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59. Effectiveness of climate change adaptation measures: Working towards a science-evidence base

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KEYWORDS: Governance, Science evidence base, Flood management

ABSTRACT

Many coastal, estuarine and riverine systems in the North Sea Region (NSR) are not in a natural equilibrium state any more. They are modified for all sorts of reasons, such as safety (building levees, dams), economy (energy production, navigational measures) and even nature (reconstruction of side channels, vegetation development in floodplains) and this happens on different scales (small streams up major rivers). Building with Nature (BwN)-like solutions have an ability to reset a system into a more natural situation, making it also more resilient to climate and anthropogenic change. There is, however, an urgent need to establish a science-evidence base to prove that BwN measures indeed contribute to adaptations to (climate) change. In doing this, effectiveness (showing local communities real examples and not just modelled projections) is demonstrated and policy and practice on the ground is less reluctant in applying these measures.

In the Catchment Workpackage of the NSR-Interreg BwN-project (2016-2019) we consider several restoration measures in Sweden, Scotland, Belgium and The Netherlands. In restoring a more natural situation, we expect that maintenance efforts are also minimized. Monitoring and modelling the cases should proof this hypotheses.

The cases that we consider are different in location and scale. We consider cases in Belgium (Kleine Nete, a small stream which will be brought back in a meandering state), Scotland (Eddleston Water, restoration works in a 70 km^2 in combination with vegetation development and extensive monitoring), Sweden (restoration of the stream Skåne in Råån and constructed wetlands for agricultural reasons and to create heterogeneous biotopes with variety of microhabitats) and the Netherlands (Rhine river, construction of side channels to mitigate flood risks and improve ecological values). Aim of the BwN-project is to evaluate the cases, and learn from the governance to increase the possibility to apply these solutions in the future. *Adaptive management* is a key part of BwN and learning by doing and stakeholder involvement are important parts thereof. Solutions require flexibility in both planning and implementation. Monitoring, modelling and forecasting can be used to get insight in the maintenance costs and may lead to adaptations of the design.

We will present the first results of these cases and formulate some preliminary findings. Apart from system knowledge of small, medium and large rivers, we will focus on finding empirical evidence of the impact of this kind of restoration measures. This will contribute to bridging the gap between science, policy and practice on the ground. This is necessary to increase the awareness of stakeholders (among others policy-makers) with respect to the value of climate change adaptation measures.

61. Flood Damage Assessment in the Selected River Basins of Asian Developing Countries under Climate Change

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KEYWORDS: Flood Damage, RRI Model, Hazard, MRI-AGCM, Climate Change.

1. INTRODUCTION

Flood disaster risk has been increasing, particularly in developing countries, due to rapid urbanization and development activities. Flood disasters cause serious damage such as loss of lives and destruction of infrastructure. Flood damage assessment is thus essential for flood management to mitigate and quantify flood risk. This study focused on assessment of damage by future floods under climate change to the agricultural sector in the Lower Mekong basin (LMB) in Cambodia and Vietnam and the Solo River basin in Indonesia. Since rice production is a major source of income in many Asian developing countries, the study specifically focused on flood damage to rice crops. Flood damage to rice crops was calculated by a function of flood depth, duration, and growth stage of rice plants. Flood characteristics such as flood depth, duration, and distribution were computed using the Rainfall-Runoff-Inundation (RRI) model to assess flood hazards under present and future climatic conditions produced by MRI-AGCM3.2S. The damage assessment methodology for rice crops was verified for severe flood events (the 2011 flood for LMB and the December 2007 flood for the Solo River basin). Then, flood damage assessment was conducted for both present climate (1979-2003) and future climate (2075-2099) conditions, using MRI-AGCM3.2S precipitation datasets. Flood damage was assessed for floods of 50- and 100-year return periods with different rainfall patterns chosen from each climate scenario.

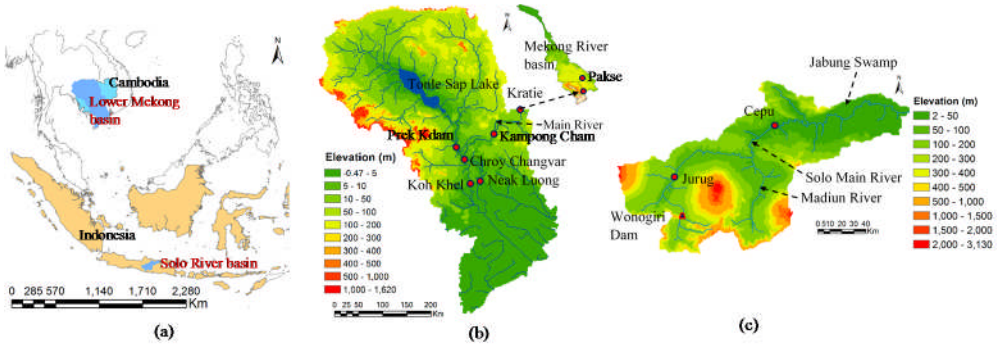

Fig.1 (a) Location of study areas; (b) Topographical features in LMB; and (c) Topographical features in the Solo

River basin.

2. STUDY AREAS AND ITS FEATURES

Fig.1 shows the location and topographical features of the study areas (LMB and Solo River basin). The considered LMB is approximately 187,000 km^2, about 24% of the total basin area of the Mekong River basin. Annual average rainfall in LMB is less than 1,500 mm over the Cambodian floodplain. The Solo River is the longest river in the island of Java of Indonesia with a length of about 600 km and a basin area of 16,100 km^2. Annual average precipitation in the basin is 2,100 mm.

3. FLOOD DAMAGE ASSESSMENT METHOD

3.1 Flood Hazard Assessment

For damage assessment under climate change, hydrological simulation was conducted for the study areas using selected MRI-AGCM3.2S experiments. An AMIP-type experiment was selected for the present climate (SPA_m01: 1979-2003). Four members of the RCP8.5 greenhouse gas emission scenario experiments with different sea surface temperature (SST) distributions were selected for future climate ensembles (named SFA rcp8.5, SFA rcp8.5-C1, SFA rcp8.5-C2, and SFA rcp8.5-C3) for 2075-2099. Flood characteristics such as flood depth, duration, and distribution were computed using the RRI model developed by Sayama et al. (2012) to assess the flood hazards under present and future climatic conditions produced by MRI-AGCM3.2S. The digital elevation model of HydroSHEDS data was used in the study. The parameters of the RRI model were calibrated to past flood events by comparing calculated and observed discharges at gauging stations. In addition, calculated flood inundation areas were also compared with available flood maps. The detail explanation of RRI model simulation for the Solo River basin can be found in Kudo et al. (2016). In the case of LMB, two hydrological models were employed in the study with bias-corrected precipitations of MRI-AGCM3.2S data sets. The output discharge by the BTOP model (Takeuchi et al., 2008) with 20-km resolution at the Kratie station was used as the upstream discharge boundary condition for the RRI model, which performed inundation simulation for LMB while taking into account rainfall distribution in the area.

Frequency analysis was conducted based on 4-month basin rainfall for LMB, and 4-day rainfall for the Solo River basin; these rainfall data were selected for their highest correlation with the peak inundation volume in each case (Kudo et al. 2016). Flood hazard analysis was conducted to assess flood damage for 50- and 100-year flood cases with different rainfall patterns chosen from each climate scenario.

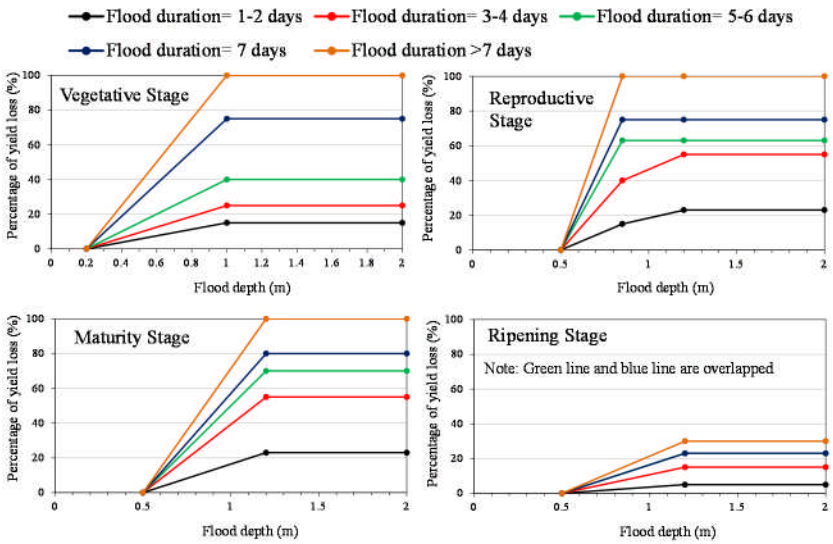

Fig.2 Flood damage curves for rice crops (Shrestha et al. 2016).

3.2 Flood Damage Assessment

Flood damage to agriculture was defined as a function of flood depth, flood duration, and rice growth stage, and it can be estimated by the following equations:

$$Loss\ Volume = Rice\ Yield \times Damaged\ \ Area \times Yield\ \ Loss \quad (1)$$

$$Damage\ Value = Loss\ Volume \times Farm\ \ Gate\ \ price \quad (2)$$

Calculation was performed using the values of farm gate price equal to 924 Riel/kg, and the rice yield equal to 2,500 kg/ha (Pech, 2013) in the case of LMB, and the farm gate price equal to 4,650 Rp/kg (Thom, 2014) and the rice yield equal to 5,230 kg/ha (Panuji *et al.*, 2013) in the case of the Solo River basin. The global land cover data developed by the Global Land Cover by National Mapping Organizations were used to extract paddy fields. Since rice crops grown in south-east Asian countries are similar in kind (Kumar and Shivay, 2008), flood damage curves (Shrestha et al. 2016) derived from past flood damage data of the Philippines (Fig.2) were applied to assess flood damage to rice crops in both basins.

4. RESULTS AND FINDINGS

For the verification of flood damage assessment, flood damage to agriculture (rice crop) was assessed for the 2011 flood in LMB and for the 2007 flood in the Solo River basin (Fig.3 and Fig.4). The figures also show the comparison of calculated agricultural damage with reported damage. The results show that the calculated agricultural economical loss in LMB is reasonably agreeable with the reported data. In the case of the Solo River basin, the calculated damage area is agreeable with the reported data although there is some discrepancy in agricultural economic loss. This is the first attempt of agricultural damage assessment in the study areas using freely available topographical and land cover data. However, damage assessment can be further improved by upgrading the quality of topographical and land cover data, for example, by using ground-surveyed topographical and land cover data.

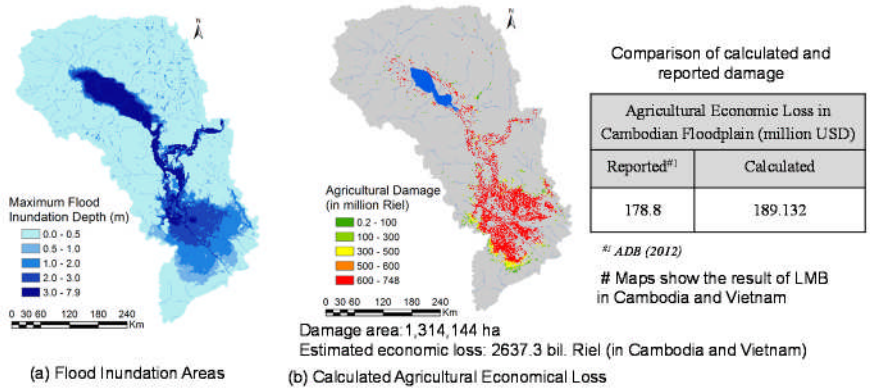

Fig.3 Flood hazard and calculated agricultural damage in LMB during the 2011 flood.

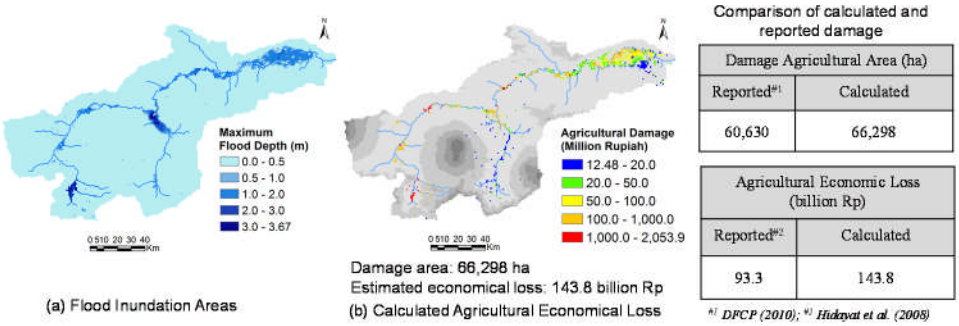

Fig.4 Flood hazard and calculated agricultural damage in the Solo River basin during the 2007 flood.

Fig. 5 and Fig. 6 compare flood hazard and damage assessment for a 100-year flood in the case of the worst scenario for LMB and the Solo River basin. The results obtained from the damage assessment were compared for the worst case, and found that the agricultural economic loss of rice crops in LMB can increase by 31 % in the case of a 50-year flood and by 27 % in the case of a 100-year flood; in the Solo River basin, by 17 % and 25 %. The results of the flood damage assessment in this study can be useful to implement flood mitigation actions for climate change adaptation.

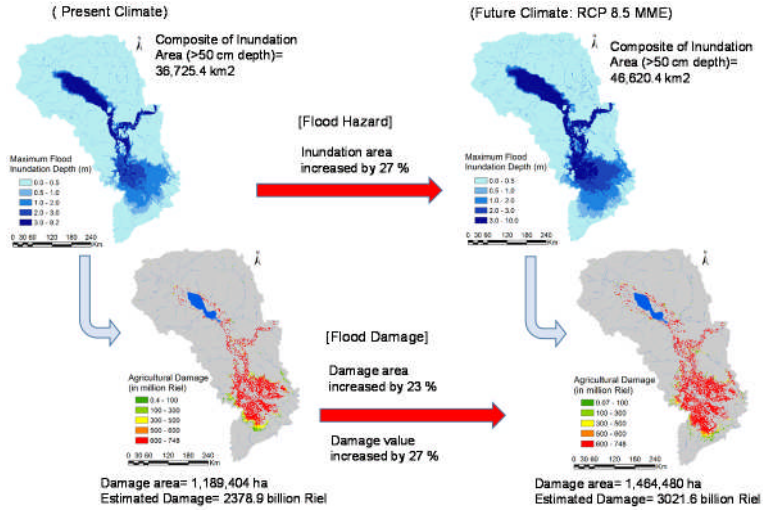

Fig.5 Comparison of flood hazard and agricultural damage for a 100-year flood under present climate and future climate conditions in LMB.

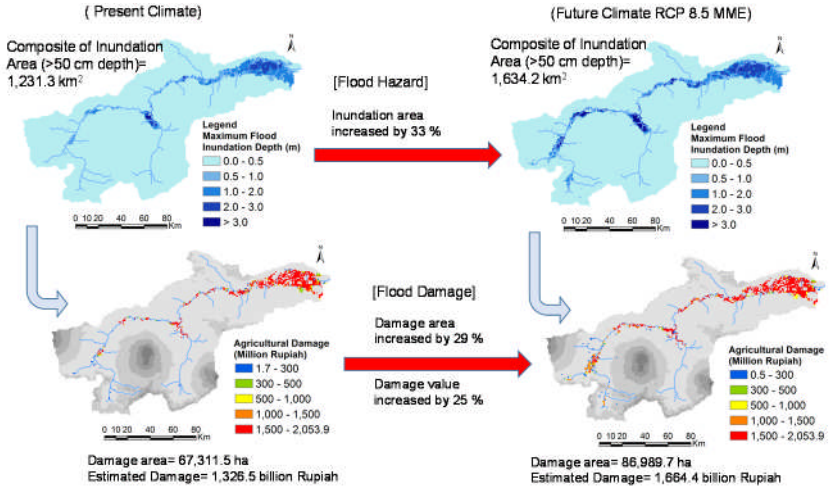

Fig.6 Comparison of flood hazard and agricultural damage for a 100-year flood under present climate and future climate conditions in the Solo River basin.

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84. Quantitative evaluation on the changes of the flood-season streamflow caused by climate change and human activities in Yanhe River Basin of the Loess Plateau

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Abstract: The Yanhe River Basin (YRB) is the first-order tributary of the Yellow River, which is located at the middle of the Loess Plateau, China. The Yanhe River is the main river that causes floods and damages to the Yanan city. The YRB contributes significantly to the total sediment yield in the Yellow River. A great number of water and soil conservation measures including terracing, afforestation, and construction of sediment-trapping dams have been implemented since the 1960s. It is important to investigate the contributions of climate change and human activities affecting the changes of flood-season streamflow and to provide a scientific basis for future flood prevention. Observations from 6 hydrological stations and 22 meteorological stations of YRB are analysed in this study. Two nonparametric methods, the Mann-Kendall test and the Pettitt test, are used to detect the trend and the change point of the flood-season streamflow for the period of 1952 to 2003. The lumped conceptual daily hydrological model SIMHYD and one kind of sensitivity-based method are used to assess the impact of climate change and human activities to flood-season streamflow. The results show that the change point in flood-season streamflow occurred in 1972. The flood-season streamflow has decreased by 34.2% from 1972 to 2003 compared with the period from 1952 to 1971. The flood-season streamflow becomes more sensitive to the change in precipitation than that in potential evapotranspiration (PET) in 1972-2003. The impact of human activites is greater than climate change after 1972. The effects of climate change and human activities on the flood-season streamflow account for about 36% and 64% respectively.

Keywords: climate change; human activities; flood-season streamflow; Yanhe River Basin.

291. Global projection of river flood risk considering autonomous adaptation

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KEYWORDS: flood, climate change, autonomous adaptation.

ABSTRACT

Objectives

The impacts of flooding are expected to rise due to population increases, economic growth and climate change. Therefere, an adequate method to project future flood damage is required to develop effective flood mitigation measures. Previous studies showed decreasing global flood vulnerability in the past associated with socioeconomic development, however, current global flood risk projection haven't yet taken this effect into account. The objective of this study is therefore to calculate global flood risk considering the effect of the improvement in flood vulnerability for the past and future.

Methods

A vulnerability scenario associated with socioeconomic development was developed and applied to estimate future global flood risk under climate change. Here, we defined an autonomous adaptation as the effect of improvement in flood vulnerability associated with socioeconomic development, which implies the effect of conventional flood disaster reduction effort observed in many developed countries. The vulnerability scenario was determined based on calculated historical vulnerability to flooding derived from flood damage records and global river and inundation simulation. The river and inundation model was driven using historical runoff of off-line land surface simulation and future runoff given by general circulation model under four Representative Concentration Pathways. The simulated inundation area was overlayed onto gridded population and assset data of three Socioeconomic Shared Pathways.

Results

The effect of the autonomous adaptation reduces 62-68% of projected potential flood fatalities and 26-37% of potential economic damage under the highest emission scenario and the highest population increase. There was a clear and positive relationship between the global temperature increase from the pre-industrial level and the estimated mean potential flood damage. Bootstrapping analysis of simulated result without vulnerability change suggested a significant increase in potential flood fatality if the temperature increases by 1.5°C to 2.0°C, whereas an increase in potential economic loss between 1.5°C and 2.0°C was not significant. A large ensemble climate simulation showed increase in flood frequency in many river basins already appeared

in recent years and the change is partly due to human-induced climate change.

Conclusions

Our method enables distinguishing between the effects of autonomous adaptation and additional adaptation efforts on climate-induced hazards, which would be essential for accurate estimation of the costs of adaptations against climate change.

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312. Study on the Temporal Downscaling using Observed Minutely Rainfall Data

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KEYWORDS: Minutely rainfall, Bias correction, Temporal Downscaling

ABSTRACT

Recently, urban flood damage due to climate change is increasing. Thus hydro-meteorological data which consist of temporal downscaling are vital to assess the hydrological effects of climate change on medium and small watersheds. In this study, after bias correction by quantile mapping of RCP 4.5 and RCP 8.5 climate change scenarios of HadGEM3-RA on the Korea peninsula (12.5 km) provided by the meteorological administration, the temporal downscaling was carried out using observed minutely rainfall data. Temporal downscaling method of this study is good method for downscaling simulated daily precipitation data to hourly especially for assessing the impacts of climate change.

Community and social resilience

69. Human response to flood events: Exploring the emergence of learning dynamics
Dr Johanna Mård, Uppsala, University Sweden

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

280. The prevention of the elderly against the risks of floods in Algeria (case of the Biskra region)
Mr Abderrahmane, Noui Scientific and Technical Research Center on Arid Regions – CRSTRA – Biskra, Algeria.

299. An overview of warning communication systems in flood hazards and its impact on flood risk reduction
Ms Sara Alonso, UNESCO-IHE Institute for Water Education, Netherlands

342. Recovery – How to incorporate this into the Multi-Layer Safety Concept
Ms Mie Thomsen, Danish Coastal Authority, Denmark

379. Street of hope: a resilient case of optimism for the future in Brazil
Prof Newton Moura, Universidade de Fortaleza Brazil

69. Human response to flood events: Exploring the emergence of learning dynamics

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KEYWORDS: Socio-hydrology, Human-flood interactions, Adaptation

ABSTRACT

Societies impact the frequency, magnitude and spatial distribution of floods in a variety of ways. At the same time, societies are also being shaped by the occurrence of flood events. The dynamics emerging from two-way feedbacks between floods and societies are key in the study of changes in flood risk, but they remain largely unknown. Here we present an interdisciplinary study aiming to uncover one of the least quantified aspects of human-flood interactions, the spatial-temporal distribution of demographic changes following flood events. To this end, we use nighttime light satellite data in four contrasting case studies in both low- and high- income countries (Lower Limpopo River in Mozambique, Mekong River in Vietnam and Cambodia, Brisbane River in Australia and Mississippi River at St. Louis in USA). The results show that population distribution of societies that strongly rely on structural measures ("fighting floods" policies) is not significantly affected by the occurrence of flood events. Conversely, learning dynamics emerge in societies that mainly rely on non-structural measures ("living with floods" policies) in terms of relative population in floodplain areas, i.e. reduced human proximity to rivers. Lastly, we propose the development of a novel approach to exploit the growing availability of worldwide information, such as nighttime lights satellite data, to uncover human response to flood events across scales and along gradients of social and natural conditions.

204. 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

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280. The prevention of the elderly against the risks of floods in Algeria (case of the Biskra region)

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KEYWORDS: Floods, elderly person, resilience, Algeria, Biskra.

ABSTRACT

Due to the geographical location of Algeria, its large area, the diversity of ecosystems linked to the phenomenon of greenhouse gases. Algeria faces major natural hazards, including floods.

The liabilities of Algeria were marked by numerous catastrophic floods. The memory of the Algerians keeps track of the often painful and sometimes distressing floods; Those of 12 October 1971 in Tizi-Ouzou, the flooding of 11 November 1982 in Annaba, or even that of 10 November 2001 in Bab l'oued and in August 1997 in Batna.

The Biskra region was one of the areas affected in 1969 and September 2009 by deadly floods. The floods caused significant human and material damage.

When a population is struck by conflict or natural disaster, the elderly are among the most vulnerable.

An elderly person is, for common sense, a person whose age is advanced and who presents the physiological and social attributes of old age as represented by society.

It is essential that assistance to the elderly should become a priority in emergencies.

Algeria has grown from 800,000 elderly people in 1986 to more than three million in 2013.

To do this, it is important to carry out reflections or work to anticipate the future needs of the elderly and to find appropriate solutions in terms of flood risks.

In this practical work in the Biskra region, we will provide some answers to improve the resilience of the elderly to flood risks.

299. An overview of warning communication systems in flood hazards and its impact on flood risk reduction

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Keywords: Flood warning; communication systems; flood risk reduction

Abstract

Floods are one of the most deadly weather related hazards and frequently have devastating impact economically and on the loss of human lives. For the mitigation of consequences of such events, communication plays an important role. This is an era of information abundance and communication evolution; the information to which we have access is growing exponentially, and in the ways it is received and shared is evolving. All conventional communication methods such as telephone, radio, and TV could be down during a disaster. However, with the growing use of internet, social media platforms like Facebook, Twitter and WhatsApp have emerged as an important source to disseminate warning information before the event, and also for helping the affected people during it. National and local institutions are updated for this reality and are making important enforcements in developing mobile apps and websites that contain updated and accurate information, which could also be used to send automatic alerts of live updates. For example, in UK, the *FloodAlerts* app and flood warning maps are used for flood warning notifications by Facebook or e-mails to registered users; and in the USA, the public access online platform called *Ready* keep the population informed. Timely warning information about coming floods is essential for the effectiveness of the flood warning systems and also for mitigating its impact. The methods of warning about floods have to follow different approaches in function of the level of risk that the receptors are exposed; if the risk is not immediate, flood educational activities, flood maps or awareness talks could be effective techniques of information. When it is the case of urgent flood, fast and more intrusive measures need to be realized. Nowadays, the children and youngsters have the vital importance as communication agents among all the family members and relatives, with the goal of building an educated society of their essential role related to this issue. The future of flood warning needs a heterogeneous approach of complementary tools considering the characteristics of each community. This paper provides an overview of communication systems which are being used for transmission of early warning and other information before and during the flood, also analyzes the impact of these systems on flood risk reduction.

342. Recovery – How to incorporate this into the Multi-Layer Safety Concept

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KEYWORDS: Recovery, Recovery plans, Multi-Layer Safety Concept, Resilience, Community planning

ABSTRACT

The North Sea region is characterized by large flood-prone areas. Storm surges pose a real and substantial risk; with low-lying areas occupying an area of approximately 40,000 km^2. Not only must communities in exposed areas be well prepared for an impact but also have knowledge on how to act throughout and recover from an event. With regard to climate change with rising sea levels, potentially stronger storms and more intense precipitation, the challenge grows while a lack of resources to protect vulnerable areas remains.

The Multi-Layered Safety (MLS) concept considers three focus areas in a layer structure; protection, spatial planning and emergency response. Recovery of impacted areas is a fourth layer that has not yet been fully incorporated in the MLS concept. Recovery is vital for impacted people to return to their daily life as fast as possible and preferably to conditions, which are improved compared to the situation prior to e.g. a flood event. For recovery to be considered successful the area must "bounce back better" and learn from the impact. In Denmark, early recovery plans and recovery plans are, in general, not in place preventing the impacted areas of undergoing a structured and efficient post-disaster recovery.

In December 2013, Northern Zealand in Denmark was hit by the storm "Xaver" and the water level rose by 2 meters above normal levels. In the low-lying areas inside the North Zealand fjords, the storm surge had a large impact. Especially the area around Roskilde Fjord, Jyllinge Nordmark, was flooded affecting approximately 250 households. In spring 2015, 1½ year after the event, a number of these households were not yet rebuilt and the effected people were still living in temporary housing-containers. The recovery phase has experienced several setbacks and a solution for a flood protection against future impacts is still not decided upon leaving the area exposed.

The EU InterReg North Sea Region-project 'Flood Resilient Areas by Multi-layEred Safety' (FRAMES), 2016-2019, is applying the MLS concept at Jyllinge Nordmark to examine wherein the recovery process the complications that hindered the progression occurred. From a qualitative analysis approach it is investigated whether incorporation of 'recovery' in the MLS concept and in the municipality plans may enhance the capability to recover from a similar future impact more efficiently.

379. Street of hope: a resilient case of optimism for the future in Brazil.

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KEYWORDS: Resilience project, urban drainage, green infrastructure,

EXTENDED ABSTRACT

INTRODUTION

One of the big challenges for resilient projects is to engage managers, investors and the community about the success that investment in a green infrastructure model can deliver. Especially in Brazil, where there are still enough obstacles about the effectiveness of these solutions. However, there are considerable advances that demonstrate an optimistic context for the future.

The Hope Street project is an example of a resilient and transformative intervention in public space, located on a street between two children's hospitals in Fortaleza/CE, one of them considered a regional reference for cancer treatment. The space was initially intended to receive a tree planting plan, but has turned into an opportunity to achieve results beyond the green amenity. The project evolved into a truly innovative and multifunctional concept, transforming a simple public space into a Street of Hope.

The aim of this article is to identify a project with a bias of resilience and sustainability, breaking paradigms before the traditional investments in Brazil, classifying it as a success case that can influence later projects. It is an empirical study, with a qualitative approach, pointing out the results of the presented project and how they can become references to the others in the search for sustainable strategies.

HOPE AS A NEW WAY

To enable health coexistence in the urban space, a clear distinction must be made between the public and the private space. This means that the barrier between the following should not prevent the inhabitants to see the street from within and to obtain spontaneous contacts of respect and confidence with the space. The lack of

that confidence is like a disaster for the street. (JACOBS, 2000: p.60)

Despite being established between two of the city's largest infamous hospitals, the stretch on which the project is located, Alberto Montezuma Street, was a clear example of space without identity. (Fig. 1) The absence of connections and trust led to an empty street, marked by urban violence, instigating the hospital's board to request the municipality to close the stretch for private use only, with the parking lot function. However, another form of intervention was suggested, the requalification of the street, as a way to guarantee the presence of users and the reduction of crime.

Fig. 1: Location of intervention site on Street. Source: Own Elaboration

Therefore, a pilot project of urban intervention was proposed with the intention of reinventing the shape of the street, transforming it into a place of coexistence, identity, respect and trust. The adoption of the street was the strategy used to make the project feasible, so the costs of implementation and future maintenance could be shared between the municipality and private donors. Developed by *Bezerra and Becker Landscape Architecture*, with the support of the City Hall of Fortaleza, the project demonstrated how to turn a closed street into a "Hope Street".

DESIGN PROCESS

At first, the use of rainwater management was already a redefinition of the usual concept for the project. The insertion of green infrastructure solutions brought the idea of the city as part of nature, as an ecosystem. But not only in its functional aspects: the idea of using natural elements and built for a more rational use of water in the city, also reinforced the potential of the beauty of nature for the urban landscape.

Fig. 2: Drawing Workshop: What if this street was mine?

In addition, the participatory process was a legitimating tool for designing project design. Through a design workshop entitled "What if this street were mine?" With children from the cancer hospital, they got simply intriguing answers: all the kids wanted to use the street to stay, not to pass. Even more: most of them could not imagine a street without a rainbow in it. They need their colored light in their daily routine. (Fig. 2) How to respond to this need for beauty and docility in these hopeful requests?

DESIGNING HOPE

By adopting the ideas absorbed in debates and actions with the various target groups, the proposal was to structure in three main grounds:

• The potential to use the space as a prototype for strategies of treatment and retaining of pluvial waters, to be integrated to the existing hydraulic system.

• The harmonic coexistence to different uses, demanded by the various experiencers of the street: the hospital staff, the patients and its accompanying persons, often arising from other cities in Ceara State; the inhabitants of the nearby residential areas; the merchants of food stalls, among others;

• The broadening of meaning of the street from primary flow space to enable also places of meeting and permanence, as well as green area, in accordance to the role of the street as local passage in the road system of the city.

The convergence of these three axes, in principle, is achieved through the incentive of harmonic interaction of the symbolic diversity, represented by the rainbow, so important for children. All this promoting the stimulation of the conviviality among the various users, a symbolic appeal for the insertion of young patients and an intense desire to integrate and enjoy the city.

THE RESILIENCE AND MANAGEMENT

Fig. 3: Hope Street. Source: Own Elaboration

Focused on sustainability, the landscape intervention started from the concept of preserving the existing traditional landscape, working on the appropriation of the urban space by the users, together with the creation of ecological services and exploring the resilience of the place, from strategies of infiltration and filtering Of rainwater, through biovalves, rain gardens and paved areas worked with permeable floors, differing in meeting functional requirements. (Fig. 3) This project had as a differential that it is possible to fulfill the role of urban green area, through the initial treatment of rainwater, reducing contamination and flood risk, making a multifaceted integration of nature and culture.

RESULTS AND CONCLUSIONS

The Rua da Esperança project is the result of the joint effort of a multidisciplinary team, aiming at a complete renovation of the street, not only in its physical characteristics, but also in its symbolic understanding by users, bringing the urban inhabitant closer to nature in his space of common life.

Results obtained with the project today are a transformation of the appropriation of space by the users that were not there before the intervention, as residents who started to use mixed the existing residences, appropriating the sidewalks and providing facades active to the place. (Fig. 4) This reinforces what JACOBS (2000, p. 60) affirms about the feeling of public identity of people, which occurs through the relationship of respect and trust with the inviting public space, promoting spontaneous contacts between people at local level.

Fig. 4: Hope Street Today. Source: Own Elaboration

This fact supports the search for a concrete contribution to bring an ecological awareness to the planning and design processes of Brazilian cities, emphasizing the role of Landscape Architecture as mediator of these actions. Pointing out how the transformations of public space, both in a sustainable and resilient character, can modify the actions of users of the urban environment.

The experience of the Rua da Esperança project demonstrates , also, the pedagogical potential of Landscape(itself) and Landscape design when faced within the collective perspective of “knowledge construction” and the development of mutual sensitivities - designer and community. If we take Landscapes as the “perceived expression of the synthesis between social, cultural and biophysical processes”, we can understand that it affects the human psyche and body in its urban daily life; when Landscapes are qualified by a sensitive design it has the possibility of transforming amorphous spaces in real “places of life”; If built in a participatory and democratic way,it becomes an experience of mutual learning, transcending the strict limits of the specialist and incorporating the plurality of eyes, feelings and hands of adults and children, thus becoming not only a place that one wishes to be a better one but also a society that can more just for everyone.

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Design of defences

239. The case study Natzschung River – A necessary crossover between technical and natural flood retention?Dr Jens Bölscher, Freie Universität Berlin, Germany

253. Economical arrangement for flood management
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380.On modified Hazard and Exposure: a case study on flood Risk change after a structural intervention
Dr Susanna Naso, University of Messina, Italy

410. Geodetic Support for Flood Risk Management in Thailand
Ms Rattikarn Khambud, Technical University of Munich, Germany

412. Innovative solutions to reduce flood risk in Leeds
Mr Peter Charlesworth, Mott MacDonald Ltd, United Kingdom

413. Totnes Flood Defence Improvements
Ms Yvonne Murphy, Mott MacDonald Ltd, United Kingdom

414. Level 2 BIMS – Stonehaven Flood Prevention Scheme
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239. The case study Natzschung River – a necessary crossover between technical and natural flood retention?

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KEYWORDS: headwater areas, flood retention, extrem events

ABSTRACT

Introduction: The concept of decentralised flood protection is based on localising and using the natural capability of a catchment to retard run off as early as possible, and at several places at the same time, by means of a combination of different small-scale technical and non-technical measures. Intense rainfall and heavy floods in August 2002, which caused extraordinarily high levels of inundation and damage, affected the Ore Mountains, a low range mountain region in eastern Germany. Against this background, the objective of this investigation has been developed to analyse the capability of headwater areas to mitigate floods for downstream locations at different spatial scales. Based on this idea, the hydrological effect of selected small, well-placed retention facilities was analysed for the Natzschung catchment.

The concept is well established in German literature and recent studies have been reviewed, but it is also well known in the international context. Over recent years, several approaches and investigations have analysed the performance of these measures in terms of retention or detention ponds and other techniques. The discussion of pros and cons is still in progress, but the lack of data clearly remains an issue, especially concerning the capability and the effect of retention facilities and other natural flood management measures at different spatial scales and for varying flood return periods.

Methods: The analysis of the Natzschung catchment offered the potential for uncontrolled retention facilities at 19 locations, in the upper and middle basin. They include already existing small retention and detention ponds, and areas with valley-crossing street embankments with an ambiguous purpose. These facilities were implemented in a distributed hydrological model (NASIM) to simulate local and regional flood retarding effects with regard to a 100-year flood recurrence interval.

Results: For all analysed locations, a distinct effect concerning the peak reduction and temporal shift of the peak could be observed. This scenario induced a decrease in peak discharge from a level of 63.4 m^3/s to a value of 45.2 m^3/s (-28.7 %) at the gauging station Rothenthal (total area of 75 km^2).The peak arrived forty-five minutes later and could be attenuated to a discharge comparable to a return period under a 50 year flood event (<HQ50). This is not only important for the main objective of flood protection, as a reduction in

discharge also means a decrease in sediment transport capacity of fluvial systems.

Conclusions: This flood retention concept considers regional and local flood protection targets and the specific hydrological conditions and capabilities of a catchment. The implementation of these kind of measures in stream headwaters could be a feasible way to establish an effective and additional flood protection for the local and downstream settlements of the Ore Mountains, and for other low range mountain systems.

253. Economical arrangement for flood management

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KEYWORDS: Flood control, hydraulic models, labyrinth spillway, rectangular labyrinth

ABSTRACT

In the recent decades, with the increase of extreme flood registration, extension of hydrological data records and the developement of discharge methods estimations, a review of safety criteria for hydraulic structures is more required. Weirs are a fundamental hydraulic structures that usually used for flood control, water level management, or as flow diversion devices in the canals. The rectangular labyrinth weir represent an effective solution to increase the capacity of weir for a given head of flow and for the same width of approach channel. This type of weir appear to be a performing solution in order to improve flood passage capacity from both technical and economic aspects. In order to provide an overview on some of the advantages of its applications in channel and/or dam rehabilitation, including economic, and hydraulic considerations. An experimental study of the influence of the two emplacement has been performed. The first arrangement corresponds to a width of inlet channel equal to the width of labyrinth. The second disposition corresponds to a width of inlet channel equal four times the width of the spillway. Effect of the relative width and a comparison with other alternatives are presented.

The results show that this configuration represents an effective solution in both hydraulic and economically terms compared to linear weir.

380. On modified Hazard and Exposure: a case study on flood Risk change after a structural intervention

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KEYWORDS: Flood Risk assessment; Flood consequences; Exposure; Flood Risk change.

ABSTRACT

In southwestern part of Sicily (Italy) is located Imera river, the longest river of the island, which crosses in the lower part at its mouth the city of Licata located in the floodplain and, hence, frequently subjected to severe flood events. As matter of fact, in the last century eight large floods occurred, the last in 1991. After the 1976 flood event, a diversion channel was realised, around 6 km upstream the mouth, to cut and to divert the flow discharges larger than 1000 cubic meter per second and to deviate them directly to the sea without affecting the city centre. The channel was not completed but anyhow the realisation gave the population a (false) sense of safety resulting in an increment of exposed elements in the floodplain.

This work investigates the influence of both the modified hazard configuration and the increased exposure on flood consequences, by calculating the damage caused by floods of different return periods in the scenarios with and without the channel, for 1966 and 1991 exposure data. The final aim is comparing the effects of exposure and hazard on flood risk assessment and understanding if the choice of deviating a part of flooding volumes from urban to agricultural areas corresponded to a reduction of flood damage for different standard events.

410. Geodetic Support for Flood Risk Management in Thailand

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Keywords: *Geodetic approaches, Digital Elevation Model (DEM), Land and Environment, Climate change, New artificial river, Flood risk management*

Abstract

This research concludes that the best benefit of geodetic approaches through water and land management in order to significantly minimize flooding in Central Thailand is a new artificial river. The new artificial Chao Phraya River would encounter challenging conditions of low-lying areas, high density population and forest areas.

This solution is properly supported by geodetic approaches and utilizes new advanced satellite surveys from the German TanDEM-X and TerraSAR-X single-pass SAR interferometry of the DLR (German aerospace center). These surveys demonstrate results with immense potential. The superior high-resolution terrain information of Hydro-DEM (12 m position and 2 m height accuracy) geo-information were fed into a Geographic Information Systems (GIS) ArcGIS to find the optimum track of the relieving river. Also, the river capacity and cross section were designed and calculated respectively. The key factors in the design of the new river channel will be that it avoids existing human settlements and forest areas. These considerations will lead to decreased land relocation and deforestation, thereby having less negative impacts as a result of the research project. This method, together with a more supportive system of water retention in various areas of functional land management in urban and rural areas illustrates encouraging results. Furthermore, a future plan of dealing with hydro-meteorological phenomena working in conjunction with the local authority encourages cooperation by raising awareness locally while establishing a communication channel. The community flood policy and plans for long-term optimized flood risk management can take a multi-functional approach by utilizing cooperative efforts from both local and national entities.

412. Innovative solutions to reduce flood risk in Leeds

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KEYWORDS: Flood risk management; Leeds

ABSTRACT

Background

Leeds is sited in a catchment where river levels can rise rapidly in response to rainfall. The growing risk of flooding from the River Aire prompted the design and construction of extensive defences along 4.3km of the river, through the city centre.

Careful planning was needed to ensure residents were not inconvenienced and properties fronting the water, including many thriving businesses, were not needlessly demolished to make way for the new defences.

Phase 1 of the scheme included three principle elements:

- Linear defences comprising masonry clad concrete walls and glazed panels along the river through the city centre
- Innovative moveable weirs at Crown Point and Knostrop which can be lowered in flood conditions
- Removal of an island between the river and adjacent canal along with targeted dredging to increase stage and conveyance capacity within the river

The work is being delivered by BMMJV, a joint venture between Mott MacDonald and BAM Nuttall.

Engaging the community

Strong engagement with the community, including open days where specially produced videos were shown, helped to convince residents of the necessity of the scheme.

Proactive management of stakeholders and neighbours has allowed the project to be undertaken with no significant complaints. Stakeholder feedback surveys have been undertaken following the completion of different work areas and revealed a positive, progressive trend in areas of staff helpfulness, pre-construction information provided and the overall improvement achieved.

Innovative solutions

The scheme includes the installation of moveable weirs which will be the first of their kind to be used for flood defence in the UK. These can be lowered to reduce river levels in advance of the flood peak reaching Leeds in order to reduce the risk of overtopping in the city centre.

We also assessed the capability of waterfront buildings to act as part of the defences themselves by establishing whether they could withstand flooding and offer protection to the streets, homes and businesses behind them. The owners of these properties were only too happy to see them saved, and this innovative use of existing assets has cut costs.

Outcome

The scheme will provide flood protection for the 1 in 100 year event for Leeds city centre including 3000 homes, 500 businesses and 120ha of development land. It will give confidence to future investors in the city, opening up key regeneration opportunities in south Leeds. It will help safeguard 22,000 jobs over the next 10 years, and create 150 jobs and apprenticeships among other community benefits.

A second phase of the scheme has now been awarded to BMMJV which will extend north of Leeds and focus on managing the water in the upstream catchments to restrict flood water from reaching the city centre.

413. Totnes Flood Defence Improvements

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KEYWORDS: Flood risk management; Totnes

ABSTRACT

Background

Totnes is situated alongside the River Dart in Devon, it is the second largest town in South Hams District with a population of 8,000. It is a long-established market town and serves a larger area of surrounding parishes.

The growing risk of fluvial and tidal flooding from the River Dart prompted the design and construction of a flood defence scheme for Totnes in 1980. The 1980 scheme was found to be sub-standard in 2014 due to newer hydrology studies which included climate and land usage changes. The Standard of Protection (SoP) provided by the 1980 flood defences varied between 10% (1 in 10) Annual Exceedance Probability (AEP) and 2% (1 in 50) AEP.

The delivery of the Flood Defence Improvements (FDI) scheme included three principle areas:

- Broadmarsh Industrial Estate: Linear defences constructed in the original 1980 scheme were re-assessed to justify their sustainable retention as part of the FDI scheme. These defences were increased in height to prevent overtopping.

- Totnes Town Centre: Slipway improvements, innovative glass panels and individual property flood resilience measures.

- Steamer Quay: a failed masonry quay wall was replaced in-line with sheet piling, clad with pre-cast masonry effect panels incorporating habitat niches. This approach minimised works in the tide and resultant impacts on this protected tentacled lagoon worm habitat.

The work is being delivered by BMMJV, a joint venture between Mott MacDonald and BAM Nuttall on behalf of the Environment Agency.

Engaging the community

Strong engagement with the community, including open days where specially produced videos of simulated events matched with photos of historic events were shown, helped to convince residents of the necessity of

the scheme.

The existing defences were demonstrated to be on the brink of overtopping on numerous occasions over the last five years with significant flood risk posed in events as low in 1 in 10 AEP.

Proactive engagement with, and management of, stakeholders and neighbours has allowed the project to progress with no objections to the planning application and no significant complaints in on site delivery.

Innovative solutions

Totnes is reported to have the most listed buildings per capita in the UK. Totnes Town Centre relies on listed waterfront buildings to act as the line of flood defence, protecting the streets, homes and businesses behind them. The owners of these properties were happy to see their properties saved and their flood resilience improved. The innovative use of existing assets was achieved by the installation of individual property measures which were sympathetically designed and customised to retro-fit into the listed settings, offering significant cost savings with no impact to the listed building status.

Outcome

The Totnes FDI scheme is designed to defend against a 1 in 100 AEP fluvial event and a 1 in 200 AEP tidal event. The improvements will remove 412 properties (211 residential and 201 commercial) from flood risk in the design event.

414. Level 2 BIMS – Stonehaven Flood Prevention Scheme

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KEYWORDS: Building Information Modelling, BIM Level 2, Flood Protection Schemes, Visualisation, Communication, Design efficiency, reduced risks.

ABSTRACT

The use of Level 2 Building Information Modelling (BIM) in design is well developed for buildings but less so for long linear infrastructure projects such flood protection schemes. Such schemes are complex with varying ground conditions and constraints along the length, and as such a varying structure. To add to the complexity, scheme generally have a non-horizontal design surface to match that of the design flood level which reduces downstream. These are considered too complex by many, but we consider this the ideal environment for BIM, enabling good communication: between Designers; the Client; and Stakeholders, also facilitating early risk identification.

The UK Government has indicated that there are over £2billion worth of savings to be had if the Construction Industry adopted BIM as standard and set a mandate to do this. So why has BIM not been adopted more widely?

Mott MacDonald has been using Level 2 BIM to deliver flood protection schemes. This paper is to provide a summary of BIM through the design process, using the case study of Stonehaven Flood Protection Scheme, developed for Aberdeenshire Council. The paper highlights that BIM is not an added extra, significant savings can be made in design, construction and during the life of the structure through BIM adoption.

Designing for uncertainty

225. Improving the specification of resilience measures in new builds through rigorous testing

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

260. Atmosphere-catchment nexus: An attribution to compound events pertaining to floods along the Dutch coast

Mr Sonu Khanal, Futurewater, Netherlands

225. Improving the specification of resilience measures in new builds through rigorous testing

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KEYWORDS: Resilience, Cost-benefits, Property Level Protection, Design Guidelines

ABSTRACT

Flood damage in the UK is estimated at £1.4bn per year and is set to rise as the risk of flooding increases (DEFRA 2004). Property level resilience measures have been highlighted by the Royal Institute of British Architects, DEFRA, and the Environment Agency as being fundamental in reducing damages at the building level and accumulated damages at regional and national levels (RIBA 2007, DEFRA 2007).

During the design process architects, developers and clients constructing in flood risk areas must decide on strategies to reduce flood risk where it exists and improved understanding of the benefits of resilience measures could dramatically improve up-take.

Guidance from the Royal Institute of British Architects and DEFRA offer suggestions regarding measures and integrated approaches for design of buildings at risk of flooding.The Government's Planning Policy Statement 25 was developed to ensure that flood risk is taken into account at all stages of planning for new developments. However, there are currently no building regulations that offer minimum standards of construction and only suggested approaches are offered that are generally non-specific and based on a lack of empirical evidence.

This paper presents the initial rsults of research intended to further understanding of the performance of specific flood resilient materials, products and measures for the benefit of architects, builders, developers and home owners. It includes results of tests to determine the performance of flood resilient materials and products in flood conditions.

It also draws on interviews with architects, planners, developers, flood specialists and property owners regarding the direct, indirect and perceived costs and benefits associated with resilience measures aimed at informing the decision making process and to ensure that condiseration is given at the most appropraite times in the design

process.

The results of the testing are presented in the form of guidance for architects, developers and home owners in such a way as to offer technical advice, design guidelines and peformance data in a way that can be easily understood thus improving the understanding of these measures and ultimately increasing their implementation.

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260. Atmosphere-catchment nexus: An attribution to compound events pertaining to floods along the Dutch coast

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KEYWORDS: Compound Event, Downscaling.

In this study, compounding event characteristics along the Dutch coast are analyzed, with focus on the combination of high storm surges and large discharge volumes. The storm surge levels are generated using a 2D storm surge model (WAQUA/DCSMv5) forced with dynamically downscaled climate information from the EC-Earth ensemble (GCM). The dynamical downscaling was performed using the regional climate model RACMO and further included bias corrections with EOS data. Discharge for the same time period was derived from a physical, distributed, hydrological model (SPHY) applying forcing fields from the same RACMO simulations. Thus simulated water levels along the Dutch coast are analysed in conjunction with the simulated discharge at Lobith and the the null-hypothesis of statistical dependence between the storm surge and fluvial discharge is tested. The results of this study will provide an insight into the effect of spatial and temporal scales at which the compounding effect becomes distinctively significant and thus contribute to the understanding of joint probabilities in regards to flood risk management.

Economic impacts, loss of life and damage estimation

86. Consequences of breaches in canal systems on flood risk

Mr Stephan Rikkert, Delft University of Technology, Netherlands

128. Assessment and Management of Bidasoa Basin Flood Risk

Ms Elena Martínez, INCLAM, S.A. Spain

153. Agent-based modelling to study the effects of shocks with a focus on indirect losses to businesses and supply chains

Ms Friederike Holz, Flood Hazard Research Centre at Middlesex University, United Kingdom

335. Multi-risk conflicts in flood protection measures

Chiara Arrighi, University of Florence, Italy

86. Consequences of breaches in canal systems on flood risk

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KEYWORDS: flood risk, dependencies, controlled water system, cost-benefit analysis, dike failure

ABSTRACT

Introduction

A large part of the Netherlands is situated below sea level, which makes the country vulnerable to flooding from the main rivers and the sea. The low-lying polders can also flood as a result of rainfall and seepage. In order to keep the groundwater levels in these polders below surface level, water is almost continuously pumped into drainage canals. From these canals, water is eventually discharged to the main rivers or the sea. All these drainage canals are surrounded by levees. In dry periods these canals also supply water to the polders.

The catastrophic potential of a flood became clear when a canal levee breached in Wilnis (2003), causing an estimated economic damage of around 15 million euros. In the Northern part of the Netherlands (2012) hundreds of people were evacuated in the middle of the night because several levees reached critical conditions.

Absolute flood safety can never be guaranteed. Flood safety standards can help the design, maintenance and managemant of flood systems, and might also be useful for communication. These standards describe the desired flood safety level for specific areas. Decision makers decide on safety standards based on different criteria. Examples of risk-based criteria are individual risk, societal risk, and economic risk.

Several factors influence the risk of flooding, such as the exceedance probabilities of water levels, the strength of flood defences, length-effects, climate change and dependencies within the water system.

The drainage canals are usually part of a network of canals surrounded by polders. A levee breach somewhere along this canal system impacts the canal water level. The change in water level influences the failure probabilities of other flood defences in the system. However, these dependencies are often neglected.

Objectives

The aim of this paper is to describe the impact of a levee breach on the water level and consequently on the flood risk of a canal system.

Method

The paper considers a canal system in which economic values of polders and strength properties of the flood defences are varied. Flood risk is calculated with and without system dependencies.

Results

Including dependencies of flood defences in a controlled water system leads to lower failure probabilities of all levee sections. Results also show that strengthening a levee section has negative consequences on failure probabilities of other levee sections, when the dependencies are taken into account.

Conclusions

Failure probability of one levee section in a controlled water system cannot be seen separately from another levee section. Taking into account dependencies within the system leads to different results of the flood risk assessment, which might lead to different decisions in flood risk management.

128. Flood risk assessment and management of Bidasoa River Basin

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KEYWORDS: Hazard analysis, flood risks assessment and management plan, mitigation measures, cost-benefit.

INTRODUCTION AND OBJETIVE

In Spain floods are a recurrent social and economic problem. The Bidasoa River Basin, located in Navarre (Spain), has suffered several floods through its history (31 recorded events from 1913 to 2013). The worst ones occurred in 1913, 1953, 1983 and 2007.

This study was developed according to the requirements of the Directive 2007/60/EC on the assessment and management of flood risks entered into force on 26 November 2007 and the Spanish Royal Decree 903/2010.

The main goal has been to draw up the flood risk management plan. This plan has established the flood risk assessment and management, focused on the reduction of the adverse consequences for the human health, the environment, cultural heritage and economic activity associated with floods.

SCOPE

The geographical area was nearly the whole basin (a total of 625 km^2) and the main streams (105 km of river) have been analysed.

METHODOLOGY

Historical events have been analysed by means of ancient historical hard copy records, digital information and 22 surveys to draw past flooded areas to calibrate hydraulic models.

Geomorphology has been studied using aerial photographs (1929, 1956, 1984, and 2010) and recollecting data from field visits to identify the alluvial fan locations, sedimentation and erosion problems and longitudinal and vertical river movements.

Hydrological study: the basis was divided into 75 catchments, data from 78 rain gauges have been used, 260 storms have been analysed and 2, 5, 10, 25, 50, 100, 500 and 1000 year-event have been simulated using HMS models calibrated with 2006, 2007 and 2011 events data.

Digital Terrain Model, gained from LiDAR technology. This information was corrected including bathymetric profiles and field data. These data has 1 meter cell sized and 15 cm of altimetry accuracy.

Hydraulic study: a two-dimensional model, Guad2D developed by INCLAM and the University of Zaragoza, has been used. 14 two-dimensional models have been set up, including 200 structures. The domains have been between 500.000 and 2.500.000 cells and a total of 96 hydrographs have been introduced as inlet conditions. These models have been also calibrated with 2006, 2007 and 2011 events data.

*Flood hazard assessment*s and *hazard maps* have been doing applying several criteria by extending the flooded area, water depth, and water velocity. The hydraulic capacity of 196 bridges was also studied.

The exposure and the territory vulnerability maps have been carried out according to the Directive methodology for to draw up this flood risk mapping Government of Navarre criteria.

Flood risk assessment and their maps were elaborated using the cadastre data and applying not only Directive criteria but also Spanish Emergency Services.

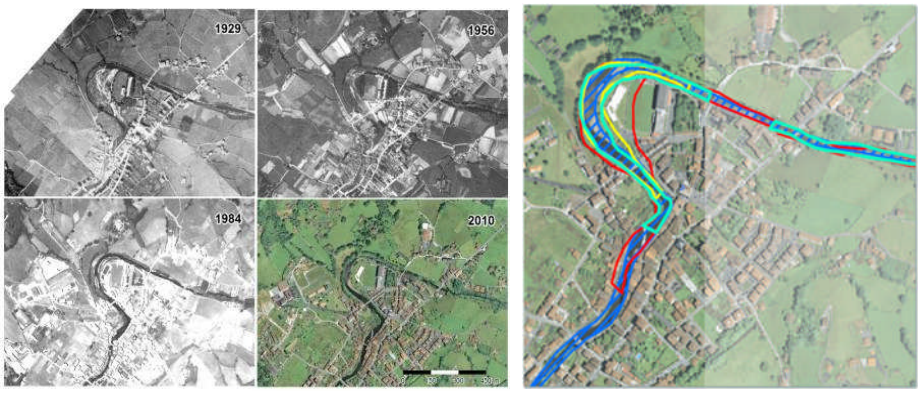
Flood risk management plan included the measure programs to play down the flood risks. The holistic *measures* were studied according to the economic and social situation, and their organization in-charge was identified. The structural and non-structural feasibility measures were evaluated by a *cost-benefit analysis* and 160 of these measures were prioritized by a multi-criteria study which includes economic, hydraulics, social, environmental and management safety factors. This Plan has also incorporated several follow-up indicators and the modification and revision plan procedures.

RESULTS

The results were a collection of maps, databases, models, documents and tools.

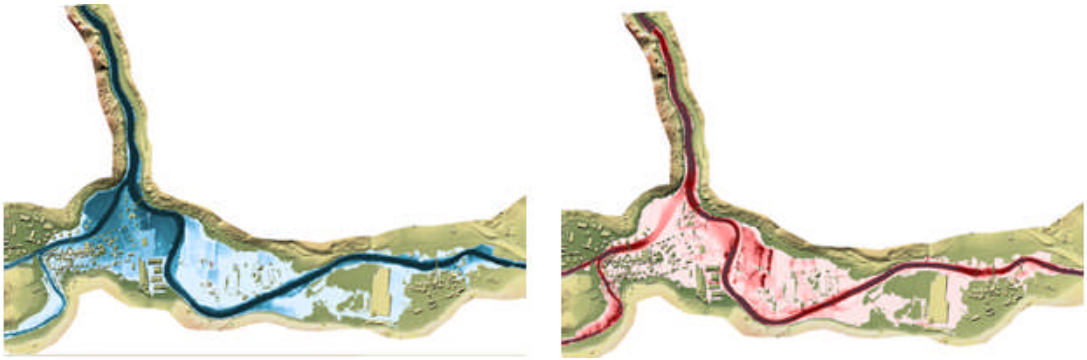
A Geotadabase have been elaborated with the historic data collected and digitalized (historical floods maps, 314 pictures and videos).

The Geomorphology study results have been the river bankfull pattern, the fluvial dynamic processes characterization and the erosion and sedimentation areas identification. Last, a flash flood risk appraisal of torrential fans haven been included.



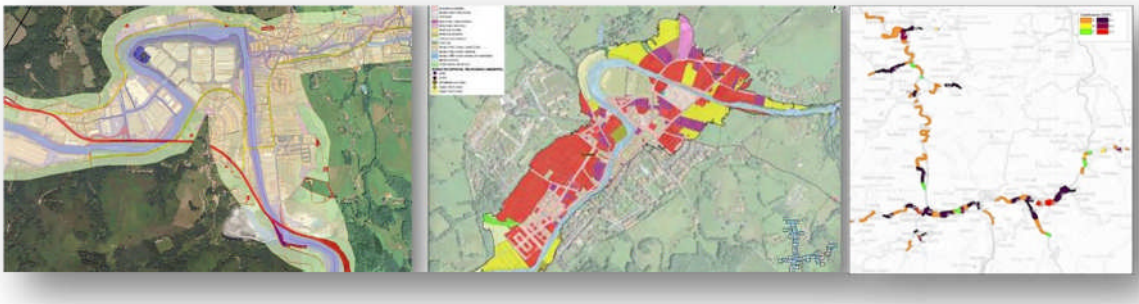
Fluvial dynamic. (1929, 1965, 1984, 2010)

The Hydraulic simulations outcomes have been the water level, depth and velocity rasters of 2.33, 5, 10, 25, 50, 100, 500 y 1000 year –event. It was also draw up a bridges capacity map and the hazard flood maps.



Water depth and Velocity rasters.

Subsequently, vulnerability and flood risk maps have been elaborated take into account different criteria (European Directive, Government of Navarre, Emergency services).

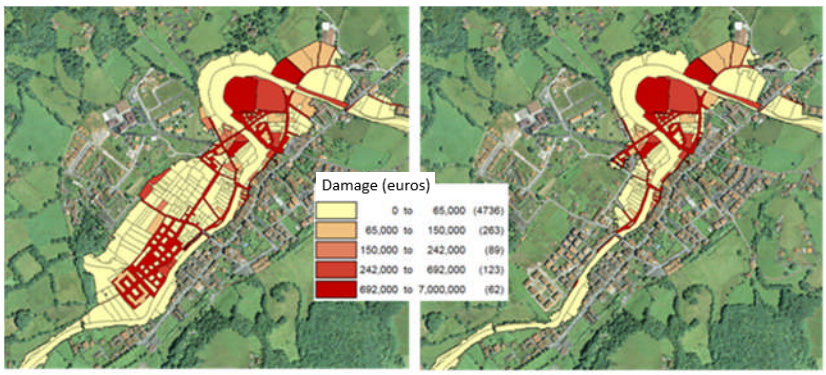


Vulnerability , flood risk and floof risk for Emercency Services maps

The measures were planned focused on the reduction of the adverse consequences for the human health, the environment, cultural heritage and economic activity associated with floods. Every structural measure was hydraulically calculated and several alternatives to solve the problems were studied.

Damage (euros) Before and after implementing the measures

The non-structural measures were aimed (i) to improve the resilience and population safety (ii) and to reduce vulnerability.



A total of 166 actions were organized into eleven measures programmes

PROGRAM 1: River restoration measures
PROGRAM 2: Measures to improve linear infrastructures drainage
PROGRAM 3: Hard Rains and Flood Prediction Measures
PROGRAM 4: Emergency Services Measures
PROGRAM 5: Land uses and urban planning measures
PROGRAM 6: Improving knowledge
PROGRAM 7: Sedimentation and local erosion control
PROGRAM 8: Improving resilience
PROGRAM 9: Training and communication
PROGRAM 10: Plan Management and Coordination with other Administrations
PROGRAM 11: Structural Measures

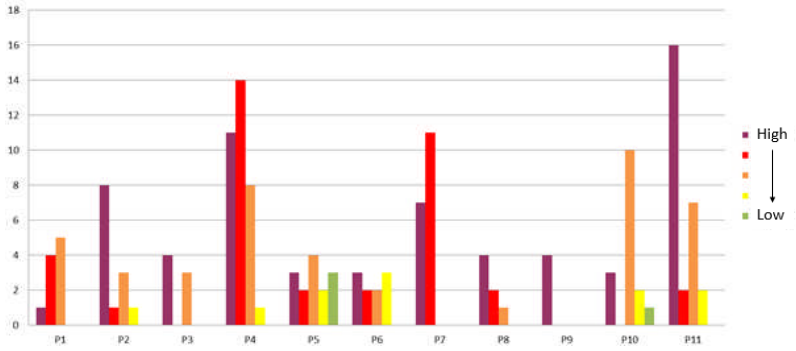
Measure programs

The economic analysis of the measures was thought-out per municipality. In order to assess the structural measures profitability, several indicators were calculated, such as NPV, TIR, B / C and a cost - effectiveness analysis calculated by the differential of the value of the losses or damages respect to the current value of the

losses per return period and the average annual profit. Finally, measures could be prioritized thanks to the multicriteria analysis results per municipality and per programme.

Measure Priority by programs.

CONCLUSIONS



Only alluvial plain slopes are lower than 3%. Thus the population, services, and infrastructures are in these zones. Some communities have resilient buildings from the beginning of the 20thcentury but it is essential to improve them.

More effective measures are focused on land planning, Decision Support, and Early Alert Systems and obtaining resilient urban areas. A comparative cost-benefit and multi-criteria analysis help the stakeholders to make decisions, to choose the best solution and to prioritize the actions.

The plan is a great boost to coordination between the organizations in-charge, avoiding duplicate efforts.

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153. Agent-based modelling to study the effects of shocks with a focus on indirect losses to businesses and supply chains

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KEYWORDS: Indirect flood impact, supply chain disruption, agent-based model, recovery

ABSTRACT

In an increasingly globalised world, with growing levels of complexity in economic networks and markets, supply chains are a critical component in the viability of a company. Optimising a supply chain helps a business to reduce costs and remain competitive, but strong interdependencies can also increase vulnerability and, in the case of a disruptive event, propagate impacts through various economic sectors.

Natural hazards such as floods can cause major disruptions to supply chains (e.g. the 2011 Japanese Earthquake and Tsunami and Thailand flood), resulting in indirect losses outside of the actual flooded area (e.g. through loss of production or shortage of goods). These so called “higher-order” or “induced” losses can account for a large part of the full costs of a disaster, but they are rarely systematically assessed.

As part of the EU Horizon 2020 funded project System-Risk (https://system-risk.eu/), this research aims to contribute to an improved understanding of indirect flood losses to businesses and their supply chains by more comprehensively addressing the interdependencies in an economic system. One of the challenges is to transfer the assessment perspective from single businesses to their supply chain network by better integrating the propagation of losses and spatiotemporal dynamics. An objective is to translate the linear source-pathway-receptor-consequence concept and generate a more systemic approach, using elements from network theory and complex adaptive systems. For this purpose, the use of agent-based models (ABM) as a bottom-up approach is explored, focussing on ripple effects following the shock of an extreme event.

In a comprehensive literature review, existing knowledge and methods from flood risk research and supply chain management are summarised and research gaps identified. In a following step, expert interviews with business stakeholders provide insight into the critical factors and mechanisms in a supply chain in order to give a better understanding of the determinants that influence indirect losses and the recovery after disruptive events (e.g. insurance coverage, business continuity management). In a further stage, the results are used for the conceptual development of the ABM to define agents (e.g. businesses, suppliers, consumers) and the associated behavioural rules for interaction and for responses after a shock. In addition, information on input and output parameters for the ABM is collected. The first results of the research will be presented, including the initial conception of an ABM. The ABM will later be applied to a selected case study area to calibrate and validate the model.

335. Multi-risk conflicts in flood protection measures

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KEYWORDS: Cultural heritage, multi-hazard, risk mitigation measures, seismic hazard.

ABSTRACT

Multiple hazards generated by different sources may affect people, environment, and infrastructures. Synergies and cascade effects between hazards are complex to quantify because risk assessments are diversified in methods, scales and metrics (Marzocchi et al. 2012). Therefore, multiple risks information, when available, is often just super-imposed layer over layer without accounting for possible interactions. This approach is reflected in the implementation of risk mitigation strategies. The aim of this work is to present an exemplary site-scale application of flood risk management to cultural heritage. Moreover, the interplay between flood and earthquake protection measures is described and analysed to identify possible antagonisms. Flood risk assessment is performed accounting for different flood probability scenarios (i.e. hazard), asset location (i.e. exposure) and vulnerability of cultural heritage with a single-building approach (Arrighi et al. 2016). Flood management strategies, which are currently debated, are then compared with seismic protection measures, highlighting strenghts and weaknesses. The method is applied to the city of Florence (Italy), which hosts priceless works of art and historical buildings and is susceptible both to inundations and earthquakes (Ripepe et al., 2014). The results of the analysis demonstrate that in absence of precautionary measures, most of the cultural heritage is at risk. Moreover, appropriate analysis on the interaction between mitigation strategies should be undertaken in order to avoid unfavorable conflicts.

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Governance

46. Federal Policy for Flood Resilience in the United States

Mr Mark Roupas, U.S. Army Corps of Engineers, United States

190. Needs for Autonomous Evacuation Under Climate Change

Mr Toshihiko Okamoto, Japan Institute of Country-ology and Engineering, Japan

249. Design of strategies for Integrated Flood Management to guide implementation in policy and practice

Mr Herman Van der Most, Delt, Netherlands

46. Federal Policy for Flood Resilience in the United States

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KEYWORDS: Executive Order 11988; Executive Order 13690; Federal Flood Risk Management Standard

ABSTRACT

This presentation will describe efforts by U.S. Federal agencies to implement the first major changes to longstanding Federal flood risk management policy in nearly 40 years. In the United States Federal floodplain management has historically been governed by Executive Order 11988 (E.O. 11988), which was issued in 1977. E.O 11988 directs Federal leadership to "take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains." On January 30, 2015, President Obama signed E.O. 13690, "Establishing a Federal Flood Risk Management Standard (FFRMS) and a Process for Further Soliciting and Considering Stakeholder Input", which amended E.O. 11988. The amendments included by E.O. 13690 directed Federal agencies to update their flood-risk reduction standards for Federal investments as one means to improve the nation's resilience to flooding and better prepare the nation for the impacts of climate change. Under E.O. 11988 Federal agencies had considered the 1-percent-annual-chance flood when evaluating actions proposed to be taken in the floodplain. The FFRMS established under E.O. 13690 expands the horizontal extent of the floodplain for which impacts of Federal investments should be evaluated and increases the flood elevation against which federal investments should be resilient. Though the FFRMS encourages incorporation of enhanced flood resilience for Federal investments, it does not serve as an explicit design standard for those Federal investments. As a result of the new requirements of the FFRMS, all Federal agencies that conduct actions subject to E.O. 11988 needed to develop new or revised agency-specific implementation procedures for E.O. 11988. Though all agencies have developed their implementation guidance independently, many agencies have attempted to develop their guidance in a coordinated and collaborative manner, given the frequent interaction of various Federal agencies in floodplain actions. Because agencies have developed implementation procedures individually, implementation of the new requirements has begun in a piecemeal fashion, as agencies have completed their guidance documents. While full implementation has not yet occurred, initial lessons learned about changes in flood resilience due to the FFRMS may soon be obtainable. This presentation will discuss the history of the E.O.s governing Federal flood risk management, discuss U.S. Army Corps of Engineers activities to implement the new requirements, and describe any lessons learned from initial implementation that have been gleaned.

190. Needs For Autonomous Evacuation Under Climate Change

KEYWORDS

evacuation strategy, the lives of residents, flood, climate change

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ABSTRACT

This paper provides perspectives to an evacuation at the time of flood event. Under the advancing global climate change, tendencies recently observed in Japan are typhoons growing in size and an intensifying strength of short-time rainfall. Consequently, unexpected flood damages have occurred nearly every year, which exceeding an anticipated design scale of flood control, and led to a threat to the lives of residents. Ultimate issues, therefore, are drawing attention at more closely; how to anticipate the unexpected flood and how to protect the lives of residents. In other words, the lives of residents depend on the evacuation approach undertaken during the flood event. Even if we say “evacuation” in one word, it varies from a home location or rainfall types in terms of the start timing of evacuation, the choice of shelter or the moving distance. Authors consider that this point should be one of factors that make a judgment of evacuation difficult rather than that from Tsunami, which is started all at once triggered by an occurrence of earthquake. In this study, therefore, we consider a necessity of evacuation strategies by classifying them into several types with a view of evacuation at the time of flood. The climate and basin character vary from country to country, hence, it could be considered that the evacuation type as well as that of flood differ among countries. However, under the global climate change that needs to anticipate the unexpected, there could be an opportunity that efforts undertaken in Japan will contribute to the flood control of other countries.

This paper, first of all, compiles the following three topics to deepen the understanding of Japan’s flood event; 1) the climate, the rainfall volume and the river condition as flood characters, 2) a historical transition of flood control and a change of residents’ awareness to evacuate, and 3) recent flood damage cases and lessons to be learned from the experiences. Next, the following topic 4) addresses a content of an extensive information provision enables residents to aware the risk, deliberate and act by oneself that has been promoted according to the “Restructuring Vision for Flood Prevention Conscious Society” formulated by Ministry of Land, Infrastructure and Transport. Subsequently, 5) as the main subject, it indicates that the flood evacuation is different with that from the other natural disasters, and suggests the necessity of evacuation strategy for flood, which key players proactively make a judgment and act by marshalling the evacuation means from various view points. Finally, the proactive evacuation and the autonomous evacuation by residents are expected under the climate change, however, the topic 6) points out that there exist challenges to be resolved before the realization.

249. Design of strategies for Integrated Flood Management to guide implementation in policy and practice

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KEYWORDS: Integrated Flood Management, Design of strategies, Framework for policy analysis and planning, Enhancing resilience

ABSTRACT

Since 2001, the Associated Programme on Flood Management (APFM) has promoted the concept of Integrated Flood Management (IFM). APFM is an associated programme of the World Meteorological Organization (WMO) and the Global Water Partnership (GWP). Over the years, the programme has issued a concept paper, four policy papers and an extensive set of so-called IFM Tools to support exchange of experience in various aspects of IFM. The last few years saw the programme shifting its focus on the implementation of IFM in policy and practice.

A concise yet comprehensive guidance document has been developed to support the shift from the "classical" strategy of focusing on disaster response to an IFM strategy geared to enhancing societal resilience through pro-active risk reduction activities. Enhancing flood resilience is a common policy objective within IFM. It relates to maintaining, protecting and restoring the natural regulating capacities of wetlands and other measures to reduce the impacts of flooding. It also includes the ability to recover from floods, in particular the pursuit of building back better as well as the coping capacity of inhabitants of flood prone areas.

The guidance document provides a comprehensive overview of structural and non-structural measures, arranged in the chain from flood hazard to flood impact. The measures presented are the building blocks for the development of strategies for reducing flood risk. The guidance document aims to support the design of well-balanced and well-motivated strategies to cope with flood risk. Development of a well-balanced strategy for IFM should always start with a proper understanding of the flood risk, not only examining the characteristics of past floods but also looking into possible future situations.

The process of developing a successful strategy will be a blend of 'top-down' and 'bottom-up' approaches. A top-down approach will produce a strategic framework of coherent strategy development, whereas a bottom-up approach will enhance stakeholder engagement and promote local linkages to other policy domains, such as urban development, nature restoration, etc.

Strategies to be developed should comprise a well-balanced mix of both structural and non-structural measures, including measures that can be implemented on the short term and maintained over the long term.

Planning for Integrated Flood Management should be an iterative process ensuring risk-informed decision making. A framework for policy analysis and planning is presented to guide the steps of IFM. This framework reflects the policy cycle and puts stakeholder engagement and open and transparent communication at its core. To elaborate on these steps, the guidance document builds on policy and tool papers that have been published previously within the APFM.

Impact on infrastructure

73. Effects of man-made terrain features in flood estimation

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73. Effects of man-made terrain features in flood estimation

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KEYWORDS: Hydraulics, Hydrology, Water Resources, Flood Estimation, Channels

ABSTRACT

In flood estimation, the effects of man-made features may not always be adequately considered in relation to the catchment specifics and risks involved. While structures such as weirs, bridges and culverts are normally well represented in flood models, some man-made terrain features such as roads, railways, boundary walls or other cut/fill terrain features may be overlooked or deliberately ignored. While the latter may be of little importance in assessing reasonably large catchments, they could have a significant effect on estimating the floods associated with small catchments. In particular, considering these effects in flood risk assessments for small impounding reservoirs could have a significant effect on the economy and safety of these structures. This paper discusses United Utilities' experience in managing their impounding reservoirs' safety by anticipating the 'unexpected' when dealing with very small reservoir catchments and extremely infrequent flood events.

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Modelling and hydroinformatics (i)

36. Application of fuzzy set theory in difuse wave models to study uncertainties during flood routing

Ms Patricia Castro, UFC – Universidade Federal do Ceará, Brazil

40. Ensemble stage and discharge forecasting for rivers in the Netherlands

Mr Robert Slomp, Rijkswaterstaat, Netherlands

41. Flood forecasting in the Netherlands for coastal areas Mr Robert Slomp, Rijkswatestaat, Netherlands

81. Simulation of Tsunami Inundation in City Scale Model

Mr Takuya, Miyashita CTI, Japan

85. Variations of Bankfull Discharge in Lower Reaches of Yellow River Channel and its Influence Upon Flood Control

Mr Chen Jianguo, China Institute of Water Resources and Hydropower Research, China

141. Reproducing the June 2007 Hull floods using radar rainfall

Mr Laurent Courty, Universidad Nacional Autónoma de México, Mexico

163. The effect of prediction the flood zone with Using a mathematical model (Mike Flood) on river flood management in Dez and Karun rivers

Mr Seyed Ebrahim Hosseini

Khouzestan, Water and Power Authority, Islamic Republic of Iran

179.Ice Jams Predicting Based on Neural Networks Model in Heilongjiang River

Prof Tao Wang, China Institute of Water Resources and Hydropower Research, China

196. Application of dual frequency ground penetrating radar for ice jam flood prevention

Mr Hui Fu, China Institute of Water Resources and Hydropower Research, China

36. Application of fuzzy set theory in difuse wave models to study uncertainties during Flood Routing

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ABSTRACT

This research aims to apply the Fuzzy Theory in diffusive wave models at natural channels, in order to verify the uncertainties related to the hydrodynamic parameters present in these models. The hydrodynamic model of flood routing was Difuse wave model in Fuzzy form. Through the Implicit Finite Difference schemes was solved partial differential. To carry out a set of simulations for the most different scenarios in the water body was developed a computer program, coded in FORTRAN. Results note that the behavior of fuzzy diffusive wave flood routing is influenced by slope feature and Manning's *n*, with this making this model a viable tool for predicting floods in susceptible areas

keywords: Flood Routing, Fuzzy Theory, Diffusive Wave Models and Uncertainties Flood Wave.

1. Introduction

Impacts caused by floods routing affect families, economic activities, public and private systems. Flood routing is a problem, both developed and developing countries. Many hydrodynamic problems that involve of the propagation flood waves along the length in natural channels are solved by Saint – Venant equations (ANDRADE, 2006). Lal (2005) stated that studies show that diffuse wave models can be used successfully to simulate a variety of natural flow conditions. A diffuse wave approximation was applied to the flood area and flow rate in a loop channel system (Luo, 2007).

Many techniques have been developed to quantify risks in various water problems. These so-called data-driven

techniques. Among the important theories available, we can highlight the probabilistic theory (e.g. Frieser,2004; Kolen et al., 2013) and Fuzzy Set Theory (e.g. Hundecha et al., 2001; Ozelkan and Duckstein, 2001; Chang et al., 2005; Chagas, 2005).

2. Mathematical formulation

2.1 – Diffusion Routing

The hidrodynamic modelling of a one-dimensional unsteady flow in open channels is usually based on the numerical solution of the well known Saint-Venant equations (PORTO, 2006). The two equations, describing continuity (1) and momentum (2), can be written as follows (CUNGE, HOLLY & VERWEY,1980)

$$\frac{\partial A}{\partial t}+\frac{\partial Q}{\partial x}=0 \quad \text{.....(1)}$$

$$\frac{\partial Q}{\partial t}+\frac{\partial\left(\frac{Q^2}{A}\right)}{\partial x}+gA\frac{\partial y}{\partial x}+gA\left(S_f-S_0\right)=0 \quad \text{.....(2)}$$

in which Q = discharge (m^3/s); A= cross-sectional area of flow (m^2); y = flow depth (m); x= distance (m); t= time (s); S_f= friction slope (m/m) and S_0 = bed slope (m/m)

According to the Cunge *et.al.* (1980) by the neglect of the inertia terms (local and convective acceleration) , Saint-Venant equations are converted into diffusion routing (3)

$$\frac{\partial Q}{\partial t}+C\frac{\partial Q}{\partial x}=D\frac{\partial^2 Q}{\partial x^2} \quad \text{.....(3)}$$

in which C is interpreted as the kinematic wave celerity, given by dQ/dA, (ms^{-1}) and D is a diffusion coefficient given by $D = Q/2BS_0$, (m^2s^{-1}).

2.2 – Fuzzy logic application to Difusive wave

In any practical applications, in industries, etc., measurement of voltage, current, temperature, etc., there might be a negligible error. This causes imprecision in the data. This imprecision can be represented by the membership functions. Hence fuzzification is performed (SIVANANDAM, SUMATHI & DEEPA, 2007). Through "fuzzification", it is possible to convert the determinist Difusive wave model in a Fuzzy Difusive model. Equations

$$\frac{\partial \tilde{A}}{\partial t}+\frac{\partial \tilde{Q}}{\partial x}=0 \quad \text{.....(4)}$$

$$\frac{\partial \tilde{Q}}{\partial t}+\frac{\partial\left(\frac{\tilde{Q}^2}{\tilde{A}}\right)}{\partial x}+g\tilde{A}\frac{\partial \tilde{y}}{\partial x}+g\tilde{A}\left(\tilde{S}_f-\tilde{S}_0\right)=0 \quad \text{.....(5)}$$

$$\frac{\partial \tilde{Q}}{\partial t} + \tilde{C}\frac{\partial \tilde{Q}}{\partial x} = \tilde{D}\frac{\partial^2 \tilde{Q}}{\partial x^2} \quad \text{.....(6)}$$

in which $\tilde{A}$ = membership function for transversal area of the river; $\tilde{Q}$ = membership function for discharge; $\tilde{S}_f$ = membership function for friction slope; $\tilde{S}_0$ = membership function for bed slope; $\tilde{C}$ =membership function for celerity; $\tilde{D}$ = membership function for diffusion coefficient; $\tilde{y}$ = membership function for depth flow.

2.3 – Discretization

Fuzzy diffusive wave equation was calculated by Implicit Finite Differences method.(ANDERSON et al., 1984). According Gomes (2006), the space and time derivatives can be written as

$$\frac{\partial \tilde{Q}}{\partial t} \approx \frac{\tilde{Q}[i, j+1] - \tilde{Q}[i, j]}{\Delta t} \quad \text{.....(7)}$$

$$\frac{\partial \tilde{Q}}{\partial x} \approx \frac{1}{2}\left[\frac{\tilde{Q}[i+1, j+1] - \tilde{Q}[i-1, j+1]}{2\Delta x} + \frac{\tilde{Q}[i+1, j] - \tilde{Q}[i-1, j]}{2\Delta x}\right] \quad \text{.....(8)}$$

$$\frac{\partial^2 \tilde{Q}}{\partial x^2} \approx \frac{1}{2}\left[\frac{\tilde{Q}[i+1, j+1] - 2\tilde{Q}[i, j+1] + \tilde{Q}[i-1, j+1]}{\Delta x^2} + \frac{\tilde{Q}[i+1, j] - 2\tilde{Q}[i, j] + \tilde{Q}[i-1, j]}{\Delta x^2}\right] \quad (9)$$

To carry out a set of simulations for the most different scenarios in the water body was developed a computer program, coded in FORTRAN. This software allows to calculate the flow control variables in the natural river under Fuzzy view.

3. Results

Each simulation was considered a natural channel of rectangular section, length 50 km, width 50m and a uniform initial flow 50 m^3/s. (CHAPRA, 1997) The temporal variation of the flow is expressed by the sine wave function.

$$\tilde{Q} = \tilde{Q}_0\left(1 + k.sen\frac{t}{T}\right), \text{ para } 0 \le t \le T \quad \text{.....(10)}$$

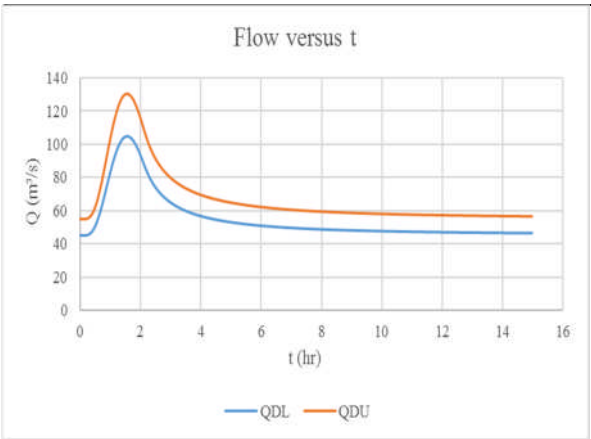

Figure 1 – Fuzzy Flow to α-cut=0.5, S_0=0.00005, n=0.01,section 10 km

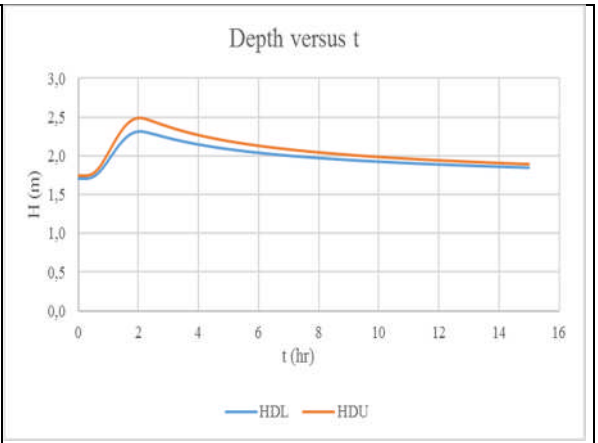

Figure 2 - Fuzzy Depth Flow to α-cut=0.5, S_0=0.00005, n=0.01,section 10 km

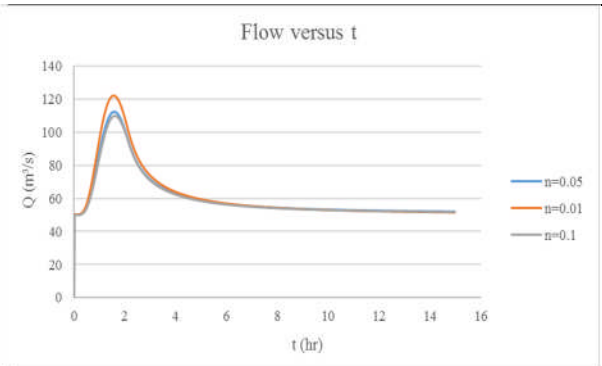

Figure 3 - Fuzzy Flow to α-cut=1, S_0=0.00005, section 10 km

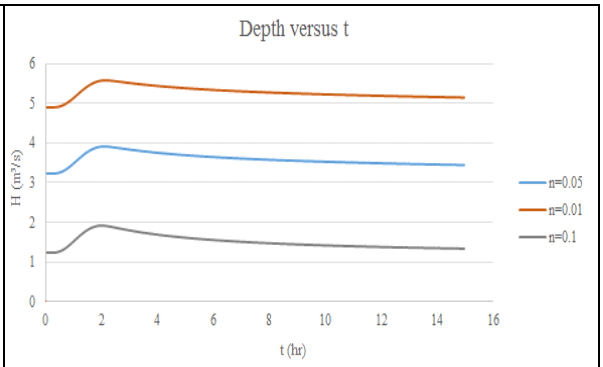

Figure 4 - Fuzzy Depth Flow to α-cut=1.0, S_0=0.00005, section 10 km

Figures 1 and 2 show uncertainties regions represented by distance between low and upper limits. By comparing outcomes with each other, it has been a dampening effects along river courses. This is due to diffusive term into diffusion routing equation.

Figure 3 and 4, it is shown that the greater the Manning's *n* values, the lower will be the Flow and Depth Flow.

4. Concluding Remarks

The results allowed establishing that is strong influence of hydraulic parameters, the slope feature and Manning's *n*. The software developed allowed to evaluate the Fuzzy form the behavior of the diffusion wave flood routing in aspects of flow, cross-sectional area, speed and depth of natural flow along the channel for different intervals observation time and different sections, for this study was emphasizes the behavior of flow and elevation above sea level. The results allowed concluding that the application of the Fuzzy Theory, in the hydrodynamic systems, in the evaluation of uncertainty is a viable alternative for determining the flooding risk and thus be more a support tool in Water Resources Management programs

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40. Ensemble stage and discharge forecasting for rivers in the Netherlands

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KEYWORDS: River forecasts, uncertainty, ensembles, river flooding, assessment of flood defences

ABSTRACT

This article is written from the perspective of the user. Rijkswaterstaat, the National Water Authority provides water level and discharge forecasts for the whole of the Netherlands through the Water Management Centre of the Netherlands (WMCN). WMCN is an organization with many participants, regional water authorities, the national water authority and the national meteorological service (KNMI). The WMCN has different teams. Warning services for rivers have been in operation for centuries, church bells and canon shots often were used as warning signs. Statistical methods were developed in the 90's to provide reliable forecasts. The most important issue is a cost-efficient and reliable forecasting and warning system. This always involves trade-offs. Reliability and redundancy are important issues. Older systems, statistical methods are always available as backup. The costs are for hardware, software and training and availability of staff 24/7. A full model train is used. This model train consists of an automated system, a model train which provides a forecast every 6 hours. It starts with a precipitation forecast for the catchment. This provides input for a rainfall runoff model and a hydro-dynamical model that start near Karlsruhe in Germany for the River Rhine or on the French/Belgium border (Chooz) for the River Meuse. Forecasts are updated automatically on the basis of observed water level and discharges in the main river and its tributaries. Data exchange with all the riparian countries is essential and it takes a lot of time to build up mutual trust.

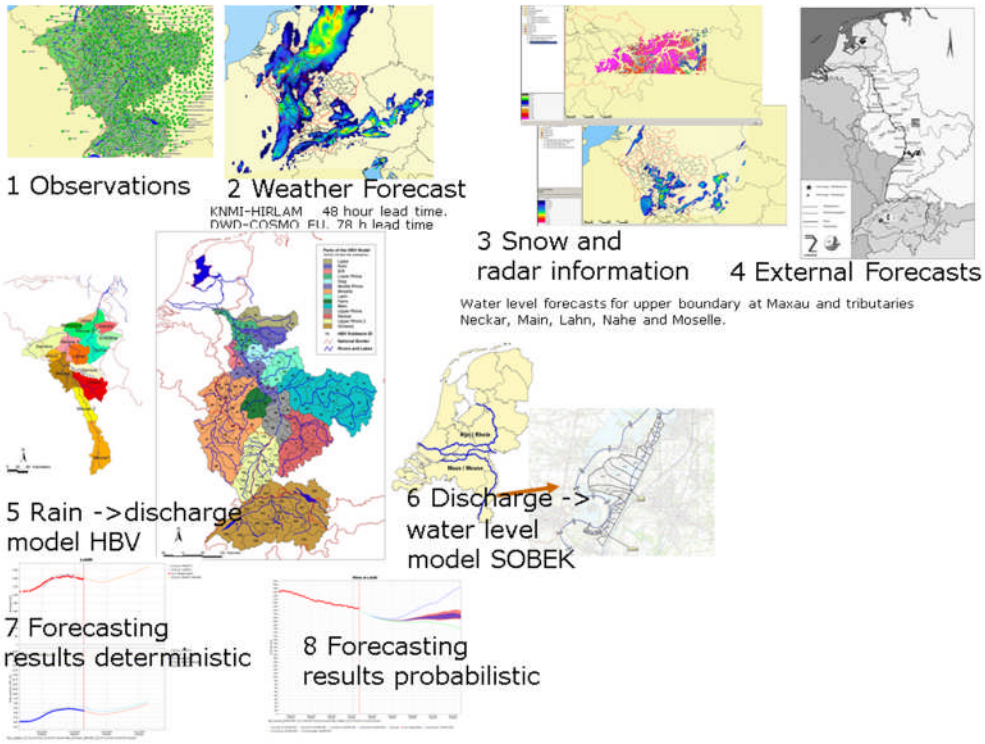
Forecasts of future events are per definition uncertain. Although knowledge about hydrological behaviour of river basins is growing and model input data is abundantly available, particularly in such a highly developed areas as the Rhine and the Meuse basin, there remain many sources of uncertainty. We don't know precisely the initial conditions of the catchment at the start of the flood period, nor do we know exactly how much precipitation will fall at what location. Furthermore, the models we use are still a simplification of reality. Users of river forecasts need references and information on uncertainty and more specific on the impact of hazards on lives, property and economy. In the past century water levels have been used as reference to determine the impact of a flood alert. More information is available, results from the 6 yearly assessment of flood defences and information comes from policy studies as VNK (Flood Risk in the Netherlands) and WV21 (Flood Risk in the 21st century). This information helps in determining the consequences of a breach in the flood defences.

For several years the flood forecasting systems in the Netherlands have included the element of uncertainty by using ensemble weather predictions. Efforts are currently being made to introduce other sources of uncertainty to produce a 'real-time' estimation of forecasting uncertainty. In the near future additional

information like levee stability, land use, topography, etc. will be used to produce risk and/or impact based forecasts.

Challenges for the future are

- further improvement of river forecasts
- improve presentation of uncertainties.
- use information on levee strength to determine dike failure probability
- use additional information toward risk based forecasting



41. Flood forecasting in the Netherlands for coastal areas

Kroos, J, Slomp, Robert *[1]*

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KEYWORDS: Flood forecasts, uncertainty, ensembles, coastal flooding

ABSTRACT

This article is written from the perspective of the user. Rijkswaterstaat, the National Water Authority provides flood forecasts for the whole of the Netherlands through the water management centre of the Netherlands (WMCN). WMCN is an organization with many participants, regional water authorities, the national water authority and the national meteorological service (KNMI). The WMCN has different teams. Storm surge warning service for coastal areas WMCN-Kust /coast (formally SVSD) is one of the oldest services in the Netherlands. It was founded 1921 after the Zuiderzee storm surge disaster of 1916. The most important issue is a cost-efficient and reliable forecasting and warning system. This always involves trade-offs. Reliability and redundancy are important issues. Older systems are always available as backup. The costs are for hardware, software and training and availability of staff 24/7. A full model train is used. This model train consists of an automated system, a model train which provides a forecast every 6 hours. It starts with an wind forecast from a global model. This provides input for a hydro-dynamical model that starts off the coast of Island and includes the whole of the north sea. Corrections are automatically carried out based on measurements in the north sea from meteorological weather stations and water level and wave measurements. Data exchange with all the countries surrounding the north sea is also essential.

Major issues to resolve are

-the trajectory of the storm. This information is often reliable 24 to 48 hours before the storm

-The phase of the storm with the tide. This can cause water levels differences of more than 1 meter.

- local phenomena e.g. seiches and/or successive shower lines which cause an additional storm surge in an Estuary. These phenomena call for a manual correction. Not everything fits in the model train. Manual corrections can also be carried out after model results are compared to results from other countries.

Users of flood alerts need references and information on uncertainty. In the past century water levels have been used as reference to determine the impact of a flood alert. More information is available, results from the 6 yearly assessment of flood defences and information comes from policy studies as VNK (Flood Risk in the Netherlands) and WV21 (Flood Risk in the 21st century). This information helps in determining the consequences of a breach in the flood defences.

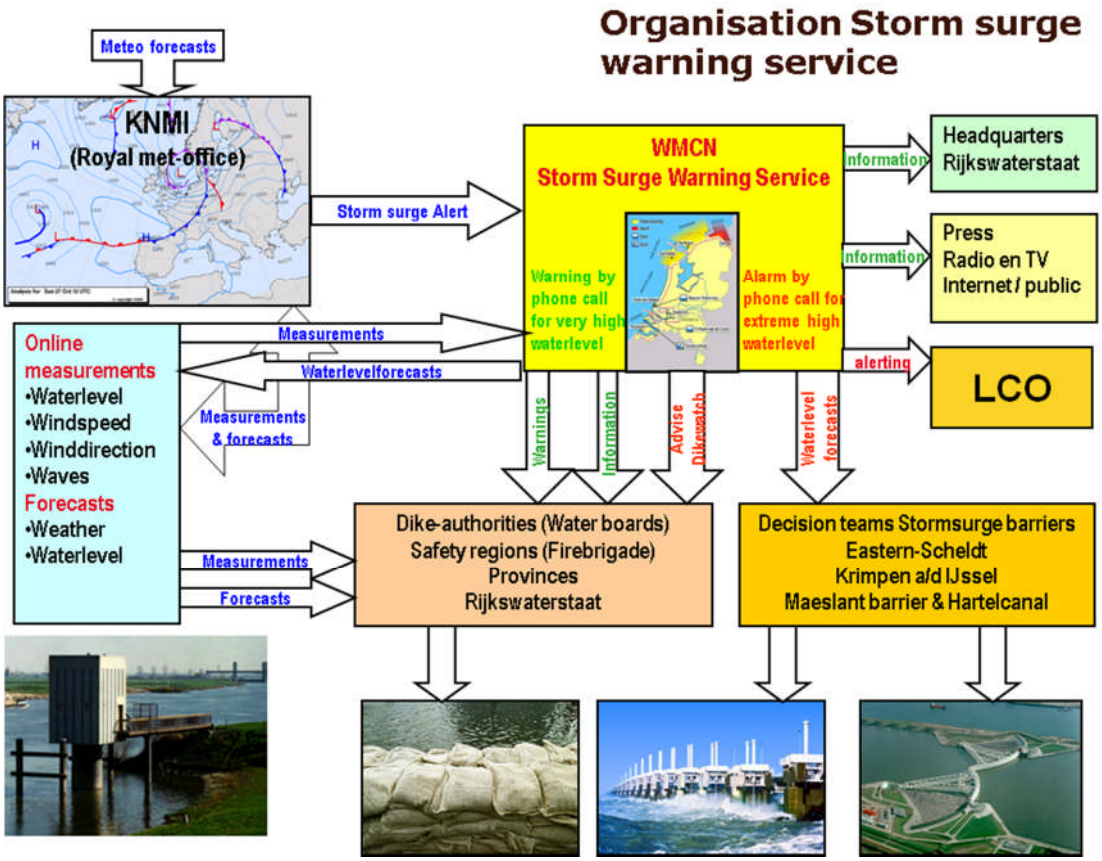
Information on uncertainty is provide by using the ensembles from the meteorological office.

Challenges or the future are

- giving more information on uncertainties.

- new references based on the new standards for flood defences in the Netherlands

- using wave information in flood forecasts
- giving information on dune failure in flood forecasts.



81. Simulation of Tsunami Inundation in City Scale Model

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KEYWORDS: tsunami modelling, inundation, quasi-3D model, 2D model, city scale model

ABSTRACT

Objectives: The 2011 Tohoku Earthquake Tsunami showed complex behaviour of tsunami inundation over the land, especially in city areas along the Japanese coast. The tsunami behaviour in these urban areas was different from rural areas and indicated importance of physical roughness (e.g. buildings, houses and streets) on inundation characteristics and hydrodynamic force estimations. The purpose of this study is to understand and validate two numerical models of tsunami inundation in the city area.

Methods: This study used quasi-three-dimensional (Q3D) model and two-dimensional (2D) nonlinear shallow water model for numerical simulation. Both models are hydrostatic. Q3D is based on Regional Oceanic Modeling System (ROMS; Shchepetkin and McWilliams, 2005) but vertical discretization are different each other. The two different numerical models are compared to the physical experiments of Seaside, Oregon, by Park et al. (2013), which examined tsunami inundation in an idealized urban shoreline at 1/50 scale.

Results: Both 2D and Q3D model agreed well with the experimental results on the strait street from shorelines. However, the numerical models were differed from the experiment at the points behind large scale buildings. The inundation depth and velocity of the 2D simulation tended to be smaller than those of the Q3D model especially further inland. This is because the 2D model allows for larger wave energy dissipation due to a fixed vertical velocity profile and excluded turbulence and vorticity modelling.

Conclusions: The 2D and Q3D model are available to estimate the damage of the tsunami in city scale but the accuracy of inundation depends on the local reflection and diffraction due to large scale buildings. According to the comparison of Q3D model and 2D model, it is likely that the 2D model underestimates the inundation extent and local hydrodynamic forces during the tsunami inundation process.

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85. Variations of Bankfull Discharge in Lower Reaches of Yellow River Channel and its Influence Upon Flood Control

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KEYWORDS: Bankfull Discharge, Flood Control, Flow Water Level

ABSTRACT

Based on the datum of the lower Yellow River from 1950 to 2014, this paper analyzes the changing course of bank-full discharge and the response relationship of it to the runoff of Huayuankou Station in the past more than 60 years. The result shows that before the water and sediment regulation of Xiaolangdi Reservoir in 2002 the bank-full discharge decreased slowly for the main, the values varied with the runoff of Huayuankou Station: large runoff made hard dominant ability, large bankfull discharge to form the main channel，the bankfull discharge in the lower reaches of the Yellow River reduced to 2260 m^3/s in 2002. After the regulation of water and sediments in the Xiaolangdi Reservoir in 2002, the bankfull discharge in the lower reaches of the Yellow River has been increasing year by year. In 2014, the bankfull discharge flow rose to 4250 m^3/s.

Influences of variations in the bankfull discharge in the lower reaches of the Yellow River exerted upon flood control are also analyzed in the paper. The results show that, with the decrease of the bankfull discharge in the downstream river channel from 7500 m^3/s in 1960 to 2260 m^3/s in 2002, the flow water level in a speed of 3000 m^3/s in Gaocun Stage Gauging Station rises 0.063m/yr. The water level with 7860m^3/s downstream flood flow in 1996 is 0.91m higher than that of 22300 m^3/s in 1958. The flow water level in a speed of 3000 m^3/s in the downstream channel-Gaocun Stage Gauging Station, has dropped 0.172m/y since 2002 as the bankfull discharge of 2260 m^3/s in 2002 increased to 4250 m^3/s in 2014.

Furtherly, research shows that, one of the most important way to increase the channel's capacity of flood is by regulating Xiaolangdi Reservoir to adjust the process of water into lower Yellow River and increase the dominant discharge

141. Reproducing the June 2007 Hull floods using radar rainfall

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KEYWORDS: Computer modelling, Digital Elevation Models

ABSTRACT

This work presents the results of the implementation of quasi-2D hydrodynamic model to characterise the uncertainty in inundation areas estimated with the use of radar rainfall (RR) estimates in urban areas. This is done in order to show how uncertainty in the radar rainfall estimation propagates to the estimation of affected areas and water depths within the City of Hull in the United Kingdom.

The event corresponds to that registered in June 2007, and the study area comprises the city and its corresponding rural area, accounting for a total surface of 87.7 km^2. The available data are a 5m Digital Elevation Model obtained by LiDAR, the rainfall measured by a gauge at the Hull University, the rainfall measured by a weather radar, and the flooded areas identified by local authorities.

The methodology incorporates the use of the bias-corrected radar rainfall field and the implementation of a correction factor of radar rainfall estimates using in-situ information from a nearby rain gauge. Hydraulic simulations of the event are carried out using the Itzï computer model developed at the Engineering Institute of UNAM (Courty & Pedrozo-Acuña 2016), which is implemented in a GRASS GIS environment and is able to manage input/output data in dynamic manner in time and space. The results will show a comparison of the differences in affected areas and water depths, calculated with the model using different radar-rainfall fields as forcing condition. This will provide important information on how an initial uncertainty in the rainfall field is propagated to the identification of affected areas within the city.

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163. The effect of prediction the flood zone with Using a mathematical model (Mike Flood) on river flood management in Dez and Karun rivers

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KEYWORDS: Flood Management, Dez River, Mike Flood, Flood Plain, Watershed

ABSTRACT

Subject the flood spreading in flood management at the end of the rivers that leads to the vast plains and flat, it is important and significant. Dez and karun rivers in Iran since the exception is not and after entering the plains of the khouzestan province, pass from flat plains with heights less than the river. In these areas, due to the plains vast and low-height in the side of river and the height difference negative between side of the river and flood plains around it, If the flood flow of rivers out and into the plain, Due to the low slope of flood plains, flood flow will remain in the river plains at long time. On the thirteenth day of April 2016, rainfall too much In the dez river Watershed, causing flooding and filling the reservoir of dez dam, that this led to the opening of the spillway gates of the dam and release the discharge in the river about 4850 cubic meters per second. Despite the low capacity of dez River in most points (less than 1,000 cubic meters per second) and flooded a large part of agriculture lands and villages in side of the river, but Because before the flood, flood zone predicted, therefore the flood was managed efficiently and reduce risks and costs. In this research, we try to explain the effect of prediction of Dez River flood zone on dez and karun rivers flood management during and after the flood(dez is the branch of karun river), which before the floods with the use of mathematical models(mike flood) was relatively accurate simulation.

179. Ice Jams Predicting Based on Neural Networks Model in Heilongjiang River

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KEYWORDS: River Ice Jam, Breakup, Flood, Forecast

ABSTRACT

In some high latitude areas, river/channel ice represents an important hydrologic element in cold environments. With the continuous accumulation of frazil ice from upstream due to low temperatures ice jams are created and the risk of flooding is increased. Heilongjiang(Amur) River is located at the most northern China where ice breakup brings the threat of severe damages and frequent disaster to life to many communities due to ice jam related floods in spring. Ice jam prediction methods are desirable to provide early warning and allow rapid, effective ice jam mitigation. Ice jam prediction models have historically been limited to empirical, stochastic or deterministic models which have the lack of an analysis of the complex and nonlinear physical processes involved.

The artificial neural network (ANN), has shown potential for modeling the behavior of complex nonlinear processes such as those associated with ice breakup and ice jam formation. The neural networks are devolped to predict the date of breakup ice and the occurrence of ice jams. The forcast data from 1958-2002 were included in the training set and ones from 2003-2015 were used for testing. The ANN model based on BP and improved by L-M algorithm was developed to forecast the date of breakup ice in the upper reach of Heilongjiang River. The errors between the forecasted and measured values are less than 2 days for the break-up date. All the forecasts are qualified according to the national standard of China. The neural network based on clustering technique is applied to forecast the occurrence of ice dam. The neural network classifier predicts whether a jam will or will not occur during breakup ice. Compared with the statistical model, the neural network clustering model functioned with an accuracy of 87%, and an accuracy of 67% for statistical model.The ice jam prediction based on the neural networks is capable of providing improved accuracy over statistical methods in obtaining a solution to a complex and elusive problem.

The models were found to provide excellent qualitative and quantitative predictions of ice jam to mitigate ice food disaster for northern rivers.

196. Application of dual frequency ground penetrating radar for ice jam flood prevention

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KEYWORDS: Ice Jam, Ice dam, Flood prevention, Ground penetrating radar, Noncontact measurement

ABSTRACT

In high latitude area, river has kinds of ice problems that cause flood disasters, such as ice jam, ice dam and so on. So it is important to obtain data of ice thickness and water depth distribution along the river for ice flood prevention. Based on ground penetrating radar principle, a dual frequency ground penetrating radar which could measure ice thickness, water depth and GPS coordinates at the same time was developed. The redesigned structure and improved principle of the radar were also presented in the paper. Field measurement at Longdao wharf section of Heilongjiang River in China was carryed out during the winter of 2015-2016. The main reasons for ice jam flood at Longdao wharf section were also analysed and the blast method under the ice cover was used to prevent ice jam flood which showed good effect.

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233. MERIT DEM: “Multi-Error-Removed Improved-Terrain DEM” for Global Flood Modelling, Dr Dai Yamazaki, JAMSTEC, Japan

261. Socio-hydrological flood models
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210. Predicting geomorphically-induced flood risk for the Nepalese Terai communities

Creed M.J.†, Dingle E.H.*, Attal M.*[1], Sinclair H.D.*, Mudd S.M.*, Borthwick A.G.L.†, Dugar S.**, Brown S.****

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KEYWORDS: Flooding risk, Sediment, River, Modelling, Nepal

ABSTRACT

Rivers sourced from the Himalaya irrigate the Indo-Gangetic Plain via major river networks that support ~ 10% of the global population. However, many of these rivers are also the source of devastating floods. During the 2014 Karnali River floods in west Nepal, the Karnali rose to around 16 m at Chisapani (where it enters the Indo-Gangetic Plain), 1 m higher than the previous record in 1983; the return interval for this event was estimated to be 1000 years. Flood risk may currently be underestimated in this region, primarily because changes to the channel bed are not included when identifying areas at risk of flooding from events of varying recurrence intervals. Our observations in the field, corroborated by satellite imagery, show that river beds are highly mobile and constantly evolve through each monsoon. Increased bed levels due to sediment aggradation decrease the capacity of the river, increasing significantly the risk of devastating flood events; we refer to these as 'geomorphically induced floods'. Major, short-lived episodes of sediment accumulation in channels are caused by stochastic variability in sediment flux generated by storms, earthquakes and glacial outburst floods from upstream parts of the catchment. Here, we generate a field-calibrated, geomorphic flood risk model for varying upstream scenarios, and predict changing flood risk for the Karnali River. A numerical model is used to carry out a sensitivity analysis of changes in channel geometry (particularly aggradation or degradation) based on realistic flood scenarios. In these scenarios, water and sediment discharge are varied within a range of plausible values, up to extreme sediment and water fluxes caused by widespread landsliding and/or intense monsoon precipitation based on existing records. The results of this sensitivity analysis are used to inform flood hazard maps of the Karnali River floodplain and assess the vulnerability of the populations in the region.

217. Analysis on SWMM Applicability in Rural Watershed Basin

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KEYWORDS: SWMM, DEM, Jiseok watershed

ABSTRACT

EPA's Storm Water Management Model (SWMM) is used throughout the world for planning, analysis and design related to storm water runoff, combined and sanitary sewers, and other drainage systems in urban areas. There are many applications for drainage systems in non-urban areas as well.

This study aim to review SWMM's rural area applicability. Study area is juseok watershed that around 80 percent of land use is farmland and mountain regions. This area happen to areas prone to floods. Materials of use included in rainfall data in Gwangju, DEM (Digital Elevation Model), degree of land use, Land cover. But outflow discharge did not exist. So, to analyze HEC-HMS model, HEC-HMS model parameter optimization conducted based on Neongju observatory. Compare and analyze both model. In the result of, SWMM model's discharges are more than HEC-HMS.

Research is lacking in domestic situations on flooding in rural areas. Therefore, the results of this study are thought to be able to reflect on future policy decisions and rural areas, disaster areas cope with disasters more effectively.

Acknowledgments

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233. MERIT DEM: Multi-Error-Removed Improved-Terrain DEM for global flood modelling

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KEYWORDS: Global DEM, Flood modelling, Satellite data

ABSTRACT

Digital Elevation Models (DEM) are fundamental data for flood modelling. While precise airborne DEMs are available in developed regions, most parts of the world rely on spaceborne DEMs which include non-negligible height errors. Here we show the most accurate global DEM to date at ~90m resolution by eliminating major error components from the SRTM and AW3D DEMs. Using multiple satellite data and multiple filtering techniques, we addressed absolute bias, stripe noise, speckle noise and tree height bias from spaceborne DEMs. After the error removal, significant improvements were found in flat regions where height errors were larger than topography variability, and landscapes features such as river networks and hill-valley structures became clearly represented. We found the topography slope of the previous DEMs was largely distorted in most of world major floodplains (e.g. Ganges, Nile, Niger, Mekong) and swamp forests (e.g. Amazon, Congo, Vasyugan). The developed DEM will largely reduce the uncertainty in both global and regional flood modelling.No more than 500 words (inclusive of title, references etc.).

261. Socio-hydrological flood models

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KEYWORDS: Socio-hydrology, feedback-loop, system-dynamics, long-term interaction.

ABSTRACT

Long-term feedbacks between humans and floods may lead to complex phenomena such as coping strategies, levee effects, call effects, adaptation effects, and poverty traps. Such phenomena cannot be represented by traditional flood risk approaches that are based on scenarios. Instead, dynamic models of the coupled human-flood interactions are needed. These types of models should include both social and hydrological variables as well as other relevant variables, such as economic, environmental, political or technical, in order to adequately represent the feedbacks and processes that are of importance in human-flood systems. These socio-hydrological models may play an important role in integrated flood risk management by exploring a wider range of possible futures, including unexpected phenomena, than is possible by creating and studying scenarios. New insights might come to light about the long term effects of certain measures on society and the natural system. Here we discuss a dynamic framework for flood risk and review the models that are presented in literature. We propose a way forward for socio-hydrological modelling of the human-flood system.

290. A Study on Hydrological Effect of Typhoon in the Gamcheon Basin

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KEYWORDS: Typhoon anlysis, Matrix analysis of the characteristics and impacts of typhoon, HEC-HMS

ABSTRACT

This Study applied actual precipitation data from 10 typhoons that had damaged Gamcheon Basin to and HEC-HMS model and optimized parameters. Moreover, data was extracted through a general matrix analysis on influential factors of typhoons: formation and development of typhoons, air-marine conditions and an impact assessment of typhoon by basin. As a result of conducting and HEC-HMS runoff simulation applying observed runoff and rainfall cause by five different typhoons, a calibration of the runoff and rainfall caused by five different typhoons, a calibration of the runoff model parameters was great with an average error of 4% compared with observed peak flooding; in particular, the time of concentration shoed little difference.

The study analysed the correlation between relatively limited observation events and typhoons effecting the Korean Peninsula and the flood damage in Gamcheon Basin. As a result, it is expected that a credible runoff analysis through continuous expansion of observed data and quantification of the uncertainty of runoff simulation results will enable the establishment of pre-emptive flood prevention system in cities and agricultural areas predicted to experience flood damage and regions vulnerable typhoon; this will eventually minimize human and property damage.

322. Quantifying sensitivity and uncertainty in a global flood model

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KEYWORDS: Global sensitivity analysis; model credibility; parameter screening; hydrological descriptors; uncertainty analysis.

ABSTRACT

The complexity of certain global flood model (GFM) formulations has meant that whilst results have been produced which look promising, the avenues of further success and improvement remain obscured (Trigg et al, 2016). This is due to the necessary assumptions and parameterisations required to make the (relatively) scarce globally consistent data sets suitable for a GFM. The particular GFM to be examined here was first presented by Sampson et al.(2015), which via pre-processing and statistical methods means 30+ parameters exist to mould the data into a necessary input for processing by the computational backbone, LISFLOOD-FP.

A global sensitivity analysis was employed using the SAFE toolbox (Pianosi et al, 2015). Morris Method among others was used to perform a preliminary screening of the parameters, and distinguish which are the most important to consider in any systematic improvement to the GFM framework. This is imperative to replace the currently presumptive approach taken to the the calibration of GFM's, which is so far heavily generalised.

Also considered is how these parameters can change in importance based on the local setting of the GFM, with regards to local climactic, geographic or hydrologic features. Hence the expectation is that spatial variability will have an impact on the importance of the parameters, and that this can be correlated with relevant climatological or hydrological descriptors. Such information helps inform modellers how best to spend time on improving the model with locally collected data, or a more nuanced calibration technique.

Sensitivity indices of the most important parameters found conclude the work thus far, and are to be accompanied by clarification on the reason for the respective indices' significance. This work is integral to further uncertainty analyses, which can then incorporate the role of data quality and location into the GFM framework, thereby allowing current hazard maps to be accompanied by confidence bounds, and more generalised, systematic improvements to the GFM framework become conceivable.

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357. Flood frequency analysis using converging Flood-Duration-Frequency (Q-D-F) model application to Wadi Abiodh, Biskra (Algeria).

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KEYWORDS: Flood Frequency analysis; Characteristic duration; Converging Flood-Duration-Frequency; Synthetic Mono-Frequency Hydrograph; Abiodh wadi; Arid areas; Biskra; Algeria.

ABSTRACT

In recent decades; Algerian cities have experienced devastating floods caused by rainstorm of short duration and high intensity. In the Saharian areas, despite their penury in water, where the climate is generally very dry and hot, they are not safe against the phenomenon. Nevertheless, the phenomenon is less studied in this area. The definition of the hydrological regime is an interesting and obligatory tool to design, assess infrastructures, management of water resources and reducing severe human and material losses. One of the privileged tools used by hydrologists is the Flood Frequency Analysis (FFA).
This work presents a Flood Frequency Analysis (FFA), which takes into account the notion of characteristic duration. The Abiodh Wadi catchment in the area of Biskra is a very interesting example for studying floods in arid areas climate using converging QDF method. Instantaneous flood discharge data from Foum El Gherza station, *downstream the Wadi,* is used to develop flood-duration-frequency (QDF) curve, using the so-called converging model. Six distributions widely used in FFA were considered in this study: The generalized extreme-value (GEV), Normal (NORM), Gumbel (Gumbel), two parameter log-normal (LN),
Pearson type III (P3), Log Pearson type III (LP3) and Frechet (EV2). Different models selection criteria were applied. The results showed that the Pearson type III (P3) distribution is the more appropriate to fit the considered data. The root mean square error (RMSE), the Bias and the visual investiga
tion shows that the L-moment method is better than the moment method and the maximum likelihood method for the estimation of the distribution parameter. These results are then used to fit QdF curves. Therefore, the findings from this research is to develop a statistical model describing the catchment flood regime that can be useful in the matter of water resource management and sustainable development in a region suffering from water penury and flash floods risk.

360. Flood inundation modelling in data sparse deltas – The case of the Mekong Delta

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KEYWORDS: Delta; Flood Inundation; Mekong

OBJECTIVES

An estimated 7% of global population currently live in deltas (Day et al., 2016), with this number increasing, particularly in developing countries. As a result, human induced impacts, coupled with climate change have already impacted on the flood dynamics in deltas, with this likely to intensify in the future. The numerous threats creates a large number of scenarios that need to be evaluated. An additional challenge is that many of the world's most threatened deltas are in areas that can be considered data-sparse. Therefore, to assess flood impacts, a flood inundation model that is both computationally efficient and flexible in its setup is required so data-sparse deltas can be assessed. As model input data for these regions are limited, we have chosen an intermediate scale that compromises between the computational speed of a global model and the detail of a case study specific bespoke model. Therefore, we have built an intermediate scale flood inundation model of the Mekong Delta using freely available data to answer the following questions: 1) How much detail is required to accurately simulate flooding in the Mekong Delta? , 2) What characteristics of deltas are most important in flood inundation models?

METHODS

The model is built with the LISFLOOD-FP sub-grid flood inundation model (Neal et al., 2012) at 540m resolution using freely available data and a vegetation-removed DEM (Digital Elevation Model). A hindcast tidal downstream boundary was generated using harmonic analysis.

RESULTS

Results demonstrate the importance of vegetation removal in the DEM for inundation extent and the sensitivity of water level to roughness coefficients. The propagation of the tidal signal was found to be sensitive to bathymetry, yet data availability for this is poor so the modeller has to be careful in their choice of interpolation. Supplementing global river channel data with additional localised data led to only minor improvement in results.

CONCLUSIONS

An intermediate scale flood inundation model of the Mekong Delta was successfully built using freely accessible data, allowing for current and future flood analysis of the Mekong Delta using numerous climate change and human induced activities (e.g subsidence) scenarios. The results from this study can help guide other flood analysis of data-sparse deltas owing to the models utilisation of freely available data with a global coverage.

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371. Simulation of a drainage network segment in Maringá, Paraná, through the use of SWMM

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KEYWORDS: Urban drainage; Urban flood; SWMM model; Flood simulation; Urban water management; Flood management.

ABSTRACT

The construction of cities and the consequent soil sealing may lead to the issue of urban flooding, whenever the amount of precipitated water exceeds the capacity of the drainage network, especially during heavy rains. This mentioned situation occurs at the intersection between the avenues Guaiapó and Palmares, in the city of Maringá, Brazil. At this intersection point, the drainage system has been inefficient at draining the intense rainfall water quickly enough. Frequent flooding is observed in the area, resulting in money damage due to the collapse of walls, residences and roads. The purpose of this paper is to diagnose the capacity of the urban drainage system that discharge at the intersection between the avenues Guaiapó and Palmares, in different rainfall intensities corresponding to different return periods.

1. INTRODUCTION

Urbanization process brings deep transformations in soil use, affecting hydrologic responses in urban areas. The most notable effects are increased run-off and decreased infiltration, with floods and urban inundation as direct consequences (JUSTINO; PAULA; PAIVA, 2011).

Some other factors of urban floods are the inefficient pluvial water drainage systems; accumulation of solid waste and litter in manholes and water bodies, which hinder proper drainage; slower alert systems, inefficient and with low coverage; and the inexistent or inadequate management for water drainage planning by municipalities (JUSTINO; PAULA; PAIVA, 2011).

The precipitation intensity observed in the city of Maringá, Brazil, has presented high rates and, consequently, some flood points are being observed in the city. At the interchange of Guaiapó and Palmares avenues, the urban drainage net has been shown inefficient at draining the intense rainwater quickly enough, resulting in frequent floods.

In this context, the purpose of this work is to evaluate the urban drainage net unloading around the intersection between the avenues Guaiapó and Palmares in the city of Maringá, Brazil, and to run simulations, through a computer program, in order to elaborate possible scenarios.

2. METHODOLOGY

Initially the water basin to be considered was defined, through the use of the computer program of Geographic Information System (GIS), *ArcGIS*® and satellite images made available by *United States Geological Survey (USGS).* Thus, it was observed that the defined study area is located at Osório creek catchment basin.

The establishment of the boundaries of the sub-catchment area that contributes to the drainage of the study area was traced using the digital file of the project of the drainage system made available by the Municipality of Maringá.

The study site was visited in dry and rainy seasons in order to make the data consistent and also to assess the condition of the catchbasins, regarding maintenance, cleaning and compliance with the project.

The performance of the drainage network was simulated by the software *SWMM 5.0 (Storm Water Management Model)* to heavy rains, in a fixed 5-minute duration and return periods of 3 years, 5 years and 10 years.

3. RESULTS AND DISCUSSIONS

The definition of the catchment basin consisted on a partial result. In this case, through topography and the software *ArcGIS*®, the catchment basin was defined and entitled Osório creek catchment basin (Fig 1).

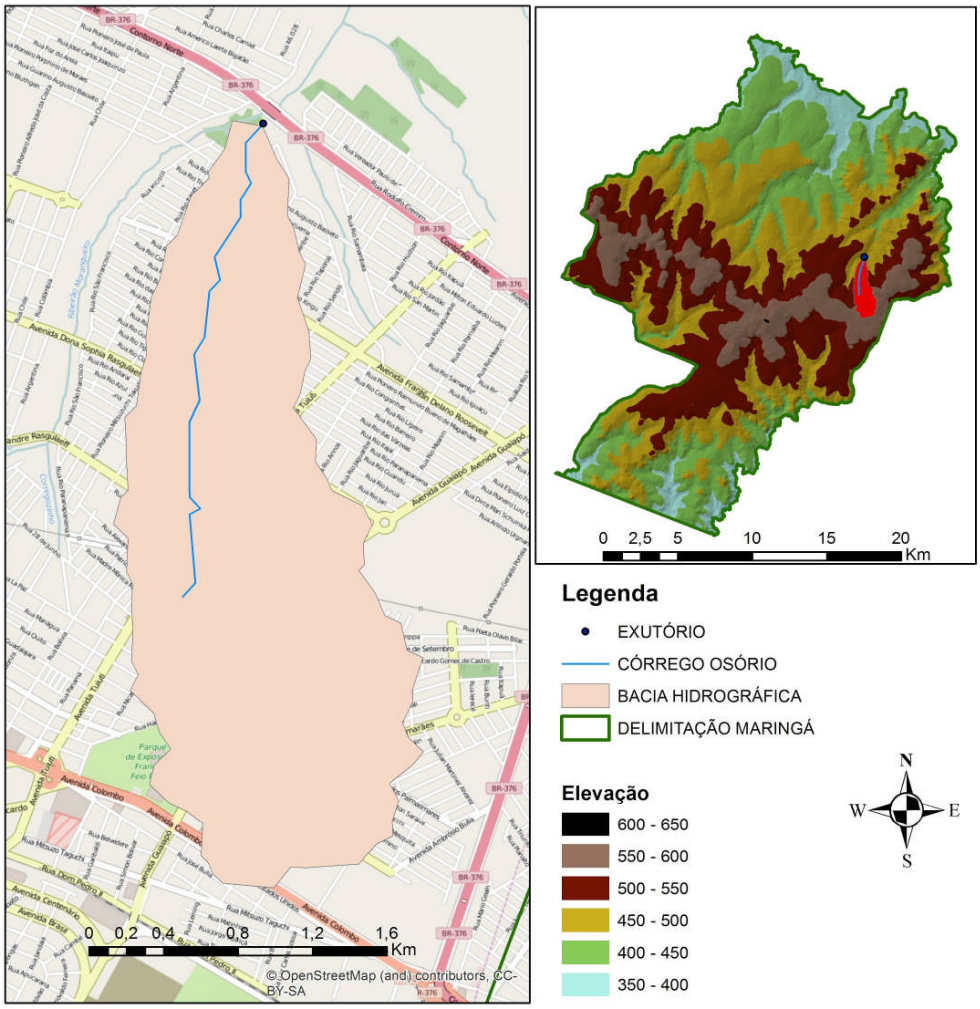

Fig 1. Osório creek catchment basin

Then, the drainage sub-catchment, catchbasins and conduits foreseen in urban drainage design were inserted at *SWMM 5.0*, showed in fig 2.

Once drainage sub-catchment was defined, the equation of heavy rain was needed (Eq. 1). Thus, the software *Plúvio 2.1* was used for such purpose, and the result was:

$$i = \frac{KT^a}{(t+b)^c} \qquad \text{Eq. 1}$$

The constants were:

K = 1341,717; T = Return period; a = 0,175; t = Rain duration; b = 15,461; c = 0,838; i = precipitation ($mm.h^{-1}$).

Fig 2. Detail of the definition of drainage sub-basins, catchbasins and conduits in the EPA SWMM program.

The values for maximum speed and flow were obtained in the modeled system and shown in Table 1.

Table 1: Velocidades máximas e vazões para diferentes tempos de retorno e intensidades de chuva.

Return Period (Years)	**Precipitation ($mm.h^{-1}$)**	**Maximum Speed ($m.s^{-1}$)**	**Maximum Flow ($m^3.s^{-1}$)**	**Pipe Diameter (m)**
3	129,60	3,83	0,37	1,00
5	141,72	3,99	0,43	1,00
10	159,99	4,21	0,51	1,00

Through the piezometric profiles of the critic segment, Fig. 3, it wasn't observed any overflow point in the drainage system at the return periods of 3, 5 and 10 years.

4. CONCLUSION

It can be concluded that the projected drainage network is suitable for the studied area, since no overflow was observed and the maximum speed is below the value stipulated by the standard NBR 9649:1986, which is 5 $m.s^{-1}$.

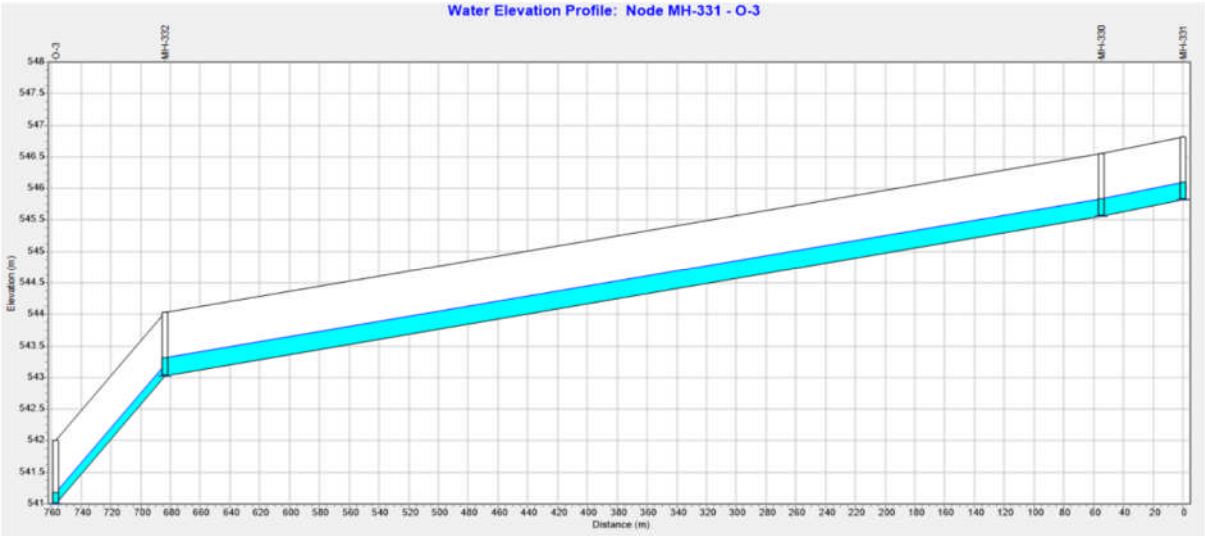

Fig 3. Piezometric profiles of the critic segment at the return periods of 3, 5 and 10 years.

Therefore, it can be deduced that the flooding problems observed in the studied area may be related to the absence of cleaning and maintenance of the urban drainage network, and the presence of solid waste and sediments carried in rainfall water, which may obstruct the urban drainage system.

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Rainfall forecasting

83. A coupled atmospheric-hydrologic modeling system for flood forecasting with real-time data assimilation

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83. A coupled atmospheric-hydrologic modelling system for flood forecasting with real-time data assimilation

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Key words: a coupled atmospheric-hydrologic modeling system; flood forecasting; weather research & forecasting model (WRF); probability distribution model (PDM); real-time data assimilation.

Abstract: Numerical Weather Prediction (NWP) models are gaining more and more attention in providing high-resolution rainfall forecasts for real-time flood forecasting. In this study, a atmospheric-hydrological modeling system is developed by coupling the newest-generation mesoscale NWP model, i.e., the Weather Research & Forecasting (WRF) model with the Probability Distribution Model (PDM) to make real-time flood forecasts in a small catchment. Dual data assimilation is carried out for real-time updating of the forecasting system. The 3-Dimensional Variational (3-DVar) system is integrated with the WRF model to assimilate radar reflectivity and traditional meteorological data; meanwhile the Auto-Regressive Moving Average (ARMA) model works with PDM to assimilated real-time flow observations. Four 24h storm events with different characteristics of rainfall-runoff responses are selected in the Brue catchment of southwest UK to test the performance of the coupled system. The forecasting accuracy is found to be largely improved by incorporating the WRF forecasted rainfall when the forecast lead time is beyond the catchment concentration time. The assimilation of real-time radar and meteorological data also show great advantage in improving the NWP rainfall forecasts.

Risk mapping

229. Floods Risks in Saharan Regions – Case of Bechar City

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229. Floods Risks in Saharan Regions - Case of Bechar City -

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KEYWORDS: Saharan regions, Wadi Bechar, hazard map, floods, Bechar City.

ABSTRACT

The Saharan regions are not protected from floods, in the last years Bechar region in Algeria has experienced several floods because of the overflow of Wadi Bechar. The greatest floods were on October 2008 following the precipitations fallen during the days 08 and 09 of October. These floods resulted an important human and material damages. The total of precipitation in 48 hours is 99 mm for an annual average estimated to 79.45 mm ; This unusual amount for Bechar city was a determining factor in the overflow of Wadi Bechar. The present study aims firstly to analyse the factors impact that favor the overflow of Wadi Bechar as a climatic factors (precipitation); the morphological characteristics of Wadi Bechar and land use changes; Secondly is to realize a hazard map of the floods in this region to determine the flood area. The realization of this map requires a hydrological study of the region to calculate the maximum flood flow of Wadi Bechar and using ArcGis and HEC-RAS software.

Sustainable approaches to flood risk management – “Blue-Green” or “Sponge” Cities

355. A lucky strike: unintentional flood risk reduction by traditional riverine land management in the Sió River basin (NE Iberian Peninsula)
Mr Jordi Tuset, University of Lleida, Spain

377. The Implementation of Sustainable Flood Risk Management

Mrs Nurul Mohd, De Montfort University, United Kingdom

355. A lucky strike: unintentional flood risk reduction by traditional riverine land management in the Sió River basin (NE Iberian Peninsula)

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KEYWORDS: flood lamination, agricultural impact, flood plain management

ABSTRACT

The analsys of two important flash floods occurred in the Sió River basin in November 2015 and November 2016 respectively has pointed out the unpremeditated effect of traditional riverine land management on flood mitigation.

Indeed, in this area, farmers have traditionally cultivated the flood plains, thus gaining land to the river, eventually constraining the channel to a very narrow section (1.3 m deep and 2 m wide). This narrowing of the channel results in a reduction of the overbank flow; therefore, floods flow over the flood plains more easily, thus slowing the flow and infiltrating part of the runoff volume and, consequently, laminating the flood downstream. Another factor that could contribute to the dramatic flood lamination observed in this basin is the high suspended sediment load, which thickens the flow and thus reduces its velocity. In any case, the 2015 peak flow was laminated from 150 m^3/s to 45 m^3/s in only 30 km of river, and to 8 m^3/s in 60 km.

This unplanned lamination limited very much the damages of the 2015 flood in the highly exposed town of Agramunt; nevertheless, these damages were great because, besides many flooded households, four people died.

Due to this ancestral non-intended flood lamination effect, recent urban growth in Agramunt has occupied the flood plain, thus increasing flood exposure. Therefore, this serendipitous land management should be preserved and even favorised in order to protect over-exposed downstream towns.

377. The implementation of sustainable flood risk management

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KEYWORDS: Sustainable, urbanisation, flood risk management, natural flood management strategies, Blue-Green Infrastructure

ABSTRACT

Flooding is a common natural disaster that happens around the world. It is expected to escalate due to the combination of climate change, urbanisation and economic growth. Any flood event could cause loss of inhabitant's live and livelihood, extensive destruction to the environment, ecology system and economic damages. As a consequence of rapid urbanisation and economic growth, numerous grey infrastructures were constructed. This including flood resistance structures such as flood walls and embankments. This current method of 'grey' solution for flood resistance has been proven to be unreliable and has failed to accommodate the aspects of sustainable, hydrology, ecology and environmental. Grey infrastructures are expensive to build, sometimes it does not meet its purpose and exacerbates carbon footprint. Therefore, the aim of this research is to implement sustainable approach or known as Natural Flood Managament (NFM) in the Flood Risk Management (FRM). It is an important component in the climate system and could play a key role in reducing the carbon emission to the atmosphere as well as mitigating flood problems.

England has started paradigm shift from grey to green/natural initiative to achieve sustainable development but still in its infancy and only recently the UK legislation has adopted the SuDS (Sustainable Urban Drainage System) manual in the FRM. In In recent years, there has been extensive research on NFM. A UK research consortium has also developed a new sustainable strategy called Blue-Green Infrastructure (BGI) which generates benefits in economic, environmental and socio-cultural. The study shown that it could reduce climate change and air pollution, improve water quality, balanced ecosystem, flood alleviation as well as socio-cultural benefits.

This study uses a flood modelling software to analyse the depth and the width of the flood spread. Conventional 2D modelling is often used to show 2D flood map but it is prevailing means for the purpose of showing to people about the risk of flooding in particular area. Therefore 3D terrain model is important nowadays as it can visualise more details of the geomorphology and urban micro-features (physical infrastructures such as buildings, roads, pavement, bridges, alleyways, etc) and give more accurate results for flood mitigation.

Sheffield is known for its significant flooding in 2007 therefore this paper considered Sheffield as a real case study of an urban flood modelling in a TUFLOW software to analyse the water movement through NFM strategies to acquire the flow velocity, flood depth and the extent of inundation. The flood models will be compared to use the NFM strategies and without it. The main finding of this research is to demonstrate that the NFM could slow the flow to mitigate the flood inundation.

Urban flood risk management

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72. Scientific Knowledge Based Decesion Making for Disaster Reduction: How was the problem of informal settlers resolved?

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KEYWORDS: Operation and Maintenance, Flood Mitigation, Informal Settlers, Decision Making

ABSTRACT

Objectives: This paper aims at proposing methods of using scientific based knowledge for activities in disaster reduction. Developing countries often face difficulties in operation and maintenance (O&M) of disaster reduction facilities because of limited budget and capacity. The facilities become deteriorated, and informal settlers encroach the facility areas. The paper examines how a scheme of scientific knowledge based decision making was established for O&M of flood control facilities in Ormoc City, the Philippines.

Methods: Ormoc City in Leyte Island suffered from Typhoon Uring in 1991, and some 8,000 people were dead or missing because of flooding. Department of Public Works and Highway (DPWH) and city government jointly implemented the flood control project of improving river channels, constructing sabo-slit dams, and reconstructing bridges under the support of the Japanese Government. Semi-structured interviews were conducted in November 2016 to staff of the city government, DPWH, Japanese aid agency, and experts involved in the project. Also, project documents and studies were reviewed.

Results: The flood control facilities were properly operated and maintained by flowing scientific knowledge to O&M activities on the ground. The city government and the local office of DPWH jointly established the flood mitigation committee to promote the activities. In particular, the committee aims at controlling encroachment in river areas not to repeat the same scale of flood disasters. Some 3000 victims of the 1991 flood were informal settlers lived inside river areas. Engineers of DPWH and the city government explained importance of O&M with scientific data at the committee meetings to barangay captains along rivers and requested them to monitor facilities status and encroaching activities. The barangay captains are the heads of the lowest layer of the government administration system and are in the good position to conduct disaster reduction activities on the ground. The city government has allocated O&M budgets annually. The engineers explained the necessity of the

budgets with engineering information to Mayor and city council members. According to decisions of the committee, the city government has removed buildings illegally constructed inside rivers, and conducted O&M activities, such as cleaning up programs, painting facilities, and cutting grasses.

Conclusions: The case of Ormoc City shows that science and technology is useful for O&M activities of flood control facilities. The organizations concerned could establish a scheme of a committee for decision making of O&M and succeeded in controlling encroachment of informal settlers.

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133. Valuing Systemic Resilience in Urban Flood Risk Management

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KEYWORDS: Resilience, systems, valuation and appraisal, flood risk, cities

ABSTRACT

The Urban Flood Resilience in an Uncertain Future project (EPSRC: 2016-2019) aims to make urban flood resilience achievable through transformative change using whole system approaches. Here we present the intial concept and design of a componet of the project focused on the evaluation and appraisal of blue/green and grey infrastructure design solutions. This is needed in order to help expand the capacity of integrated systems using Blue / Green + Grey infrastructure designs to contribute to sustainable urban flood resilience from local to national scales. In this paper we examine two key research questions: are we capturing the full dimensions of value in current appraisal of blue/green and grey infrastructure adaptation designs?, and if not, how do we better value the impacts/benefits of innovative designs across multiple infrastructure sectors and domains (e.g. social, technical, environmental, economic)? In seeking to address these questions we examine the current approach to system valuation from multiple disciplines in order to identify barriers and oppurntunities for better valuation of the system benefits of urban flood resilience solutions. The need for new design methods and decision support tools that co-optimise inter-operability of the urban flood risk and water management systems with other urban systems including transport, energy and land-use will also be explored, and the methodological steps required to achive the overall study aim will be outlined.

257. Economic evaluation of potential adaptation strategies against sea level rise in Los Angeles County

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KEYWORDS: Flood Adaptation; Cost-Benefit Analysis; Adaptation Pathways; Flood Risk Assessment

ABSTRACT

Introduction/objectives

The National Research Council estimated for Los Angeles County (LAC) a likely sea level rise of 0.5m in 2050 and 1.4m in 2100, which raised many questions regarding the coastal vulnerability of LAC (NRC, 2012). The aim of this study is to assess potential flood damage and risk in LAC for various sea level rise scenarios and to evaluate potential adaptation strategies for LAC in terms of their costs and benefits.

Moreover, we assessed different adaptation pathways, to evaluate the effects of delay and alternating adaptation options, and how they influence coastal flood risk in the greater Los Angeles area. Our method is a systematic approach for evaluating the economic desirability of flexible adaptation strategies that are robust to uncertainty in climate change impacts. Adaptation pathways are defined as a sequence of policy actions that can be used for adapting to changing flood hazard conditions. Adaptation pathways are often used conceptually to help visualise a decision-centred approach to adaptation(e.g. Wise *et al.*, 2014), but have lacked systematic evaluation using Cost-Benefit Analyses (CBA). By doing so, we will gain insights into the economic efficiency of transitioning from an initial adaptation strategy to an alternative one after a certain period when learning about climate change scenarios has occured.

Methods

A flood damage model is used to assess the total economic damage for each future scenario. Subsequently, probability loss curves are developed to calculate the (reduced) flood risk or 'expected annual damage' (EAD). Lastly, the EADs are used in three types of CBAs: (1) the economic effectiveness of implementing the strategies now, (2) the effects of delaying the implementation, and (3) the effects of transitioning from an intial strategy to a second strategy after a certain delay period.

Results

Initial results show an EAD of about $100 million per year without sea level rise, that will increase to about $300 million with the projected 1.4m sea level rise in 2100. Three adaptation strategies, varying from smale scale resilience measures (e.g. floodproofing of houses) to large scale engineering adaptation measures, are proposed with initial investment costs ranging between $0.5 billion up to $9.5 billion.

Conclusions

The results can support decision makers in getting a better understanding of future flood risk and the economic attractiveness of potential adaptation options in the LAC area.

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297. Formative Scenario Analysis for the definition of consistent system scenarios to evaluate the effectiveness of non-structural measures in flood risk management

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KEYWORDS: Flood Risk management; Non-structural measures; Flood resilience; Formative Scenario Analysis.

ABSTRACT

According to EU Flood Directive, prevention-oriented approaches should be the preferred way to gain flood risk management, with a particular attention to non-structural measures aiming at reducing the consequences of floods rather than directly act on its characteristics. The lack of data on the effectiveness of such measures remains as the main obstacle to the achievement of this goal. This represents also a big difficulty for stakeholders who are willing to adopt them.

This work proposes a methodology to construct well-defined sets of assumption for the development of consistent system scenarios in which non-structural measures for flood defending are implemented, using Formative Scenario Analysis FSA (Scholz and Tietje, 2002; Mazzorana et al., 2009).

The scenarios can be the starting point to study the effectiveness of combinations of non-structural measures, thus giving an important contribution to the different actors having a decisional role in flood risk management.

The main advantage of this method is its double flexibility: on one side, the scenarios derived through the FSA can be used for different case studies; on the other side, the analysis can be extended including the study on the implementation of different non-structural measures, according to new occurred necessities.

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372. Solid waste and the problem of urban floods

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KEYWORDS: Urban Floods, Solid waste and stormwater, Urban water management, Urban solid waste and floods, Flood management, Solid Waste management.

ABSTRACT

This paper aims to study the problems of urban flooding, having as study factor the urban solid waste, either by disposed waste in public roads or wrong packaging by population. Urban areas represent the most significant anthropogenic interventions in the natural environment. Consequences of the urbanization process, population growth and relative increases in consumption, not always in a responsible way, end up resulting in the excess of solid waste. This solid waste left in public roads aggravates floods caused by obstruction of the urban storm drainage system. It should be considered that the urban stormwater drainage system, when dimensioned, was designed exclusively for rainwater and eventually for other types of water runoffs, but not for solid waste collection. Solid waste makes it difficult to drain rainwater from a gutter, located on the public road, to a body of water, due to the formation of waste banks in the beds and the obstruction of the sewers. Difficulties are found in quantifying the amount of solid waste that gradually accumulate in storm drains and public roads, due to the various sources of this waste. It was observed through the fieldwork in different cities and through local visits that the packaging and destination of solid domestic or construction waste does not happen correctly, taking as an example the cities of Porto Alegre (RS), Londrina and Maringá (PR) in Brazil. The population is driven by consumption through different types of media, sometimes purchasing products without needing it. On one side is the population, who irresponsibly consumes and disposes products, on the other side, the system, whether private or public, that must manage the waste, and also the maintenance of the urban storm drainage system, as the three main factors related to urban floods and their implications for the population. Therefore, actions are suggested aiming minimize the effects of each of these factors, starting with the environmental education of the population with respect to what they consume and how they should dispose their waste. This action perhaps presents the greatest difficulty, taking more effort into realizing and perceiving the changes. Finally, the responsibility of competent bodies, the building and setting up of effective projects able to avoid the collapse of catchment water systems in times of great rainfall rates, having adequate technical conditions to discharge a large volume of water, avoiding disturbance to the local people and the environment.

405. Numerical Simulation and Risk Analysis of Urban Dam-break Flood Based on MIKE FLOOD

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KEY WORDS: dam-break; flood evolution; risk analysis; MIKE FLOOD

ABSTRACT

Objectives

Based on MIKE FLOOD, this paper studies on the dam-break flood evolution process in the downstream areas of Minzhi Reservoir which located in Shenzhen, China. Calculates the flood hydrograph of dam-break and the flood developing process under different failure situations including instantaneous dam-break (partial dam-break as well as full dam-break) and gradual dam-break. Finally draws the flood innovation maps to make the risk analysis.

Methods

This study adopts two breach mechanism, instantaneous dam-break (partial dam-break as well as full dam-break) and gradual dam-break. Based on different reservoir's water levels (design water level and check water level), flood hydrograph of dam-break under four operating conditions was calculated.

MIKE FLOOD is a system that integrates the one-dimensional model MIKE11 and the two-dimensional model MIKE21 into a single, dynamically coupled model. In this study the one-dimensional river model MIKE11 was built by river cross-section data, and the two-dimensional flood plain model MIKE21 was built by the scatter data. We choose lateral links to allow a string of MIKE21 cells to be laterally linked to a given reach in MIKE 11 to construct the MIKE FLOOD model.

Results

Finally the flood innovation maps at different times under 4 operating conditions are obtained. And four typical positions where the life and property highly centralized and most submerged are chosen for detailed analysis. We obtain the water depth and velocity change graphs of the 4 typical positions under 4 operating conditions. The flood risk information has been analyzed, including inundation range, maximum water depths and flood velocity.

Conclusion

This paper take Minzhi Reservoir as a research object to simulate dam-break flood evolution process in the downstream areas. The results of the study are follow:

1. Calculates the flood hydrograph of dam-break under different failure situations. Result shows that the peak flow of instantaneous dam-break is larger at the beginning of the dam break. Gradual dam-break peak flow is relatively small when the deformation of seepage failure develops to the upper of dam.

2. Based on MIKE FLOOD, integrates the one-dimensional model MIKE11 and the two-dimensional model MIKE21 into a single, dynamically coupled model by the lateral links to obtain the submerged information.

3. Draws the flood innovation maps. And for the typical areas, risk information is discussed in detail, including inundation range, maximum water depths and flood velocity.

406. The Effect of Deep Tunnel and LID on Urban Stormwater Management in Guangzhou of China

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KEYWORDS: deep tunnel; pollution; LID; DongHaoChong basin; SWMM

ABSTRACT

Objectives

The DongHaoChong basin is located in the central city zone of Guangzhou City. Waterlogging and combined sewer overflow pollution are serious problems during the rainy season. Therefore, a deep tunnel for the DongHaoChong basin has been planned and the LID (Low Impact Development) measures have been considered. In this paper, the urban rainstorm model of the DongHaoChong deep tunnel drainage system, built on the basis of the SWMM (Storm Water Management Model), is described. The SWMM was built to evaluate the effectiveness of LID measures and different regulation scenarios of the DongHaoChong deep tunnel drainage system. And both the interception effect of pollution and the degree of mitigation of flood were analyzed.

Methods

The flow and water quality in the study area can be determined from the SWMM simulation results. Additionally, this model can simulate not only on a single rainfall event dynamically but also the runoff generated by continuous rainfall, the water quantity, and water quality changes after importing the drainage network system. Basic data for DongHaoChong District, such as its topographic maps, satellite images, drainage network diagrams, and land use types, were used to build the DongHaoChong urban rainstorm model.

Results

Combining the LID and deep tunnel, we could find that the reduction of runoff and pollution were obvious. The simulation results for rainstorms with different design recurrence periods in terms of the water quantity of the catchment outlet, total suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total phosphorus (TP), total nitrogen (TN), and ammonia-nitrogen (NH_4-N) pollutant load are analysed. The reduction in each index after analysis of the simulation results listed in Table 1.

Table 1. Reduction of runoff and pollution per unit time

Rainfall of intensity	Water quantity/%	TSS/%	BOD/%	COD/%	TP/%	TN/%	NH_4-N/%
P = 0.2	43.34	26.37	54.6	31.47	34.98	52.6	53.75
P = 0.5	42.69	7.36	45.32	12.01	16.39	51.04	52.07
P = 1	42.39	4.59	35.83	6.57	8.92	46.81	47.87
P = 2	42.06	3.09	26.68	3.49	4.52	43.04	44.04
P = 5	41.71	2.46	16.95	2.49	2.55	38.35	39.22

Conclusions

The flood control and drainage capacities of the region were improved by the construction of the deep tunnel. Furthermore, with the LID measures and deep tunnel, the pollution could be reduced and the reduction rate was higher during the low repetition period of rainfall.

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