirical information and variables (e.g. water depth or warning time), during the last decade more complex simulation based approaches have been developed. Although these simulation-based methods approch the problem of life loss estimation from a process-based perspective, there are still a lot of questions related to the ability of these models to represent a real system. This paper summarizes efforts with USACE to validate the LifeSim model, which includes running the LifeSim model on historic events, comparison of model results versus actual life loss, and lessons learned from the experience.

System approaches to flood risk assessment and management (i)

87. Improving flood risk management by better understanding system behaviour
Mrs Karin De Bruijn, Deltares, Netherlands

381. Smart City Flood Index: identifying urbanised delta regions most vulnerable for flooding and improving their smartness against flooding
Dr Bas Kolen, TU Delft, Netherlands

91. An exploratory modelling technique to support long-term flood risk management
Mrs Karin De Bruijn, Deltares, Netherlands

321. Understanding a system of flood risk interventions across multi-sector levels and scales
Ms Lydia Cumiskey, Flood Hazard Research Centre at Middlesex University, United Kingdom

214. The increase of flood risk vulnerability due to backwater effects and in-channel aggradation after river impoundment
Dr Patricio Bohorquez, University of Jaén, Spain

95. Review of system behaviour components for flood risk analyses, focusing on river deltas
Mr Alex Curran, Deltares, Netherlands

87. Improving flood risk management by better understanding system behaviour

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KEYWORDS: Flood Risk Management, flood risk analysis, system's approach

ABSTRACT

The fields of flood risk analysis and flood risk management have signficantly developed over the last decades. Flood risk analysis techniques are constantly improving and our understanding of means to cope with flood risks continuously increases. However, most innovations relate to small components of the flood risk chain, or to types of structures or materials available for flood protection or flood proofing. Although this surely leads to improvements of societies' ability to cope with flood hazards, we believe that there is also a need to improve the consideration of spatial and temporal interdependencies between areas and the precise timing of events in order to advance flood risk management.

Flood risks are often analysed at local scales. Even nationwide flood hazard maps and flood risk plans, as required for, for example, the EU Flood Directive are usually compiled from local analyses and plans. For countries with many small rivers this may be acceptable, although extreme weather events may affect multiple river systems at the same time, whereas planning management strategies may also benefit from cross-catchment considerations. For larger river basins such as the Rhine, Elbe, Po or Danube River such an approach may lead to inefficient choices, less effective strategies or future regret. To overcome this we advocate a systems approach, not only in flood risk analysis, but also in flood risk management. We operationalise such an approach by developing a flood risk analysis framework for large areas which takes into account spatial interdependencies, and by developing methods to enhance system-based flood risk management. For the latter we develop and operationalise criteria which help decision makers to evaulate strategies for the system as a whole, such as economic efficiency, social equity and no-regret. These criteria take into account spatial differences, temporal dependencies and uncertainty about future changes. We show how such criteria can be defined and assessed by using exploratory modelling of system's behaviour given different strategies taking into account both statistical and deep uncertainties.

In the paper we discuss current methods and our approach to fill gaps in the existing approaches and to improve flood risk management of large river systems. We illustrate the ideas by examples for the Rhine River.

381. Smart City Flood Index: identifying urbanised delta regions most vulnerable for flooding and improving their smartness against flooding

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KEYWORDS: flood management, flood index, flood risk, ranking list

ABSTRACT

Objectives

Flooding is an ever increasing problem in cities everywhere around the world. Over the last 50 years global economic losses due to flooding have significantly increased. According to projections of the World Bank in 2050 two-third of the world's population will live in urbanized deltas, which are vulnerable to flood disasters. In the context of the underlying demographic, urbanization and climactic trends, city-managers, national and provincial policy-makers in urbanized deltas have to make difficult decisions over medium and long-term investments in order to make their cities and communities more resilient to the existing and future flood risks.

Facing these challenges, there is a need for a more comprehensive view on flood management issues world-wide. Since cities and deltas are constantly changing, flood management turns out to be a dynamic process. The ability to change the flood vulnerability of a city depends on various aspects. Also the attidude regarding the way authorities face flood issues differ. Some countries (viz. the Netherlands) have traditionally a strong focus on flood protection as a means to improve the flood protection level and reduce the flood risks involved. Whereas in other countries (viz. America or United Kingdom) focus is more flood prepardness and responds/recovery.

Method

In this research, a framework is proposed to get a quick overview of the flood management indicators of cities worldwide incorporating indicators such as flood risk level, flood protection standard, landuse management & flood damage mitigation, public prepardness, flood responds/ recovery & emergency and disaster plans.

Application of the framework provides a Smart City Flood Index enabling us to identify urbanized delta regions that are most vulnerable for flooding and/or most flood resilient from a comprehensive point of view. Each city will get a score for each indicator, yielding in an overall score on the Smart City Flood Index. To assess cities, we make use of public data (open streetmaps, Remote Sense data, mobile data collection, etc.) that is freely online available.

Results

In this way, a global ranking list of cities and urbanized delta regions can be produced based on their existing and future flood risks, accounting for climate change and socio-economic development, and their scores on the multiple flood management indicators. The list will be published on yearly basis including updates in order to get up with recent changes.

Conclusions

The outcomes per city and the global ranking list provide a basis for futher action. For instance, based on this, an evaluation of the flood management status of a city can be done, resulting in a preliminary advice for the appropriate measures or management actions. Moreover, the global ranking list provides a way to communicate about flood management issues between the cities, and creates an atmosphere where cities can

learn from each other, or induces some sort of competition between cities to come up with sustainable solution to better deal with flood issues. Ultimate aim of the Smart City Flood Index is to make urbanized delta around the world more resilient to the physical, social and economic challenges that are a growing part of the 21st century.

91. An exploratory modelling technique to support long-term flood risk management

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Key words: Deep Uncertainty, Exploratory Modelling, Flood risk management

Uncertainty characterizes the assessment of every component of the flood risk system: from forecasting meteorological and hydrological conditions to predicting socio-economic development. Uncertain is also the way river-dike interactions take place (e.g. upstream-downstream hydrodynamic interactions), whose understanding and evaluation is of paramount importance in large-scale flood risk management. Notwithstanding such uncertainty, policy makers are often required to implement long-term flood risk management strategies which have to meet stakeholders' needs over the planned period (e.g. 50 years or more). Policy analysts refer to this as a deeply uncertain problem: a problem where analysts and decision makers struggle to provide a proper and unique model formulation to describe the interaction among the model's variables, and have no or limited knowledge about the probability distribution of the uncertainties involved.

Current approaches in long-term flood risk management barely account for uncertainty and, when they do, they assume probability distribution functions beforehand. As a consequence, future management strategies are designed on the basis of scenarios that are deemed the most likely, neglecting less likely but possible ones. This results in unexpected failures of the designed measures. One way to overcome this is to make use of exploratory modelling techniques for designing robust strategies that are expected to perform well under a variety of possible future developments of the system. These exploratory modelling techniques can also be used to address two additional flaws of traditional flood risk management frameworks: the use of a single decision criterion, and the lack of a system perspective.

The current work introduces an exploratory modelling technique for the study of large-scale flood risk systems with the aim of developing long-term flood risk management strategies. The technique will serve stakeholders and policy makers in exploring trade-offs among outcomes given different system configurations, and will foster discussion and learning about system performance in the face of deeply uncertain futures. To this end, the model provides a spatially distributed characterisation of flood risk by explicitly focusing on upstream - downstream interactions. The performance of each management strategy is assessed with respect to a heterogeneous set of performance indicators, belonging to both the economic and social domains. In particular, cost-benefit indicators, which are commonly used in flood risk management studies, will be used next to indicators related to equity and casualties.

The model will help answering three main research questions: (1) given the huge system uncertainty, how can policy makers develop robust long-term flood risk management plans? (2) would the adoption of a system approach change current flood risk management policies? (3) how to best analyze trade-offs emerging from conflicting stakeholder's values and priorities?

Future research will focus on the application of the proposed modelling technique on two case studies: the lower branch of the Rhine River (from Bonn, Germany to the river Delta in The Netherlands) and the Po River (Italy).

95. Review of system behaviour components for flood risk analyses, focusing on river deltas.

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KEYWORDS: Flood Risk Analysis, System behaviour, Dike breach,

ABSTRACT

Introduction

For historical reasons, the majority of the economic and societal risk on large river systems is located near the delta or in the lower-region floodplains, giving rise to large-scale flood defence structures. This is especially true in countries like the Netherlands and Germany, where flood defences are vital to the national economy and safety.

In flood risk analyses, a common simplification is to assume that the expected loads for a precipitation event will be routed downstream to an area of interest without any interaction with the floodplain. The possibility of upstream breaches is thus not considered in the assessment of downstream loads and flood risks. This interaction is termed 'system behaviour' and as the return period of an event increases, this phenomenon becomes more likely.

This project aims to investigate and improve various components of flood risk analyses that include system behaviour, and to apply the updates to an analysis for the lower Rhine region. As part of the project a qualitative review and categorisation of system behaviour analysis methods and components is being undertaken, which is to be presented here.

Methodology

The presented research will give a brief explanation of the general concept of system behaviour as well as conceptual frameworks as suggested by Courage et al., (2013) and De Bruijn, et al. (2014). It is assumed that a more detailed explanation will be provided in other presentations at the conference.

The various components of system behaviour will be discussed under the following headings;

- Boundary Conditions to system behaviour model.
  This includes sampling methods, weather generation and the inclusion of other variables such as downstream sea-level conditions and wind metrics.
- Abstractions from system behaviour models.
  The abstractions arise from defence overtopping or failure, and the subsequent breach growth, and current failure modules will be discussed. The abstractions will also be dictated by the 2D modelling techniques used and recent schematisations will be presented.
- Analysis of system behaviour model outputs
  A brief review of potential outputs from system behaviour analysis will be presented.
- Recent Projects
  Demonstration of large scale projects from Hydrological Engineering Corps in the U.S. and Reinsurance industry.

REFERENCES

Courage, W., Vrouwenvelder, T., van Mierlo, T., & Schweckendiek, T. (2013). System behaviour in flood risk calculations. *Georisk: Assessment and Management of Risk for Engineered Systems and Geohazards*, *7*(2), 62–76. https://doi.org/10.1080/17499518.2013.790732

De Bruijn, K. M., Diermanse, F. L. M., & Beckers, J. V. L. (2014). An advanced method for flood risk analysis in river deltas, applied to societal flood fatality risk in the Netherlands. *Natural Hazards and Earth System Sciences*, *14*(10), 2767–2781. https://doi.org/10.5194/nhess-14-2767-2014

214. The increase of flood risk vulnerability due to backwater effects and in-channel aggradation after river impoundment

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KEYWORDS: backwater effect; silted-up reservoir; paleohydrology; Guadalquivir River; vegetation encroachment.

ABSTRACT

The present study aims to quantify the importance of the factors that have increased the flood risk vulnerability in flood prone areas of the Guadalquivir River (Southern Spain). A stretch of the river near Andújar city (Jaén, Spain) was selected as the study site because it has suffered an unexpected increase of the flood stage over time few years after downstream river impoundment, i.e. the year 1962. Exceptional floods with a characteristic return period of about 50 years occurred in 2009-2010-2013 routeing about 1300-2200 $m^3 \cdot s^{-1}$. Economic losses amounted to 149 M€. The extent of the inundation was much lower for similar water discharges during the periods 1920-1930 and 1960-1970.

First, we revisit the climate component which shows the decrease in time of the observed trends in annual precipitation across the Guadalquivir Basin and the increase of the projected changes in heavy daily precipitation events (European Environment Agency, 2017). Next, the hydrogeological counterpart is studied combining standard methods in paleohydrology with modern systematic data. We extend the approach presented in Bohorquez (2016) by including Landsat and Terrasar-X satellite images of the inundated floodplains into the analysis. Two-dimensional numerical simulations were performed with Dassflow-Hydro 2.0 (Monnier et al., 2016).

The dynamic simulations correctly capture the backwater wave that inundated the floodplains during the most severe flood in February 2010 in close agreement with observations from a series of helicopter flights. Furthermore, they served to identify its origin downstream, namely: Marmolejo dam. The maximum increment of the water stage due to the backwater wave and in-channel sedimentation provoked 50% deeper floods, which is much higher than the effect of vegetation encroachment that developed after flow regulation (10% deeper floods).

We conclude that the long-term evolution of riparian vegetation, the decrease of the thalweg slope with respect to the basin slope and old-fashion hydraulic infrastructures may act as geomorphic drivers of flood hazard. Socio-economic stresses on irrigation led to current policies on water resource management, provoking the transformation of the Guadalquivir river into an aggraded channel. Consequently, current

projections of one-in-a-century river floods need to include such factors as they clearly compete with the reduction of peak discharges in southern Spain.

REFERENCES

Bohorquez P. (2016) Paleohydraulic reconstruction of modern large floods at subcritical speed in a confined valley: proof of concept. Water, 8, 567.

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.

Monnier J., Couderc F., Dartus D., Larnier K., Madec R. and Vila J.P. (2016) Inverse algorithms for 2D shallow water equations in presence of wet dry fronts. Application to flood plain dynamics. Adv. Water Res., 97, 11–24.

321. Understanding a system of flood risk interventions across multi-sector levels and scales

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KEYWORDS: multi-sectoral; scales; levels; interventions; resilience; systems

ABSTRACT (500 words)

A typical flood risk system includes a layer of interventions that prevent new, reduce existing, and manage residual flood risk. Interventions can be measures, investments, programmes, policies, activities or actions taken individually or jointly across public sectors (e.g. emergency response, environment/water, agriculture, transport) and/ or private sectors (e.g. insurance, businesses, households, NGOs). Responsibilities for planning, implementing and monitoring such interventions cut across multi- sector resources (e.g. financial, human/knowledge capacity) at local, national and/ or international levels. Most interventions do not act independently and are generally directly or indirectly connected and/ or dependant on interventions taken by different sectors at various levels and scales. For example, household property level protection measures could require local awareness raising programmes, financial incentives from insurance companies or national governments, and implementation via local companies to ensure effective uptake and operation of such measures. This depicts a complex system of interventions all interconnected and interdependent on different sectors across planning, administrative, institutional, hydrological, knowledge, network and temporal scales.

This research develops a multi-sector, cross layered approach to disentangle this complexity and understand this system of interventions. To develop the approach, firstly a quick-scan review in a selected number of cases is carried out to identify the existing system of interventions at various levels and scales. This involved analysing existing interventions, defining different actor responsibilities across sectors and mapping the causal connections/dependencies between the interventions and sector actors. Next the different scales and levels at which these interventions and actors operate are disentangled. To do this, the following scales and their functioning levels were analysed; multi-sector networks (e.g. national or local platforms, partnerships and groups); risk knowledge (e.g. national, regional or local scale modelling capacity); planning mechanisms (e.g. flood risk, sustainable development, climate change); hydrological (e.g. catchment, sub-catchment, urban); administrational (e.g. local, district, national), and time (e.g. short, medium or long term). The general cross level and cross scale interconnectivity and interdependency is then mapped for each case study for a selected number of interventions. The results of this process are a set of visualisations that reflect the multi-sector multi-scale complexity of different interventions in different areas. These visualisations are compared across each of the interventions in each case whereby the similarities and differences are discussed.

This approach helps to examine the redundancies, interdependencies and conflicts within and across the system of interventions. Ultimately this approach could improve the identification and selection of future flood risk interventions in the system as part of an integrated multi-sectorial planning process. In the next phase of this research this approach will be applied in detail and adapted based on the local context. This will focus on interventions which aim to manage the residual risk by strengthening the social and economic resilience of individuals and societies.

Local scale approaches to community flood resilience (ii)

331. City to City learning for resilience Results of a preliminary study
Prof Chris Zevenbergen, UNESCO-IHE Institute for Water Education, Netherlands

336. Civic and social capacities in flood risk management
Ms Corinne Larrue, University of Paris Est Créteil, Lab'Urba, France

353. Flooding from Hurricanes Floyd and Matthew in North Carolina: An Analysis of the Effectiveness of Community Response
Prof Burrell Montz, East Carolina University, United States

369. Catalysts for transformative resilience to flooding? The role of community volunteers
Dr Clare Twigger-Ross, Collingwood Environmental Planning Ltd, United Kingdom

389. Building local resilience – in-field research-grade weather and water monitoring technology to broaden your spatial coverage
Mr Robert Zeijlemaker, Onset Computer Corporation, United States

331. City to City learning for resilience Results of a preliminary study

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KEYWORDS: City-2city learning, peer learning networks, urban resilience

ABSTRACT

Introduction: Cities nowadays are facing unprecedented challenges and opportunities. Responding to these challenges, and seizing the opportunities, is placing new and complex demands on decision makers. To keep pace and cope with the rapid changes occurring in cities nowadays, requires accelerated learning through 'learning from each other' (peer learning). The emphasis on accelerated learning stems from the insight that combined processes of peer learning and learning from experiments and full scale pilots will be crucial. That's why the capacity to learn and to engage in city to city networks will play an imminent role in this process of life-long learning. With climate change mitigation and adaptation increasingly present on the urban agenda, many cities aim to increase resilience of residents and businesses, but have multiple challenges in operationalizing this generic concept: finding appropriate solutions, data, the right partners, technical expertise and enough funding. International city networks such as C40 (http://www.c40.org/), 100RCs (http://www.100resilientcities.org/), ICLEI (http://www.iclei.org/), and many others offer an avenue for cities that are building resilience, by supporting and connecting to potential sources of funds and knowledge.

Methods: This paper discusses the results of a preliminary study on City-to-City learning. In total 30 cities have been interviewed and 13 networks analysed.

Conclusions:The results reveal that city peer learning remains young with a limited base of practice, case studies, and guidance. To make deliberate and strategic change and to accelerate uptake of good practices, it is generally recognized that cities need to engage in city to city learning networks and have to learn from lessons of other cities. C2C learning networks, such as UNISDR's Making Cities Resilient Campaign, Rockefeller Foundation's 100 Resilient Cities, EU Mayors Adapt, C40, ICLEI, are currently providing the platforms to build and share evidence around adaptation in practice. They put in place rigorous monitoring and evaluation systems to share planning frameworks, decision making tools, resilient development measures. Based on this review conditions for effective peer city learning has been identified.

336. Civic and social capacities in flood risk management: an assessment tool and its implementation in five case studies in Europe

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KEYWORDS: social and civic capacities, flood risk management, assessment tool

ABSTRACT

Involving inhabitants in flood risk management is regularly highlighted as an important step for a better mitigation of flood risk damages by both practitioners of floods risk management and researchers. It is therefore important to be able to assess ex-ante the capacities of communities to get involved in the management of flood risks that concern them.

The paper, based on the first results of the CAPFLO project[1], will firstly analyse the social and civic capacities that communities should possess in order to actively participate in flood risk management. Secondly it will discuss how their level of development can be assessed.

After a definition of social and civic capacities related to flood risk management based on a literature review, the paper will present the indicators used for analysing and assessing social and civic capacity. This grid has been elaborated within the CAPFLO project, under the leadership of the French team, and is based on collective work among all the members of the consortium.

The grid differentiates social and civic capacities assessment of communities/citizens on the one hand and the flood risk management institutions on the other. A multi-scale approach was used as the communities' capacities are related to those of the institutional actors placed at different scales (local, river basin, regional and/or national). The assessment tool differentiates specific capacities within five dimensions: knowledge, motivation, network, finance, and participation. The communication will present the reasons why these dimensions have been chosen, and how they can be assessed.

[1] Research project on local resilience capacity building for flood mitigation coordinated by the Institute of Government and Public Policy (Autonomous 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 Vrije Universiteit Amsterdam, The Netherlands; Institute for Social Research, Italy; and Institute of Sustainability Governance University of Luneburg, Germany)

The grid was applied in five case studies, one per country included in the project: Ribera Alta (Spain), Meuse river near Maastricht (The Netherlands), Vitry-sur-Seine (France), Trebbia river (Italy), Iller river (Germany). The communication will present some of the results of the assessment in the five case studies and especially those related to the participation dimension which appear to be very low in each of the case study.

In conclusion we will point out some prospects for developing participatory tools which can help to strengthen social and civic capacities.

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 Knaap 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.

353. Flooding from Hurricanes Floyd and Matthew in North Carolina: An Analysis of the Effectiveness of Community Response

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KEYWORDS: Flooding, Community, Mitigation, Hurricane Matthew

ABSTRACT

Objectives: The purpose of this study is to evaluate the effectiveness of community mitigation during Hurricane Matthew in eastern North Carolina. Following Hurricane Floyd in 1999, several communities undertook mitigation projects consisting of removing some structures from the floodplain and elevating other buildings. Using two communities with different flood regimes and different locational characteristics, Greenville and Windsor, impacts from Hurricane Matthew are evaluated in the context of post-Floyd mitigation.

Methods: Data on community losses were compared between the 1999 event and the 2016 event. Windsor was flooded earlier in 2016 as well, and that flood is also considered in this analysis. GIS was used to map the flood extents and the spatial patterns of damage and losses, along with floodplain boundaries. Census data were analysed to evaluate the socio-economic characteristics of those flooded in both comunities in 1999 and 2016. The results of these analyses were combined to determine the effectiveness of post-Floyd mitigation with an eye to developing recommendations for a truly comprehensive mitigation planning scheme that addresses the differing community contexts.

Results: Post-Floyd mitigation in each community spared many buildings, particularly residences, from being flooded in Matthew. Yet, damage was still extensive. While some of these differences can be attributed to differences in storm patterns, others cannot, suggesting that the mark was missed on some counts. Examples include (1) reluctance to (or a lack of knowledge on how to) alter historic buildings to prevent flooding; (2) a focus on response to one event rather than on floods of the future; (3) a “blame game” on the causes of flooding; and (4) the influence of local economic interests. Planning for future flood mitigation, to date, does not indicate any change from these foci, which calls into question the resilience of both communities.

Conclusions: Despite the lessons from Hurricane Floyd and the post-event mitigation, little seems to have been learned. Those properties in Greenville and Windsor that were elevated following Floyd were not flooded, or in some cases were not flooded as badly (as they were not elevated enough). This is seen as a success story,

but the impacts from Matthew suggest that perhaps the communites were not as successful as was thought. It appears that some of the same issues have arisen after Matthew. Although in Greenville the spatial pattern of flooding is somewhat different from what occurred with Floyd, that is not the case in Windsor which suffers from repeat flooding due to its location. At the same time, the absolute economic losses to Matthew were greater in Greenville. Thus, there is a need for greater resilience to flooding in both communities and the results of this project highlight recommendations to that end.

369. Catalysts for transformative resilience to flooding? The role of community volunteers

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KEYWORDS: flooding, community, resilience, engagement, evaluation

ABSTRACT

Background: Policy-makers, practitioners and academics have increasingly focussed on the concept of resilience in the context of flood risk management, and specifically on community resilience which is understood as not just the ability to resist flooding but also the capacity to adapt and transform better to cope with flooding (see Twigger-Ross et al, 2014 for overview). Cutter et al's (2008; 2010) resilience framework provides a useful way to develop indicators and measure community resilience. Cutter et al's (ibid) framework describes disaster resilience as inextricably linked to capacities that exist on a day-to-day basis within a community. These capacities (institutional, social, economic, infrastructure and community capital) form the basis for resilience to flooding. However, it is also clear that there are specific capacities that are needed in order to be resilient to flood risk: e.g knowledge of flood risk, actions to take in a flood, developing flood plans. Further, floods themselves provide opportunities to create resilience with the emergence of groups, structures and activities.

Objectives: This paper draws on findings from an evaluation study focussed on improving the resilience of flooding of local communities with an emphasis on developing the role of community groups and volunteers as catalysts for change within flood risk management governance. This paper examines the nature of that change within flood risk management governance and the potential for the engagement of flood volunteers to be catalysts towards more transformative resilience processes.

Methods: This paper draws on research carried out for the UK Department for Environment Food and Rural Affairs (Defra) to evaluate the Flood Resilience Community Pathfinder (FRCP) scheme in England. This scheme consisted of thirteen partnership projects funded by Defra across England, involving local governments and other organisations such as voluntary sector groups, Environment Agency etc. The pathfinder scheme was designed to enable communities at significant or greater risk of flooding to work in partnership to develop innovative local solutions that in particular:

- Enhanced flood risk management and awareness in ways which quantifiably improved the community's overall resilience to flooding.

A key part of the pathfinder scheme was its evaluation. Whilst each project had to carry out its own evaluation, a whole scheme evaluation was also carried out over the two year period. The evaluation used a mixed methods approach of document review, surveys and interviews over the time of the project.

Results: Findings highlight the importance of developing linking social capital between communities and institutions in order to improve resilience to flooding throughout the flood risk management cycle, not just in emergencies. The work also shows for community engagement processes to be successful in the context of flood risk management they need to be co-produced between community members and members of institutions with key responsibilities for flood risk management; they take time to develop and they need to be made an explicit focus.

Conclusions: The findings will be discuss in relation to the framework of community resilience with a focus on governance and understanding the role of community groups as catalysts for change towards more transformative flood risk management.

REFERENCES

Cutter, S.L., Barnes, L., Berry, M., Burton, C., Evans., E., Tate, E., and Webb, J. (2008) 'A place-based model for understanding community resilience to natural disasters', Global Environmental Change, 18: 598–606.

Cutter, S., Burton, C. and Emrich, C. (2010) 'Disaster resilience indicators for benchmarking baseline conditions', Journal of Homeland Security and Emergency Management, 7(1): 1-22

Twigger-Ross, C., Kashefi, E., Weldon, S., Brooks, K, Deeming, Hugh, Forrest, S., Fielding, J., Gomersall, A., Harries, T., McCarthy, S., Orr, P., Parker, D. and Tapsell, S. (2014) Flood Resilience Community Pathfinder Evaluation: Rapid Evidence Assessment. Project Report. London: Defra

Twigger-Ross, C., Orr, P., Brooks, K., Sadauskis, R., Deeming, H., Fielding, J., Harries, T., Johnston, R., Kashefi, E., McCarthy, S., Rees, Y. and Tapsell, S.(2015) Flood Resilience Community Pathfinder Scheme Evaluation. Department for Environment, Food and Rural Affairs.

389. Building local resilience - in-field research-grade weather and water monitoring technology to broaden your spatial coverage

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ABSTRACT

Building local resilience - in-field research-grade weather and water monitoring technology to broaden your spatial coverage

Robert Zeijlemaker will share latest best-practice for flood warning technology, drawing on the experiences of European civil protection installations.

Learn how next-generation research-grade remote data logging stations can provide instant access to site-specific weather and water data anywhere, anytime via the internet to facilitate the early warning, planning, and preparedness phases to prevent and mitigate local risks.

The new stations combine the flexibility and sensor quality of more expensive systems, an onboard LCD display, and the convenience of plug-and-play operation to deploy stations more densely and effectively to give notice, monitor, and supervise events and risk levels on a local level. The technology offers flexible data sharing options and continuous system health monitoring to disseminate data on a broader scale to increase awareness.

Global flood models: from theory to practice

137. The case for using early flood forecasts from the Global Flood Awareness System
Mr Ervin Zsoter, European Centre for Medium-Range Weather Forecasts (ECMWF), United Kingdom

250. Study on compound effects of fluvial flood and storm surge using a global river-coast coupling model
Hiroaki Ikeuchi, The University of Tokyo, Japan

270. From small to large scales: the potential of 2D numerical flood models for geographically large areas
Ms Iuliia Shustikova, University of Bologna, Italy

295. Global hydrological modelling from National Hydrological Services' Perspective
Mr Jan Daňhelka, Czech Hydrometeorological Institute, Czech Republic

317. Application of a Bayesian Network-based hydrologic model to the contiguous United States
Mr Dominik Paprotny, Delft University of Technology, Netherlands

205. The application of a global flood model for national flood risk assessment in Belize
Dr Mark Trigg, University of Leeds, United Kingdom

323. Providing impact based flood forecasts at global level
Mr Peter Salamon, European Commission – Joint Research Centre, Italy

356. Estimation of river bathymetry in regional scale flood inundation models
Dr Jeffrey Neal, University of Bristol, United Kingdom

137. The case for using early flood forecasts from the Global Flood Awareness System

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KEYWORDS: Early warnings, flood prediction, disaster risk reduction, forecast skill, data-scarce areas.

ABSTRACT

The Global Flood Awareness System (GloFAS) is a global scale early flood information system based on the concepts of the European Flood Awareness System (EFAS) funded by the Copernicus Emergency Management Service.

GloFAS is developed by the Joint Research centre of the European Commission (JRC) and the European Centre for Medium-Range Weather Forecasts (ECMWF) with the support of national authorities and research institutions. It couples state-of-the art weather forecasts with a hydrological model to produce daily ensemble forecasts of river discharge with a forecast horizon of 30 days across a global river network (for a a technical description of the pre-operational system see Alfieri et al.,2013 and a general overview is available in Emerton et al., 2016). GloFAS has been pre-operational since June 2011, while past forecast runs are available on the web interface (http://www.globalfloods.eu/) from April 2008 onwards. GloFAS has already shown its potential for aiding disaster risk reduction in data-scarce areas where few or no local flood models are available, including during floods in Pakistan (August 2013), Sudan (September 2013) and Malawi (January 2015).

This has led to the uptake of GloFAS by a number of organisations. For example the Red Cross is involved in a Forecast-based Financing project using GloFAS outputs to trigger pre-disaster humanitarian action in Uganda (see Coughlan de Perez et.al., 2016) and Peru. Similarly, in Nepal the Department of Hydrology and Meteorology (DHM) successfully used GloFAS forecasts alongside existing forecasting capabilities, to issue early flood warnings during the monsoon season. The Brazilian national centre for monitoring and warning for natural disasters (CEMADEN) also uses GloFAS as a forecasting tool for some of the Brazilian rivers, where only limited information is available, to foster knowledge exchange for strengthening and improving the national forecasting capacities.

In this paper we introduce the methodology behind GloFAS and highlight the general skill of the forecasts in different areas of the globe. We demonstrate the potential benefits on some of the above mentioned examples that may be gained by using early flood forecast information from GloFAS. Finally we highlight the ongoing developments and future outlook.

REFERENCES

Alfieri L. et al. (2013). GloFAS – global ensemble streamflow forecasting and flood early warning. Hydrol. Earth Syst. Sci., 17, 1161-1175, doi:10.5194/hess-17-1161-2013.

Coughlan de Perez E. et al. (2016). Action-based flood forecasting for triggering humanitarian action. Hydrol. Earth Syst. Sci., 20, 3549-3560, doi:10.5194/hess-20-3549-2016.

Emerton R. E. et al. (2016). Continental and Global Scale Flood Forecasting Systems. WIREs Water 3 (3), 391-418, doi: 10.1002/wat2.1137.

205. The application of a global flood model for national flood risk assessment in Belize.

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KEYWORDS: Global Flood Model, Flood Risk, National Hazard Assessment

ABSTRACT

The development of global flood hazard models has accelerated in recent years due to advances in modelling frameworks and in response to societies need to answer fundamental flood risk questions at a global scale. However, due to their recent availability, limited validation as well as fundamental differences to traditional engineering approaches in their quantification of flood hazard, there are many questions from the global flood risk community on how to use these models in a flood risk reduction frameworks. Here, we detail the application of flood hazard output from one of these global models at a national scale in the country of Belize in the absence of engineering flood model output. We examine the use of local data in improving the model, and the validation of outputs against historical records and previous national scale studies. We discuss the issues related to validation and use of the output and its application scale and limitations. We conclude that the global models have significant advantages over a traditional engineering modelling approach through faster implementation and lower cost, but are still in their infancy and therefore need careful application when used for national assessments.

250. Study on compound effects of fluvial flood and storm surge using a global river-coast coupling model

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KEYWORDS: fluvial flood, storm surge, global river-coast model

ABSTRACT

Objectives

Fluvial flood risk is estimated to be exacerbated in the future due to climate change. Particularly in estuarine regions, storm surges pose additional flood risks. Co-incidence of these two major water-related disasters would lead to hazardous situation. Hence, analysing both fluvial flooding and storm surges is of great importance. To address this issue, we developed a global river-coast coupling model and applied it to compound simulation of fluvial flood and storm surge.

Methods

We employed a global river routing model, Catchment-based Macro-scale Floodplain (CaMa-Flood) model and a global tide and surge reanalysis (GTSR) dataset. CaMa-Flood is a state-of-the-art river model that facilitates river discharge calculation with the backwater effect included. In this study the river model was adjasted to deal with changing sea levels to clarify the impact of tide and surge on fluvial flood inundation. On the other hand, GTSR is a world's first global dataset of sea level reanalysis. Incorporating GTSR into the CaMa-Flood river flood simulation, we discuss how dependent river discharges and coastal water levels temporally.

Results

Global simulation revealed that tides and surges have meaningful contributions (>0.5 m) in determining river water levels in estuarines located in low elevation areas, such as Southeast and East Asian rivers. Therefore,

taking major Asian rivers (catchment areas larger than 160,000 km^2) as an example, we discuss those impacts in more detail. Validation of river water levels in coastal regions such as Ganges-Brahmaputra River and Mekong River demonstrated that coupled river-coast model's results become better than the modelled results without GTSR input, i.e., increase in correlation coefficients of ~0.06 and decrease in root mean square errors of ~0.22 m. Moreover, we found that in case of Chao Phraya River, seasonal cycles in sea water levels amplified those in river water levels due to the correspondence of them, which resulted in an increase in the high water level (+0.32 m) and decrease in the low water level (-0.40 m).

Conclusions

In this study we applied a global river-coast coupling model to compound simulation of fluvial flood and storm surges. Incorporation of the tide and surge reanalysis dataset, GTSR, into the river model, CaMa-Flood, enhanced the reproducibility of river water levels such as in Ganges and Mekong Rivers. Furthermore, in Chao Phraya River, seasonal cycles of river and sea water levels were in accordance, amplifying temporal variation of modelled river water levels.

270. From small to large scales: the potential of 2D numerical flood models for geographically large areas

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KEYWORDS: floods, 2D model, uncertainties

ABSTRACT

Hydrodynamic modeling of inundation events still brings a large array of uncertainties. This effect is especially evident in the models run for geographically large areas. Recent studies suggest using fully two-dimensional (2D) models with high resolution in order to avoid uncertainties and limitations coming from the incorrect interpretation of flood dynamics and unrealistic reproductions of the terrain topography. This, however, affects the computational efficiency increasing the running time and hardware demands. Concerning this point, our study evaluates and compares numerical models of different complexity by testing them on a flood plain inundation event that occurred in the basin of the Secchia River, Northern Italy, on 19th January, 2014. The event was characterized by a levee breach and consequent flooding of over 75 km² of the plain behind the dike within 48 hours causing population displacement, one death and economic losses in excess of 400 million Euro. We test the well-established TELEMAC 2D, and LISFLOOD-FP codes, together with the recently launched HEC-RAS 5.0.3 (2D model), all models are implemented using different grid size (2-200 m) based on the 1 m digital elevation model resolution. TELEMAC is a fully 2D hydrodynamic model which is based on the finite-element or finite-volume approach. Whereas HEC-RAS 5.0.3 and LISFLOOD-FP are both coupled 1D-2D models. All models are calibrated against observed inundation extent and maximum water depths, which are retrieved from remotely sensed data and field survey reports. Our study quantitatively compares the three modeling strategies highlighting differences in terms of the ease of implementation, accuracy of representation of hydraulic processes within floodplains and computational efficiency. Additionally, we look into the different grid resolutions in terms of the results accuracy and computation time. Our study is a preliminary assessment that focuses on smaller areas in order to identify potential modeling schemes that would be efficient for simulating flooding scenarios for large and very large floodplains. This research aims at contributing to the reduction of uncertainties and limitations in hazard and risk assessment.

295. Global hydrological modelling from National Hydrological Services' Perspective

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KEYWORDS: global hydrological modelling, World Meteorological Organization, EFAS, National Hydrological Services.

ABSTRACT

Several global or regional hydrological forecasting initiatives have developed recently, either in a research or an operational mode. Their performance and value have at times been demonstrated, however here we aim to discuss their value, limitations and deficiencies from the point of view of National Hydrological Services (NHSs).

The benefit of global modelling with the aim to produce forecasts might be obvious in developing countries. Global models are also a valuable means for verifying global trends and global climate models. However, conflicts may arise in countries, where well developed models are operated at national or sub-national scale.

The applicability of global forecasting products at a national scale is affected by three critical factors:

- data availability (measured hydrological and meteorological data for calibration, verification and running in real-time, as well as near-real time data availability including information on infrastructure, for example, reservoir operations);
- existing legal arrangements in flood risk management at the national scale including requirements from users (e.g. civil protection authorities);
- potential conflict with NHSs responsibilities (risk of violating the single authoritative voice principle).

For example, the European Flood Awareness System (EFAS) has been developed since 2002 in close cooperation with NHSs across Europe. It provides pre-warnings for NHSs based on ECMWF and COSMO-LEPS ensembles for period up to 10 days. However, the evaluation of EFAS warning and alert messages delivered to one NHS that has a well-established hydrological modelling system, the Czech Hydrometeorological Institute, shows the limited value of the regional model for the national warning system for 2006 to 2016 (POD= 0.28, FAR= 0.4, CSI = 0.24). What this highlights in general is that for a developed hydrological service operating hydrological forecast models, national forecasting activities should form the basis of its warning services. Global modelling efforts should be viewed as being complementary to its national forecasting system.

The World Meteorological Organization is a specialized agency of the United Nations dedicated to weather, climate and operational hydrology. Among other activities, WMO established WMO Integrated Global Observing System (WIGOS), and Global Data-Processing and Forecasting System (GDPFS) in order to share important data and results of modelling among Member States. In the field of operational hydrology, regional

cooperation at the basin scale is often more successful in providing decision support than existing global systems.

WMO has initiated the process of developing the Seamless Data-Processing and Forecasting System (SDPFS) as a future step of GDPFS that will likely include hydrological centres with global and regional coverage. Although this concept has not been fully accepted by the hydrological community during recent on-line discussions, the 15th Session of the WMO Commission for Hydrology agreed to develop a proposal of a comprehensive structure for hydrology within the new SDPFS; and to develop documentation describing the procedures for the designation, mandatory functions, and activities of new Centres, taking into account the principle that such Centres shall respect the primary roles and responsibilities of NHSs in the delivery of flood forecasting and warning services.

We present an initial proposal including criteria for the WMO SDPFS hydrological centres including system description and verification statistics available for users, a list of operational products that support flood warnings produced and communicated by competent national authorities, proposed approaches that potentially benefit NHSs from the synergies of modelling at global, regional and local level brings, and the means of distribution of data and products to NHSs.

317. Application of a Bayesian Network-based hydrologic model to the contiguous United States

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KEYWORDS: river discharge; copulas; return periods; flood hazard

ABSTRACT

Objectives

Global flood models are increasingly powerful, but challenges remain such as reducing computational time and increasing accuracy. In this study, we evaluate the performance of a Bayesian Network-based (BN) hydrologic model, originally prepared and validated for Europe (Paprotny and Morales Nápoles 2016), for the continguous United States (US). The model is used to estimate annual maxima of daily river discharges (Q_{amax}) in ungauged catchments and obtain return period discharge that can be used as a basis for flood hazard mapping.

Methods

The BN model utilizes the fact that many characteristics of catchments influence the intensity of river discharges. The joint probability distribution of seven variables (i.e., based on catchment area, steepness, climate, and land use) are used to describe the conditional probability distribution of Q_{amax}. Historical observed values of Q_{amax} were obtained at 4,765 river gauge stations and catchment characteristics were obtained from several global-scale datasets. A modelled series of Q_{amax} was generated and used to calculate return periods for each gauge station. We also compare the performance of the BN-approach to that observed in Europe.

Results

The comparison of modelled and measured average Q_{amax}, as well as discharges with different return periods, to the performance of the model applied in Europe shows moderate performance for the gauges in the contiguous US. We observe large regional differences in the model's performance across the US primarily due to greater geographic and climatological diversity across the contiguous US than in Europe. However, estimation of Q_{amax} using the conditional probability distributions derived for Europe improved the performance of the model. Additionally, the performance of the BN-based approach was compared with another data-driven model, the Regional Frequency Analysis (RFA) from Smith et al. (2015). It was found that as in Europe, the BN model achieves better results in simulating Q_{amax} and return periods than a RFA.

Conclusions

The results of this study show that the application of a BN to model extreme river discharges with given return periods at the scale of the US is a computationally-efficient alternative for preliminary flood risk assessments. We recommend, however, that further refinements to the model are made to better utilize the global-scale spatial datasets and improve model performance at the continental-scale.

REFERENCES

Paprotny D. and Morales Nápoles O. (2016). Estimating extreme river discharges in Europe through a Bayesian Network. Hydrology and Earth System Sciences Discussions, doi:10.5194/hess-2016-250.

Smith A., Sampson C. and Bates P. (2015). Regional flood frequency analysis at the global scale. Water Resources Research, 51, 539–553.

323. Providing impact based flood forecasts at global level

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KEYWORDS: global model, flood early warning, flood hazard mapping, impact assessment.

ABSTRACT

Global flood early warning and monitoring systems are nowadays recognized as crucial components of strategies for disaster risk reduction and management. Here, we present the ongoing developments of the Global Flood Awareness System (GloFAS) aimed at integrating flood forecasting with risk assessment and impact forecasting. The first development is the update of the existing global flood hazard maps based on GloFAS data, using downscaling techniques and new datasets of elevation and water surface dynamics. These maps, together with recently developed global datasets of damage functions, population and built up areas, are used as input in a new procedure for rapid risk assessment which produces event-based flood maps and impact assessment based on GloFAS forecasts. The accuracy of the updated flood hazard maps is evaluated and discussed in a number of test areas against observed data and results from global models. Similarly, impact estimates are evaluated in terms of potential economic damage, affected urban areas and population in some recent flood events. Finally, we present the ongoing integration in GloFAS of a methodology for social media monitoring, which allows for real-time verification and correction of impact forecasts.

Around one billion people are thought to be exposed to flooding with an annual probability above 1%. Despite the prevalence of flood risk in every country, flooding is an extremely localised process in space with direct impacts limited to the land adjacent to rivers or topographic low points where runoff can accumulate. To understand flood risk it is necessary to map how frequently floodplains inundate and what the consequence of that inundation might be at hyper-resolution (<100 m). Such mapping is now routine in the developed world, but elsewhere requires a substantially shift from the current data and modelling methods available. The key reasons for this capability gap across most of the globe are a lack of suitable modelling frameworks, with which to simulate the hazard, and the absence or poor quality of data that describe river geometry and river discharge, upon which traditional flood risk assessment methods depend.

Emerging methods for global scale flood inundation modelling show much promise. However, they lack the uniqueness of place needed to identify risk hotspots because the spatial variability in the relationship between the size of rivers and extreme flood generating flows is unknown. This research will make a first attempt to recognise uniqueness of place by using the earth observation record to help identify how frequently the land adjacent to rivers has inundated, and then use this information to resize rivers in the global inundation model.

Here, a number of approaches to bankfull discharge estimation from ICEsat and Envistat altimeter data are evaluated using a hydrodynamic model of the Inner Niger Delta in Mali. Previous models of this site parameterised the river channel using downstream hydraulic geometry theory, which related the reach averaged channel width to depth via two calibrated parameters. This approach achieved at best a 1.2 m RMSE to 126 ICEsat virtual stations. Directly estimating reach averaged depth for a number of reaches was shown to reduce these errors by over 50%.

Inundation estimates from 2002-2009 were evaluated against optical imagery from Landsat. Finally, historical gauge records were used to simulate the inundation history from the 1960's when peak discharge on the Niger was over twice that of the past two decades, primarily because of different land use practices upstream.

356. Estimation of river bathymetry in regional scale flood inundation models

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Around one billion people are thought to be exposed to flooding with an annual probability above 1%. Despite the prevalence of flood risk in every country, flooding is an extremely localised process in space with direct impacts limited to the land adjacent to rivers or topographic low points where runoff can accumulate. To understand flood risk it is necessary to map how frequently floodplains inundate and what the consequence of that inundation might be at hyper-resolution (<100 m). Such mapping is now routine in the developed world, but elsewhere requires a substantially shift from the current data and modelling methods available. The key reasons for this capability gap across most of the globe are a lack of suitable modelling frameworks, with which to simulate the hazard, and the absence or poor quality of data that describe river geometry and river discharge, upon which traditional flood risk assessment methods depend.

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Inundation estimates from 2002-2009 were evaluated against optical imagery from Landsat. Finally, historical gauge records were used to simulate the inundation history from the 1960's when peak discharge on the Niger was over twice that of the past two decades, primarily because of different land use practices upstream.

System approaches to flood risk assessment and management (ii)

258. Temporally-Dynamic Flood Vulnerability: The influence of watershed-scale adaptation and vulnerability reduction efforts on flood losses

Ms Marleen de Ruiter, Vrije Universiteit Amsterdam, Netherlands

265. How do changes in different drivers along the risk chain affect flood risk?

Ms Ayse Duha Metin, GFZ German Research Centre for Geosciences, Germany

320. How well do flood damage models capture changes in vulnerability

Ms Nivedita Sairam, German Research Centre for Geosciences, Germany

314. Flood risk changes in Northeastern Italy: a multi perspective overview

Dr Alessio Domeneghetti, DICAM, School of Engineering of Bologna, Bologna, Italy

258. Temporally-Dynamic Flood Vulnerability: The influence of watershed-scale adaptation and vulnerability reduction efforts on flood losses

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KEYWORDS: flood risk; vulnerability; temporal variability; disaster risk reduction; adaptation

ABSTRACT

Introduction

Despite increasing trends in annual flood losses in the United States, the effectiveness of adaptation and vulnerability reduction efforts on reducing flood losses are still poorly understood. When assessing the influence of adaptation measures on vulnerability trends, it is crucial to have sufficient baseline-data; however, lack of historical data related to losses is one of the main reasons for this gap in understanding the impacts of disaster loss reduction policies (e.g. Gall et al., 2011). This study addresses this limitation by analysing temporal changes in flood vulnerability using FEMA floodclaims and the effectiveness of adaptation measures taken in response to regional flood events in Harris County, Texas (USA).

Harris County suffers regularly from flood events. In 2001, Tropical Storm (T.S.) Allison caused major flooding in Brays Bayou, a large watershed in Harris County, damaging 73,000 residential properties (Harris County Flood Control District (HCFCD), 2002). Besides numerous smaller flood events since T.S. Allison, this period of relative calm ended on Memorial Day 2015 when devastating flooding damaged 1,185 residences. There are several adaptation programmes in the watershed such as Project Brays. Recent studies have evaluated the influence of structural interventions on reducing flood severity in the Brays Bayou Watershed (Bass et al. 2016), however they do not consider parcel- and community-level adaptation measures.

Objectives

We analyze the influence of both structural and non-structural measures aimed at reducing flood vulnerability in the watershed in the wake of T.S. Allison, and their influence on the evolution of flood risk over time.

Methods

We use FEMA insurance claims data to compare changes in building damage during T.S. Allison (2001) and subsequent flood events. While adjusting for other temporal changes that might influence flood damage, such

as changes in exposure and population growth, we statistically analyse the temporal evolution in vulnerability in the watershed. In reviewing flood adaptation measures, we assess which risk reduction methods have been implemented and their relative effectiveness.

Results/Conclusions

The results from this study will explore how temporally dynamic vulnerability levels can be investigated and how this has affected flood risk in Harris County. Not only will this study aid future research on flood vulnerability, but it will also provide empirical evidence that will support local policymaker and stakeholder strategies for managing flood risk.

ABBREVIATED REFERENCES

Bass *et al.* (2016). 2015 Memorial Day Flood Impacts for Changing Watershed Conditions in Houston. *Natural Hazards Review.*

Gall *et al.* (2011). The unsustainable trend of natural hazard losses in the United States. *Sustainability*, *3*(11), 2157-2181.

HCFCD, *Tropical Storm Allison Public Report* (2002). https://www.hcfcd.org/storm-center/tropical-storm-allison-2001/, 24-01-2017.

265. How do changes in different drivers along the risk chain affect flood risk?

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KEYWORDS: flood risk, sensitivity, river flooding, hazard, vulnerability

Flood disaster risk stems from the interaction of socio-economic and hydrological processes. Therefore, the analysis of flood risk ideally deals with the entire flood risk chain, from the atmospheric processes through the catchment and river system processes to the damage mechanisms in the affected areas. Since different factors at various scales are interacting along the flood risk chain, the effect of single components on damage and risk is not clear. After all, it is essential to know the controlling factors of flood damages for flood risk assessment and management. The main objectives of the study are to understand the influence of different drivers and to discuss the state of knowledge regarding the sensitivity of flood risk to disturbances along the risk chain using as example the flood-prone Mulde catchment in Germany. The sensitivity analysis includes five risk components which are climate, catchment, river system, exposure and vulnerability. A set of models covers the complete risk chain to understand how the sensitivities develop along the risk chain by taking into consideration three plausible change scenarios for each of the five components. Flood risk is computed using the Regional Flood Model (RFM) which includes rainfall-runoff, 1D river network, 2D hinterland inundation and damage estimation models. The model chain is driven by a multi-site weather generator. This model setup is capable of providing a spatially consistent, large-scale image of flood risk and is based on a long-term continuous simulation approach. In total, the sensitivity analysis includes more than 240 change scenarios and it estimates how changes in different components affect risk indicators, such as the risk curve and expected annual damage (EAD). The results suggest that changes in exposure and vulnerability outweigh changes in hazard.

314. Flood risk changes in Northeastern Italy: a multi perspective overview

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KEYWORDS: flood hazard, exposure, system approach, climate changes, trend analysis

ABSTRACT

In Italy, as well as in many other European countries, economic losses and social consequences induced by inundations have been steadily increasing over the last three decades. Climate change and the resulting intensification of extreme hydrological events are often indicated as the main responsibles for such an increase. However, a scrupulous and detailed investigation of all components of flood risk (e.g. hazard, vulnerability and exposure) may provide a dramatically different picture and support the need for a general rethinking of flood risk policies and management strategies; by adopting a system approach our study attempts at investigating the dynamics of different flood-risk components in the area of interest. First, we sought possible changes in flood hazard at regional scale by taking field significance into account and considering several long time-series of different hydrological extremes, such as: i) partial duration series (PDS) and annual maximum series (AMS) of hourly rainfall depths (series length ~30 years); PDS and AMS of daily rainfall totals (min. and max. series length are equal to 68 and 88 years, respectively); and iii) AMS of flood peaks observed across Nothern Appennines and Northeastern Alps (mean and max. series length are equal to 30 and 89 years, respectively). Second, we assessed the dynamics of exposure to floods by looking at the spatial and temporal evolution of urban settlements and industrial assets during the last half century over the study region. The main findings of our study are: i) no significant variation of magnitude and seasonal frequency on rainfall extremes can be observed for the entire study area; ii) a few statistically significant changes of flood frequency can be observed, which are likely to result from river training or water resources management structurers constructed during the observation period; iii) a significant variation of exposure to floods can be observed both in time and space after the second World War, mainly associated with severe urban and industrial developments in flood-prone areas.

320. How well do flood damage models capture changes in vulnerability?

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KEYWORDS: Flood Vulnerability, Precaution, Bayesian Networks, Causal Interference

ABSTRACT

The losses due to floods are estimated by a variety of models with different structures and varying input parameters that fall into the broad skeleton of Hazard, Exposure and Vulnerability. Losses due to floods are commonly estimated using the only measurable hazard parameter - water depth. However, flood loss also depends on other factors such as preparedness of the exposed population, precautionary measures undertaken and technological advancements to provide emergency information to the exposed population. A large number of study reports have been published in the domains of public awareness towards natural disasters from sociology and economics perspectives. However, it is important to quantify several cognitive and private precautionary practices that are proven to abate the consequences of floods.

The objective of this research is to quantify the impact of private precautionary measures and evaluate the benefit of early warning systems. Additionally, the aim is to develop a flood loss model that sufficiently represents vulnerability changes, in addition to hazard and exposure attributes.

A couple of existing flood loss models such as Stage Damage functions (Kreibich et al, 2016.), FLEMOps (Elmer et al, 2010) and regression trees (Merz et al, 2013) are analyzed for appropriate representation of vulnerability attributes. Additionally, a Graphical Model - Bayesian networks implying causal inference will be implemented in order to study the changes in vulnerability by applying different private precautionary measures and under the influence of different qualities of early warning systems. Bayesian Networks have been increasingly used in the domains of several risk assessments scenarios. They provide an advantage over deterministic approaches in dealing with highly random processes where relationships between variables involve higher level of uncertainties. This causal relationship helps in identifying the interferences (precautionary methods/warning systems) and their implications on the estimated loss. Flood vulnerability in this context is identified by the expected loss to building and contents during a flood event.

It is statistically evident that precautionary measures and warning procedures have a strong influence on flood loss. Hence, our results are valuable for communicating the underlying benefit of precautionary activities to the society and motivating exposed households to get active.

REFERENCES

Kreibich, H., Botto, A., Merz, B., & Schröter, K. (2016). Probabilistic, Multivariable Flood Loss Modeling on the Mesoscale with BT-FLEMO. Risk Analysis. doi:10.1111/risa.12650

Elmer, F., Thieken, A. H., Pech, I., & Kreibich, H. (2010). Influence of flood frequency on residential building losses. Natural Hazards and Earth System Science, 10(10), 2145-2159. doi:10.5194/nhess-10-2145-2010

Merz, B., Kreibich, H., & Lall, U. (2013). Multi-variate flood damage assessment: a tree-based data-mining approach. Natural Hazards and Earth System Science, 13(1), 53-64. doi:10.5194/nhess-13-53-2013

Land for flood risk management

90. System of small-scale urban flood protection measures as a complement to large catchment-wide measures: On the road to coexistence?
Prof. Lenka Slavíková, J. E. Purkyne University in Usti nad Labem, Czech Republic

142. Identifying and communicating 'win:win' nature based measures to farmers and flood risk managers
Dr Mark Wilkinson, James Hutton Institute, United Kingdom

238. Hidden benefits of multifunctional land use of floodplains – A NEXUS approach for water retention areas
Dr Jens Bölscher, Freie Universität Berlin, Germany

267. Handling Critical Infrastructure in the Event of Flooding
Ms Corinna Gall, Uniwasser GmbH, Kaiserslautern, Germany

319. "Flood originating areas": Prospects and limitations of an innovative instrument of preventive flood protection
Dr Juliane Albrecht, Leibniz Institute of Ecological Urban and Regional Development, Germany

90. System of small-scale urban flood protection measures as a complement to large catchment-wide measures: On the road to coexistence?

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KEYWORDS: cost-benefit analysis, nature-based solutions, small-scale flood protection measurers

ABSTRACT

Objectives

Because of high urban density and complicated land ownership, many cities periodically affected by floods have only limited options for adaptation to changing conditions of water regime in the landscape. Nature-based solutions for flood protection have become increasingly popular and implemented in practice in the recent decades, but emphasis has been rather on larger measures in the open landscape. Small-scale nature-based measures in urban areas can serve as a complement to the large measures. On the other hand, implementation of these measures faces many obstacles: (i) because of the droughts in recent years, floods are not perceived as a significant risk; (ii) the politicians prefer short-term results due to the political cycle; (iii) a lot of measures designed are located on private land and negotiations with owners increase the costs. Rational ignorance may be the common denominator of the problems. Neither decision-makers nor the public are fully aware of the importance of small-scale measures, including their indirect benefits.

Our contribution focuses on finding ways of persuading decision-makers and private landowners to become involved in practical implementation of urban small-scale measures.

Methods

The Czech city of Plzeň belongs among areas heavily affected by floods in the year 2002 (with damages over EUR 20.8 million). This city is used as a case study for increasing awareness about importance and indirect benefits of urban wetlands via the results of an economic cost-benefit analysis (CBA). The assessment of the measures employs annualisation of both direct and indirect costs and benefits, derived from the concept of real value of money and the opportunity to invest funds elsewhere. This is followed by a comparison of the annualised costs and benefits with respect to costs and benefits that are only qualified.

Results

In addition to flood protection benefits, applications of urban wetlands provide a number of environmental benefits and ecosystem services. In our case, the annual benefits are EUR 1.53 million and include the benefits of providing biodiversity, the supply of surface and ground water, water quality improvement, recreational benefits and aesthetic amenities. The annual costs are about EUR 0.06 million and involve both investments and operating costs. The annual net social benefit is EUR 1.47 million.

Conclusions

Besides the direct benefits, urban wetlands bring numerous other co-benefits for both property owners and the entire society. CBA integrates all impacts of the measures and thus the results in the form of a detailed description and analysis of costs and benefits, and hence the calculation of net social benefits, are appropriate for raising awareness of all stakeholders.

142. Identifying and communicating 'win:win' nature based measures to farmers and flood risk managers

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KEYWORDS: Runoff, Natural Flood Management, Farming, Multiple benefits, Flooding

ABSTRACT

Over the past decade many European catchments have experienced an unusually high number of flood events. In the UK, the role of Natural Flood Management (NFM) is now at the forefront of the flooding and environmental management debates after the winter 2015/16 floods. The recently published House of Commons Environment, Food and Rural Affairs Committee "Future of Flood prevention" report has suggested catchment measures need to be adopted on a much wider scale and that farmland in some places should be used to store flood water. However, there are currently limited funding mechanisms available in order to pay for the services of farmers to allow sufficient water to be stored on farmland during intense storm events. There is a need to identify measures, at an approriate scale, which may provide additional persuasive benefits to both farmers and flood risk managers, to enhance flood mitigation efficently and cost-effectivly whilst efficiently tackling practical farm concerns such as soil loss. Measures which disconnect overland flow, such as raised bunds and corner-of-field wetlands, exemplify these criteria and this paper assesses what such combined benefits are to the farmer and for local and potential wider flood risk management. We highlight practical bottom-up tools to help locate measures in the farmed landscape, assess their hydrological functioning and determine benefits such as sediment retention. The Floods and Agriculture Risk Matrix (FARM), an interactive communication/visualization tool and FARMPLOT, a GIS mapping tool, have been used to promote such measures, by showing how and where temporary ponded areas can be located along flow and erosion lines ro reduce risk whilst minimising disruption to farming practices. Case study examples are presented from Aberdeenshire and N.E. England, where measures have been constructed sucessfully with stakeholders (and scoping of new measures is taking place). Results show that small temporary ponding areas, which fill during moderate to large events (e.g. annual maximum flow) but are designed to hold water for less than a day, are favourable to the local farming community as these usually do not disrupt cropping or livestock productivity. Taking a treatment train approach through a network of measures has been shown to achieve greater benefits, for example local flood peak reduction and capturing significant amounts of sediment (which can later be re-applied to the upslope farmland). Observations of trapped sediment in features are providing powerful messages to farmers of how much valuable soil can be lost in a storm. However, there remains a pressing need to replicate sufficient densities of such measures across multiple higher risk locations and to

document benefits to raise awareness and uptake of catchment-based measures for flooding.

238. Hidden benefits of multifunctional land use of floodplains

- A NEXUS approach for water retention areas –

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KEYWORDS: floodplain, water retention, floods, energy, agriculture, stakeholder

ABSTRACT

The German Government has released in 2014 the National Flood Protection Program in response to serious flood events of recent years along the Elbe, Danube and Rhine and its tributaries. It encompasses the identification of potential areas for dike reallocation, reactivation of floodplains and construction of new retention polders. This spatial turn in flood risk management is also ongoing in other European countries, also triggered by the European Floods Directive (Directive 2007/60/EC) and the European Water Framework Directives (Directive 2000/60/EC).

The main challenge of the National Flood Protection Program and for spatial flood risk management is, that land for such essential measures is increasingly scarce and a conflict of competing interests is inevitable (i.e. flood risk management vs. farming, natural conservation, or shipping). Water managers are desperate to get the land needed for water retention because many projects for space for the rivers or restoring the floodplains are hindered by resistance of land users – mainly farmers. This ultimately increases flood risks for vulnerable urban areas. This contribution discusses how linking water retention with the Food-Energy-Water NEXUS debate can create some momentum to realize water retention measures more effectively.

The most suitable land to retain floodwater is usually farmland that is intensively used for food production. One of the problems with getting agricultural land for flood protection is, that such measures substantially affect the way it can be used for traditional farming.

Water management currently pursues a sectoral approach to acquire the land. The Food-Energy-Water Nexus offers a new perspective to develop multi-functional uses of water retention areas that ultimately help to increase water retention to benefit flood prone areas. This requires an interdisciplinary approach and linking up of at least the water sector, food production and biomass energy production. It will be explored how such land uses can be used not only to produce sustainable renewable energy but also serve for retention of floodwater and nutrients and others.

Such a multifunctional land use needs to be economically viable for farmers, hydrologically and ecological

meaningful and embedded in a spatial planning strategy that facilitates benefits for all stakeholders.

The River Elbe serves as a case study to identify the potentials and restrictions for a perspective of a multifunctional use of current and planned inundation areas to unify different stakeholder approaches.

The contribution explores an approach to overcome conflicts on land between competing sectoral spatial requirements. This can finally contribute to solutions to get land for flood risk management.

267. Handling Critical Infrastructure in the Event of Flooding

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KEYWORDS: Flood Risk Analysis; Critical Infrastructures; Flood protection concepts

INTRODUCTION

Modern societies are increasingly dependent on a steady availability of various services and products that are ensured by a network of infrastructures. Infrastructures that are “organizational and physical structures and facilities of such vital importance to a nation's society and economy that their failure or degradation would result in sustained supply shortages, significant disruption of public safety and security, or other dramatic consequences” (BMI 2009), are defined as Critical Infrastructures.

The uninterrupted availability of Critical Infrastructures is especially endangered in the event of a major flood. To insure the availability of Critical Infrastructures, including flood protection measures, it is necessary first to identify the flood risk for these infrastructures. This can be accomplished through the implementation of a flood risk analysis approach, which consists of assessing the flood danger at the location of the infrastructure as well as assessing information about the vulnerability of the infrastructure itself. Based on the results of a flood risk analysis it is possible to develop effective flood protection measures for Critical Infrastructures.

APPROACH OF A FLOOD RISK ANALYSIS

Flood events can cause wide-ranging failures of Critical Infrastructures. Therefore, it is mandatory to know the potential flood risk in order to efficiently apply the resources, which are limited in both a financial and a personnel way, to ensure the protection of the Critical Infrastructures (BMI 2011).

In general, the term “risk” is defined as interaction between hazard and vulnerability (DKKV 2003). Accordingly, the flood risk can be minimized by the reduction of the hazard on the one hand (e.g. by the enlargement of a retention area in the drainage basin), and on the other, by the reduction of vulnerability (e.g. by protection measures for individual buildings). In order to adequately handle flood risks, protection measures are essential that, in their conception and design, respond to the identification and quantification of the risks. When the risks are unknown, the affected citizens have no possibility to react purposefully. That`s why in flood-prone areas it is important to implement risk analyses aimed at identification and quantification of risks (MERZ 2006).

A flood risk analysis for Critical Infrastructures consists of: 1) a criticality assessment, 2) a hazard and vulnerability analysis, and 3) a risk investigation. Based on the results of a flood risk analysis it is possible to develop precautionary measures to protect Critical Infrastructures. The procedure of a flood risk analysis for Critical Infrastructures, as well as the subsequent range of protection measures, is described in Figure 1. For the most part this approach conforms to the recommendations of the German Federal Ministry of the Interior

and the German Federal Office of Civil Protection and Disaster Assistance related to the protection of Critical Infrastructures (BMI 2011, BBK 2013).

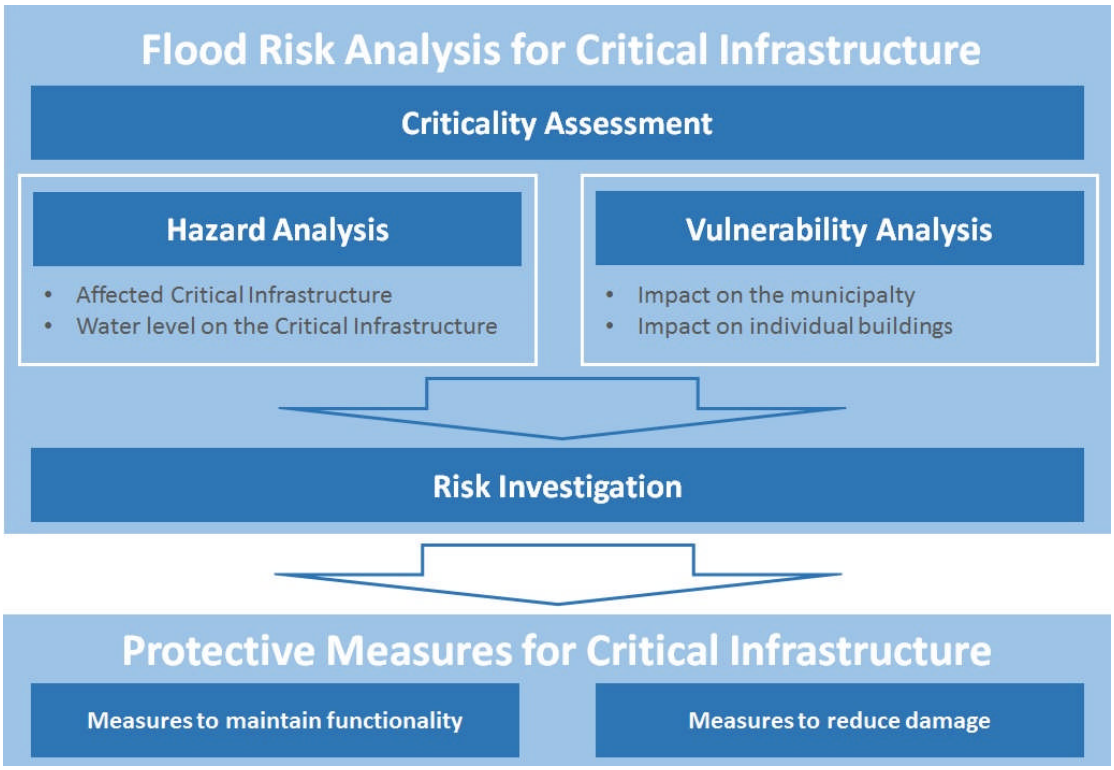

Figure 1: Approach of a Flood Risk Analysis for Critical Infrastructures (GALL & JÜPNER 2015, referring to BMI 2011)

In the criticality assessment, the Critical Infrastructures that will cause particularly serious impacts in the case of failure due to a flooding event will be determined. This step of the flood risk analysis predominantly serves to limit the scope of investigation. Subsequently, hazard analysis will determine at which water level on the reference gauge the Critical Infrastructures are likely to be affected by a flood event. Based on this information it is possible to develop emergency plans for the Infrastructures. Furthermore, the assessment will envision various flooding scenarios in order to determine at what above-ground water level possible impacts might result to Critical Infrastructures. Possible impacts on Critical Infrastructures will be the main topic of the vulnerability analysis. On the basis of the information provided by the hazard analysis - and with the help of the responsible operator of the Critical Infrastructure – we can determine if the function of the investigated infrastructure would be interrupted, or even fail, in the case of a specific flooding event. In this case, one can distinguish between the impacts on the municipality and on individual buildings. This information can be used to generate evacuation plans for citizens in the municipality. The information provided by the prior steps will be incorporated into the risk investigation in order to deduce the overall risk for the Critical Infrastructure.

PROTECTIVE MEASURES FOR CRITICAL INFRASTRUCTURE

The function of a Critical Infrastructure should be maintained in the case of flooding to prevent serious impact on the population. The fact that Critical Infrastructures are often not sufficiently maintained is demonstrated by numerous examples of past flood events. With the help of flood hazard maps created at the direction of the EU Flood Risk Management Directive for all areas in the European Union with a potential flood risk, it is easily possible to assess the risk of degradation or failure of a Critical Infrastructure for various flood scenarios. On the basis of this information one can develop precautionary measures to protect Critical Infrastructures. A determination of the most effective measures for a particular situation results from a careful consideration of the characteristics of the protected infrastructure in concert with how the protected infrastructure would be affected by various underlying flood scenarios.

In general, two concepts of protection measures for Critical Infrastructures can be distinguished. On the one hand, there are measures focused on maintenance of the Critical Infrastructure's functionality. On the other, there are measures to reduce damage to the Critical Infrastructure. Basically, the strategies for building precaution can also be used to maintain functionality, e.g. the strategies "Avoid" and "Resist". To implement the strategy "Avoid", the infrastructure can be moved to another location that is not flood-prone, or perhaps, enlarged at the same location. In the strategy "Resist" one must use water pressure-tight materials.

Figure 2: left: enlarged power substation (source: Gall 2015); right: power substation sealed with a submarine door (source: Gall 2015)

The "Resist" strategy should ordinarily be implemented if relocation, enlargement, or sealing are not economically viable. This is the case, for instance, when an infrastructure fails, but only a few individual buildings are affected or if the flooding scenario has a very low probability of occurrence (GALL & JÜPNER 2015).

REFERENCES

BMI, BUNDESMINISTERIUM DES INNERN (2009). National Strategy for Critical Infrastructure Protection (CIP-Strategy), Berlin.

BMI, BUNDESMINISTERIUM DES INNERN (2011): Schutz Kritischer Infrastrukturen – Risiko- und Krisenmanagement. Leitfaden für Unternehmen und Behörden. Berlin.

BBK, BUNDESAMT FÜR BEVÖLKERUNGSSCHUTZ UND KATASTROPHENHILFE (2013): Abschätzung der Verwundbarkeit gegenüber Hochwasserereignissen auf kommunaler Ebene. Schriftenreihe des BBK: Praxis im Bevölkerungsschutz. Band 4. Bonn.

DKKV, DEUTSCHES KOMITEE FÜR KATASTROPHENVORSORGE E.V. (2003): Hochwasservorsorge in Deutschland – Lernen aus der Katastrophe 2002 im Elbegebiet. Schriftenreihe des DKKV. Band 29. Bonn.

GALL, CORINNA; JÜPNER, ROBERT (2015): Umgang mit Extremereignissen auf kommunaler Ebene – Notfallkonzepte als Mittel der Wahl? In: Jüpner, R.; Müller, U. (2015): Tagungsband zur 7. Veranstaltung des Forums der EG-HWRM-RL am 11. Juni 2015 in Meißen. S. 45-61.

MERZ, BRUNO (2006): Hochwasserrisiken. Grenzen und Möglichkeiten der Risikoabschätzung. Schweizerbart`sche Verlagsbuchhandlung (Nägele und Obermiller). Stuttgart.

319. "Flood originating areas": Prospects and limitations of an innovative instrument of preventive flood protection

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KEYWORDS: flood orgiginating areas, German water law, water retention, compensation, land use

ABSTRACT

As a response to the 2002 catastrophic flooding, the Saxon Water Act of 2004 introduced a new category of protected area, so-called flood originating areas (German: Hochwasserentstehungsgebiete). These category is assigned to headwater catchments in upland and highland regions as source areas of flooding where surface runoff during heavy rainfall events or springtime thawing greatly increases the likelihood of downstream flooding, presenting a significant threat to public safety and order (cf. Section 76 Para. 1 Saxon Water Act). Such flood originating areas can be seen as the counterpart to flood retention areas in lowlands: Whilst the latter serve to retain floods, the former are those areas where floods originate. Since the introduction of the instrument in Saxony, five flood originating areas have been designated. Preparations for the designation of additional areas are underway.

The protection of flood originating areas is a regulatory approach of land management, providing certain orders of land use, e.g. duty to reforest (cf. Section 76 Para. 2 Saxon Water Act), and prohibitions for land use (cf. Section 76 Para. 3 to 5 Saxon Water Act). Although the concept is certainly a novelty in the field of German water law, and one that could be of interest not only to other federal states (Länder) with upland/highland regions but also abroad as an instrument to increase flood prevention, up to now, it has been scarcely discussed outside Saxony. However, at present, the introduction of flood originating areas into the Federal Water Act is provided (Draft of the Federal Ministry of Environment: Act for further improvement of flood protection and simplification of flood protection procedures of 30 May 2016, Section 78d). These developments are an inducement to take a closer look at the preconditions of flood originating areas, before undertaking an interim review of the current situation.

This contribution examines the legal and technical requirements of flood originating areas in the field of land use, as well as the practical implementation in the administrative process. It focuses on the questions, which type of legal orders are provided for water retention, to which extent changes in land use may be restricted or impairments of water retention have to be compensated by land users and how the regulations are implemented in practice. Furthermore it is discussed, which measures are suitable for the compensation of impairments of water retention and how effective they are. The contribution considers also the fact that, in addition to their use as farmland and woodland, flood originating areas frequently possess valuable ecological functions, particularly as wildlife habitats. Measures undertaken in flood originating areas are therefore

examined not merely in terms of their hydrological impact but also their compatibility with other forms and functions of land use.

A panta rhei perspective on changes in flood risk

115. Strategic Flood Risk Management as a Part of City Planning – From Protect to Protect, Adapt, Retreat
Prof Karsten Arnbjerg-Nielsen, Technical University of Denmark, DTU Environment Denmark

206. Learning from floods to mitigate flood risk
Dr Heidi Kreibich German Research Centre for Geosciences Germany

268. Multiple flood experience: The benefits and limits of adaptation
Dr Christian Kuhlicke, UFZ Helmholtz Centre for Environmental Research, Germany

303. Uncertainty and benefit of updating model parameter on flood loss assessment
Ms Sarah Kienzler, University of Potsdam, Germany

115. Strategic Flood Risk Management as a Part of City Planning – From Protect to Protect, Adapt, Retreat

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KEYWORDS: urban water management, strategic planning, scenario development, planning indicators, exploratory modelling

ABSTRACT

Objectives

Mainstreaming flood risk management with general city planning process provides the opportunity to create solutions that not only reduce flood risk, but also contribute to water management in a broader sense and have a positive impact on livability. Such solutions will in general be more economically efficient than traditonal engineering measures because they serve several purposes for society. As an example, (Zhou et al., 2013) demonstrated that the consideration of ecosystens services strongly changed the results of a cost-benefit analysis of flood adaptation towards a preference on open storm water systems that benefit surrounding areas. Such solutions can make a significant contribution towards solving the issue of increasing flood adaptation cost as a result of climate change.

Two key points need to be considered for the development of integrated planning approaches. First, there is a need to assess to what extent flood adaptation measures fulfill the preferences of different stakeholders and to encourage communication between them. Second, stakeholders may have difficulties in acknowleging each others values, system understanding, and planning horizons of city and infrastructure planners. Hence the approaches must include consideration both on the local and the regional scale.

Methods

Potential future developments paths are identified based on climate, population and economic projections, as well as an analysis of historical developments in the case study. Similar to the approach of (Lienert et al., 2015), we perform workshops with a broad range of stakeholders to define realistic and broadly accepted development scenarios for city and society along with the anticipated impact on functionality and implementability of adaptation measures.

Finally, we model the impact of planning and infrastructure measures on the defined indicators in the considered scenarios. In this setup, we apply agent-based urban development models (Urich and Rauch, 2014), hydraulic models as well as GIS-based assessments to evaluate the robustness of different strategies.

Conclusions

Strategic planning of flood risk adaptation measures can contribute to the development of efficient, robust and livable solutions. It is important to approach this task in a transparent and quantifiable manner. We identify room for improvement in the combination of a thorough analysis of stakeholder preferences with a systematic, model-based testing of adaptation measures that includes the consideration of city planning strategies.

REFERENCES

Lienert, J., Scholten, L., Egger, C., Maurer, M., 2015. Structured decision-making for sustainable water infrastructure planning and four future scenarios. EURO J. Decis. Process. 3, 107–140. doi:10.1007/s40070-014-0030-0

Urich, C., Rauch, W., 2014. Exploring critical pathways for urban water management to identify robust strategies under deep uncertainties. Water Res. 66C, 374–389. doi:10.1016/j.watres.2014.08.020

Zhou, Q., Panduro, T.E., Thorsen, B.J., Arnbjerg-Nielsen, K., 2013. Adaption to extreme rainfall with open urban drainage system: An integrated hydrological cost-benefit analysis. Environ. Manage. 51, 586–601. doi:10.1007/s00267-012-0010-8

206. Learning from floods to mitigate flood risk

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KEYWORDS: flood risk change, focussing event, paired event studies

ABSTRACT

BACKGROUND AND OBJECTIVES

Flood risk is expected to increase in large parts of the world due to climate change and globally increasing

exposure. Efficient integrated flood risk management needs to be implemented to counteract this trend. Societies can learn from floods, and consequently improve their risk management. Objective of this study is to increase our knowledge on how societies learn from floods and what measures they implement to reduce their flood risk.

METHOD

Societal learning can occur through 'focusing events', i.e. events that provide a sudden, strong push for action (Kreibich et al. 2011). Thus, we undertook a semi-quantitative assessment of eight paired flood events around the world, i.e. consecutive floods that occurred in the same catchments, with the second flood causing significantly lower damage. We present these eight success stories of risk reduction and unravel what risk management concepts were implemented after the first flood and how these changed the flood risk and thus the resulting damage of the second flood.

RESULTS AND CONCLUSIONS

Across all case studies, we find that lower damage caused by the second event was mainly due to significant reductions in vulnerability. The role of changes in exposure is less apparent; positive and negative changes are reported. In some cases, significant investments in flood protection between the floods have played a large role in exposure and damage reduction. Reduction of vulnerability seems to be a key for better risk reduction via integrated flood risk management. Thus, efforts need to be redoubled to improve our understanding of vulnerability.

REFERENCES

Kreibich H., Seifert, I., Thieken, A. H., Lindquist, E., Wagner, K., Merz, B. (2011) Recent changes in flood preparedness of private households and businesses in Germany. Regional Environ Change, 11(1), 59-71.

268. Multiple flood experience: The benefits and limits of adaptation

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Abstract

This paper addresses the interrelation between multiple flood experience and households' and companies' adaptation to flood risks. While several studies have aimed at scrutinizing what motivates households and companies to take adaptation actions as well as on what are the (monetary) benefits of taking private actions, the consequences of multiple flood experience are rarely investigated. The paper addresses this gap, by focusing on the 2013 flood in Germany and the multiple flood experiences of the affected people.

The analysis is based on three independently collected data sets, two with a focus on affected households and one with a focus on affected companies (Sample 1 on households includes 1,380 surveys, Sample 2 on households includes 1,651 surveys and sample 3 includes 557 surveys on companies). While the samples were collected individually, all three samples address a shared set of questions allowing us to perform a comparative analysis.

The results show the following: (i) There is a significant, robust and linear correlation between multiple flood experience and adaptation: The more frequently households experienced a flood event in the past, the more likely they took actions in order to adapt (including constructional measures, informational action, contracting an insurance and emergency measures). (ii) The interrelation between multiple flood experience and perceived as well as financial damage are less straight-forward. While financial consequences seem to show no linear pattern with multiple flood experience, there are indications that households and companies build up adaptive capacities with regard to mobile objects. However, findings also suggest that with multiple flood experience the perceived overall consequences, as well as the stress and health-related consequences seem to increase too. By means of discussion, the paper engages with the benefits as well as the limits of adaption and outlines in a first step the practical implications for flood risk management; in a second step, it please for more standardized cross-case study research in order to better understand the wider consequence of multiple flood experiences on households' and companies' adaption as well as on their resilience in different catchments across the globe.

303. Uncertainty and benefit of updating model parameter on flood loss assessment

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KEYWORDS: flood loss assessment, uncertainty, sensitivity, data update

ABSTRACT

In modern flood risk management, flood loss modeling is an essential tool for risk analyses. Most commonly applied flood loss modeling approaches require input data on flood characteristics (e.g. inundation depth), potentially affected elements at risk (e.g. buildings), the asset value of these affected elements as well as their susceptability to the hazard characteristics (damage functions). Though, it is assessed and acknowledged by many studies that respective input data and hence loss model results are subject to large uncertainty. Main error sources originate from the used asset values and damage functions. Yet, regarding the flood hazard maps, there are also often difficulties to obtain large consistent data sets due to a variety of different approaches and quality of the input data. Despite these shortcomings, it is important to regularly review and update the data used as the flood risk may change over time. For risk assessment in Germany, one possibility to tackle the latter aspect is the use of the flood hazard maps prepared within the framework of the European Floods Directive (2007/60/EC), which represent officially accepted and nationwide existing information on flood hazards and will be revised every six years. Similarly, the recently published Basic European Asset Map for Germany might serve as basis for risk appraisals, since it will be also updated every six years.The aim of this study is hence to complement uncertainty investigations and examine the effect of different hazard maps, asset value of residential buildings and multi-factorial damage functions on flood loss estimates for residential buildings in Germany – also with regard to the effect of temporal changes in the input data. Uncertainty will be assessed by varying the respective parameter of the flood loss model chain manually, using a 'one-factor-at-a-time' approach.

Coastal flood risk in changing climate

77. Storm Impacts on the Sefton Coastline

Mr William Bennett, Swansea University, United Kingdom

92. Climate change: past, present or future?

Mr Rudolf Versteeg, HKV, Netherlands

116. Projection of future storm surges around Korean peninsula based on ensemble future climate simulations

Mrs Jung-A Yang, Kyoto University, Japan

123. Advances in model-based flood impact forecasting: sensors, ensembles and downscaling

Dr Daniel Bachmann, Deltares, Netherlands

160. An explorative study on the incorporation of resilience in the design of coastal risk reduction systems

Prof Bas Jonkman, TU Delft, Netherlands

235. Assessment of tropical cyclone and storm surge hazards in Mozambique and Cabo Verde

Dr Joao Rego, Deltares, Netherlands

77. Storm Impacts on the Sefton Coastline

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KEYWORDS: Storm Impacts, Coastal Flooding, XBeach, Morphological Modelling

ABSTRACT

Recent storm events such as the 2013/14 winter storms have highlighted the vulnerability of UK coastlines to coastal flooding and erosion, with increasing concern over the likely long term effects of changes in natural environmental forcing factors.

This research focuses on the impacts that storms have on coastal erosion and coastal flooding, focusing on specific return period wave and water level conditions. The Sefton coast in Liverpool Bay will be used as the test study site. The Sefton Coast hosts numerous sites of national and international significance and acts as a natural coastal and flood defence system. As such it provides an important focus for the investigation of storm impacts. The main objectives are to develop a framework through which the impacts of storm conditions on coastal erosion and flooding can be investigated providing a useful tool in assessing the vulnerability of UK coastlines, with the potential to be expanded for international applications.

To accurately model morphological changes, it is important to use detailed predictions of changes in metocean variables. Bennett et al (2016) investigated changes in storm climate for sites around the UK coast, using global present and future wave climate predictions. The same dataset is used to provide wave boundary conditions for the modeling approach presented here. Data for the boundary points is analysed using extreme value analysis to provide wave conditions corresponding to storm events with specific return periods; while corresponding water levels are determined using the approach described in McMillan et al. (2011).

The modelling approach utilises the numerical models Delft3D and XBeach. To ensure an adequte overlap with global wave model outputs, a domain extending beyond the Irish Sea in to the Celtic Sea and North Channel was implemented in order to transform the wave outputs in to Liverpool Bay using the Delft3D WAVE module. A smaller Sefton domain is used in a coupled Delft3D FLOW and WAVE model to generate hydrodynamic boundary conditions for the morphological grid implemented in XBeach.

The paper will present and discuss the model set up, as well as the morphological changes of the dune system to a range of storm scenarios. The morphological impacts resulting from the different storm event combinations will be analysed to assess the correlation between morphological response and the severity of the storm conditions.

REFERENCES

Bennett, W.G, Karunarathna, H, Mori, N, Reeve, D.E, 2016. Climate Change Impacts on Future Wave Climate around the UK. *J. Mar. Sci. Eng.* 4(4), 78.

McMillan, A, Batstone, C, Worth, D, Tawn, J, Horsburgh, K, Lawless, 2011. Coastal flood boundary conditions for UK mainland and islands - Project: SC060064/TR2: Design sea levels. Environment Agency.

92. Climate change: past, present or future?

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KEYWORDS: Climate change, detrending of measurements, probability of floods, climate web services, flood modelling.

ABSTRACT

Objective

Probabilities of floods are often determined using extreme-value distributions of river discharges and hydraulic models representing river flow and flooding. The discharges are usually measured or simulated by hydrological models forced with historical meteorological input. However, historical data series are susceptible to already perceptible climate change and underestimate the probability of flooding in the current climate. This affects the planning and urgency of mitigation measures for flood prevention. This paper presents the approach used by Dutch Water Authorities to correct for already noticeable climate change effects, based on analyses of the Reusel catchment in the Netherlands.

Methods

Trends in meteorological data are identified using a season dependent Loess smoother (Cleveland, 1979) on precipitation and evaporation time series ranging from 1906 to 2015. Time series are subsequently detrended based on the Loess smooth, resulting in meteorological data representing the current climate (Beersma, 2015).

Changes in expected flood frequency are determined in a three step procedure. First, the detrended meteorological data are fed into the Wageningen rainfall-runoff model (Warmerdam, 1996) to simulate flows to the river. Second, using extreme-value distributions several synthetic flood waves are derived for return periods of 1 year up to 100 years. Third, hydraulic processes and flooding are simulated using a 1D2D-Sobek hydraulic model.

Results

Applying the Loess smoother to the meteorological data showed an increase in precipitation in extreme events of 20% over the period 1906-2015. Subsequent analysis of flood frequency indicated that floods in the Reusel occur approximately three times more often when using the detrended meteorological data compared to using the original meteorological measurements. Other Dutch catchments also showed two to three times more frequent flooding. The impact for other catchments will vary depending on the already realised climate

change and the catchment characteristics.

Conclusions

The Reusel case study indicates that climate change is already noticeable in historical time series of flow, precipitation and evaporation in the Netherlands. The Reusel case also clearly demonstrates the importance to detrend meteorological data to the current climate and adjust data to future climate projections, in order to maintain flood protection at the desired level. Therefore, the Dutch Water Authorities have made these time series and related statistics available to all water managers (www.meteobase.nl).

REFERENCES

Cleveland, W.S (1979). Robust locally weighted regression and smoothing scatterplots, Journal of the American statistical association 74.368, 829-836.

Beersma, J, J. Bessembinder, T. Brandsma, R. Versteeg and H. Hakvoort (2015) Actualisatie meteogegevens voor waterbeheer 2015 (in Dutch) – Update meteorological data for water management 2015, STOWA-report 2015-10

Warmerdam, P.M.M., Kole, J., Chormanski J. (1996), Modelling rainfall - runoff processes in the Hupselse Beek basin, Proceedings of the Strassbourg Conference (24-26 september 1996), 154-160.

116. Projection of future storm surges around Korean peninsula based on ensemble future climate simulations

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KEYWORDS: storm surge, typhoon, climate change and ensemble climate simulations

ABSTRACT

This study evaluates future storm surge around Korean peninsula considering climate change. Output of over 5000 years of ensemble future simulations by general circulation model with 60 km resolution was applied as the driving force for simulating the future storm surge. To examine the future storm surge, the simulations were conducted for the past historical climate (1951~2011) and the future climate (2050~2111). The present study showed that annual average number of typhoons which may directly and in directly have an effect on Korean peninsula will decline under the future climate. On the other hand, the intensity of typhoons will be increased. It was found that the future storm surge height along the Korean peninsula will be higher in the future climate than those in the present climate.

123. Advances in model-based flood impact forecasting: sensors, ensembles and downscaling

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KEYWORDS: flood forecasting, impact, ensemble, sensor, downscaling

ABSTRACT

Introduction

Flood forecasts, warning and emergency response are important components in flood risk management. Currently, the model-based prediction of discharges and/or water levels in a river or coastal region is common practice for flood forecasting. Based on prediction of these hydrologic-/hydraulic-based values decisions about specific emergency measures, for example emergency dike reinforcements, temporary object protection or evacuation, are made. However, broader model-based information about the flood defence line, the hinterland and the assets at risk is rarely provided for decision support.

Model-based flood impact forecasting tries to close this gap by providing forecasted information about: (a) the dike strength during the event, (b) the flood spreading in case of an overflow or a dike failure and (c) the resulting impacts. This work presents an overview over three test-cases where this approach is applied. Special features are highlighted.

Flood Impact forecasting

The basic principle of model-based flood impact forecasting is the extension of the hydrologic-/hydraulic based forecasting chain by models which are commonly used in a strategic risk analysis such as probabilistic failure analysis, 2D-flood spreading simulation and the analysis of flood impacts and consequences.

Sensor information

In the first test-case the full model chain of a flood impact forecast is applied to a coastal region in the Netherlands. The dike reliability during a storm surge event is forecasted using fragility curves – a summary of the dike strength conditional to the water level. The information is combined with real-time data from sensors in the dike section providing water pressure in the dike body. If a dike failure is predicted a 2D-flood spreading model is applied. Within a qualitative impact analysis spatial information about the population density and critical objects such as hospitals or fire-stations is overlaid by the flood spreading.

Ensemble forecast

The second test-case shows a flood impact forecast for a riverine region in Scotland. The existing forecasting system is extended with a 2D-flood spreading model in combination with a quantitative impact model. To include also uncertainties in the forecasted information an ensemble forecast is applied to the complete model chain.

Downscaling

Whereas the first two examples use local/regional scale forecasting information about storm surge and precipitation as input, the last test-case is based on inputs of a global model. The system is set-up for the Manila Bay (Philippines). The forecasting chain combines global forecasted data about storm surges, a local 2D-hydrodynamic model of the bay and the hinterland and a quantitative impact model.

Conclusion

All three test-cases prove the added value of a model-based flood impact forecasting system by providing information for decision makers about: weak spots in the flood defence line, flood spreading and flood extent as well as impacts and consequences of a flood event.

160. An explorative study on the incorporation of resilience in the design of coastal risk reduction systems

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KEYWORDS: Coastal structures, resilience, design, extreme events.

OBJECTIVE

A overarching conclusion after large-scale flood disasters is that the coastal defense systems should be more resilient against these types of extreme flood events. For instance, the Interagency Post Katrina Evaluation Team (IPET) defined resilience in its post-Katrina report as follows: “The ability to withstand, without catastrophic failure, forces, and conditions, beyond those intended or estimated in the design”. A challenging question is how to translate this into practical design of coastal structures. The objective of this paper is to explore the concept of resilience and provide some insights in how this could be incorporated into design of coastal structures.

THE CONCEPT OF STRUCTURAL RESILIENCE

The classical design approach for design of coastal protection structures is based on providing adequate protection to the surge and wave conditions with a specific annual exceedance probability (AEP) in any given year. The 1% AEP design standard is widely applied for flood plains along rivers and coasts in various countries. However, also higher (or lower) design standards are considered based on cost-benefit considerations (e.g. in the Netherlands, United Kingdom). The hydraulic design conditions are applied to design the main dimensions and elevation of these protection structures. Following the previous definition ,resilience requires an assessment of situations greater than the design standard, and modifying the design to prevent catastrophic failure of the system in these conditions.

EXAMPLE: STRUCTURAL RESILIENCE IN HSDRRS

During the design phase of the Hurricane Storm Damage Risk Reduction System (HSDRRS) in New Orleans after Hurricane Katrina, the notion of including resilience in the system design has been considered from the start. New design rules have been developed during this design process based on latest insights and lessons learned from Katrina. This has resulted in the HSDRRS Design Guidance with design criteria for the design standard for the 1% AEP and Design Checks for the 0.2% AEP (or 500 year return period). The 0.2% AEP has been chosen based on various reasons including Katrina because considered to be slightly less frequent event (roughly 0.25% AEP, see IPET).

DISCUSSION AND OUTLOOK

The New Orleans case is a good showcase towards including more resilience into hurricane risk reduction system design. Several fundamental questions are unaddressed as of yet. First, the cost-effectiveness of adding structural resilience is not fully known. Justifying the additional costs of resilience measures asks for a rigorous analysis of the benefits in the form of risk reduction of including resilience. In the conference paper, other (idealized) examples will be provided which show the different outcomes for different designs, such as the design of coastal tsunami defences in Japan. Second, the New Orleans case has also shown that translating the concept of structural resilience into practice is challenging. This is partly due to the lack a solid conceptual framework for including resilience in flood risk reduction systems. It will be discussed in the paper what elements should be included in a conceptual framework.

235. Assessment of tropical cyclone and storm surge hazards in Mozambique and Cabo Verde

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KEYWORDS: storm surge, extreme tide, wave setup, tropical cyclones, hazard assessment

ABSTRACT

Mozambique and Cabo Verde are increasingly vulnerable to impacts of tropical cyclones and (sub-tropical) storm events due to on-going economic development and geographical location. The World Bank's Global Facility for Disaster Reduction and Recovery wishes to undertake a risk assessment for extreme meteorological events in these countries that can be interpreted in a similar way to other risk assessments (e.g. flood and drought etc.) in the region. Tropical cyclone and (tropical) storm risk requires a different approach from river flood risk, as cyclones are relatively rare, occur at a limited scale, and their impact is strongly dependent on the shape and bathymetry of the coastline. The total water level for hazard assessment is obtained from a combination of extreme tidal levels, storm surges, and wave setup. The scope of this project involved two stages, firstly to determine the natural hazards, and a secondly determine the associated risks for return periods ranging from 10 to 1000 years. This paper covers the first stage hazard assessment. An important objective of this study was to develop pragmatic and generic assessment approaches that can easily be extended to other countries.

Extreme tidal water levels were analyzed from the FES 2012 model, and surge levels generated by distant, sub-tropical storms were analyzed based on Muis et al. (2016). Additonal storm surge levels caused by tropical cyclones (focus on Mozambique) were calculated for thousands of synthetically generated cyclone-tracks using a regional hydrodynamic model based on the Delft3D Flexible Mesh code. The resulting storm surge levels along the coast were converted to a Probability Density Function (PDF) of storm surge levels using a peak over threshold statistical analysis. The total extreme water levels are obtained through a convolution of the PDF of extreme tidal levels and the PDF of cyclone storm surge levels. Wave setup estimates (focus on Cabo Verde) were obtained from a transformation of deep water waves to the coast using one-dimensional models for a selected number of sites. The boundary conditions for deep-water waves were derived from the ERA-interim reanalysis. This approach includes the effects of large ocean swells that may originate from (sub-tropical) storms in the region. To translate the extreme water levels into inundation estimates a planar inundation method was used, applying corrections for noise and attenuation due to vegetation and built-up areas.

Results are discussed and distinctions made between these two very different sub-Saharan countries: Mozambique with a coastline of 2,500 km, a continental shelf extending up to hundreds of km and the regular occurrence of cyclones, and Cabo Verde, a country comprising ten small, steep volcanic islands with extremely

rare cyclones. The end-products are summarized and ultimately made public as GIS-compatible datasets comprising hazard footprints.