Abstract Proceedings

5th International Conference on Flood Management (ICFM5)

- Floods: *from* Risk *to* Opportunity -

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Organized by:

ICFM5 Secretariat at
International Centre for Water Hazard Risk Management (ICHARM)
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Public Works Research Institute (PWRI)

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Foreword

Three years between the two ICFM meetings were overloaded with catastrophic flood events including Japan, Pakistan, China, United Kingdom, North America, and Brazil, just to mention a few. They took a lot of lives, damaged the economies of the countries, ravaged the environment and generated impacts far outside of the watershed boarders. They brought to the surface a new reality – much more interconnected world subject to large scale floods and other hazards. Timing, location and magnitude of these hazards are subject to various sources of uncertainty that generally create higher socio-economic risks. This new reality calls for the international community to exchange experience, improve the knowledge and significantly invest in building capacity necessary to deal with future flood events. The Fifth International Conference on Flood Management and contributions in these Proceedings are offering insights in the current state of flood management around the world and will be an important forum for interdisciplinary exchange among flood management professionals, scientists and representatives of various governmental bodies responsible for flood mitigation, preparedness, disaster response, and recovery.

Slobodan P. Simonovic,
Chairperson, ICFM Ad-Hoc Committee
London, Canada, August 2011

Preface

The first International Conference on Flood Management (ICFM) was held in Kassel, Germany, in 2000 under the name of the International Symposium on Flood Defense (ISFD). It was followed by ISFD2 in Beijing 2002, the 3rd in Nijmegen in 2005 and the 4th in Toronto in 2008. After the Toronto event, it was decided to change the name from ISFD into the International Conference on Flood Management (ICFM), rephrasing flood defense to flood management. This was to reflect the evolution of the view on floods from an enemy to fight against to a partner to live with.

ICFM is a unique organization established and mainly participated in by grass-root practitioners engaged in flood management such as government officers, private company professionals, researchers and internal organizations. It is the only conference solely dedicated to floods. But naturally the subjects include all excess water disasters such as landslides, debris flows, storm surges and tsunamis. This time tsunami is specially focused and discussed with the six-month experience after the Great East Japan Earthquake and Tsunami.

I greatly appreciate for the authors of the abstracts totaling 410 from 51 nations. They cover all the management issues on floods with a large proportion in the fields of flood risk management (prevention, mitigation and adaptation) and forecasting and early warning, which clearly reflects the interest of participants and the needs for practical attention. I also wish to thank the International Technical Committee members for their kind reviewing the abstracts and encouraging colleagues to submit abstracts as well as full papers. I also take this opportunity to thank the Local Organizing Committee members for your strong support for the realization of the Conference regardless of difficulties in the aftermath of the mega disaster. Also my deep gratitude extends to UNESCO, WMO, UNU and the Foundation of River and Watershed Environment Management of Japan for their kind financial sponsorship for the Conference.

Finally I hope that all the authors and participants will have good presentations and fruitful discussions at the Conference and also that outcomes will be soon put into practice to save more lives and livelihoods.

Kuniyoshi Takeuchi
Co-chair ICFM5, Director of ICHARM
Tsukuba, Japan September 2011

Acknowledgements

Japan and the world were stunned by the news and images of the March 11 mega-quake, tsunami and their aftermath. The daily life of the ICFM5 Secretariat members was also disrupted for a few days. In addition to all our worries regarding the reportedly once-in-a-thousand-year event, there was another serious concern that came immediately to occupy our minds: After all this, should we continue working towards ICFM5 as scheduled?

The answer came out very soon. The number of submitted abstracts jumped during the last two weeks of March as the end of the month, the first abstract deadline, approached. As a matter of fact, more than two-thirds of the abstracts were submitted after March 11. More surprisingly, the on-line registration started a few days before March 11 and a large majority (almost all, in fact) of the ICFM5 participants registered after that date. People gave us no time to wander about the question and an encouraging push to keep going.

We would like to extend our deep gratitude and appreciation to the abstract authors and ICFM5 participants for the faith they had in us and tangible encouragement they quickly gave us in times of need. Without them, it would have been very difficult to keep our motivation to work toward the Conference. We can never thank enough for the brave actions they took amidst the grave situation with a bleak prospect at that time. 410 abstracts submitted to ICFM5 covering all five topics as follow:

128 abstracts on “Flood Risk Management (Prevention, Mitigation and Adaptation)”
55 abstracts on “Flood Disaster Management (Preparedness, Emergency Response and Recovery)”
98 abstracts on “Flood Forecasting and Early Warning Systems”
62 abstracts on “Flood Management in Different Climate Conditions and Geographic Zones”
67 abstracts on “Cross-cutting and other topics”

In total, 359 of them were accepted after an extensive review. We are pleased to see about 190 (more than half) of the accepted abstracts were from Asian nations, clearly demonstrating the importance of flood management in Asia. We would like to convey special thanks to all ad-hoc committee, international organizing and technical committee for their great support and review of all abstracts.

We would like to express special thanks to the authors of the selected abstracts to submit their full papers. In total, 120 full papers were submitted to the ICFM5 secretariat, out of which about 50 of them has been selected for two post conference publications. The selected papers will be announced in due time after the ICFM5. We know the other papers are a product of hard work with useful information and insights but had to limit the number of papers due to the publication capacity and ask for their understanding.

We would also like to extend great appreciation to all participants of the ICFM5 booth exhibition for accepting our invitation to demonstrate their latest products and findings at the conference.

ICFM5 is organized with several sessions including plenary, special, parallel and poster sessions. We are pleased to provide opportunities for oral presentations for more than 180 participants as well as for about 50 poster presentations.

We hope that it will be a fruitful conference for all participants. We will be at the disposal of all ICFM5 participants for any request at and after the Conference.

Ali Chavoshian
ICFM5 Secretariat at ICHARM
Tsukuba, Japan

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Plenary Session 1

"Flood Forecasting and Early Warning Systems"

Organized under the auspices of

INTERNATIONAL FLOOD INITIATIVE

U-Thant Hall (UNU), 27 September (10:10 to 11:30)

Overview and Scope of the Session

Floods play a vital role in the economic development and societies in many parts of the world have taken full advantage of the rivers and other water bodies that are highly prone to flooding, as vehicles for development. At the same time floods also pose the most taxing water-related natural hazard to humans, economic activities, as well as to cultural and ecological resources. Integrated approach to flood management, therefore, calls for a balanced approach to make best use of the flood plains while reducing the risks due to flooding to a minimum.

Hashimoto Action Plan prepared by UN Secretary-General's Advisory Board (UNSGAB)'s High-Level Expert Panel in the "Water and Disaster" identifies flood early warning as an essential element that supports the Hyogo Framework for Action. Many international efforts are focusing on assisting nations and regions in dealing with challenges of water related disasters. The International Flood Initiative jointly proposed by UNESCO and WMO and supported by ISDR, UNU, IAHS and IAHR; the Associated Program on Flood Management and other similar initiatives, in their own way are implementing follow up on the actions identified therein.

Efficient early warning system that deliver dependably accurate information on the likely flood events for preparation and response to the impending flood situation, which form a vital element of this integrated approach are not getting the investment they deserve as a risk reduction tool. Particularly, in the developing countries, the benefits of latest scientific and technological advances are not being fully reaped. Full exploitation of basic and advanced information technologies to improve flood forecasting and early warning, fostering inter-sectoral communications, and collaboration is called for. New developments in aerial photography, satellite communication and computational sciences have to be used to further expand our understanding of the climate system and forecasting and warning of flood events.

There is need for greater thrust in international efforts to share new, innovative developments in flood risk reduction methodologies; exchanging experiences gained in the areas of integrated flood management; bridging the gaps that exist between the flood research and development community on one hand and the flood professionals responsible for responding to and mitigating the adverse impacts of major flood events on the other.

The session will provide a brief overview of some of the present mechanisms being used for transferring the existing technologies in flood forecasting and early warning to the developing countries and would discuss the advancements in the flood forecasting and early warning technologies and the gaps that need to be addressed through research.

FLOOD EARLY WARNING SYSTEMS – RESEARCH GAPS AND FUTURE NEEDS

Slobodan P. Simonovic

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A complete and effective flood warning system comprises four elements, spanning knowledge of the risks faced through to preparedness to act on early warning (Simonovic, 2011). Failure in any one part can mean failure of the whole system. (1) *Risk knowledge phase* involves systematic data collection and flood risk assessments. (2) *Monitoring phase* involves development of flood hazard monitoring and early warning services. In this phase questions such as—Are the right parameters being monitored? Is there a sound scientific basis for making forecasts? Can accurate and timely flood warnings be generated?—should be answered. (3) *Dissemination and communication phase* provides for communication of risk information and early warnings to all of those at risk in understandable form and on time. (4) *Response capability development phase* is aimed at building national and community response capabilities. Good warning systems have strong linkages between the four elements.

Behind all of these activities lies a solid base of political support, laws and regulations, institutional responsibility, and trained people. Often there are warning signs well ahead of a flood event. Good early warning systems also need to consider community vulnerabilities as well as the flood hazard. What are the early warning signs for vulnerability? Key signs are growing poverty, environmental degradation, populations crowded in risky locations, civil strife, and lack of knowledge and preparedness.

All flood warning systems, however simple they may be, are based on some idea—model—of how the flood phenomenon behaves. Models are then used to say what is likely to happen next. In the simplest cases, the model may amount to no more than common sense—for example, the recognition that poor people who have settled in a river valley will lose their dwellings and all their belongings in even a small flood. At the other extreme, models of the physics of the global weather system are immensely complex and require large computers to do all their calculations and produce detailed forecasts for the whole globe.

Predictions are never perfect or precise. There is always some uncertainty. Often the warning may be expressed statistically. In addition, there is always a great deal of uncertainty about the social components of a flood warning, and about the specific human impacts that might occur. This can make it difficult for decision makers to act. Decision makers and those at risk must weigh up the chances and consider the implications for their particular situation.

Canada has no national flood warning strategy that covers all hazards in all places. Public warning practice is decentralized across different governments and private sector. Public alert systems can be improved with the new hardware and technology, but disseminating warning preparedness knowledge is a much more complicated problem. There is a threat that further technological advances will only increase the gap between the practice and the state of the art.

Improvements to local flood warning systems can be done by (a) improving procedures, training, knowledge sharing and management practices, and (b) investing more seriously in better communications and warning system equipment. Most advances in Canada have come from better monitoring, instrumentation, data collection, and modeling. 100% reliable flood early warning system does not exist.

Simonovic, S.P. (2011). *Systems Approach to management of Disasters: Methods and Applications.* John Wiley & Sons, Hoboken, New Jersey.

A PROPOSAL ON PRACTICAL APPROACH TO IMPLEMENT FLOOD FORECASTING / WARNING SYSTEM IN POORLY-GAUGED RIVER: APPLICATIONS OF IFAS

Kazuhiko Fukami
Nabesaka. S., Miyamoto, M. and Sugiura, A

International Centre for Water Hazard and Risk Management (ICHARM) under the auspices of UNESCO, Public Works Research Institute, Japan

Water-related disaster is still one of the challenges that need to be overcome to achieve sustainable development and poverty reduction. Their effect is increasing with population growth and concentration and increasing value of assets in flood plains in recent years. In countries where river improvements are not sufficient, smooth evacuation from flooding is important for limiting the loss of life and property. The timing and magnitude of flooding should be clearly identified in advance. This is very crucial, in particular, in flash floods that often occur in small river basins with the scale less than several tens of thousands square kilometers. Even in the case of larger continental river basins, especially in monsoon regions, mid-term flood forecasting with its timing, level and duration is very important to schedule not only evacuation from flood risk areas for residents in riparian zones but also water-related activities such as planting and/or harvesting. Such information should be the minimal requirement so that the “living with floods” concept is tolerable.

However, in reality, we still have many flood-prone areas without any effective flood forecasting/warning systems. The failure of their implementations mainly lies on the lack of hydrological data and in particular rainfall data both quantitatively and qualitatively. This is the reason which motivated the development of the IFAS (Integrated Flood Analysis System) with rainfall-runoff models which can run based on global and freely available geographical and rainfall data and with a very limited amount of field data. IFAS is a freely distributed comprehensive toolkit including 1) the modeling of any river basin based on global geographical data (DEM and land use data available freely online), 2) the possibility to input not only ground-based rainfall data but also satellite-based ones to analyze flood runoff and finally 3) the display of results to be analyzed for flood warning.

ICHARM is promoting applications of IFAS with capacity-building activities in poorly-gauged rivers in developing countries. IFAS is expected to enhance local ownership of flood forecasting / warning system. Some examples are introduced.

Plenary Session 2

"Floods, Landslide and Debris Flow due to Torrential Downpours"

U-Thant Hall (UNU), 27 September (17:35 to 18:55)

Overview and Scope of the Session

As the global climate changes, torrential rainstorms occur more frequently in many regions around the world. Flash flood, landslide and debris flow caused by heavy rainstorms always happen suddenly with poor predictability and short time for warning, and these are the main causes for the flood-related casualties. The destructive powers of such calamities are so strong that they not only damage encountered assets and infrastructures, but also deteriorate river ecosystem and environment. Meanwhile, pluvial flood due to heavy rains in urbanized areas are getting more and more serious. How to deal with the sudden floods, landslide and debris flow disasters has become one of the major challenges that communities are facing. Especially in developing countries, such risks have been increasing due to the intensification of human activities, rapid urbanization, accelerated development in high-risk areas, etc.

The objective of this plenary session is to explore the new features of such calamities in context of the global climate change and socioeconomic development, and how to strengthen the capacity building in a comprehensive way to restrain the growth of the risk effectively. The key points that will be discussed in the session include:

- Disaster chain of torrential downpours, floods, landslide and debris flow and their risk features;
- Predictability of the outburst floods, landslide and debris flow and the effectiveness of countermeasures
- Appropriate coping strategies for nations or regions with different social economic development level.

We expect to improve the understanding of the complexity of such outburst calamities through the discussion and exchange in the plenary session, and then, contribute to the best choice of solutions proper to the local conditions, and to promote the combination of the effective traditional experiences and new technologies. It is a long-term and arduous task, coexisting risk and opportunity. We have to devote more efforts consistently to enhance the security level step by step.

CHANGES OF FLOOD RISK AND THE COPING STRATEGIES IN CHINA

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According to the analysis of statistical data, flood damages in both property losses and casualties in 2010 exceeded those of China in 1998. It is worth pointing out that the1998 is a year with severe floods in some major river basins which lasted the whole summer from south to north in China, while in 2010, through the operation and adjustment of some key flood control projects, there were almost no big floods occurred in the mainstreams of the large rivers. In fact, most of the casualties in 2010 were caused by flash floods, debris flows and landslides in medium and small rivers in the mountain areas, which took as high as 92% of the total number of victims and almost doubled than that in 1998. And in the total direct economic losses caused by floods, only 35.3% of it came from the damages of agriculture, forestry, animal husbandry and fishery, while in the past, such part normally took above 80% of the total losses. The other nearly 2/3 of the total losses was composed of the damages of industry, traffic and transportation, and the damages of infrastructures. Especially, more than 250 cities at or above the county level were inundated in 2010, and most of them were caused by the local rainstorms. Such facts indicate that the components of flood risk and their distributions in China have changed greatly with the rapid development of social economy.

In order to cope with the stress and challenges, the Ministry of Water Resources has been promoting the strategic transformation from flood defense to flood management, and the input for water security will be multiplied from the governments at all levels in the twelfth five-year plan started from 2011. For instance, the National Flash Flood Prevention Plan has been ratified by the State Council in 2007, and then, some non-structural measures were taken in 103 pilot counties, such as setting up automatic monitoring and early-warning systems, formulating flash flood preparedness plan at three levels of counties, towns and villages, and escaping rehearsal, etc. Now, the plan is going to extend to 1836 counties threatened by flash floods within three years, among them 500 counties have been launched in 2011. Some other plans to strengthen governance of medium and small rivers, renovation and construction of irrigation areas, and reinforcement of medium and small-sized dams are all being actively promoted and implemented.

Based on the field survey and comprehensive judgments of the influence factors in social economic development and climate change, this paper analyzes the difficulties and problems we have to meet in water security, and discuss the coping strategies in how to establish a benign interaction mechanism and to grasp the moderation.

DEBRIS FLOW DISASTER AND MITIGATION IN CHINA

Peng Cui

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Debris flows occur extensively over mountainous area in China and cause serious propertylose and casualties. It is established that Tibet plateau upheaval, intensive tectonic movement, complicated geology, steep topography and frequent concentrated rainstorm, all of them contribute to the magnitude and scale of debris flow occurrences. As one of the typical geo-hazards, debris flows often behave as destroying villages, ruining highway, occupyingfarmland and reservoir, and pose a danger for nearby inhabitants, thereby considerably harm the local society safe and economy development in the mountainous area. It is always regarded as a key factor in blocking regional economic development. Especially, many tremendouscatastrophes such as Zhouqu giant disaster have caused by debris flows due to the trigger of extremes rainfalls in 2010. Chinese Government in the past play an important role in the debris flow control around the western mountainous area. Research on debris flow was encouraged and supported financially by the Government. Therefore, a series of technologies for debris flow control have been developed and evolved into a unique Chinese manner of debris flow control, which made a great success in geo-hazards control in the past. This paper mainly includesfollowing topics:

1) Debris flow activity and it ‘s harm in China;
2) Debris-flowformation mechanisms;
3) Methodology of Risky analysis for debris flow disaster;
4) Monitoring and alarming technology for debris flow;
5) Control technology of debris flow.

ASSESSING AND MITIGATING THE RISK OF TORRENTIAL AND DEBRIS FLOW ACROSS THE GLOBE

Nigel Wright

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The presentation will assess the extent of damage from extreme flows across the globe with examples from a number of countries. This will be used to highlight the main issues to be addressed and then to look at the measures that can be taken to mitigate the risk. Finally, methods for modelling the flows will be presented along with results.

Special Session 1

"Flood Risk Management Approaches as Being Practiced in Japan, the Netherlands, United Kingdom and United States"

UDX-Theatre, 28 September (11:00 to 12:30)

Overview and Scope of the Session

Floods affect some 520 million people every year, claiming the lifes of about 25,000 worldwide and causing global economic losses between $50 and $60 billion annually. Therefore, it is essential to seek to manage flood risk effectively and appropriately. Consideration of flood risk includes the probability of occurrence of a flood hazard; the vulnerability of individuals, society, and the environment despite flood mitigation from a broad variety of measures implemented to dampen flood consequences; and the consequences that result from the mitigated hazard event.

The Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT), the Dutch Rijkswaterstaat, the United Kingdom Environment Agency, and the United States Army Corps of Engineers agreed to develop a document to explore risk-informed approaches as being practiced and developed primarily in those four countries. Although very different in frequency and scale of flooding as well as cultural and governmental characteristics, each country had significant efforts underway to better orient its practices to flood risk realities, including those induced by altered land use and by climate change and variability. The collaboration was envisioned as a continuing step in international collaboration and as a way to share information more broadly within the four participating countries and perhaps beyond.

Commonalities among the four countries are striking. Despite their varied histories and circumstances, the four countries face similar key challenges. These include adapting to new understandings of risk that take into account the impacts of climate change, bridging gaps between land-use decisions and flood risk management considerations, effectively communicating risk to the general public in a way that promotes individual as well as societal responsibility, and aligning planning and actions to identify and meet the most critical risks within a framework that is socially, environmentally, economically, and politically acceptable.

There are also some notable distinctions in approaches between the four countries. These include whether or not national levels of protection are specified and, if so, whether those levels are legislated or aspirational; whether or not the government supports flood insurance programs; and historic practices that influence how flood risk management is delivered in each country.

This special session will provide an overview of the four countries' collaboration and their resulting jointly-prepared document. Presentations by each country will then highlight example approaches, the drivers for those approaches, and practices that are working or hold particular promise. The session will conclude with a facilitated discussion.

RISK INFORMED FLOOD MANAGEMENT APPROACHES, AS BEING PRACTICED IN JAPAN, NETHERLANDS, UNITED KINGDOM AND UNITED STATES

Lisa Bourget[1]
Van Alphen, J.[2], Fujita, K.[3], Riedstra, D.[4], Rooke, D.[5], Tachi, K.[6]

[1]*U.S. Army Corps of Engineers, United States*
[2]*Staff Delta Program Commissioner, The Netherlands*
[3]*National Institute for Land and Infrastructure Management, Japan*
[4]*Rijkswaterstaat, The Netherlands*
[5]*Environment Agency, United Kingdom*
[6]*River Bureau, Ministry of Land, Infrastructure, Transport and Tourism, Japan*

Countries around the world are working to better orient flood management approaches and practices to flood risk realities. In 2009, the Dutch Rijkswaterstaat, the Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT), the United Kingdom Environment Agency, and the United States Army Corps of Engineers agreed to work together to develop a document that explored risk-informed approaches as practiced in their countries and to identify best practices. Each country had significant risk-oriented efforts underway, and each believed it could gain by building on previous collaborative efforts and by sharing information.

The resulting document reflects contributions from agencies within the four participating nations, but is not an official position of any government or international organization. The document highlights approaches in each country, the drivers for those approaches, and practices that are working or hold particular promise. Specific examples illustrate various approaches, rather than trying either to fully reflect the entirety of any one country's effort or to include an example from each country for any particular aspect. A description of the flooding characteristics and circumstances in each country provides an overarching context for the approaches described and underscores issues to keep in mind when considering use in other contexts (one approach does not necessarily fit all contexts.)

The document is organized by an overarching framework that encompasses flood risk drivers, risk assessment, and the source-path-receptor concept; the flood risk management cycle with its overarching policies and supporting players and mechanisms; and the adaptive management cycle of maintenance, monitoring, evaluation, and adjustment over time. It includes short descriptions of approaches to risk assessment at both national and regional/local levels; consideration of future developments such as climate change and aging infrastructure concerns; policy development, including environmental considerations; emergency preparedness and response, including exercises and communication; and topics worthy of international collaboration and research.

Commonalities are striking. Despite their varied histories and circumstances, the four countries face similar key challenges. These include adapting to new understandings of risk that take into account the impacts of climate change, bridging gaps between land-use decisions and flood risk management considerations, effectively communicating risk to the general public in a way that promotes individual as well as societal responsibility, and aligning planning and actions to identify and meet the most critical risks within a framework that is socially, environmentally, economically, and politically acceptable. Distinctions in approaches, such as legal prescriptions versus aspirational goals for levels of flood risk, or specific flood insurance provisions, are highlighted.

The effort provides a vehicle for those within each participating country to learn from the others, furthering the ability to bootstrap from others' efforts and incorporate aspects suitable to their own circumstances. The resulting document provides a vehicle for sharing the resulting information more broadly within the four participating countries and perhaps beyond.

Special Session 2

"Practical Steps for Adapting to Climate Change"

UDX-Theatre, 28 September (13:30 to 15:00)

Overview and Scope of the Session

The session should focus on presenting ideas for an international consortium of leading world hydrologic centers to undertake a coordinated program of activities that would address the key aspects of adaptation to climate uncertainty related to the development of a new family of methods and procedures for planning and design of hydraulic infrastructure and water management approaches consistent with IWRM. This initiative is part of the UN Secretary General's Advisory Board (UNSGAB) series of actions. The 'High Panel on Water and Disasters' (UNSGAB) recognizes that the world must move beyond reaction and disaster assistance, to prevention, mitigation and adaptation to climate change and increased variability. Floods, droughts and sea level rises are the most frequently mentioned immediate water related disasters projected under various climate change scenarios. Therefore water-related actions will be central to rich and poor societies' abilities to adapt to these projected changes. Since the importance is so high and time is short, the water resources community should bring together the best we have worldwide to discern what can be done to adapt.

UNSGAB Action 29 (Report: Water and Disasters: High Level Expert Panel on Water and Disasters/UNSGAB, March 2009) reads as follows:
"National and international hydrological institutes must take the initiative to identify underlying analytical and data requirements to meet climate changes that are likely to be highly uncertain and so as to support structural and non-structural measures for disaster risk deduction."

Major practicing hydrologic research institutions worldwide should form a consortium to develop a new family of practical hydrologic engineering tools, methods, procedures and professional standards for the planning, design, operation and maintenance of infrastructure under non-stationary climate trends and climate change uncertainty. The consortium would assess existing, and generate new 'best management practices' under climate uncertainty, that could be used by water managers and specialists throughout the developed and developing countries that would guide them through the transitional period of improved GCM development. International aid agencies such as the World Bank, USAID, FAO and UNDP, would be engaged, as they would also benefit from these new procedures,

There are five complementary parts to the issue:

- Analytical Tools: the technical development of new hydrologic/hydraulic tools and techniques which adapt to the new climate variability trends which can be used for engineering design and operation of the existing water infrastructure; and

- Vulnerability assessment protocols: the integration of new climate variability /change hydrologic assessments and protocols as part of watershed planning, formulation of response actions and evaluation of benefits and costs under increasing climate uncertainty. This is the IWRM component of the inquiry.

- Development of project evaluation/justification protocols that are based on accepted benefit cost procedures that rely on concepts of flood and drought frequency, return periods and 'expected annual damages', along with risk assessment procedures.

- Development of risk-based engineering design criteria for various types of water-based infrastructure (spillway design, levees, 'safe yield', maximum probable flood, etc.)

- Improvement of reliability of short-term hydrologic forecasting tools for flood, drought and reservoir management (10-, 30-, 60- and 90-day seasonal forecasts)

CHANGES IN FLOOD RISK IN EUROPE – CLIMATE TRACK

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Even if most destructive deluges in recent decades have occurred in Asia, European continent is not immune to floods. The continent has been hit by many damaging inundations, including the event in summer of 2002, with record-breaking material loss.

There is no doubt that flood damages have been on increase at various spatial scales (global, continental, and national). Since several destructive floods have occurred in Europe in the last decades, it is of considerable interest and relevance to take a closer look at the multiple factors driving the changes in flood risk, of socio-economic, terrestrial, and climatic nature. Identification of climate track in flood records, amidst strong natural variability and multiple factors driving flood risk is not a trivial task. However, even if detection and attribution of changes in flood risk are difficult, there have been many studies in Europe, at both continental and national levels.

Increasing trends in temperature have been found to be ubiquitous, with impact on air humidity and changes in (intense) precipitation. The law of Clausius-Clapeyron suggests that the warming leads to an increase of the potential moisture holding capacity of the atmosphere. Hence, the warming contributes to intensification of the hydrological cycle. Growing trends in heavy precipitation are significant in many regions of Europe and this can be translated into the rise of rain-caused flood hazard and flood risk. Projections for the future, albeit bearing considerable uncertainty, indicate increase of frequency and intensity of heavy precipitation. However, since snow cover is less abundant, snowmelt floods are decreasing in many areas of Europe.

Since increase of flood risk has been observed, and is projected, over a large part of Europe, there is a must to adapt to changing conditions and to revise design rules (design flood frequency and design period estimates). The safety factor approach has been used in several countries of Europe, leading to increase of design flood by 15-30%.

Floods Directive urges European Union Member States to carry out flood risk assessment, to produce flood hazard maps and indicative flood damage maps, and – finally - to embark upon flood risk management.

European Union Floods Directive

“Firstly, the scale and frequency of floods are likely to increase in the future as a result of climate change, inappropriate river management and construction in flood risk areas. Second, there has been a marked increase in vulnerability due to the number of people and economic assets located in flood risk zones.”

- The impact of climate forcing on flood risk is complex and depends on the flood generation mechanism.
- Higher and more intense precipitation has been already observed and this trend is expected to strengthen in the warmer world, directly impacting on flood risk.
- It is difficult to disentangle the climatic change component from strong natural variability and direct human impacts, hence a question „adapt to what?“ comes about. Common-sense changes to design rules have been introduced in some countries, based on precautionary principle rather than robust science.
- Be careful with flat-rate statements!

Special Session 3

"A Decade of Integrated Flood Management"

Organized to celebrate the 10th Year Anniversary of

Associated Programme on Flood Management (APFM)

UDX-Theatre, 28 September (15:15 to 16:45)

Overview and Scope of the Session

Established jointly by the World Meteorological Organization (WMO) and the Global Water Partnership (GWP) in 2001, the Associated Programme on Flood Management (APFM) is the world's premier comprehensive knowledge base for the development and implementation of best practices in Integrated Flood Management (IFM), worldwide. Realizing that IFM has a high return on investment, this innovative approach – where implemented – creates tangible socio-economic benefits for national flood management strategies and related programmes as well as on river basin and regional scales.

Floods are increasingly affecting the world's population. Growing population pressure in flood-prone areas, combined with increasing climate variability, climate change and often inadequate land use and natural resource management, are increasing the challenge to address floods in a sustainable manner. While flood waters are an essential water resource in many countries and floodplains hold many benefits for society for economic development, they can also cause huge losses of lives, livelihoods and properties and thus can be a hindrance to socio-economic development of nations.

Therefore, an integrated approach to flood management is necessary to balance development opportunities on flood plains and flood risk. An important aspect of integrated flood management strategy is coordinating the needs of different stakeholders.

The APFM draws on the professional capacity of its multidisciplinary partners – including highly specialized centres of excellence, established development partners, national governments and international organizations – to provide a demand-driven mechanism for addressing flood management realities.

Case studies, demonstration projects, and a considerable number of technical tool publications are the main elements that form the growing knowledge base of the APFM since its inception. The IFM HelpDesk is the main access gate to this knowledge base that has been accumulated to facilitate finding pragmatic solutions bridging the gap between international policy consensus and management challenges.

The IFM HelpDesk is designed for use by stakeholders in the fields of water resources management, disaster risk reduction and climate change adaptation. They include national, provincial and local agencies, National Meteorological and Hydrological Services, river basin organizations, non-governmental organizations, universities, community-based organizations and other flood management practitioners and planners. The domain www.floodmanagement.info provides the central access point where a range of services can be requested; and various tool documents, capacity building and learning materials retrieved.

In occasion of ICFM 5, the APFM Team and its partners take the opportunity to present its achievements and lessons learnt over the past decade and to express its continued dedication to promote the IFM concept. The way forward will be guided by the vision for IFM implementation at all levels and the APFM Team looks forward to your inputs and thoughts during the open discussion of this special session.

Special Session 4
"Education and Capacity Building in Flood Management"

UDX-Theatre, 28 September (17:00 to 18:30)

Overview and Scope of the Session

The challenges related to flood management are huge! Humans continue to live more and more in flood prone areas (floodplains, deltas etc.), which results in an increasing exposure to severe flooding. At the same time, climate change and other global changes (incl. land use changes, concentration of economic values, river channelization) continue to alter the frequency and severity of floods and coastal storm surges. A number of studies demonstrated that the stationarity assumption, which is key for most of the usually applied time series analysis methods, often does not apply any more. In addition, in most river basins human activities have disrupted the natural hydrological regimes. Therefore, new methods need to be developed to better understand coupled human/natural systems and provide suitable inputs for sustainable flood management. To this end, a great opportunity is offered by the current growing availability of remote sensing products and, in particular, of globally and freely available space-borne data. However, so-call called ground-truthing data is essential for fully utilizing the potential of remotely sensed data and this is often not available in particular in the developing world.

Many studies showed that flood management approaches that relay only on hard engineering (dams, dykes etc.) do not result in a desired outcome. They are restricted due to physical, societal, environmental and financial conditions. Therefore, integrated flood management approaches are suggested that include a case-specific combination of structural and non-structural measures. It has been shown that integrated approaches are often more effective in reducing flood risk, while at the same time maximizing the benefits of floods. However, how to implement integrated flood management schemes including the needed capacity development activities in an ever changing world is often unknown and requires research and rethinking of our current approaches. This seems to be true in particular in the developing world, where a better flood management is very much needed to limit the societal impacts of floods.

This special issue aims at discussing challenges in education and capacity building as well as ways forward. The following questions will be addressed (not limited to):

- What are the main challenges for education with particular emphasis on integrated flood management? And, how they can be addressed?
- What are the necessary skills and competency profiles for flood experts of the future to remain effective in a changing and increasing complex world?
- What are the best ways to improve the education of flood experts?
- What are the roles of tertiary education programmes, continuous professional development (CPD) programmes and international collaboration programmes in the field of integrated flood management?
- How can integrated flood management in less developed countries be improved, countries which are most vulnerable to global changes but have the least resources for training and capacity building?

FLOOD MANAGEMENT IN A CHANGING WORLD - WHY AND HOW DO WE HAVE TO CHANGE OUR APPROACH IN EDUCATION?

Stefan Uhlenbrook[1,2]
Di Baldasarre G.[1], B. Bhattacharya[1], Brandimarte L.[1], Maskey S.[1], Mynett A.[1,3], Szollosi-Nagy A.[1], Z. Vojinovic[1], Werner M.[1,3], Zevenbergen C.[1,4]

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Humans continue to live more and more in flood prone areas (floodplains, deltas etc.), which results in an increasing exposure to severe flooding. At the same time, climate change and other global changes (incl. land use changes) continueto alter the frequency and severity of floods and coastal storm surges. A number of studies demonstrated that the stationarity assumption, which is key for most of the usually applied time series analysis methods, often does not apply any more. In addition, most river basins canno longer be considered pristine as human activities have disrupted the natural hydrological regimes. Therefore, new mathematical methods need to be developed to better understand coupled human/natural systems and provide suitable inputs for sustainable flood management. To this end, a great opportunity is offered by the current growing availability of remote sensing products and, in particular, of globally and freely available space-borne data.

Many studies showed that flood management approaches that relay only on hard engineering (dams, dykes etc.) do not result in a desired outcome. They are restricted due to physical, societal, environmental and financial conditions. Therefore, integrated flood management approaches are suggested that include a case-specific combination of structural and non-structural measures. It has been shown that integrated approaches are often more effective in reducing flood risk, while at the same time maximizing the benefits of floods. However, how to implement integrated flood management schemes including the needed capacity development activities in an ever changing world is often unknown and requires research and rethinking of our current approaches. This seems to be true in particular in the developing world, where a better flood management is very much needed to limit the societal impacts of floods.

Current flood management approaches lack the ability to cope with uncertainty and to respond flexibly and adaptably. Addressing future complexity will require (i) a redefinition of the (future) socio-economic and environmental systems that will need to be managed, (ii) development of new mathematical models to better understand these systems and their interactions, (iii) experimentation and learning by doing, (iv) effective measurement and monitoring of system performance, (v) engagement and capacity building of all stakeholders, and (vi) reforming governance.

This presentation will discuss (i) challenges for education with particular emphasis on integrated flood management. Hereby, a global perspective will be taken, and the partly differently/partly similar challenges in the Global South and North will be examined. (ii) Competency profiles for flood experts of the future will be suggested, which all will have components of a T-shape competency profile. Special attention will be give to tertiary education vs. continuous professional development (CPD) in the field of intregrated flood management. Finally, (iii) different ways to improve the education of flood experts will be discussed. This includes revisiting the university curricula, CPD programmes, applied teaching and learning methods, and joint educational activities in knowledge partnerships.

EXPERIENCES AND LESSON LEARNED FROM FLOOD MANAGEMENT TRAINING COURSES AT ICHARM

Shigenobu Tanaka

Deputy-director, International Centre for Water Hazard and Risk Management (ICHARM),under the auspices of UNESCO, Public Works Research Institute (PWRI)

The International Centre for Water Hazard and Risk Management (ICHARM) under the auspices of UNESCO hosted by the Public Works Research Institute was established in March 2006 as an only UNESCO category II centre focusing on water-related disasters. As flood disasters have recently occurred frequently, flood risk management has become more necessary than ever. The expectation of ICHARM has also been increasing in the international community.

ICHARM conducted a training course on flood hazard mapping from 2004 to 2008 in collaboration with the Japan International Cooperation Agency (JICA). In 2009, ICHARM started another training course entitled “Local Emergency Operation Plan with Flood Hazard Map” as an extension of the 2004-2008 course, which is scheduled to be provided until 2011. This training course is designed for participants to learn how to develop an appropriate evacuation system for a flood-prone area by using flood forecasting and warning, which provide information on where and when flooding may occur, in addition to flood hazard maps, which shows high flood-risk areas during flooding. The course is also unique in that it aims to improve organizational capacity in flood risk management. Participants are selected from different positions of the same organizations every year for three years and provided with different training contents each year.

ICHARM has also conducted a one-year master’s program, “Water-related Risk Management Course of Disaster Management Policy Program,” in October 2007 in collaboration with JICA and the National Graduate Institute for Policy Studies (GRIPS). The program is designed to train water-related risk management specialists with practical expertise who can develop comprehensive flood damage mitigation plans and contribute to implementation of local activities. Students spend the first six months studying various subjects in lectures and practices and the second six months working on their graduation theses under individual supervision.

Further, ICHARM has developed a rainfall runoff model, Integrated Flood Analysis System (IFAS). IFAS can use satellite rainfall through internet and it is expected to forecast flood even without ground precipitation. Because rainfall runoff calculation is a basic and important technique of flood risk management, ICHARM has conducted short seminar and training course of it as well as a part of above mentioned short program and master program.

CHALLENGE IN THE CAPACITY DEVELOPMENT TO MOVE TOWARD IFM

Yusuke Amano

Japan International Cooperation Agency (JICA), Japan

The Japan International Cooperation Agency (JICA) has provided various assistances to some countries in the field of integrated flood management (IFM). It is found through the implementation of JICA's projects that the capacity development of the responsible people and organizations/ agencies is essential to strength IFM. There are however some constraints to promote the capacity development in IFM, which are broadly grouped under lack of responsibility and lack of management.

One question is who should be trained. To minimize flood damage, it is clear that the government should take the responsibility to manage comprehensive activities against flood. The responsibility for flood is however unclear in the government of some countries. In the case that the organization to be in charge of flood issues is clearly settled, there are often few flood experts and its experience and knowledge is not so much accumulated in it. One of the major challenges for JICA is to establish and/or strength the organization in the field of flood management.

Lack of views on flood management is also a serious issue. While the governments and donors tend to concentrate on the construction of flood control facilities, those existing facilities may not have functioned well. The existing flood control system may not be optimized due to insufficient flood monitoring. In many countries, non-structural measures are to be implemented by local governments while structural measures are usually taken by the central/regional governments and/or river basin organizations. Despite that, there is limited coordination among various agencies/organizations concerned. One of the most critical issues is that none has the overall view on IFM. To settle those issues, Therefore JICA's challenge is always to take an issue-oriented approach and to focus on the development of institutional capacity.

Several training programs provided are important portions of ways to develop the capacity of responsible organizations. Those programs try to directly tackle on the constraints through practical study and hands-on training.

FLOOD MANAGEMENT – URGENT NEEDS FOR INTERDISCIPLINARY EDUCATION

Slobodan P. Simonovic

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Integrated flood management is an iterative process of decision making regarding prevention of, response to, and recovery from, a flood (Simonovic, 2011). Large and more frequent flood disasters in last few decades have brought a remarkabletransformation of attitude by the flood management community toward integrationof economic, social and environmental concerns related to floods, and of action todeal with them.The most significantcontribution in last 10 years is a fundamental shift in the character of how thecitizens, communities, governments, and businesses conduct themselves in relationsto natural environment they occupy. Flood management education being divided among disciplinary boundaries has faced anuphill battle with the educational approaches that are used in many countries around theworld. They have not been conducive to the integrative character of systems approachthat is inherent in simulation and optimization management models. Fortunately,recent trends in education include consideration of the entire region under flood threat,explicit consideration of all costs and benefits, elaboration of a large number ofalternatives to reduce the damages, and the greater participation of all stakeholdersin decision making. Systems approaches based on simulation, optimization, and

multiobjective analyses have great potential for providing appropriate support foreffective flood management in this emerging context.

Simonovic, S.P. (2011).*Systems Approach to management of Disasters: Methods and Applications.*John Wiley & Sons, Hoboken, New Jersey.

Special Session 5

"Building Flood Resilient Communities"

UDX-Theatre, 29 September (9:15 to 10:45)

Overview and Scope of the Session

Floods are among the most common and destructive natural disasters bringing devastation to human life/settlements and causing extensive damage to infrastructure, public and private services, environment and economy. A study based on CRED1 database revealed that, in the last decade of 20th century, floods killed about 100,000 persons and affected over 1.4 billion people. For the past few decades, the pattern of floods across all continents has been changing, becoming more frequent, intense and unpredictable for local communities. IPCC2 also confirms that 'heavy precipitation events, which are very likely to increase in frequency, will augment flood risk'. While flooding can not be protected fully, there are measures that can be put in place to minimize the damage and speed up the recovery time.

Conventional flood control measures mainly focused on constructing dams, levees and other hardware structures which tend to incur large costs and attracts much public attention due to environmental problems. Often, the general strategy adopted to control flood is to prevent high floods through the incremental construction of flood control infrastructures. Global change (for example, climate change, urbanization etc., which increase flood frequency and intensity) will require ever increasing flood control investment that makes floods rarer. This process inevitably leads to a stalemate situation where further flood control works are too expensive, while a flood, which is greater than the design levels would cause catastrophic losses. This situation compels governments, NGOs and communities to take community-based approaches to reduce disaster risks and build resiliency.

Building community resilience to flood risk, which promote an integrated flood risk management approach that incorporates both hard and soft measures with active participation of community, is the way forward. Building flood resilient communities will become an essential adaptation measure to cope with flood risk increases brought about by climate change. This necessitates the need to incorporate 'flood resilient communities' as a specific target in development programmes. This session will focus on following themes:

- Capacity building at different institutional levels to enhance community based flood management
- Flood risk reduction projects that contribute to community development and vice versa
- Interventions and strategies that enhance community flood resilience

This session will benefit to those who have been involved in flood management issues as policy makers, developers, researchers, academicians and people from flood-prone region.

[1] Centre for Research on the Epidemiology of Disasters (CRED), Brussels
[2] Fourth Assessment Report (2007) of the Intergovernmental Panel on Climate Change (IPCC)

PEOPLE-CENTERED APPROACH IN INTEGRATED FLOOD RISK MANAGEMENT IN LOWER MEKONG BASIN

Aslam Perwaiz
Sudhir Kumar

Asian Disaster Preparedness Center, Thailand

The Lower Mekong River Basin (Cambodia, Lao PDR, Thailand and Viet Nam) is home to approximately 60 million people. Floods along the Mekong every year have the potential to directly endanger life; do millions of dollars worth of damage to property; destroy livelihoods and crops; and put people at increased risk of poverty, malnutrition and disease. At the same time, they are an important and essential natural process, bringing water, nutrients and other benefits to floodplains, wetlands and ecosystems. Climate, and particularly the Southwest monsoon, is the immediate cause of the annual floods. Most basin inhabitants are poor rural farmer/fishers although they may be resource rich. Being poor make them more vulnerable to floods and flooding because the cheapest places to live are those which are mostly threatened by floods. Flood damage in the lower Mekong basin arises from a combination of direct losses due to the fact of inundation and secondary losses as a result of the suspension of normal economic activities in the commercial and service sectors which can accumulate long after the end of the event itself.

Flood preparedness and emergency management strengthening remain core elements in dealing with effective flood management and mitigation in the region, as these directly address the needs of flood vulnerable communities, and also indicate/guide the strengthening and operations of government agencies at different levels: national, provincial, district and commune as well as of national and international NGOs. This is vital for enhancing communication, coordination and cooperation between these stakeholders, as well as the consistency of national disaster management and mitigation policy implementation. It also provides assessment-based solutions to how partnerships at various levels work in implementation of some of the important aspects of flood risk management.Be it public awareness or capacity building on community based flood management, a longer term programmatic approach and up-scaling to a wider geographical area is essential to ensure that the flood management and mitigation policy objectives are solidly embedded into the national disaster management strategies in each of the countries

The paper showcases the overall strategy with experiences on how the increased capacity of the key officials of the provincial, district and commune Disaster Management (DM) committees has led to a better flood preparedness in 28 districts of 11 most flood prone provinces in the lower Mekong Basin. The paper analyses the capacities of the selected provinces in the member countries for developing and implementing flood preparedness programs (FPP), community early warning systems, flood damage and needs assessment, and flood emergency response contributing the overall flood risk reduction initiative by the national governments. Active involvement of national government and local has been a major step to ensure consistency, ownership and sustainability, in addition to the activity of integrating Flood Risk Reduction (FRR) into local development plans.

RESIDUAL FLOOD RISK ANALYSIS FOR BANDA ACEH FLOOD CONTROL PROJECT

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Banda Aceh is the capitol city of Aceh Province located in the northern tip of Sumatra Island, Indonesia. The city has experiences in annual riverine floods due to an over capacity of flood flow for KruengAcehRiver which flowing through downtown of the city. To overcome the flood problems in the city, the Krueng Aceh Flood Control Project was created. By introducing some technical flood protection systems such as river reach normalization, the construction of floodway, and the reconstruction of city's drainage system, the city is already protected from a 20-year return period of flood. It means that the city is proved for flood with magnitude less than 1200m^3/s.

It is noted that the flood protection systems are limited in their resistance that the city is still exposed to a residual flood risk especially for the floods for greater return periods. This paper aimed to demonstrate by means to evaluate the residual flood risk for different scenarios. The study is executed by identifying the sources, pathways, receptor of the floods and the consequences city's properties exposed to the floods. The flood risk map based on flood risk analysis will be developed to assess the government in rehabilitation and reconstruction programs.

A COMPARATIVE STUDY OF DISASTER RECOVERY PROCESS: DISASTER RECOVERY BEGINS BEFORE THE DISASTER

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International Centre for Water Hazard and Risk Management (ICHARM) under the auspices of UNESCO, Japan

This paper tries to overview disaster recovery theories and utilize those as frameworks, then, attempts to analyze and consider the lessons learned and challenges from case studies with field works.

Concerning the first theory, Haas et al.(1977) says "The recovery process follows the trend which the affected communities originally had before the disasters. The declining communities would stay or decline after the events. The growing communities would catch up quickly and grow even if the communities had been completely devastated" It mentions the disaster recovery reflects the pre-disaster situation, for example, growing communities can get to recover so fast, however, remaining or decreasing communities cannot recover so well.

In regard to the second theory, Hirose(1982) indicates that the disaster recovery process depends on three major ingredients, physical scale of the hazard, aid from outside, and community strength.

To analyze the disaster recovery process while utilizing the above two as the main theoretical frameworks, the paper selected four cases to examine. As for flood disaster cases, Nagoya city struck by Typhoon Isewan in 1959 is examined as a growing city, New Orleans hit by Hurricane Katrina in 2005 is investigated as a remaining or declining city. As for earthquake disaster cases, Kobe city devastated by the Great Hanshin Awaji Earthquake in 1995 is a growing city, Nagaoka city (Yamakoshi village) attacked by the Chuetsu Earthquake in 2004 is a remaining or declining city. The paper utilizes population as a benchmark to assess the disaster recovery process because population change reflects loss of life, house damage, loss of workplace, difficulties of daily life, infrastructure damage, and so on after the disaster.

With reference to the disaster recovery trend, Nagoya city was heavily devastated by the worst typhoon disaster in Japanese history, however, the city quickly recovered, just within one year, and caught up the growing trend. Kobe city was also severely damaged by the Great Hanshin Awaji Earthquake, but the city has gradually recovered and reached the same population compared to the pre-disaster situation in 9 years, it is just like the same trend before the disaster. On the other hand, New Orleans is still struggling to recover. Nagaoka city, including the former Yamakoshi village, is also not enough situation compared with the pre-event situation even now.

With respect to the three major ingredients of disaster recovery theory which Hirose mentioned, the paper investigated that community strength could impact the recovery process more than the physical scale of the hazard and aid from outside.

Through analyzing the disaster recovery process as mentioned above, the paper attempts to answer the following inquiries: Could it be said that disaster recovery reflects the pre-disaster situation? What is the community strength as a key ingredient to impact the disaster recovery process? What is the better way to consider the disaster recovery? Not only the statistical data, but also qualitative field survey data are given to analyze.

REVIEW ON JAPANESE ASSISTANCE OF COMMUNITY-BASED MANAGEMENT FOR FLOOD DISASTER

Mikio Ishiwatari[1]
Mimaki, J.[1], and Shaw, T.[2]

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It is widely recognized that a community plays a crucial role in managing natural disaster risks. Hyogo Declaration adopted at the World Conference on Disaster Management in 2005 stressesthat strengthening community level capacities is needed to reduce disaster risks. Japan International Cooperation Agency (JICA), a major implementing agency for Japanese official development assistance,is shifting its approach in disaster management from engineering-oriented approaches to comprehensive ones including community-based disaster management (CBDM).However, the development assistant methods of CBDM have not been established. This is because JICA has limited experiences of CBDM projects, and has not conducted the holistic research works of CBDM.

This study aims to proposethe practical methods of development assistance for CBDM through reviewing JICA projects from a capacity development point of view. Capacity development is regarded as the ongoing process of enhancing theproblem-solving abilities of developing countries by taking into account all the factors at theindividual, organizational, and societal levels.The community is described as the "main actor", which plays key roles in disaster management. Other organizations around the community,such as governmental agencies, local governments, and non-governmental organizations, are described as"supporting actors" to the communities. JICA supports to develop the capacitiesof the communities as well as supporting actors.

The study reviews projects for management of flood and sediment disasters in Nepal, flood early waning in Morocco, disaster management in Caribbean countries, and development of cyclone shelters in Bangladesh, andmanagement of volcanic sediment disasters in Indonesia. Various lessons were learned from these projects. Firstly, at a project designing stage,the capacities of organizations concerned should be assessed. During projects, flexible implementation is needed to respond to unpredicted factors. Secondly, a wide range of concerned organizations should be involved in the projects. Collaborative activities between targeted communities and these organizations are effective in achievingproject objectives. Thirdly, focusing on the communities is required for activities in the field. End-to-end systems for early warning and evacuation should be established from observation until evacuation so that communities can utilize warning information for their evacuation. Hazard maps should be produced through participatory approaches for communities to understand their risks and assets. Communication mechanism should be established between experts and the communities for mutual understanding. Based on these lessens learned, the study furtherrecommends methods to design the projects, to secure sustainability of activities, to take interactive risk communication between governments and communities, and to utilize technology and experience in Japan for the project activities. Finally, the study discusses remaining issues to be resolved: 1) how to formulate projects that contribute to community development, 2) how to include livelihood activities in projects, 3) how to examine the projects from social capital prospective, and 4) how to manage knowledge of CBDM.

Special Session 6

"Advances and New Directions in Hydraulics of Flood Modelling"

UDX-Theatre, 29 September (11:00 to 12:30)

Overview and Scope of the Session

Probably the most frequent and widespread of all natural disasters, floods continue to cause every year loss of life and extensive property damage. Despite considerable advances in hydrology, hydraulics, numerical modeling and simulation, both the loss-of-life and the property damage due to floods seem to have increased considerably over the last century due to various factors. Rapid growth of urbanization leads to increased encroachment on the flood plains, reduces room for the river, and increases vulnerabilities. Increased impermeable surfaces lead to rapidly rising runoff hydrographs with higher peaks. Global climate change may modify precipitation patterns and intensities, and influence extreme event probabilities. Changes in hydrology lead to a serious questioning of the adequacy and safety of various hydraulic structures that store and/or control water. The expectations of the populations and the local and state governments with regard to protection against flood hazard and its direct and indirect consequences have evolved in recent years and more is expected of engineers, floodplain managers and decision makers with regards to flood protection.

In order to respond to emerging needs, the science and technology of flood modeling is rapidly changing in parallel with the advances in unsteady flow hydraulics, numerical modeling of unsteady flows with and without consideration of erosion, sediment transport and deposition processes, remote sensing and GIS technologies, and computer hardware and software. These new developments are likely to radically change the practice of flood modeling for flood protection, preparedness, response and mitigation.

During this special session four invited presentations will introduce a variety of topics such as automated two-dimensional dam-break modeling, operational flood modeling using game programming, bank stability and sediment transport issues during floods, the use of observations in flood modeling, and urban flood modeling. The panel discussion following the presentations will look into recent advances and new directions in hydraulics of flood modeling. Discussion topics may include, but are not limited to, the following:

- Realistic flood modeling over large areas, faster-than-real-time flood modeling and mapping, operational flood modeling, representation of hydraulic structures, etc.
- Challenges of urban modeling, representation of urban structure, interaction of flood with urban environment, integrated flood modeling by taking into account underground infrastructure, etc.
- Unsteady sediment transport, bank stability, erosion and deposition during floods, contaminant transport
- Data needs, data accuracy, data driven modeling, risk and uncertainty in flood modeling, etc.

INFLUENCE OF DETAILED TOPOGRAPHY WHEN MODELING FLOWS IN STREET JUNCTION DURING URBAN FLOODING

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When flooding occurs in an urban area, most of the water flows in the street network. Crossroads play a major role in urban flood dynamics: they govern the flow distribution to the downstream streets and the flow regime in the upstream streets. When modeling urban flooding, it is thus important to compute with accuracy flow pattern in each crossroad, as well as to estimate the related uncertainty. Moreover, the representation of the domain is usually extremely simplified and details of the street topography are usually neglected (sidewalks, obstacles, façade irregularities etc…). Indeed, measuring and including such topographical details in the numerical mesh is time-consuming and should be considered only if the computed flow pattern is noticeably improved. We thus aim at studying the impact of the local topographical details on the junction flow in order to assess of their importance for urban flooding management.

In this study, flows in crossroads are studied with both experimental and numerical approaches. Experiments are performed on a 90° junction of two inlet and one outlet horizontal glass channels, 0.3 m wide and 2 m long each. The three controlled parameters are the flow-rate entering each inlet and the water depth at the downstream section of the outlet. LSPIV (Large Scale Particle Image Velocimetry) and ADV (Acoustic Doppler Velocimeter) measurements allow a fine description of the flow at the free-surface and within the water column. The same flow configurations are computed using a 2D shallow-water equation numerical model to validate the use of such model for urban flooding simulations and to assess the resulting uncertainties.

Both experimental and numerical data result in a fine description of the flow pattern which is consistent with the literature. A stagnation area appears on the upstream corner of the junction, which limits the width of the lateral branch flow when entering the junction. A mixing layer is observed within the junction at the frontier between both inflows. Finally, a recirculation zone is observed just downstream of the junction along the lateral side wall, which accelerates the flow in the contracted section along opposite side wall.

A reference flow configuration is extensively measured experimentally and serves as calibration data for the 2D model. The model shows a good agreement with experimental data, provided that appropriate turbulence diffusion coefficient is selected. The impact of sidewalks and generic obstacles (representing possible bus-stops, stores etc…) on the flow is then studied numerically for different flow configurations. The presence of sidewalks mainly affects the recirculation area (the width of this area increases about 20 % for a 6 cm by 2 cm sidewalk) and can increase local velocities in the contracted zone (up to 10% for the same sidewalk). Their influence remains limited but can grow with other flow configurations, especially for lower water depths. On the other hand, inserting generic obstacles strongly affects the flow pattern, which can results in significant differences in the velocity field.

FLOOD AND BANK EROSION OF THE BRAHMAPUTRA/JAMUNA RIVER: COUNTERMEASURES AND INDIGENOUS KNOWLEDGE

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The Brahmaputra River ranks in the top group of the earth's large rivers in terms of both water and sediment discharges. In the reach within Bangladesh, the river is named Jamuna River and wanders with a distance of approximately 240km and a mean bank-full width of some 11km. It originates from the Kailas Range of the Himalayas and flows across China, India and Bangladesh. The river meets with some major rivers in its lower part: the Teesta, the Ganges and the Meghna, and supplies sediment into one of the world's largest deltas before finally entering the Bay of Bengal. The Brahmaputra/Jamuna River has cultured thousands of people living nearby since ancient time. On the other hand, flood and bank erosion of the river are severe problems of Bangladesh, and which have consumed large areas of floodplains, made lots of people homeless and destroyed a huge amount of infrastructures in the past several decades. Besides the important scientific and engineering relevance, flood and bank erosion also exert significant social and economic impacts in this southern Asian country. The government of Bangladesh has made a lot of efforts such as the construction of the BRE (Brahmaputra Right Embankment), spur dykes and revetments and the implementation of recurrent dredging.

This paper describes typical flood protection/mitigation countermeasures of the Brahmaputra/Jamuna River as well as their hydraulic and morphological consequences. The countermeasures mainly include hard points, spur dykes and Bandals. Based on field investigations at several representative locations, attempts have been made to clarify the mechanisms of flood and bank erosion along this large alluvial river. Moreover, the performances of existing countermeasures are evaluated and possible solutions for further enhancement are proposed. It is found that conventional river training structures designed using extrapolation methods based on experiences of small rivers in other places are not favorable for the Brahmaputra/Jamuna River since those structures will be very huge in both size and cost as well as they may exert great disturbances on the river dynamism and environment system. Special attention has been paid to a historied and indigenous river training structure: the Bandal structure. Compared with other countermeasures, the Bandal-like structure is both cost-effective and environment-friendly. In addition to field surveys, laboratory experiments and numerical simulations are conducted to understand the hydraulic and morphological implications of Bandal-like structures. The recurrent use of Bandal-like structures is suggested for flood protection and channel stabilization of the braided Brahmaputra/Jamuna River.

2D NUMERICAL COMPUTATION FOR FLOOD FLOW IN UPPER RIVER BASIN WITH TRIBUTARY ENTRIES BY USING WATER LEVEL HYDROGRAPHS OBSERVED AT MAIN STREAM

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Recently, many upper river basins in Japan are suffering from flood damage due to localized torrential rainfalls. The frequency and intensity of the rainfall is estimated to be increased by the climate change. So, river management and maintenance method in upper river basin are required. However, it is difficult to clarify characteristics of flood flow in upper river basin, because of data insufficiency of tributary riversand flood flow. Because water level can be observed in low-cost and high-accurate,one of the authors has developed the unsteady two-dimensional numerical analysis method by using observed water surface profiles. The method has been applied to various flood events and phenomena in rivers, including river bifurcation, retarding basin and dike break. In many Japanese major rivers, water level hydrographs in the main stream are being observed. So, the application of the method is expected for the management and maintenance of the upper river basin.

The objective of this study is to develop the unsteady two-dimensional numerical analysis method for a river with tributary channels in upper river basin by using water level hydrographs at few observed stations in the main stream. Our computational target is the flood flow at August 2009in the Asa River of the Tama River basin. The longitudinal length of the computational domain of the Asa River is 13 km from the junction point with the Tama River. In the computational domain, there are three tributary channels and five water level observation stations, which include two discharge observation stations. The hydrographs from tributary entries have to be estimated by observed water level hydrographs. However, the water level observation stations are installed far from the junction points of tributary channel for the Asa River.

First, we develop an estimation method of discharge hydrographs from tributary entries by adjusting computed water level to observed one at observation stations, considering propagation time between the junction point and water level observation point. We demonstrated that the discharge hydrographs of main and tributary streams can be estimated by the present method. Second, we develop a flood water tracing method. Weinvestigated that the deformation of the discharge hydrograph and its composition ratios of main and tributary streams. The generation mechanism of discharge hydrograph of the Asa River flood is discussed. Third, the installation method and interval of water level observation stations are discussed. We indicated that a water level observation station is necessary within about 5 km downstream from a junction point of a tributary channel to compute flood flow for the computation of the Asa River flood.

REAL-TIME FLOOD MAPING AND EMERGENCY MANAGEMENT BASED ON FAST TWO-DIMENSIONAL NUMERICAL MODELING

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In recent years, considerable advances were made in two-dimensional numerical modeling of floods using conservative, shock-capturing, upwind schemes. Availability of high-resolution geospatial data sets and remote sensing data that can be manipulated in geographical information systems (GIS) has facilitated providing input data to these two-dimensional models. Despite these developments, the use of two –dimensional modeling for real-time flood simulation and mapping has been hindered for various reasons. The paper presents two two-dimensional food modeling tools as an attempt to respond to this need:

- DSS-WISE is an integrated modeling environment that combines a two-dimensional numerical model with a series of GIS-based decision support tools for consequence analysis, such as loss of life, agricultural damage, etc. The numerical model, CCHE2D-FLOOD, solves shallow water equations over a regular rectangular grid using HLLC scheme, such as a digital elevation map. In addition to the classical array-sweeping type implementation, a linked-list implementation of the scheme is also provided to take into account the fact that in many cases the number of cells containing water is considerably less than the total number of cells. Very large domains, consisting of tens of millions of cells, can be solved in relatively short time, allowing the model to be used for fast simulations during flood emergencies.
- WGFEM is a computer-game-like environment, which provides faster-than-real-time flood simulation with simultaneous, realistic visualization. The numerical model solves shallow water equations over complex natural terrain using the Kurganov-Petrova second-order central-upwind explicit scheme. This scheme is well balanced, can handle wet-dry interfaces, preserves positivity of depth and does not require a Riemann solver. Computational domain is discretized as a staggered regular Cartesian grid. The scheme is implemented on Graphics Processing Units (GPUs) using CUDA programming language. On a desktop equipped with a modern commercial graphics card, computations can be carried out at the rate of 300-350 millions of cells in a second, which translates into computational speeds of 15 to 100 times faster than real life on relatively large domains consisting of several millions cells. The computer-game-like environment provides interactive controls to zoom in and out of the visualization, and to pan and rotate it. Interactive tools are provided to introduce flood protection measures and simulate their effect. This tool can be used for real-time operational emergency management, tabletop exercises and training of emergency management personnel.

Both models share a GIS-based, user-friendly graphical user interface and a pre-processor that greatly facilitates input data preparation. These models were developed at the National Center for Computational Hydroscience and Engineering with funding from the Department of Homeland Security (DHS), Science and Technology Directorate. During the spring floods of Mississippi River, these models were used to provide rapid long term simulations and flood mapping for several hypothetical levee breach floods in order to assist the emergency managers to prepare emergency management plans. An automatic dam break modeling capability has also been developed to allow dam owners to carry out dam safety studies of their own facilities. The paper presents the theory and implementation details that led to the development of these new generation models and presents examples of application.

Special Session 7

"Flood Risk Management tools and their application"

UDX-Theatre, 29 September (13:30 to 15:00)

Overview and Scope of the Session

This special session is about Flood Risk Management (FRM) tools and their applications, with a focus on showing how FRM tools can be used to assist decision makers and practitioners involved in flood risk management. Several international projects are presented in which FRM tools have been developed and successfully applied for flood mapping, risk mapping, calculation of failure probabilities of flood defenses, risk assessment, etc.

The results of these projects will be interesting for practitioners, researchers and decision makers, in both developed and developing areas in the world. We envision a lively setting, which allows for presentation and discussion of practical cases and research results, where participants from around the world can share their experiences and views.

The discussion session is intended to be a dynamic experience that will be stimulated by the presentations in the session. Discussion topics include the generality of the presented approaches, differences in methodologies, challenging application areas, ongoing research into improved techniques, experience with challenges, opportunities, etc.

FLOOD RISK ANALYSIS; CHALLENGES AND APPLICATIONS

Ferdinand Diermanse

Deltares, The Netherlands

Over the last few decades, the world has experienced an increasing number of devastating floods. These events have compelled many governments to embark on disaster management, such as flood control, early warning systems and evacuation planning, with the ultimate aim of protecting their inhabitants from the vagaries of nature. Flood risk management encompasses a wide range of activities and measures, ranging from the traditional flood defense measures, such as dikes and dams, to spatial planning, early warning, evacuation and reconstruction. This reflects the increasing awareness that solutions should be sought in a combination of measures to protect against flooding and to reduce vulnerability. At the same time this poses the question as to how the optimal combination of measures can be found. Costs and benefits need to be weighed while at the same time intangibles such as socio-cultural preferences, environmental consequences and practical applicability have to be accounted for as well. This requires an integrated approach towards flood risk management.

Flood risk analysis (FRA) serves as the basis for sound flood risk management. FRA involves the quantification of probabilities of (extreme) meteorological events, the modeling of rainfall-runoff and hydrodynamic processes, the assessment of potential damages and probabilistic analyses to derive flood risks for the entire area under consideration. Furthermore, the influences of, among others, climate change, land subsidence and human interventions on flood risks have to be taken into account as well. The main benefit of FRA is that it enables to asses the effects of potential measures for flood mitigation. As such it prevents costly investments in structural and non-structural measures that turn out to be ineffective or even counter effective.

One of the main challenges in FRA is to gather and validate data on rainfall, water levels, discharges, catchment characteristics, configurations of the drainage network and dimensions of flood defense structures. The outcome of this process generally determines to a large extent the optimal approach towards FRA. Pragmatic decisions inevitably have to be made, as the available data generally does not live up to the desired levels of quantity and quality.

The presentation will present a number of practical applications of FRA in Vietnam, Indonesia and China (Hong Kong). For each case both FRA of the existing system and the assessment of efficiency of potential measures will be demonstrated.

FLOOD RISK MANAGEMENT, RECENT DEVELOPMENTS IN THE NETHERLANDS

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Flood risk management can be optimized using a risk-based approach, in which management alternatives are compared based on the resulting reduction of flood risk, including the human casualties that may result from potential flooding. The optimal level of safety minimizes the cost of flood protection and expected damage from flooding. An assessment of flood defenses is an essential part of an optimal flood risk management strategy, in particular to determine where investment is needed to keep the area protected. In the Netherlands, recent studies have focused on the determination of new risk-based safety standards. This has involved state-of-the art research into the probability of various flooding scenarios and the resulting damage and casualty responses. Parallel research is focused on the assessment of the flood defenses, to determine whether they meet the risk-based safety standards. This research involves the computation of flooding probabilities for low-lying areas protected by systems of levees, dunes, and hydraulic structures, as well as the determination of assessment methods (e.g. safety factors) to assess stretches of the levees independently for many different failure mechanisms. The risk-based approach to flood risk management also involves the adoption of a multi-tiered safety approach, including 1) prevention through conventional means (e.g. levees), 2) flood-resistant spatial planning, and 3) disaster management and evacuation. Which alternative is optimal is determined based on cost-benefit analysis in which the reduction in risk is weighed against the cost of the various alternatives. This presentation will highlight some of the research that is being carried out in the Netherlands and will discuss the generality of the methods and potential applications in international contexts.

THE DELTA PROGRAM IN THE NETHERLANDS: A LONG TERM PERSPECTIVE ON FLOOD RISK MANAGEMENT

Jos van Alphen

Staff Delta Program Commissioner, The Netherlands

As a transitional zone between the marine and land environment, delta regions are important ecological habitats, attractive areas to live and generate new economic developments. All over the world these delta regions face a similar challenge: how to deal with soil subsidence, the continued growth of urban areas and the effects of expected climate change: increased sea level rise and extreme river floods.

In September 2008 the Dutch Committee on Sustainable Coastal Development (the 2nd Dutch Delta Committee) advised to develop and implement a Delta Program to adapt flood risk management (and fresh water supply) to climate change in order to maintain the Netherlands as an attractive place to live and work3). Not as a response to a disaster, as usual, but in advance, to avoid it. The same year the government approved the advice and incorporated it into the National Water Plan. On 1 February 2010 the Delta Program Commissioner was installed, in order to elaborate and implement the advice into a rolling-on Delta program4).

Regarding flood risk management the Delta-program will result in a new policy regarding flood proof urban (re)development and actualized standards for flood protection. These new standards anticipate on potential climate change and socio-economic developments towards 2050. They will be based on cost-benefit analysis and consider societal risk (loss of life, group risk) as well. The program also includes the necessary measures on the short term (maintenance, improvement of "aging infrastructure"), framing these measures into the long-term perspective. Multifunctional design of measures is stimulated, since it increases societal "added value" (regarding nature, recreation or urban development) and enhances acceptance.

Within the Delta program one of the largest challenges is dealing with uncertainties in the future climate, population, economy and society. Reducing the uncertainty by research or improved measurements is not enough, the Delta program is also exploring an adaptive way of planning. Adaptive planning is an iterative feedback and learning based strategy to cope with uncertainty in decision making. It seeks to maximize flexibility, keeping options open and avoid "lock in".

The Delta Program Commissioner directs this multi-governmental process of policy development and implementation, monitors the progress, reports to the Parliament every year in September and takes the necessary steps when problems arise.

The implementation of the Delta-program is essential for the future of the Netherlands. From 2020 on a Delta-fund of about 1 billion euros per year provides stability in financial resources, reducing dependency of economic developments and political decision-making.

Finally the Delta Act forms the legal basis for the implementation of the program, the responsibilities of the Commissioner and the Delta Fund.

[3] www.deltacommissie.com
[4] www.deltacommissaris.nl

Special Session 8

"Flood resilience: Interdisciplinary approaches emerging from recent European research projects"

UDX-Theatre, 29 September (15:15 to 16:45)

Overview and Scope of the Session

The existing concepts of resilience to natural hazards still vary in many respects: they are incompatible across temporal and spatial scales, and they are not carefully separated from related concepts such as vulnerability, sustainability and adaptive capacity. Timmerman (1981) defined resilience as a "measure of a system's or part of the system's capacity to absorb and recover from hazardous event" and was among the first to move from the concept of ecological resilience towards social resilience. Adger (1997) defined resilience as "the ability of human communities to withstand external shocks or perturbations to their infrastructure such as environmental variability or social, economic, or political upheaval and to recover from such perturbations". The recognition of resilience in social sciences went hand in hand with the adaptation of the concept to natural hazards. In recent years, many other approaches were developed, which relate resilience to natural hazards.

Across the EU, the concept of resilience in the field of flood risk management has been investigated in a fragmented way. In this context previous or current European research projects address specific dimensions of flood resilience. In response to that, this session is presenting and bridging the knowledge gained from leading European projects in the field of societies' resilience against flooding. The EU research projects whose flood resilience output on this topic will be presented under this session are the following:

- CONHAZ (Costs of Natural Hazards)
- CapHaz-Net (Social Capacity Building to Natural Hazards)
- RISK MAP (Improving Flood Risk Maps as a Means to Foster Public Participation and Raising Flood Risk Awareness)
- ENSURE (Enhancing resilience of communities and territories facing natural and na-tech hazards)
- MOVE (Methods for the Improvement of Vulnerability Assessment in Europe)

Demonstrating the research output of five leading EU projects, the scope of this session is to communicate, in a comprehensive way, these results to a wider scientific audience. Also another major objective of this session is to bridge different aspects of floods resilience (economic, social, communication, vulnerability) and to open the dialogue for establishing an integrated flood risk assessment approach.

The primary ambition of this session is to deliver a step change in flood risk management communities' ability to exploit capacities as a way of enhancing resilience. This session will provide a major contribution towards flood resilience management and may, together with other sessions, complete a portfolio of strategies to enhance flood risk management in an integrated framework.

The expected results are:

- Communication of the output of leading EU research projects and bridging the gap in flood resilience scientific community.
- New clarified and largely accepted concept(s) and methods to define and measure the resilience of a society to flooding events.
- Framework for a more comprehensive approach to be shared and tested in Europe and elsewhere.
- Identification of mechanisms and measures to enhance flood resilience and improve prevention and recovery.

SOCIAL CAPACITY BUILDING FOR FLOODS: AN EMERGING FIELD OF PRACTICE AND RESEARCH IN EUROPE

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Social capacity building for natural hazards is a topic increasingly gaining relevance not only for so-called developing countries but also for European welfare states which are continuously challenged by the negative social, economic and ecological impacts of natural hazards. This is quite remarkable, as European countries have so far been considered as the capacity builders; the idea that it is necessary to build capacities in Europe itself is a rather recent one and implies that there is also a lack of capacities on the part of contemporary European societies. The aim of this paper is to develop perspectives on the idea of social capacity building in Europe. Therefore it presents central findings of an extensive literature review, assessments of existing practices as well as insights gained from a recent workshop focusing on fluvial floods in a Central European context.

We first develop a heuristic model of social capacity building by taking into account a wide range of existing expertise from different fields of research and practice. Particular attention is paid to social vulnerability and its assessment as well as to risk communication and risk education as specific strategies of social capacity building. This part of the presentation takes into account relevant stocks of knowledge, expertise and experiences that have been published and debated over the past 40 to 50 years in the discourses on capacity building, natural hazards and disasters, as well as recent discussions on climate change. The second part of the presentation focuses on current social capacity building practice in European flood risk management by referring to insights gained from interviews and a workshop with stakeholders that focused on the implementation of the European Floods Directive. The aim of the workshop was to identify and assess current knowledge and practices on stakeholder involvement, public participation and risk communication during the assessment, mapping and management of flood risks.

The paper builds upon work of the CapHaz-Net consortium, an ongoing research project funded by the European Commission in its 7th Framework Programme.

IMPROVING FLOOD RISK MAPS AS A MEANS TO FOSTER PUBLIC PARTICIPATION AND RAISING FLOOD RISK AWARENESS – RECOMMENDATIONS FROM THE RISK MAP PROJECT

Volker Meyer[1]
Christian Kuhlicke[1], Sven Fuchs[2], Sally Priest[3], Wolfgang Dorner[4], Kamal Serrhini[5], Joanna Pardoe[3], Johanna Seidel[4], Jochen Luther[1], Herwig Unnerstall[1], Gaëtan Palka[5], Simon McCarthy[3], Christophe Viavatenne[3], Sebastian Scheuer[6]

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The EU Floods Directive requires the establishment of flood risk maps for high risk areas in all European member states by 2013. However, if existing at all, the current practice of risk mapping in Europe still shows some deficits: Risk maps are often seen as an information tool rather than a communication tool. This means that, for example important local knowledge is not incorporated. Furthermore, the contents of risk maps often do not match the requirements of the end users. Finally, risk maps are often designed and visualised in a way which cannot be easily understood by laypersons and/or which is not suitable for the respective needs of public authorities in risk and event management.

The project RISK MAP aims at improving flood risk maps as a means to foster public participation and raising flood risk awareness. For achieving this aim RISK MAP: (1) develops rules for appropriate stakeholder participation enabling the incorporation of local knowledge and preferences; (2) improves the content of risk maps by considering different risk criteria through the use of a deliberative multicriteria risk mapping tool; and (3) improves the visualisation of risk maps in order to produce user-friendly risk maps by applying the experimental graphic semiology method that uses the eye tracking approach.

Research in the project is being carried out in five European case studies. In each case study the status quo of risk mapping and the legal framework were analysed, several stakeholder interviews and workshops are being carried out, the visual perception of risk maps has been tested and – based on this empirical work – exemplary improved risk maps will be produced. Our presentation will outline the main findings of the project (ending in August 2011). This presentation will show exemplary case study and user group-specific results as well as overall recommendations on: 1) stakeholder participation; 2) contents of risk maps; and 3) user-friendly visualisation of flood risk maps.

MODELING THE VULNERABILITY TO FLOODS FOR THE SALZACH RIVER - APPLICATION OF THE MOVE FRAMEWORK FOR DIFFERENT SCALES

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In the frame of the EU FP7 research project MOVE - Methods for the Improvement of Vulnerability Assessment in Europe – a conceptual framework has been developed in a joint effort. The framework conceptualizes vulnerability in a hazard and scale independent context which is embedded in the context of risk governance and with emphasis on climate change adaptation. The overall objective of MOVE is to provide policy makers,public administrators, researchers, educators and other stakeholderswith an improved generic framework and methodologyfor the measurement and assessment of vulnerability to naturalhazards in Europe's regions. It employs an integrated,comprehensive approach that will help to guide decisionmaking in the future. The framework and proposed procedural steps have been developed and tested in seven European case studies with a focus on different hazards and scale levels. Next to the scientific work, the project undergoes a scientific and user validation, which is currently feeding back into the project.

The developed conceptual framework defines risk as a relationship of hazard (natural or socio-natural events) and vulnerability which is associated to society. Coupling and feedback loops between the hazard domain and the society through its vulnerability are also recognized. Vulnerability applies to different scale levels, which are essential to be specified. Domains of vulnerability are made up of exposure (spatial/temporal), different susceptibility dimensions (physical, ecological, social, economic, cultural, institutional) and the lack of resilience which is described through the (in)capacities to anticipate, to cope and to recover. Options for intervention are defined within the hazard and vulnerability domain, which are also seen in the light of adaptation on the risk management/governance side of the framework.

The Salzach case study implements the developed MOVE framework in the context of flood hazards and has developed assessment methodologies on the catchment and community scale. The Salzach catchment is characterized through its alpine upstream area and highly dynamic river valleys and the city of Salzburg with its wider agglomeration area in the downstream areas. Recent floods have occurred in 2002 and 2005. As on the one hand it is important to recognize the catchment scale, as it is also seen in the EU Water Framework Directive, on the other hand decisions in regard to disaster risk reduction are made at the local community scale. Additionally opportunities have been explored to link the results to the EU Floods Directive.

The methodology applied uses traditional approaches such as Multi-Criteria Assessment and the involvement of expert weights, but further progress through the identification and modeling of homogenous vulnerability regions which include the different domains of vulnerability as an integrated indicator. The methods build on regionalization algorithms which have been applied for the two different scale levels. A discussion of the results for the different scale levels and opportunities to model vulnerability in the frame of the MOVE project will be highlighted within this presentation.

FLOOD DAMAGES ASSESSEMENT: TOWARDS A BETTER APPROACH IN SUSTAINABLE FLOOD RISK MANAGEMENT

Green Colin[1],
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Severe flooding, such as the floods in the UK of autumn 2000 and summer 2007, and the Elbe and Danube 2002 floods, have highlighted the weakness and threats of flooding for European cities. Those events resulted in a shift to treating flooding within the wider perspective of integrated water resource management. At the same time, the recognition of the need to both mitigate and adapt to climate change, and broader need to change to sustainable development, together with a new emphasis on the centrality of stakeholder engagement, established a new policy context. These new challenges are expressed in the political agenda by the European Water Framework Directive and the European Flood Directive. Central to this new policy paradigm are change, and specifically: learning as successful adaptation to change, and resilience as the capacity to recover from shocks.

Economics, as the application of reason to choice, potentially offers a means of helping the stakeholders to decide what is the best course of action to adopt. From the wider social perspective, economic analysis must also respond to the requirements to deliver sustainable development in a context of external change where a flood itself can be seen as a perturbation. Such an economics must address what the stakeholders mean by 'best', and help them to negotiate or agree what is the best available course of action and to invent better courses of action.

The European ConHaz project aims at answering these questions for various hazards (floods, storms, drought and alpine hazard) by compiling the state-of-the-art approaches, methods and terminology in economic cost assessment, by exploring with stakeholders their needs and the gaps in using these methods. This paper will focus on the conclusions and recommendations synthesized on the flood hazard.

Methods for direct cost assessment have been extensively developed in Europe as a means of assessing the magnitude of the shock to the economy delivered by a flood. However significant issues remain in terms of data collection and availability to enable validation and to reduce the uncertainty associated with their assessment. Much more difficult to evaluate is the dynamic response of the economic, environmental and social systems to this shock so that the resilience of these systems to external perturbations can be determined. That response spreads not only over time but also spatially outside of the area that is flooded. Further challenges are to take account, first, of the Millennium Ecological Assessment concept of ecological supporting services which approach frames ecosystems services as underpinning all human activity rather than being an add-on extra to the economy. Secondly, to understand the assessment of a flood in terms of the Stiglitz Commission's concept of 'well-being' as a multi-dimensional concept.

DEVELOPING AN INTEGRATED VULNERABILITY FRAMEWORK TOOL FOR FLOOD RISK MANAGEMENT

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Vulnerability has long been a key concept in disaster literature. However, the majority of studies have focused on research related to the hazard, therefore neglecting the influence of the vulnerability of exposed systems to the consequences of such hazards, such as the death toll, damage to infrastructure and other losses from natural or man made disasters. There is also a need to better identify and measure the ability of 'at risk' and affected communities and territorial systems to respond to such disasters. This paper will focus on findings from the ENSURE project (Enhancing resilience of communities and territories facing natural and na-tech hazards) which is a Collaborative Project financed by the European Commission under the 7th Framework Programme. The project runs from June 2008 to May 2011 and involves 10 European partner institutions.

The basic assumption of ENSURE is that our ability to better understand and evaluate different types of vulnerabilities constitutes a crucial tool to strengthen communities in the face of disasters and natural hazards such as flooding. Improving the understanding of the factors that make a community more vulnerable is crucial. This will involve addressing the various physical, psychological, cultural, systemic, social and economic components that shape the relationship between societies and the "natural" environment, and will permit more tailored and articulated mitigation measures. Thus the overall objective of ENSURE was to contribute to an improved analysis of vulnerability for improving the resilience of communities. The research is seeking to do this by developing a new methodological framework for Integrated Multi-Scale Vulnerability Assessment. The framework is based on a comprehensive, integrated and inter-disciplinary understanding of how mitigation strategies can be improved in the future. It is hoped that such a framework will contribute to the reduction of human losses, economic damage and social disruption due to extreme events striking communities exposed to a variety of natural hazards, as well as to the potential consequences of Climate Change. It will provide support for policy decisions with key stakeholders, at various scales, relating to prevention measures and plans in order to minimise damage from natural disasters;

This paper will outline the development of the integrated methodology, the various challenges this has posed, and how these have been addressed. It will report on the testing of the framework at the local scale in one of the project's case study sites in Ilia, Greece, an area which is not only at risk from flooding but also from forest fires and earthquakes. Finally, the paper will make recommendations for further improving the framework.

Parallel Oral Sessions

Topic 1

Flood Risk Management (Prevention, Mitigation and Adaptation)

- Structural measures (design, construction, operation and maintenance)
- Non-structural measures
- Flood risk management policy and strategic planning
- Land use control measures
- Climate change adaptation
- Environmental and ecological consideration
- Flood management in the context of Integrated Water Resources Management
- Maximizing flood benefits

A TENTATIVE PLAN FOR CLASSIFIED MANAGEMENT ON FLOODPLAIN OF THE LOWER YELLOW RIVER

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The vast floodplain of the lower Yellow River is not only a flood way that plays an important role for flood detention and sediment deposition, but also the region as homeland for 1.89 million farmers. Along with the operation of the Xiaolangdi Water Control Project and gradual improvement of river training works on the lower Yellow River, the management model that generally used to take floodplain areas on the lower river as a flood area can not meet the needs of social and economic development. It has arosed many scholastics' attention that how to deal with the risk of the floodplain land use.

The paper puts forward a new idea of dividing floodplain areas on the lower Yellow River into 3 types according to their functions for construction and management based on overall study and analysis , i. e. Type 1 is flood areas , Type 2 detention basins and Type 3 centralized residential districts.

In order to carry out classified management of floodplain area, the key emphasis should be stressed at present on the aspects of a pilot project of classification, compensation policies and construction standards and policies for management of the local dykes.

AUTOMATED FLOOD RISK ASSESMENT

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Worldwide, hundreds of thousands of kilometers of levees along coasts and riversprotect the hinterland against flooding. Manyof those levees are old and little is known about their strength under hydraulic loads. In addition tohydraulic loading and geometrical data, information on the subsoil and its conditions are of great importance for assessing the reliability of a levee system. Dependent on the failure mechanism, these mainly involve thickness and properties of the soil layers and geo-hydrological conditions, including their uncertainties. By means of empirical or physical-based models that describe the various failure mechanisms, the probability of failure given a hydraulic load can be calculated. Especially in operational flood risk management, there is a need for practical methods or systems with which the transient strength of levee sections, consisting of many cross sections, can be calculated real-time and accounting for uncertainties in both strength and (changing) hydraulic load. An important requirement on such a system is that it can process large quantities of data automatically and fast. The results can be used for decision-making (e.g. emergency measures). In order to cope with this challenge, several software toolsforautomated assessment and design of levees are currently being developed in the Netherlands.

Many data acquired in the field or by geological analyses are raw measurements and cannot be used directly in the models describing the failure mechanisms used to assess the safety of levees. This data needs to be first processed (e.g. conversion into input parameters with a certain uncertainty) and filtered before it can serve as input for the models. FEWS-DAM is a software tool that automatically processes the gathered data and combines the data with each other. Therefore, it uses schematization algorithms based on guidance and expert knowledge. Currently the failure mechanisms macro-instability and backward erosion have been implemented and can be used in a probabilistic manner.

Automated assessment tools offer an additional aid in flood risk management and emergency response. These tools can be applied in different phases of flood risk management (see figure) varying from computation of scenarios as input for contingency plans, real time risk assessments for flood mitigating, design of emergency measures to pre-flooding computations to optimize prevention measures.

Figure 1. Phases of flood risk management and emergency response

This paper shows the application of FEWS-DAM on a real dike ring, located in the province of Overijssel (the Netherlands), and surrounded by rivers. The case study focuses on the application for flood risk mitigation. For a large number of cross sections along the dike ring the probability of failure of the levee due to the failure mechanism “backward erosion” has been assessed real-time and automatically, based on real-time predictions of water level (including its uncertainty) and strength parameters (including their uncertainty as well). The results do not only provide insight in when and where along the dike ring the situation may become critical (i.e. an unacceptable high probability of failure), but also in the relative contributions of several sources of uncertainties to the probability of failure by backward erosion. This information is useful for emergency response.

PREDICTION OF EFFECT OF HUGE STRUCTURES ON ECO-HYDROLOGICAL CHANGES IN CHANGJIANG BASIN

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Increasing frequency of severe floods on the middle and lower Changjiang (Yangtze) River during the past few decades is understood to attribute to both abnormal monsoon rainfall and landscape changes that include extreme deforestation, shrinking lakes, and levee construction that reduced the areas available for floodwater storage. It is also estimated that the Three-Gorges Dam (TGD) and the South-to-North Water Transfer Project (SNWTP) will affect the frequency and intensity of severe floods in the PoyangLake region of the middle region.

Here, process-based Nies Integrated Catchment-based Eco-hydrology (NICE) model (Nakayama, 2008a, 2008b, 2010, 2011a, 2011b; Nakayama and Fujita, 2010; Nakayama and Hashimoto, 2011; Nakayama and Watanabe, 2004, 2006, 2008a, 2008b; Nakayama et al., 2006, 2007, 2010, 2011), which includes surface-unsaturated-saturated water processes and assimilates land-surface processes with satellite data describing phenology variation, was further developed for controlled discharge released at reservoirs to predict the impact of TGD and SNWTP on eco-hydrological changes.

The model predicted that the TGD might promote flood risk during early summer monsoon against original justifications for building the dam, which is also related to complex river-lake-groundwater interactions. Several scenario analyses for long-term periods predicted that morphology change would promote the flood risk around the lake, mostly during the early summer. This indicates the importance of managing both flood discharge and sediment deposition for entire basin. Next, the authors evaluated the impact of sand mining in the lake after its prohibition in the Changjiang mainstream, and clarified that alternative scenario of sand mining in lakes currently disconnected from the mainstream would reduce the flood risk to a greater extent than intensive dredging along junction channel.

Furthermore, the Time-Integrated NDVI (TINDVI) estimated from satellite images during the past two decades showed a spatially heterogeneous distribution and generally decreasing trends beside the lakes, which indicatesthe increases in lake reclamation and the resultant decrease in rice productivity were closely related to the hydrologic changes. This integrated approach would help to minimize flood damage as far as possible and make the better decision on sustainable development in the basin.

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FLOOD RISK ASSESSMENT FOR URBAN CRITICAL INFRASTRUCTURES- FROM SIMPLE RISK ASSESSMENT TO ADVANCED MODELS

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Floodis one of the major natural hazards that has caused loss of lives, significant economic damage, pollution on the nature and the built environment, loss of cultural heritages, and even cause community disorder and health problems. Climate change has increased the risk of flooding. Intensive development and urbanization have caused cities to be more vulnerable to the emerging risks of natural disasters.

Critical urban infrastructures are defined in the paper as those facilities and their buildings, such as electricity supply, telecommunication, transport, water supply and sewage drainage systems, and those providing for public service and emergency actions. A small failure in the networks may cause a series of failures in the chain of critical infrastructures. This paper will investigate how flood risk will affect urban drainage systems and associating infrastructures.

A Risk and Vulnerability Assessment (RVA) can, based on simple risk analysis approach,estimatethe risk levels of the identifiedrisk events and resulting consequences, which however cannot provide detailed information of the risk such as affecting people, buildings and infrastructures. Advanced numerical models are necessary be applied to identify risk areas, vulnerable bodies and levels of the risk with regard to given scenarios.

The paper presents a three-stage approach comprising RVA, GIS-based analyses and modelling approaches to make assessment of flood risk for selected cases in Norway. Catchments from different climate regions with higher and lower development levels are selected to demonstrate the need for data (e.g. types, resolution and quality) and methods to perform the analyses.

The paper presents some initial results of currently on-going research projects of flood protection of and climate change impacts on the built environment.

NATIONWIDE ASSESSMENT OF THE DEGRADATION OF FLOOD DISASTER MITIGATION EFFECTS OF RIVER IMPROVEMENT WORKS DUE TO GLOBAL CLIMATE CHANGE

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Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is struggling to implement adaptation measures against floods under the global climate change, since its importance has been emphasized, for example, in the policy report “Measures to adapt to climate change due to global warming that causes flood disasters” by the Panel on Infrastructure Development, MLIT, submitted in June 2008.

Since Japan is much vulnerable to flood disastersbecause of the high density of land use and the deep dependence on alluvial plains, the river improvement projects have been carried out toward the safety level prescribed in the river improvement framework plans, though the gap between the prescribed and achieved safety levels still exists. Under the global climate change, additional river improvement work is to be needed for making up for the increased flood discharge, if we attempt to secure the same target safety level. It is important, therefore, to estimate this additional amount of river improvement work in comparison with the amount of river improvement work planned in the current river improvement framework plan as a key index of overall difficulties in coping with GCC impacts on flood disaster mitigation policies. How it will be affected by the range of torrential precipitation projection due to the uncertainty over the calculation of future climate change is also important for discussing the adaptation measures against floods under the global climate change.

The authors have estimated the median and the confidence intervals of the rate of increase of following three values, flood discharge, amount of river improvement work, and probability of exceedance (for representative flood discharge, e.g. 1/100 year flood discharge on the current river improvement framework plan) for major rivers in Japan. For this estimation, the authors calculated the median and the confidence intervals of the rate of increase of the annual maximum rainfall per day in each region from the results of 20km mesh Global Circulation Model and 5km mesh Regional Circulation Model simulations conducted by Meteorological Research Institute, Japan Meteorological Agency, MLIT. The estimation has been conducted for two periods, one for about 30 years later from now, and another around the end of 21st century. The authors have drawn nationwide figures indicating the results above.

This estimation method provides one of the useful tools for capturing basic nationwide information mentioned above, and it will contribute to the research and discussion on the specific adaptation measures against floods. It has been shown that the rate of increase by GCC impacts and its confidence interval of future rainfall are amplified as it is transformed into flood discharge, river improvement work, andprobability of flooding. These results implicate that we should discuss the specific adaptation measures considering the large uncertainty of the three factors.

THE POTENTIAL OF CBA TOWARDS INCREASING THE UPTAKE OF PROPERTY-LEVEL FLOOD RISK ADAPTATION

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The economic and environmental costs of flood disasters have increased rapidly in the UK over the last decade. Due to the increase in economic costs, the flood risk management policy in the UK has now moved away from flood defence towards 'living with floods', ‘prepare for flood’, live with risk’ and 'making space for water'. This means that individual property owners need to take on the responsibility of protecting their properties against future flooding.

Cost benefit analysis (CBA) is a project appraisal method that sums up the equivalent monetary values for all the costs and benefits of a project, thereby allowing one to assess if a project is worthwhile. The CBA approach is used by the UK government in carrying out appraisals of proposed flood defence schemes. The government has recently changed its flood risk management investment criteria to allow consideration of both tangible and intangible impacts of flooding in this process. Intangible impacts (such as PTSD, mental health problems) are now being captured by use of a system of differential social weights, although, there is little evidence that this has so far affected the decisions that are currently been made on flood defence scheme investment.

At an individual property level, the main driver for investment especially on flood mitigation is how much the scheme will cost and can I afford it? The concept of applying the CBA approach to assess the long-term benefit of such investment is rarely given rigorous consideration.

This study reports on the potential application of the cost benefit analysis approach for appraising at an individual property-level, the cost effectiveness of flood mitigating measures, by reviewing relevant literature. The review reveals that the CBA approach could help property owners to clearly quantify in monetary terms both the tangible and intangible benefits of investment in flood mitigation measures. It is therefore recommended that the use of CBA at an individual property level for project appraisals should be developed towards increasing the uptake of property-level flood risk adaptation.

PRELIMAINARY IDENTIFICATION OF FLOOD PRONE AREAS IN THE DOWNTOWN AREA OF SHANGHAI CITY

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Flood risk mapsgive important information for flood risk management and more specifically for spatial planning and risk zoning.A flood risk map can providedirect insights to identify the flood prone areas and help decision-makers to make efficient choices on the mitigation measures such as arrangementsof evacuation routes during a threatening flood. A delta city like Shanghai, China, which is located around sea, rivers and lakes, is imperiled by several hazard factors such as rising sea level, high river discharge, heavy rainfall and land subsidence, etc. in the coming future.In addition, Shanghai is playing a prominent economic role in China even in the world, a threatened flooding may lead to a massive negative consequences in terms of direct and indirect economicdamage. Until now, limited work has been done on the flood risk mapping in Shanghai city and therefore there is a need to create a flood risk map to identify the flood prone areas in Shanghai city.

Shanghai is a flat and relatively low area with an average elevation of 3-3.5m*(under Wusong datum system) withespecially low parts in the downtown area (no more than 3m).It is surrounded in the north by estuary of Yangtze River, in the south by HangzhouBay, TaiLake in the west and ChinaEastSea in the east. Moreover, HuangpuRiver forms a main drainage way from the TaiLake and this river meanders through the city including the downtown area. Under the pressure of climate change and the booming socio-economic development with expanding of urbanization in the whole city, the question of which place has potentially high risk of flooding in Shanghaiis brought up. The objective of this paper is to identifyrisky placesindowntown area of Shanghai city based on the flood hazard assessment and socio-economic vulnerability assessment due to river flooding from HuangpuRiver.

With the approaches of hydraulic modeling in HuangpuRiverfor flood simulation, probabilistic methods for vulnerability identification and geographic information system for mapping, the flood prone areas of flooding in Shanghai city can be presented by flood risk maps. Flood prone areas indicate the high hazardous place (high-inundation area) with high socio-economic vulnerability. Results can be provided to indicate the places in downtown area of Shanghai city in need of mitigation measures for the policy makers for further planning on flood risk management. This paper presents the first results based on limited data and a limited number of flood hazards and flood scenarios. Recommendations will be provided on how to improve the accuracy of these maps. Recommendations will focus on the collection of higher resolution elevation data and more information about the current socio-economic situation. For a more complete flood risk map of Shanghai city, other patterns of flooding, such as coastal flooding, will be considered in the further research.

*: Wusong datum= China Yellow Sea datum (sea level) +1.924m

ANALYSIS METHOD ON DRIVERS AND RESPONSES OF FUTURE FLOOD RISK IN TAI BASIN

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Scenario analysis for future flood risk in the Taihu Basin involves many physical and man-made factors, as well as complex relationship among them. To design future flood risk scenario, it is necessary to identify key factors that have a great impact on flood risk and to get to know the relation among those factors. Based on the foreign achievement experience, this paper proposed the concept and method of drivers and responses analysis for future flood risk, which is better to study the mechanism of the flooding system. Taking the Taihu Basin as an example, the relationship between drivers and responses in the flooding system was founded based on the deep description of each driver and response, and the degree of impact on the future flood risk of drivers and responses are given, which provided valuable information for foresight research of future flood risk in the Taihu Basin.

FLOOD RISK MANAGEMENT PLANS IN EUROPE: EXPERIENCES WITH THE PREPARATION AND IMPLEMENTATION

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The European Floods Directive (FD, 2007/60/EU) requires Member States to define objectives for the management of flood risks in river basins, focusing on the reduction of potential adverse consequences of flooding for human health, the environment, cultural heritage and economic activity. Flood risk management comprises physical measures to reduce the likelihood and consequences of flooding and, where appropriate, non-structural initiatives.

The first generation of these flood risk management plans (FRMP's) will become available in 2015.

This paper presents the first experiences with the elaboration and implementation of these FRMP's in 20 European countries on the following themes:

- suitable level of detail of objectives and FRMP's in relation to the spatial scale of the river basin,
- types of measures, including prevention, protection and preparedness, methods to prioritize, legal frameworks, anticipation on climate change;
- (inter)national process design, including involvement of relevant authorities, stakeholders and public, coordination with EU Water Framework Directive, role of international river basin commissions
- funding and cost benefit assessment.

DYNAMIC ASSESSMENT OF FLOOD HAZARD RISK IN RURAL FLOODPLAIN

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Landuse changes due to urbanization increase flood hazard risk and these dynamic changes in urbanizing rural floodplains need to make a dynamic investigation on flood risk. This paper has a technical view on flood hazard assessment of developing rural floodplain by comparison of present and probable future of landuse in study area. In this study, flood hazard risk of agriculture floodplain under two scenarios- present and future landuse in rural and semi-urban areas is analyzed. In this study for both scenarios, the flood damage cost calculated based on the Annual Average Flood Damage (AAD) related to landuse and the values evaluated using Analytical Hierarchy Process (AHP) and Reasonable Goal Method (RGM). In this paper, one pattern predicted to landuse pattern of urban area and using another pattern or multi pattern of development in urban area can change the results. Results shows that under the normal pattern of development in study area, urbanization can increase AAD by more than 800 times and based on comparison of value to cost ratio, the present scenario could be better scenario. As urbanization is unavoidable in urbanizing rural floodplains, urban development through effective planning and solutions with more planted area are a must to help decrease flood hazard risks in the future.

GAP ANALYSIS OF THE FLOOD MANAGEMENT SYSTEM IN METRO MANILA, PHILIPPINES: A CASE STUDY IN THE AFTERMATH OF TYPHOON ONDOY

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For decades, floods caused by heavy rains have repeatedly submerged critical areas in Metro Manila, which prompted the Philippine government to establish a flood management system that consists of both structural and non-structural measures. However, most of the operational flood mitigation infrastructures were proven inadequate during the onslaught of the typhoon Ondoy, as the storm brought in rains that exceeded the rainfall intensities of all the country's previous typhoons on record. The aftermath of typhoon Ondoy paints a bleak scenario for the highly urbanized communities of Metro Manila as the effects of climate change increase the likelihood of storms that will arrive with the same or higher intensities in the years to come. This study deals with the gap analysis of Metro Manila's flood management system using the observations made during the aftermath of typhoon Ondoy, with primary focus on the effectiveness of flood control structures and early warning system in the core areas of Metro Manila. The gaps were determined by assessing the planned objectives of the current flood prevention and control programs as against to the operational flood management system and infrastructural needs determined from the experience with typhoon Ondoy. The rainfall and water levels recorded in EFCOS were also analyzed to investigate the gaps that may be present in the early warning system. The investigation reveals that factors such as inadequacy in the hydraulic design of flood control structures to cope with higher flood return periods, lack of proper maintenance of flood warning infrastructures, constriction of drainage systems that reduced the basin flow capacities, and etc., have contributed to the unprecedented flood events of September 2009. Significant damages occurred in areas where flood mitigation programs were either lacking or inadequate, which is primarily the result of improper land use planning. The study concludes by stressing the need for distributed and enhanced flood mitigation programs in planned and constructed flood control structures, including the upgrading of early warning systems. The initial flood management programs should be reviewed and revised in accordance with a new safety level for flood prevention and control.

LONG-TERM CHANNEL CHANGES IN THE MEKONG RIVER: TOWARDS A SUSTAINABLE RIVER CHANNEL MANAGEMENT

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River-channel changes are a key factor affecting physical, ecological and management issues in the fluvial environment. In this paper, long-term channel changes in the Mekong River were assessed using remote sensing and a channel-evolution model. A channel-evolution model for assessing long-term channel changes of a meandering channel was developed using a previous fluid-dynamic model, and was applied to the Mekong River in order to assess channel changes of two meandering reaches. Unstable extents of the reaches could be historically identified using remote-sensing technique. The erodibility coefficients of the reaches were calibrated by comparing remote-sensing measurements and model simulations. The difference in erodibility coefficients between both reaches depends on the difference in bank height rather than the geotechnical properties of floodplain sediments. Possible eroded floodplain areas and accreted floodplain areas of the Vientiane reach were zoned over the next 50 and 100 years based on long-term simulations.

In the Lower Mekong Basin, the river is characterized by large areas of alluvial channels. The impact of river-channel changes on humans, flora, and fauna is a serious problem. Riverbank erosion has occurred at many sites along the lower Mekong River, thereby imperiling the nearby settlements and infrastructure. The deep pools along the Mekong River provide critical habitats for fish, especially during the dry season. Bank erosion and deposition affects the deep pools. Nutrient transport influences the ecology in the Mekong River. The Mekong River is now facing a disruption of its nutrient balance, as large increases in nutrient input to surface water are expected in the twenty-first century.

Dam construction changes flow and sediment regimes, thereby changing the river channel and the associated habitats. In the main stream of the Mekong River, three dams were completed and five dams are under construction or planned in the Yunnan province of China. Meanwhile, eleven dam development plans are going on in the main stream of the lower Mekong River, in order to satisfy the increase in domestic power demand and to obtain foreign currency. The suspended sediment load actually decreased by closure of dams. For all of these reasons, understanding the channel changes of the lower Mekong River is very critical for sustainable river management. However, such changes are poorly understood, and so we address this problem towards a sustainable river channel management

CREATING NEW OPPORTUNITIES BY INTEGRATING WATER SAFETY AND SPATIAL PLANNING

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The Netherlands is worldwide famous for it's continuous battle against the water. In the last decades more and more building have been build, where no place is for water. In order to be able to anticipate to climate change and to ensure that water aspects are incorporated in spatial plans, the WaterCheck has been designed. So in the last decades, the role and importance of water has changed within spatial planning in the Netherlands.

Moreover, the National Water Plan (NWP) has become active. This plan outlines the policy and corresponding implementation measures for the full scope of water management and contains an initial elaboration of the Dutch Delta Programme.

One striking aspect of the NWP is there is a deviation of a long trend. The Netherlands is a country which is known from time immemorial that she takes prevention measures against floods. In the NWP there is a new central approach, the so-called 'multi layer safety. With floods it is important to deal with uncertainties in a sensible manner. The Dutch policy is directed towards protection against water and limiting social disruption in the event of a disaster.

The multi-layer safety consists of three layers:

1. Prevention as the policy cornerstone;
2. Sustainable spatial planning;
3. Systematizing and sustaining disaster mitigation.

In the second layer the aim lies to increase the coping capacity of the Dutch society. This is new for the Netherlands, whereas else in the world more experience has been gained on this topic.

Besides increasing the coping capacity for the buildings, also adjustments are necessary for the vital and vulnerable objects in possible flooded areas. This requires a new systematic approach between two disciplines, water management and spatial planning.

The conclusions and recommendations of the 2nd Delta Committee give way to new multifunctional flood defense concepts, also to give some release on the spatial pressure.

In this paper more information regarding the new opportunities for integrating water safety and spatial planning in relation to flood risk management are explored. Also lessons learned from other countries are incorporated in this paper and possibilities to use reserved land temporarily are further explored as a new spatial concept to use abandoned land for a shorter period.

The different roles of the actors in this decision making process are further explored and the way they fulfill this role and possible improvements. The water managers are adjusting their role in spatial planning at this very moment in the Netherlands, as elsewhere in e.g. Europe.

The aim is clear for the Dutch: to create a safe and livable delta, now and in the future.

INVESTMENT-BENEFIT ASSESSMENT OF FLOOD RISK MANAGEMENT MEASURES

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To secure commitment and involvement of donors and funding agencies in disaster management it is required from governments and flood management entities to provide evidence on the benefits of risk reduction activities on society and country's economy. This paper presents a methodology to develop and apply key performance indicators to assess the effectiveness of investment policy in flood risk management. The proposed approach to the investments-benefit assessment involve the estimation of future social benefit of investment based on historical socio-economic flood losses and damages. To this end, the key indicators are estimated over a period of 43 years (from 1966 to 2009) to measure the multifaceted dimensions of flood risk using data from Japan selected for it is a country with rich flood disaster database with open public access. The result shows an elucidative paradigm of embedding multi-dimensional flood risk indicators into a unified dimensionless mapping system that will serve to (1) measure flood damage and (2) asses efficiency of adopted measures, and (3) assess the effectiveness of flood investment policy. Despite the number of challenges to overcome, the methodology shows that investment-benefit assessment, when correctly applied, can provide important rational information to empower decision making in flood planning (such as to select structural and non-structural alternatives) and furthermore to improve government and professional accountability.

ASSESSMENT AND USE OF DISASTER-REDUCTION FUNCTIONS OF PADDIES WITH PUMP DRAINAGE DURING ABNORMAL FLOODS

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The heavy rainstorm known as the "7.13 Niigata-Fukushima Storm," which occurred on July 13, 2004, caused breaches of two rivers and severe flood damage in the Kariyata River right bank and Nakanoshima regions in southern Niigata Prefecture, Japan. These are low-lying areas surrounded by three major rivers. The Former region has natural drainage downstream (in the main catchment) and drainage by pumping upstream (in the sub-catchment), but the flow from the latter region is drained into one of the major rivers by pumps. During the storm, the two regions experienced different volumes and durations of flooding, presumably because of the different types of drainage systems. We examined the effects and functions of drainage facilities introduced or modified in agricultural and rural development projects in terms of reducing the damage caused by such disasters. The results indicated that use of even the low-capacity pumps intended primarily for agricultural purposes reduced the duration of field and urban inundation.

We therefore propose the utilization of agricultural land as a countermeasure in basin-wide disaster management against heavy floods, which are anticipated to increase in frequency as well as in volume with global climate change.

The heavy storm caused dike breaches in the Igarashi and Kariyata rivers and heavy damage in the lower reaches of those river basins. An estimated 14.06 million m^3 and 8.84 million m^3, respectively, of water overflowed out of the Igarashi and Kariyata rivers into urban and agricultural areas. Despite the enormous input from rainfall, breaches, and overflows, the Kariyata River right bank pumping station, with only a 15-year return period capacity, and the pumps in Sanjyo City reduced inundation depths by the third day after the storm, and a total of 37.07 million m^3 of floodwater was drained within 4 days. In the Nakanoshima region, however, pump drainage by the Ohnuma pumping station and natural drainage by the Nakanoshima River removed a total 20.64 million m^3 of water, but a large area of paddies remained flooded and it took a full 7 days to complete the drainage. Our simulations showed that this 3-day difference in drainage completion was equivalent to 2.43 million m^3 of water (or an average depth of 73 mm in the entire area) remaining in the Nakanoshima region, which no doubt prolonged inundation damage to houses and inflicted greater agricultural damage.

In both regions, the magnitudes of inflow from the river dike breaches were beyond the design standard for the irrigation and drainage facilities, but even these low-capacity agricultural drainage pumps proved to be effective in lessening the damage of this extremely large flood. It is important to evaluate the flood prevention and water storage functions of agricultural lands and agricultural facilities—especially the use of low-lying paddy areas—for flood prevention. This function should be included in any evaluation of the potential value of utilizing paddy areas for watershed management.

USING THE NATIONAL FLOOD RISK MANAGEMENT PROGRAM TO REDUCE FLOOD RISK IN THE UNITED STATES

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The United States Army Corps of Engineers (USACE) established the National Flood Risk Management Program (NFRMP) in May 2006. The purpose of this program is to integrate and synchronize USACE flood risk management programs and activities internally and with counterpart activities of other Federal agencies, state organizations, and regional and local agencies. USACE has played a role in flood risk management since the Flood Control Act of 1928. The attitude of USACE has shifted from controlling floods using structural solutions to reducing flood damages to the current attitude focusing on flood risk management. Flood risk management is now considered to be a shared responsibility, with multiple Federal, state, local agencies, and the private sector playing a role in managing the nation's flood risk.

The vision of the NFRMP is to lead collaborative, comprehensive, and sustainable national flood risk management and to protect the public and reduce flood damages to our country. The mission of the NFRMP is to integrate and synchronize the ongoing, diverse flood risk management projects, programs and authorities of USACE both internally and with counterpart projects, programs and authorities of the Federal Emergency Management Agency (FEMA), other Federal agencies, state organizations, and regional and local agencies. The NFRMP focuses not just on flood risk management, but also making the best use possible of the nation's water resources, by promoting use of water resources for multiple purposes.

Three primary concepts employed by the NFRMP are integrated water resources management, life-cycle risk management and driving down risk. Integrated water resources management requires the use of a systems approach, risk-informed decision making and communications, adaptive management, collaboration and partnering, and state-of-the-art technology to manage water resources. Life-cycle risk management focuses on steps that can be taken to manage flood risk in four states: preparation and training for an event, response to an event, recovery from an event, and mitigation activities to prevent future events. The concept of driving down risk identifies the various activities that can be used to reduce risk by all involved parties. These activities include outreach, natural storage, structural and non-structural solutions, contingency plans, building codes, zoning regulations, and insurance. Each of these activities contributes to reducing flood risk in a given area.

Since 2006, the NFRMP has been involved in a number of activities. The NFRMP has assisted in conducting an inventory and assessment of levees that are either part of a USACE project or in the USACE inspection program. Representatives of the NFRMP have coordinated with representatives of FEMA to develop a joint risk communications plan and to develop levee certification guidance for both USACE District offices and FEMA Region offices. The NFRMP also coordinates regularly with the Silver Jackets program.

This presentation will discuss the experiences, including successes and challenges, of the NFRMP to date. An overview of the programs' use of Integrated Water Resources Management, life-cycle risk management, and the driving down risk concept will also be provided. Further, the primary activities being undertaken by members of the NFRMP will be discussed.

OPTIMIZING THE FLOOD CONTROLLING CHECK DAM HEIGHTS

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Flow discharges of rivers are diverted in order to various applications using check dams. For using of total flood volumes in far regions from river path, check dams cannot be applied; hence, application of appropriate reservoir volumes for probable floods is inevitable. Reservoirs of these dams decrease of floods damages; thus, these dams are well known to check dams. Check dam revenues are as a result of floods volume storage and decrease of floods damages.

Generally, flood occurrences with various recurrence intervals probabilities are different in the dam operation longevity; therefore, revenues of these dam's floods diverting aren't equal. In order to calculate total revenues of diverting of all probable floods must be equivalent and then to be summed. In this paper a new method is presented based on the mathematical principles for calculating actual revenues resulting from probable flood diversion and decrease of damages in sites where check dams are constructed. And also, a new method due to determine dam optimized heights is presented. Finally, details and results of proposed method application on Gavazang dam (Zanjan, Iran) are presented as an actual case study. By Using of developed relations in this paper, probable flood diversion and controlling profit for construction of dam with every specific height can be calculated logically. On the other word, by means of presented relations in this paper for check dam with specific height, two operations profit include flood volume diversion and profit of flood damages decreases with various recurrence intervals can be calculated logically. Comparison basis, finding of application of presented relations in this paper are more real and actual than the other classic check-dam optimized heights calculation methods.

IMPACT OF CLIMATE CHANGE ON FREQUENCY AND INTENSITY OF EXTREME RAINFALL EVENTS IN UPPER BAGMATI RIVER BASIN OF NEPAL

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It is considered that climate change is going to impact more or less in every sector. Stormwater management under climate change scenario has got one of the great challenges for water resources managers. Rainfall frequency and intensity, which are key input for stormwater management, are expected to change (increase) in future. In this study, impact of climate change on frequency and intensity of extreme rainfall events in upper Bagmati River Basin of Nepal has been assessed. Bagmati River Basin with a total area of 3700 km^2 inside the Nepal is broadly divided into upper (hilly) and lower (plain) regions. The lower region (with drainage area of 1000 km^2) gets flooded frequently causing significant life and infrastructural damages.

Projections of global climate models (GCM) are employed for assessing impact of climate change. In general, GCM outputs are found to have coarse spatial/temporal resolution and biases in their magnitudes. In this study, Meteorological Research Institute (MRI), Japan's GCM precipitation data with 20-km spatial and daily temporal resolution has been employed. The MRI-GCM data can be considered adequate from spatial/temporal resolution point of view. To address another limitation, quantile-based bias correction was applied in each of the grids for reducing biases in the GCM outputs. In this technique, bias in rainfall frequency is minimized by truncating smaller GCM rainfall values based on non-exceedance probability that corresponds to zero rainfall in observation data series. Bias in rainfall intensity is corrected in such a way that cumulative distribution functions (CDF) of the truncated GCM rainfall approaches to that of observation rainfall series.

Periods of 1979-2003 and 2015-2039 have been considered as current and future climate respectively for the assessment purpose. Observation daily rainfall point data was compared with the corresponding bias-corrected grid data of future climate. A value of 99th percentile daily rainfall was determined for the current climate and used as a threshold to examine the change in the frequency and intensity of extreme events. The 99th percentile value was calculated for 1-, 2- and 3-days observation maximum rainfall for assessing any significant change in the frequency and intensity of extreme rainfall events in upper Bagmati River Basin. Change in frequency of extreme rainfall events has been assessed by comparing number of occurrences over threshold values for current and future climate period. Change in rainfall intensity were assessed by considering top 10 rainfall values and return period estimates using the current and future 25 years of rainfall values. Return period estimates were made for 5-, 10-, 25- and 50-years values.

Results of the assessment suggest that traditional approach of stormwater management are no longer reliable under non-stationarity i.e., climate change. It points out to consider risk-based design procedure for stormwater management.

DESIGN FOR FLOOD DISASTER REDUCTION SYSTEM BASED ON RISK DISTRIBUTION IN ALLUVIAL PLAIN

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Present paper proposes new strategy to implement a robust flood management system based on usual flood control facilities as well as on flood plain managements. The flood management policy in Japan has emphasized to control floods safely using artificial structures such as dike, reservoir etc. ever since the present system started. Meanwhile, measures for excessive floods such as riparian forests, open levees, secondary dikes, land use and building regulation, evacuation etc. have been conducted rarely.

It is supposed that a climate change makes excessive floods increased. Such a circumstance enhances necessity for conducting countermeasures against excess floods larger than the facilities' capacities. To implement such measures effectively we need to assess a risk level of place to place precisely in the whole flood plain. The risk level is described using a local inundation depth and its occurrence frequency; e.g. above floor level, 1st floor submersion, house washout and so on. To evaluate such risk levels a numerical model which consists of a 1-D river flow model and a 2-D flash flood model for evaluating local inundations has been developed. Using the risk level and exposure of place to place, a spatial distribution of damage resulting from each flood is computed corresponding to each countermeasure performing in the river reach and the flood plain. Eventually, effect of each countermeasure is evaluated using the computed damages.

We estimated the effects of various measures on flood hazards reduction and mitigation in the Northern-Lake area, Shiga prefecture, which is useful for developing an execution plan for reducing the flood damages. If the distributions of risk level and corresponding damages in alluvial plain are assessed all round and shared universally to each other, these will shock people, their society and the public, bringing a high motivation for performing the measure against flood disaster reduction. In addition, if a land use and associated architectural management are specified as a most suitable measure, they will discuss how to conduct it. However, it is very difficult for regional administrations to conduct such measures in a present political system where the legal responsibility for flood plain management lie is not clarified clearly.

To conduct the robust flood plain management based on risk levels and associated potential damages, Shiga Prefectural Government has founded an organization such as "floodplain administrator". It is to carry out followings;

1) To require people to construct waterproof architecture in the area where 1st floor submersion (h≥3.0m, where h is inundation depth) or house washout ($u^2h \geq 2.5 m^3/s^2$, where u is current velocity) is expected facing a 200-year flood.
2) To prohibit in principle that the area, which is submerged above floor level (h≥0.5m) facing a 10-yaer flood, is added to urbanization promotion area.
3) To require the owners to absorb risk increase resulting from their performances such as a close-type embanking.
4) In collaboration with the community and residents, to conduct a robust regional flood management plan including how to evacuate flood hazards place to place.

DEVELOPMENT OF FLOW PROFILE AND LOCATING HYDRAULIC JUMP DOWNSTREAM OF PROPOSED GANGES BARRAGE IN BANGLADESH

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Hydraulic jump is a hydraulic phenomenon by which, supercritical flow dissipates its energy and convert to subcritical flow. For most of the hydraulic structures, hydraulic jump occurs downstream to it. If the jump is not controlled to the downstream, it will scour the river bed and gradually the structure will subside. Elevation of barrage basin in both under sluice and bay portion is fixed according to the location of hydraulic jump. Ganges river is one of the major river of Bangladesh. And Ganges Barrage Project is so far the mega project for Bangladesh. A study has been conducted to observe the flow profile after the hydraulic jump due the construction of Ganges Barrage under different boundary condition. A stationary hydraulic jump and a moving hydraulic jump have been modeled with changing upstream boundary. The downstream boundary for the modeling of jump has been generated by simulating a hydrodynamic model of the Ganges Gorai river system. The modeled stationary hydraulic jump is able to describe the jump length, jump height and the type of jump. On the other hand the moving jump can describe the phenomenon of jump when the upstream flow is altered. The basin type of the under sluice of the barrage can be selected from the length of the jump. The lowest location of the jump defines the elevation of basin. This research can play a vital role in some significant design considerations of the barrage. And this sort of model can be used in further design consideration of various hydraulic structures.

CONSIDERATION OF INDIVIDUAL AND SOCIETAL RISK FOR THE NEW FLOOD PROTECTION STANDARDS IN THE NETHERLANDS

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The Netherlands have been flooded in the past many times, as a result of the fact that more than half of the country lies below sea level or is prone to riverine floods. In the flood prone area 9 million people live and 65% of our GNP is earned (invested value ± $2,400 billion).The current protection standards proposed after the 1953 flood, range from 1/10,000 a year for Central Holland with major cities like Amsterdam, Rotterdam en The Hague up to 1/1250 and 1/250 a year for the levee systems along the upper rivers.

A policy evaluation of the Dutch flood risk management concluded a few years ago that the current flood protection was insufficient to achieve the desired level of safety: The probability of a flood will increase by sea level rise and more extreme river discharges. And on the other hand population and economic growth has increased the country's vulnerability to the extent that a flood would result in massive economic and social disruption. Therefore a new – risk based – flood management approach was proposed with protection standards which should not only be based on cost-benefit analyses but on loss-of-life calculations as well.

A partly probabilistic risk assessment has been performed for the fictive situation that all levee systems in the Netherlandsjust comply to the current protection standards. The project that started in 2009 and was completed in March 2011 only considers overflow and wave overtopping as a failure mechanism. In this simplified approach the other failure mechanisms are supposed to be negligible with regard to overflow (in compliance with the Flood Defense Act). For each levee system the consequences of several breach locations were calculated.The likelihood of evacuation was taken into account, based on the warning time and the population density in relation to the distance to a safe area and infrastructure capacity.

Loss-of-life calculations have been assessed from an individual viewpoint as well a societal perspective. Individual risk is related to a person's probability to die at a certain location as a result of a flood. It will be used to determine a base level of protection for each citizen in flood prone areas. Societal risk is related to the probability of many fatalities due to one flood event. Both viewpoints are relevant for the discussion on future flood protection standards.

The paper discusses the method and results of the quantitative risk assessment performed for all the major levee systems in the Netherlands. Further it shows how these results are used in the discussion on new flood protection standards to be fulfilled in 2050.

LOCAL SCOUR AROUND SERIES OF SPUR DIKES

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Consider to importance and necessity of river training, the use of structures to stabilize the riverbanks and shape of structure type is the very important. One of the stabilization methods with a good efficiency in river is use of spur dikes.

Spur dikes are structures, constructed transverse to the river flow extending from the bank into the river. Spur dikes are divided into two types: Permeable or pervious spur dikes and impermeable or impervious spur dikes. Impermeable spur dikes which are usually made of rock fill embankment, earth embankment or gabions, protect the bank by deflecting the current toward the axis of river. In this type of spur dikes, due to impermeability of structure, the vulnerability is so high and scouring may occurs in the nose of spur dikes. The permeable spur dikes, usually made of pile or trees, decreases the eroding ability of flow by reducing the velocity near the river banks, consequently protect the banks.

A spur dikes causes the contraction of flow, as a result the local shear stress increases which may lead to local scour. Different investigator has done considerable studies on the maximum depth of scour around a single spur dike, but less attention has been paid to study the scour on series of spur dike.

In this study, in order to study effect of different parameters on scour around series of spur dike, experiments were conducted. Parameters under study are: flow conditions and spacing of spur dike. It was found that scour around the first spur dike is maximum, while that due to last spur dike is minimum. Approach Froude number and ratio of L/S (L = length of spur dike, S = spacing of spur dike) are important parameters in the scour phenomena. The results of experiments are reported in this paper.

Results showed that:

1. The spacing parameter between impermeable spur dikes has a significant effect on scouring rate. The scouring rate is reduced with spacing reduction.
2. The scouring rate around impermeable spur dikes in all spacings is higher than permeable ones.
3. In impermeable series spur dikes, the considerable scouring is occurred around the nose and in upstream of spur dikes. The maximum scour depth is occurred on the upstream at about 30-cm of spur dikes nose, but in permeable series spur dikes the scouring is occurred all around the length of spur dikes.
4. In series spur dikes with different opening ratio, the sedimentation rate in first spur dikes is higher than the second one and in second one is higher than the third one etc.

'IT JUST KEEPS FLOODING BACK': ENGAGING LOCAL DECISION-MAKERS WITH FLOOD SCIENCE

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In July 2007, substantial areas of the west of England (UK) were inundated by rivers and localized flooding, following prolonged and intense rainfall. Within the River Severn catchment, the event was estimated to have a recurrence interval of between once in 250 and once in 1000 years. Fortunately, few lives were lost directly as a result of the flood, but major areas of infrastructure such as power supplies, road and rail beds were damaged and over 400,000 people were left without a piped water supply for up to eighteen days. The economic consequences were very serious for the towns and villages, and for the UK as a whole. Moreover, the local authority investigation into the actions taken after the flooding provided a stimulus to the UK Government to make significant changes to the legislative responsibilities for flooding. The changes, enacted through the *Flooding and Water Management Act, 2010*, place greater responsibilities upon local authorities in England to coordinate flood management in their region. Stakeholders who need now to understand concepts of risk, flood modeling and forecasting, complex responses of systems, and a range of other 'wicked' planning problems include not only land use planners, the emergency services, engineers, disaster recovery and social services and policy makers, but also local politicians. However, many local authorities, despite their professionalism in other realms, are ill-prepared for these new responsibilities of prevention, mitigation and adaptation to flooding, and are seeking training.

Project FOSTER is exploring effective ways of educating both the employees in local government, and the elected Members of Councils, in the cutting-edge science that must underpin successful flood management. Drawing on scientific research undertaken by leading UK hydrologists, a programme of experimental workshops has been undertaken with members of three English local authorities in the region seriously affected by the 2007 floods. Workshops have been delivered in three different formats: standard tutor-led workshops; role-playing exercises using floodplain planning and emergency response scenarios; and seminars delivered through the interactive, on-line virtual world Second Life ™. The prior knowledge needs of the participants, and their experiences prior to, during and after the workshops have been evaluated through structured pedagogic research using questionnaires, in-depth interviews and observations. Recommendations on styles of engagement are being developed. The paper provides detail on the experiences and needs of the workshop participants, and the issues surrounding engagement of flood scientists with non-specialist professionals.

Project FOSTER leaves a legacy of well-tested materials and approaches that may be used by non-specialists for group or personal education on flood science. The Project is a unique partnership between the Natural Environment Research Council, the UK Environment Agency, three English County Councils and two universities, with contributions from many research institutes, community groups and the Confederation of British Insurers.

LIVING WITH FLOODS: COMMUNITY-BASED ADAPTATION TO FLOODS IN KOSI REGION, INDIA

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Floods in Kosi Region of India have always been in the limelight, given the complexities of the event from geographical, social, technological, economic, political and environmental perspectives. Before 1950, the region witnessed the river course shifting 120 km in a period of 250 years. The changing scenario of India's vision of development forced the planners to take up the challenge. Flood Control Policy was formulated in 1954 to build structures and put an end to the annually recurring floods. Embankments were constructed all over the river course and a multi-purpose dam was proposed as a part of agreement with the Nepal Government.

Since the beginning, maintenance of these structures has never been the priority of the government. As an inherent drawback with the embankment, first breach occurred in 1963 leading to small loss. The disaster caused in 2008 was as a result of breach caused in embankment located in the territory of Nepal. The disaster triggered numerous researches on embankment failure and causes like weakness in Kosi Treaty, irrelevance of structural measures, lack of coordination between responsible agencies etc. were identified. Most of these reasons are inherent in the system and cannot be resolved completely.

My work assumes 'Living with Floods' as the most appropriate way to deal with floods in Kosi Region. The paradigm shift in Disaster Management Policy of India has also laid major emphasis on adaptation measures and declared it to be more effective than relief and response. Similar approach has been highlighted in the Hyogo Framework of Action. Thus, adaptive management of floods is emerging as one of the most important concern in the present time.

Owner Driven Reconstruction is an innovative measure of disaster preparedness which was implemented after Gujarat Earthquake and the Tsunami in Tamil Nadu. A similar attempt is being made in Kosi Region in the present time. The paper details the experience of ‘Owner Driven Reconstruction’ in flood-prone Kosi Region. The added relevance of the Reconstruction Programme is the huge scale at which it is planned and also the collaboration of many governmental bodies and civil societies, which makes it unique in the history of the region.

ECONOMICALLY EFFICIENT FLOOD PROTECTION STANDARDS FOR THE NETHERLANDS

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The Netherlands is vulnerable to flooding from the sea and from the large rivers, such as theriver Rhine. Dikes have been built throughout the ages to control the risk of flooding, often inresponse to a flood disaster. The current standards for flood protection were proposed by theDelta Committee following the major flood of 1953, which struck the south-western delta of TheNetherlands. The standards were partly based on an economic optimization of investment costs andthe benefits of damage reduction some 50 years ago and are therefore in urgent need of updating. Such an update is one of the objectives of the policy study 'Flood protection for the 21stCentury'.Thenew flood protection standards will be decided by Parliament. The decision will be based on a cost-benefit analysis and an analysis ofcasualty risk.

The cost-benefit analysis uses a dynamic optimization model (*OptimaliseRing*) todetermine an optimal investment strategy for dikereinforcement. This strategy minimizes the discountedinvestment cost and residual flood damages over along time horizon. The impacts of economicgrowth and climate change on flood risk are taken into account. The cost-benefit analysis usesinformation on flood probabilities, flood consequences and the costs of investments in dike reinforcement. Consequences consist of direct flood damages, but also include an estimate of immaterial damages (based, among other, on the valueof statistical life) and indirect damages. From the optimal investment strategy, economicallyefficient (optimal) flood protection standards for the comingdecades (until 2050) are derived.

Policy makers have expressed the desire to know the level of uncertainty around the derived optimal flood protection standards. Many of the inputs used in the optimization model are indeed characterized by high degrees of uncertainty. Since one calculation run of the optimization model lasts more than a day, it is practically impossible to perform a Monte Carlo analysis directly on the model.

Fortunately, Eijgenraam (2006) has shown that the optimal flood protection standards have a linear relationship with the ratio of flood damages (*V*) to the costs of an incremental decrease of the flood probability (*Ip*). Both factors of this ratio have many sources of uncertainty. Flood damage V is composed of material and immaterial damages, which in turn depend on inundation characteristics and future developments. Immaterial damages depend on mortality functions, evacuation strategies, the value of statistical life, etc.; material damages on damage functions, and so on. Also with respect to costs, various uncertainties can be identified.

Based on literature study, expert opinions and expert workshops the major uncertain variables having an influence on flood damages or flood protection costs were identified, and probability distributions for those variables were defined. Next a Monte Carlo model was built that calculated the distribution of the ratio of damages over costs as the best available indicator for the uncertainty around the optimal protection standards. This study resulted in confidence intervals for the optimal flood protection standards that were based on the best available expert judgments, and therefore provide valuable information for decision makers.

IMPROVING THE UNDERSTANDING OF PLUVIAL FLOOD RISKS AND MITIGATION MEASURES AT URBAN SCALE WITH GIS TECHNIQUES

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Over the last decade knowledge on urban flood risks and techniques of assessment has improved considerably. Our comprehension of flood risk management has moved from reactive flood defense management towards pro-active integrated flood management with a full set of innovative approaches to improve the resilience of the societal response. This pluvial flood knowledge, with strategic policies developed at “top” administrative and regulatory level has been pushed forward into the national political and legal agenda and, in a number of countries, local authorities are now facing the challenges to adopt the best decisions on drainage infrastructure without having sufficient experience or knowledge. In Europe the engagement of stakeholders in the decision process is also strongly recommended by the Water Framework Directive. However, the variety of backgrounds and skills involved in the consultative structure do not facilitate the decision process. The use of a central data integration and communication GIS tool as a precursor to analytical modeling represents a clear potential for reducing the lack of knowledge and supporting the decision process.

In the context of a typical urban development scenario, establishing a sustainable surface water management plan represents one of these challenges both in terms of water quality and flood risks. The SUDSLOC GIS-based tool has been developed in this sense to inform and support stakeholders in the early decision-stage. The model provides an information support system on SUDS (Sustainable Urban Drainage Systems) coupled with a map interface to investigate potential locations of mitigation measures. A coupled 1D/2D urban sewer/overland flow model has been developed and tested in conjunction with the SUDS selection tool to enable a full and robust management approach to surface water flood risks and to improve the resilience of the urban drainage infrastructure.

The paper will present the various functionalities in SUDSLOC to better inform the stakeholders as well as the numerical and modelling basis of the integrated 1D/2D and SUDSLOC approach. The role of the SUDSLOC modelling component in quantifying flow and surcharge reduction benefits in the urban environment arising from the strategic selection and location of differing SUDS controls will be demonstrated by UK case studies.

LEARN TO LIVE WITH FLOOD: A BANGLADESH SCENARIO

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Flood, although is a natural calamity, unleashes into Bangladesh in an unnatural dimension beyond the scope of money and effort of Bangladesh alone to mitigate, not to speak of control.

For over five decades, giant efforts have been made and billions of dollars spent on studies and projects mostly funded by multilateral donor organizations; yet there is no effective solution in place. The situation is likely to get aggravated significantly with the impact of climate change in the future. The key is to find the balance between “mitigate flood” and “learn to live with flood.”

The proposed paper’s objective is to argue with evidence that since single-handed structural flood control measures, stand alone, turned out to be ineffective, a mitigation to the flood situation needs to be seen as a holistic one involving the neighboring countries sharing the cross-border river and the catchment and suggest country wide network of compartmentalization, channeling and control of flood water, Practical adaptation strategies for rural Bangladesh adhering to the slogan ‘Learn to Live with Flood’ should be the focus of solution for perspective sustainability.

INFLUENCE OF COMPREHENSIVE URBANIZATION ON FLOOD RISK IN SUXICHANG REGION IN CHINA

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The rapid development of urbanization has resulted in serious flood disasters in urbanizing areas in China. Nevertheless, Current studies about flood risk in these areas focused on land use change, ignoring the relationship between comprehensive urbanization and flood risk. Based on the remote sensing images and social-economic data of Suzhou, Wuxi and Changzhou region (SuXiChang region) in the Yangtze River delta in 1991, 2001, and 2006, the influence of comprehensive urbanization on flood risk was researched using GIS-based spatial analysis and fuzzy mathematics method. The results showed that comprehensive urbanization correlated closely to flood risk. From 1991 to 2001, the flood risks in large part of SuXiChang region except the cities of Suzhou, Wuxi and Changzhou varied slightly due to the slow comprehensive urbanization. From 2001 to 2006, the flood risks in the whole region increased significantly, owing to the rapid comprehensive urbanization, and the increase of flood risk in the cities of Suzhou, Wuxi and Changzhou where comprehensive urbanization developed fastest was the most significant. In the future, with the lack of land for further urban sprawl in the three cities, the effect of land use change on flood risk will be smaller and smaller; whereas flood risks caused by social and economic development will be higher and higher. In the rest of SuXiChang region, flood risks tend to increase more and more quickly with the rapid development of comprehensive urbanization. This study can provide reference to regional flood prevention and sustainable development.

DECISION SUPPORT SYSTEM FOR LOCATION SPECIFIC EARLY WARNING SYSTEM FOR FLOOD RISK REDUCTION

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Early warning is a key element of disaster risk reduction. All the advances in research in generating hazard risk information is not incorporated into operational forecast system and not all operational forecasts are integrated into decision making process to reduce disaster risks. This research paper aims to design location specific user need based weather and flood forecast products of different time scales for reducing disaster risks in vulnerable sectors. Based on the downscaled WRF forecasts and 1-15 days multiple weather ensembles (EPS) forecasts by ECMWF, integrating hydrological tools combining with GIS and social conditions, the DSS will be able to interpret, translate and communicate science based risk information into user friendly early warning information products to assist emergency managers and decision makers to prepare for appropriate response. Two sets of indicators have been defined for the DSS- the resources based indicators (RBIs) which represent the state of the local resource base and the decision support indicators (DSIs), which represent to improve livelihood conditions to cope with disaster. Relations between these two sets of indicators can be visualized though a cross-reference matrix, which, in fact, is considered as a conceptual framework for analyzing how the state of the local resource base affects livelihood conditions to cope with disasters. In a monitoring mode, indicators would allow following year-to-year developments and thus “measure” performance of interventions. In a predictive mode, they could contribute to a ranking of alternative interventions by measuring the extent to which objectives are met. DSS interface invites the users in an interactive way to specify the objectives and criteria that are involved, the management options (strategies) that are possible and the exogenous influences (scenarios) that should be taken into account. At the same it may be able to provide damage monitoring specifically to agriculture to estimate loss on agricultural output and quickly assess and report damages in agriculture sector with appropriate response mechanisms.

ANTICIPATORY FLOOD RISK ASSESSMENT BY CONSIDERING POTENTIAL LAND USE DEVELOPMENT SCENARIOS

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Over the period of recent decades reported flood damages increased tremendously and continuously. One of the main causes is the change in land use of flood prone regions from agricultural to industrial and residential areas. Obviously, these modifications are leading to a remarkable increase of the damage potential. During the past centuries partly contradicting approacheswere applied to cope with flood events, varying from river training and straightening to river restorations. Traditional approaches of structural flood protection measures are nowadays increasingly replaced by flood management approaches, aiming at minimising human, economic and environmental losses. One strategy is to protect flood prone areas up to a predefined design level and to simultaneously minimize the residual risk. Recent flood experience, consideration of residual risk and the awareness of non-achievable total safety supported the change to an integrated flood risk management approach. Management measures are usually set referring to the current state of development, assessing the overall flood risk and communicating the residual risk. Thereby it is generally neglected that the residual risk will increase by developing the hinterland in the future. To be able to account for this change in residual risk anticipatory flood risk assessment and management is required. This paper discusses approaches, time scales and potential land use development scenarios based on three case studies in Austria to outline the necessity of assessing anticipatory flood risk and – importantly – considering land use development scenarios.

The development of flood risk is analysed based on ex-post and ex-ante approaches. Case study 1 (city of Gleisdorf; ex-post approach) analyses the influence of hinterland development on the overall flood risk after flood protection measures were set, designed to resist a 100-years flood. Subsequently, large parts of the former floodplain were transformed into industrial and residential areas. As a consequence, the numbers of exposed objects and people at risk increased substantially.Results clearly indicate the increase in expected annual losses triggered by hinterland development.

Case studies 2 (Mattig) and 3 (Gr. Rodl) aimed at developing ex-ante approaches to assess anticipatory flood risk,enabling strategic regional development within flood prone areas. Therefore, typically appliedmethodologies – assessing the current state of development – are extended by future potential land use development scenarios.Several data sources referring to demography, land use, building types, settlement characteristics, historic data, etc. were utilised to define land use scenarios. Both case study sites are characterised by rural settlements exposed to medium sized rivers.Case study area 2 is not protected against floodsat all, and the case study area 3 is protected against a 100-years flood. Therefore, aspects of risk (case study 2) and residual risk (case study 3) are discussed by this paper and are incorporated to the presented anticipatory flood risk assessment approach. Both case study sites show remarkable increase of the overall flood risk. For case study 2the increase of the expected annual losses is estimated at roughly 40% until 2100; for case study 3 tremendous increases are expected as areas without protection are highly likely to be adapted (filling up to HQ_{100} level) and settled. Nevertheless, an increase of the expected annual losses by a minimum of five times the current values has to be expected until 2100.

The results clearly indicate that the consideration of potentialland use development scenarios is needed to enable comprehensive and anticipatory flood risk assessment providing a reliable basis for adequate flood risk management strategies.

EXPLORE SPATIAL PATTERN OF URBAN FLOOD BASED ON LAND USE PLAN STRATEGY - A CASE STUDY OF TYPHOON MORAKOT.

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This paper introduces the theory of urban disaster prevention to respond to the impact from urban flood. The contemporary sustainable urban theory should not be limited in the opposite perspective on urban and nature. In addition, the radical change of present urban and nature inspires new challenge to the urban spatial planning thought. By facing urban flood issues, it is a major demonstration to reorganize the systematic network between urban and disaster.

This study discusses the urban disaster prevention spatial planning by utilizing the spatial analysis technique to investigate urban environmental feature and different compound disaster issues happened in different location while facing the complicated coexistent relationship between urban and disaster. Typhoon Morakot in Tainan will be the case study. This study will measure the urban flood index and utilize the Geographically Weighted Regression (GWR) to explore the variables of urban environment. The outcome may serve as basis for establishing future land-use indicators and as decision-making reference for concerned government agencies.

UNCERTAINTY AND SENSITIVITY OF FLOOD DAMAGE MODELLING

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Floods are one of the most frequent and costly natural disasters. With the recent transition from protective flood management to a risk based flood management approach, flood risk assessment and modelling play an increasingly more important role to support decision making. Flood risk models assess flood risks simulating both the probability of a flood and its consequences in monetary terms. These simulations can be used to feed cost-benefit analysis of management measures or set up insurance schemes.

Flood risk modelling simulations contain, however, considerable uncertainties (see e.g. Merz and Thieken, 2009). This is the result from uncertainties in the many different input parameters propagating through the model(s) and accumulating in the final estimate. Whilst quite common in other disciplines, extensive uncertainty and sensitivity analyses of flood risk assessments have only recently started to emerge in flood risk assessments (e.g. Apel et al., 2008).

In this research we investigated the uncertainty in flood risk simulations using a Monte Carlo approach. Both a flood inundation and flood damage model are integrated in this Monte Carlo framework, where a variety of input parameters is (quasi-)randomly varied. We apply the model simulations to two case studies in the Netherlands. The first case concerns coastal flooding in the West of the Netherlands, where the uncertainty and sensitivity of flood damage estimates is assessed. The second case concerns an area in the fluvial part of the Netherlands, for which a probability-loss curve has been constructed, and where the uncertainty surrounding this probability-loss curve is estimated. In these cases, the uncertainty currently present in estimating flood losses is also compared to uncertainty surrounding future developments, in particular climate change and socio-economic changes.

The results show that there is considerable uncertainty surrounding flood damage estimates and that the effect of future uncertainties is small compared to the already present uncertainties. The sensitivity analysis further shows that uncertainty in hydrological boundary conditions (e.g. duration of storm surge, timing of storm with respect to astronomical tides) are of particular importance. It is thus important to evaluate a range of these parameters in flood inundation and damage modelling.

RISK STUDY OF FLOODWATER UTILIZATION BY PONDS AND WETLANDS

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This paper mainly introduces the methods of identification, assessment and control of floodwater utilization risk in order to provide decision basis and utilize flood resources more effectively. Storing floodwater by ponds is one of the important ways for flood resource utilization in middle and lower reaches of rivers, it is the main description object of this paper. The risk identification method is proposed, which identifies the risk factors and risk factors losses during the use of flood resources. The analytic hierarchy process and principal component analysis are applied to screen the main risk factors of use of ponds flood storage on the basis of risk factors identification result for use of flood resources. It includes: uncertain risk of benefit losses, uncertain risk of calculation and parameter, risk of long-term rainfall-runoff forecasting errors, risk of scheduling decision as well as risk of implementation. The assessment method of flood resources utilization is proposed. On the basis of time & space dimension, a two-dimensional risk rate estimation model of ponds flood storage, which takes Cile Pond in Baicheng City, Jilin Province, China as an example, is established. The model is solved based on practical to get the risk rate of flood storage during different flood times in situation with and without control measures. The risk factors result is applied to implement 200mm of rainfall to flood the late for obtaining the risk loss value of during different flood storage times in situation with and without control measures in Cile Pond. The study indicates that the risk level of ponds flood storage with control measures is smaller than that without control measures, and the former is defined light risk, the latter is defined between small and heavy one. On the whole, the risk law is: in space dimension, the greater the flood storage capacity, the greater the risk is, whereas smaller; in time dimension, the earlier the storage, the greater the risk is. When the flood storage is large, the risk loss with control measures is obviously smaller than that without control measures. The risk control measures of flood resources utilization which includes “long-term planning, pre-plan, real-time control” is introduced, and the principles, objectives and main contents are described in the paper.

A FRAMEWORK FOR FLOOD IMPACT ASSESSMENT IN CITIES

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The CORFU (Collaborative Research on Flood Risk in Urban Areas) Project is funded by the European Commission's Seventh Framework Programme. The project has two major objectives. The first is to develop and then investigate the effectiveness of state-of-the-art measures that can be implemented in cities that increase their resilience to flooding. The second objective is that cities learn from each other. The project is working with partner cities across Europe and Asia, each with their own characteristics and flooding problems. This research is especially important given the potential changes to flooding patterns as a result of climate change and socio-economic development. These include such trends as increasing prosperity and urbanisation that is taking place worldwide, and the challenges these changes will bring.

So that the effectiveness of various resilience strategies can be evaluated, it is vital that the impacts of flooding can be assessed in a comprehensive and consistent manner. To this end, a framework has been developed that will incorporate all the major impacts of floods. It has long been noted that the development of such a framework is fraught with difficulties, but it is necessary if we are to make progress in understanding the wider impacts of flooding. These include the direct damage that is caused to residential and non-residential property, the indirect effects that arise through disruptions to business and to infrastructure networks (such as transportation and power supply), and the intangible impacts of flooding, such as the cost to human health and to the environment. These latter impacts have often been ignored in the literature, so that their importance has not been truly measured.

In this paper, the development of the CORFU flood impact assessment framework will be outlined, along with a justification for each of the components, and laying out the principles that will underpin the research. The paper will detail how the full impacts of flooding can be assessed, and how the framework can quantify resilience measures, especially those that have largely been ignored in previous research. The work will be illustrated with results from some of the case study cities, and it will be described how this research can be advanced to improve the development and uptake of flood resilience measures.

Cultural Planning as a Solution at Displacement and Recovery Problem in The Porong Mud flood Disaster

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The Porong Mud flood in Sidoarjo represents a major environmental and social disaster in Indonesia. In order to mitigate the negative impact of the Mud eruption, government set up some policies. However those policies that are set up still cannot fulfill community satisfaction especially for the victims. Policies that cannot achieve community expectation are a sign that there are missing links in the mitigation and redevelopment plan mechanism.

For example, the Mitigation Agency just concentrated only on conduct of physical mitigation programs such as damming of the mud and rebuilding of the freeways. Moreover, the payment of compensation was implemented only by buying the land and properties that were buried. Whereas the social aspects of this disaster are tend to be ignored. By 2008, thousands of hectares of rice fields, plantations and factories have been buried. Furthermore, around 15,000 workers had lost jobs, 1,022 farmers were unable to continue farming and some 2,299 small and medium business enterprises were bankrupted (BPS, 2008; Hamzirwan, 2007; Tempo January 22, 2007; Williamson, 2007). In short, there are four gaps that are observed between the mitigation program and the community needs: firstly, there was no adequate support given to the affected small and medium businesses which could have been empowered through assistance programs. Secondly, there was insufficient re-training for those who lost their jobs. Thirdly, there were inadequate educational incentives and very little support was given to the victims. And lastly, there were no cultural settlement assistance programs for those moving to new settlement areas.

Ramesh & Howlett (2003) stated that every policy is always related to politics. However, the targeting policy must reach the citizens to give satisfaction. To give that satisfaction, a long term strategy in policy making should consider people's behaviors, which is influenced by social norms. Policy that has a long term dimension could create more favorable outcomes for landowners, and create greater opportunities for investment (Sterner 2003).

The implementation of cultural planning, in combination with the sustainable livelihood framework would reduce these policy gaps. Moreover, the implementation of cultural planning, in combination with the principles of the sustainable livelihood framework, would be an effort to increase the attractiveness of the region. In the long term, it could increase the potential opportunity that could be gained by the societies by increasing income, reducing vulnerability, developing networking, building national identity and providing the sustainable use of natural resources.

APPROACHES FOR THE RESTORATION OF THE ENVIRONMENT IN KUSHIRO MIRE CONTRIBUTING TO FLOOD RISK CONTROL

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ABSTRACT: Kushiro mire located in eastern part of Hokkaido is the largest wetland in Japan. It is the first registered wetlands under the Ramsar Convention in Japan and designated a national park. The Kushiro River runs through Kushiro mire providing water resources; it has an abundance of natural scenery and serves as an important habitat for wildlife. It has been pointed out that the environment of Kushiro mire has been rapidly changed and 30% of the mire area has decreased in recent 60 years. The colonies of reed and sedge, characteristic vegetation of the wetland, have been replaced by the black alder forest. The area of black alder has increased four-fold in this duration. This phenomenon is considered to be caused by followings: the directive development of the wetland to the farmland and residential area, the increase of sediment inflow by the cut-off works of the rivers in upper area, the development and deforestation in the surrounding areas. With this situation in mind, Hokkaido Regional Development Bureau organized “Committee for Conservation of the River Environment in Kushiro Mire” in 1999. The Committee summarized and released “Proposal for Conservation of the River Environment in Kushiro Mire” in 2001. Thereafter the governments and other organizations have conducted the measures based on the proposal for the restoration and conservation of Kushiro mire. This action triggered the enactment of “Act on the Promotion of Nature Restoration” in Japan and the nature restoration projects have been implemented. These general projects consist of countermeasures as follows: reducing sediment inflow, restoring straightened rives to meandering courses, conservation of forest, re-afforestation, restoration of adequate water and material cycle, promoting environmental education, and so on. This year the river restoration in Kayanuma area, one of the main and symbolic projects, has completed and various monitoring researches are being executed. In the lower side of Kushiro Mire and River, Kushiro City is located. The population of the city is about 200,000. Kushiro Mire has function as a natural flood control basin and reduces the risk of being damaged by flooding. Thus restoration and conservation of Kushiro Mire greatly contribute to maintaining the function of flood control.

EFFECTIVE FLOOD CONTROL THROUGH INTEGRATED AND COLLABORATIVE DAM OPERATION AT THE THREE NABARI RIVER UPSTREAM DAMS

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Early in the morning on 8thOctober, 2009, thetyphoon No.18 brought heavy rain to the NabariRiver Basin, Kansai region andthreatened the area with inundation. The NabariRiver is a tributary of the Yodo river system whose basin contains Osaka and Kyoto and runs through NabariCity which is a residential zone as commutable distance area from Osaka city.In the upper reach of the Nabari, there are three multi-purpose dams; Shorenji Dam, Hinachi Dam, and Murou Dam, which are operated by Kizugawa Integrated Dam Control and Management Office (KIDCMO), a branch office of Japan Water Agency (JWA). Since it rained heavily in the downstream of the three dams, the regular operation by three dams complying with the given flood control regulation seemed not to be able to prevent inundation in NabariCityfrom. Therefore, JWA and Ministry of Land, Infrastructure, Transport and Tourism (MLIT) conducted collaborative operation of the three damsto avoid the inundation in the city area.

In this case, flood control operation of three dams commenced in early stage before the inflow reached the defined flood discharge in consideration of the water level of the NabariRiver, rainfall condition and capacity of the reservoirs. During the operation, discharge from the dams was changed timely and appropriately through the collaborative work of the three dams in order to maximize the effectiveness of all flood control capacities of the reservoirs according to the advanced rainfall forecast technology and runoff analysis.

The use of advanced rainfall forecast technology and runoff analysis model enabled the effective application of this flexible operation protocols. It is estimated that this operation has resulted in 1.5m decrease of the water level at Nabari design control point, andprevented inundation to approximately 1,200 households.

Considering the recent climate change, it is possible to have extreme rainfall more often. The proof of adaptability of this flexible operation is quite meaningful not only for flood damage mitigation in the downstream, but also for future prospects of flood control by dams.

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DANUBE FLOODRISK PROJECT

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ISPRA is involved in the Danube Floodrisk "Stakeholder-oriented flood risk assessment for the Danube floodplains" project, a European transnational project promoting the cooperation between spatial planning and water protection in the Danube river basin. Almost all relevant institutions responsible for flood risk management representing the countries along the DanubeRiver are involved in the project activities: nineteen authorities from Austria, Slovakia, Hungary, Romania, Bulgaria, Italy, Serbia and Croatia. The Italian territories in the DanubeRiver Basin belong to Slizza, Drava, Stiller Bach and Spöl river basins. The project was approved in March 2009 and its duration is scheduled until April 2012. It is funded by the EU through the European Regional Development Fund (ERDF), in the framework of the SEE Programme.

The DanubeRiver is one of the most important natural axes in South-East-Europe. It links most of the countries in the SEES area. There is a long history of cooperation in the Danube region and all Danube countries are engaged in the field of flood risk prevention despite of their differences in their economy, sociology and topography make difficult the tasks of the states. The ICPDR has created the basis for the cooperation in the Danube region through the implementation of the Flood Action Program, which requires close transboundary cooperation of all Danube countries also on issues related to land use and spatial planning. In the Danube Floodrisk project, for the first time, all Danube countries cooperate actively in data management and harmonisation activities. Moreover, a joint transboundary implementation of flood risk assessment and mapping actions are developed.

The main objective of the project is to determine cost-effective measures to minimise flood risk by risk assessment and drawing up of flood hazard maps using an harmonized methodology, involving all stakeholders and reducing risk by appropriate spatial planning. The project emphasizes the need to learn adaptation to floods and risk management through a basin approach, with governments, municipalities and stakeholders participation.

The main expected result is a Danube atlas with flood hazard maps and flood risk maps and documentation of 3 pilot project applications in three Member States (AT, BG, RO).

Finally, it's worth taking into account that the Danube river basin is now largely a European Union (EU) space. Therefore it is seen as a model to effectively apply the Integrated River Basin Management (IRBM) through the Water Framework Directive (WFD) which is a very comprehensive and integrated water legislation and the EU Floods Directive (EFD) which provide for the Flood Risk Management Plan. Both directives constitute flexible and adaptive planning instruments to allow an integrated approach and an international coordination across the whole river basin.

CHARACTERISTICS OF FLOOD DISASTER AND EVACUATION ACTIVITY OF RESIDENTS IN THE SUMIYO RIVER BASIN IN AMAMI OSHIMA ISLAND ON OCTOBER 20, 2010

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This paper describes characteristics of flood disaster and evacuation activities of residents in the SumiyoRiver basin in AmamiOshimaIsland, KagoshimaPrefecture, on October 20, 2010. Record-breaking rainfall amounts were observed at the rain gauge of the Sumiyo suboffice located in the southern part of AmamiOshimaIsland. The amount of hourly precipitation had exceeded 130mm for the time period between 11:00 and 13:00 on 20 October.This torrential rain caused disasters such as flood inundation, landslides and debris flows all over AmamiOshimaIsland. There were three casualties who were elderly people in this heavy rainfall. One of them was killed by landslide and others which lived in group home for elderly people called Wadatsumi-En, were by flood.

It is expected that the disaster like that of AmamiOshimaIsland will occur with increasing frequently in Japan due to global warming. Thus, it is important to investigate the characteristics of the disaster in AmamiOshimaIsland in detail in order to take adaptation measures to mitigate the impact of those disasters.A hearing investigation was carried out in the SumiyoRiver basin in order to find out the reasons why the number of victims was low. We focused on the evacuation activities of residents in the SumiyoRiver basin.

According to hearing investigation, the reasons why the number of death was small despite of the record torrential rain are as follows;

In Amami Oshima, a local community worked so effective that residents urged themselves to evacuate. However, some escaped from his house to the roof when the house was flooded above the floor and water level reached to the ceiling of the house, and others were washed away by the flood in escaping. People who were swept away were rescued when they held on to a tree or a telephone pole. Furthermore, it is suggested that the number of victims would increase if the torrential rainfall occurred during the night.

RISK ASSESSMENT METHOD FOR FLOOD CONTROL PLANNING CONSIDERING GLOBAL CLIMATE CHANGE IN URBAN RIVER MANAGEMENT

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Urban river basins have high flood damage potential owing to their concentrated populations and assets. For flood prevention, reasonable and appropriate flood protection plans are naturally demanded regarding the budget capacity of the governments and the expected security of the people living in urban river basins. Thus engineering methods based on risk assessment are required by decision makers, such as municipal engineers and the public officials in charge of flood management for an effective and efficient means of evaluating flood protection projects. Besides, we have a wide spread consensus that the global warming is a real threat to the future climate. The risk assessment for global climate change is alsoneeded to evaluate the impact on the urban drainage infrastructure and the flood protection plans.

The objective of the study is to present a methodology of flood risk assessment dealing with the risk decrease by flood protection projects and the risk increase by the impact of climate change in the framework of flood risk management for urban river basins. In risk managements, the risk of a hazardous event is generally quantified by multiplying the occurrence probability of the event by its impact. Few flood risk assessment studies, however, have been done strictly on the basis of this concept. The concept of “flood risk” in the study is defined as the product of flood damage potential and its occurrence probability.

For the risk assessment a flood damage prediction model FDPM using GIS is applied to calculate flood damages for any design storms with different return periods. FDPM is composed of two models: a flood inundation prediction model (Model 1) and a flood damage estimation model (Model 2). The monetary damages calculated by FDPM for the design storms with their occurrence probabilities enable us to quantify flood risk as an annual risk density curve which gives the relationship between return period and flood risk density for design storm. The expected value obtained by the integral of the annual risk density curve generates the annual flood risk cost. The annual flood risk cost should be important to estimate the risk decrease owing to flood control projects and the risk decrease caused by global climate change. The risk cost decrease for flood protection plans are calculated from the difference of the two flood risk costs with and without flood control facilities, whereas the risk cost increase by climate change can be estimated from the difference of the two IDF curves before and after the predicted climate change. The change in risk cost is finally interpreted as a flood risk impact factor.

The presented risk assessment method with FDPM stated above was applied to the flood risk assessment of the Zenpukuji river basin in the Tokyo Metropolis, Japan. The river basin, having an area of 18.3 km2, is highly concentrated with population and assets. The study clearly shows the applicability and usefulness of the presented flood risk assessment method.

A REVIEW OF THE IMPLEMENTATION OF FLOODPLAIN MANAGEMENT PLANS ON THE HERBERT AND JOHNSTONE RIVERS IN NORTH QUEENSLAND AUSTRALIA

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The Herbert and Johnstone Rivers catchments are located in tropical North Queensland in Australia and have catchment areas of approximately 10,000 km2 and 1,600 km2 respectively. The lower river in both catchments traverses alluvial distributary plains formed by frequent flooding and associated sediment deposition. The floodplains are predominantly utilised for agricultural purposes but there are also many townships that are subject to frequent flooding. The main townships are Ingham on the Herbert River and Innisfail on the Johnstone River.

Flood studies and floodplain management plans for both river systems were completed in 2003. Average annual damages (AAD) for the Lower Herbert River were estimated to be AUD$4.3M and for the Lower Johnstone River AUD$3.0M Floodplain management plans were developed for both catchments to reduce the flood damages in urban areas and to reduce the risk to human life. Both management plans recommended structural and non-structural measures that broadly included:

- improvements to the flood warning systems and emergency management planning;
- community education programs;
- voluntary house raising;
- modifications to planning schemes to recognise and appropriately manage flood risk;
- minor upgrades to existing levees and floodgates.

Many of the recommendations of the plans have now been implemented and there has been a number of floods on the Herbert River and one on the Johnstone River. This paper reviews the implementation of the management plans and the effectiveness of the management measures. Based on these experiences, recommendations are made for consideration in the development of floodplain management plans.

ASSESSMENT OF FLOOD EMBANKMENT INTEGRITY USING ELECTRICAL RESISTIVITY TOMOGRAPHY

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For centuries flood embankments were constructed to protect low-lyinginfrastructure, properties and the people living within. They are constructed along coasts and rivers mainly as earth structures using the fill material that is available on site. Flood embankments are built as open structures, which have to withstand various internal and external conditions, such as variation in the ground water table and extreme weather conditions. As the body of the embankment is usually located well above the water table, the fill material is considered to be in the unsaturated state and undergoes series of seasonal variations in climatic conditions which crucially affect the water retention in soils;increased volumes of pore water result in swelling of the soil, whereas reduced volume result in shrinkage. This shrinkage is commonly associated with the formation of cracks, which affect both natural and man-made structures by increasing the permeability of the soil. Desiccation cracks can appear as single fissures penetrating the structure to a certain depth, or as an interconnected cracking network which affects the outer layer of an embankment. It is however difficult to visually assess the extent of cracking without digging a trial trench. Thus, in the recent years, new non-invasive methods have been employed in order to be able to assess the subsurface of the required field.

In the presented study, Electrical Resistivity Tomography (ERT) was used to detect desiccation cracking in the soil mass. Two laboratory models, small and macro-scaled, were examined using miniature resistivity arrays. In addition to that, a field investigation was carried out in order to validate laboratory results and in particular to assess the integrity of an embankment built in 2003, along the Humber estuary as a part of Paull Holme Strays flood prevention scheme. The results obtained from this research confirm that ERT is capable of detecting desiccation cracking in the subsurface without interfering with the embankment body and can be used for the proper assessment of itsintegrity. The comparison of standard and miniature arrays shows that both can be combined in the field to give the complete picture of the extent of desiccation cracking.

INVESTIGATING MOVEABLE FLOOD BARRIERS IN THE RHINE-MEUSE ESTUARY – METHODOLOGICAL LESSONS FROM A MULTIDISCIPLINARY EXPLORATION

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River mouths and estuaries around the world will have to respond to rising water levels and/or required increase of flood safety standards. This can be done by building solid embankments or retreating urbanisation to higher grounds, but this is difficult in heavily urbanised areas. It is possible to reduce flood risk in estuaries without having to drastically modify the river banks by levees or block shipping routes and ecological flows by dams. ‘Storm surge barriers’ close off a river mouth in times of high water levels at sea, but keep the river open in normal times. A ‘moveable river flood barrier’ can redirect a river towards less urbanised parts of a delta. It is likely that with climate change and continuing economic growth more of these barriers will be built worldwide. These are costly and have a high impact on further urbanisation and infrastructure patterns, so their implementation should be carefully considered and can use scientific support.

In the Dutch Rhine-Meuse delta, new policies are currently being researched to use existing and new surge barriers to direct high river water flows in desired directions over the various river branches at times when a storm at sea coincides with high river discharges. This will create a historically complex system of flood defenses, which needs thorough modelling to evaluate various cost and benefit options. This paper will compare alternatives is as follows: locate the various barriers on different locations, see where additional river widenings would be possible, calculate the remaining required levee modifications (dictated by Dutch national law) as a function of sea level rise, determine the effects on shipping, on urbanisation of the river banks and on ecological flows, and do this for so many alternatives until the most desireable ‘configuration’ is found. Problems arise in (1) the limited resources to estimate all the effects, (2) the high number of possible configurations, (3) the non-quantitative effects on urbanisation, function-combinations and ecology, (4) the relations to flood policies of adjacent water systems and (5) the uncertainty in climate change predictions and scenarios for urbanisation, shipping and future environmental concerns.

This paper follows from a multidisciplinary research project (11 different researchers) conducted under the ‘Hotspot Rotterdam-region’ Knowledge for Climate programme (October 2009 - May 2010). It will present the key results of this explorative and practically-oriented research, and add a methodological dimension: how can a multidisciplinary research on the interface between science and policy deal with the five problems mentioned above? The hypothesis, so far, is that the key lies in the balance between rough long-term regional projections and more detailed short-term local analyses.

FLOOD RISK ESTIMATION USING PROBABILISTIC CLIMATE CHANGE SCENARIOS

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Traditionally, flood management has focused on providing protection against floods up to a given return-period, but recently there has been a shift towards a more risk based approach, whereby flood risk is defined as the probability of flooding multiplied by the consequences. However, both the probability of flooding and the consequences are expected to change in the future as a result of changes in climate and socioeconomic factors. To date, there is relatively little known internationally about how these will influence flood risk. Most studies examining this issue have considered a limited number of discrete climate change scenarios, representing single future pathways. One of the reasons that only a limited number of climate change scenarios are used in flood risk assessment is the large amount of computational time required to convert discharge into inundation maps using hydraulic models. Moreover, for the same reason, flood risk is usually estimated based on the damage resulting from a very limited number of flood return-periods (for example European states are only obliged to map flood extents for three return-periods).

To address these issues, we present results of a project examining methodologies for probabilistic flood risk assessment, using the Meuse and Rhine basins in northwest Europe as case-studies. Several aims of the project were to: (a) develop a methodology to couple probabilistic climate change scenarios with hydrological discharge projections; (b) develop a rapid inundation model to map inundation depths for large numbers of scenarios and return-periods; and (c) assess how flood risk estimates are influenced by using the probabilistic climate change scenarios.

In brief, the method consists of developing long time-series (3000-years) of climate parameters (temperature, precipitation), by statistical resampling from 30-year series, for simulations derived from seven Regional Climate Models (RCMs) and twelve General Circulation Models (GCMs). Each of these climate time-series (runs) was then used as input to a hydrological model (HBV) to simulate daily discharge time-series of 3000-years length; for each run a statistical relationships was derived between discharge and return-period. We then developed a rapid inundation model to estimate flood extent and depth, based on stage-discharge relationships, and used this to produce flood maps for large numbers of return-periods (>50) for each run. These inundation maps were then used as input in a flood damage model (Damagescanner), together with land use maps and estimates of land value, to estimate damage for each return-period and for each run. Finally, risk curves were developed for each run, in order to assess the difference in risk (annual average damage) between the different runs.

The research shows the effects of estimating risk based on damage estimates for large numbers of return-periods compared to the more common approach of using just a few return periods. It also demonstrates how the estimation of flood risk is affected by using climate data from a large number climate models.

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ROBUST RIVER MANAGEMENT IN THE NETHERLANDS: THE ROUTE TO 2100 AND BEYOND

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Without a proper water management, the Netherlands would not exist in its current state. Dutch water management already started as early as the year 500, and has resulted in the best protected delta in the world to date. In order to maintain that state, it is of utmost importance to maintain the system of dikes and dams as such, but on the other hand be prepared for the future, and hence take into account a possible climate change for the long term. To be prepared for the long term is the subject of a special program, which is called the Delta program. Its aim is to keep the Netherlands safe against the threat of water, and on the other hand maintain the country as an attractive place to live in and work in. The horizon is set to 2100. One of the challenges is to get a proper image of how the world will look like in 2100.

The Delta program deals with the coastal zone as well as the river area. In this paper, we will discuss the impact of climate change on the river area (i.e. an increased discharge for Rhine and Meuse, and an increased sea level) for the Netherlands, in combination with other developments that play a role on the long term (and which are put forward in socio-economic scenario's for 2100).

This problem can actually be divided in a technical and a societal problem. The technical problem is induced by the increased discharge and the sea level rise. The result is an increase of flood levels for the rivers, which should be counteracted in order to maintain the safety standards. The challenge is in hydraulic and morphological modelling. The result is actually a claim on precious space in and around the river area, namely measures in the floodplain to create more discharge capacity and/or space needed for dike reinforcement or dike relocations. However, apart from this claim which is the direct result of climate change there are more claims in the river area. Nature, economic development and recreation all put a call on the same space. The ultimate goal of the program is to develop a robust strategy for 2100 which is able to comply with most of the claims and simultaneously, fit in the prospective images for 2100. Local initiatives in the river area (which act on a shorter timescale and are often commissioned by local authorities) should then be tested against this strategy in order to see whether they fit (are no-regret) or not.

The societal problem lies in the proper communication with the stakeholders: provinces, water boards and local authorities. These have in general also a much shorter window of interest, whereas the long-term strategies typically spread out over many decades. The challenge lies in the coupling of the short term and the long term, such that support in the society for the measures is guaranteed.

It is obvious that tackling this problem is a combination of beta-science (hydraulics and morphology) and governance related studies.

In the paper, we will address both problems (the technical and the societal), and sketch the route of the problem analysis (with the boundary conditions given by the climate as well as the socio-economic scenario's), the possible solutions (dike reinforcement, room for the river, or even solutions in the spatial planning to reduce risk) and eventually the contours of the robust strategies for 2100.

RECONSTRUCTION OF MULTI-STRUCTURED STRATEGY OF FLOOD RISK MANAGEMENT FROM SIMPLE FLOOD PROTECTION POLICY

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The strategy of flood management has been based on flood protection by using continuous flood levee and dams up to now in Japan though urban drainage infrastructures have been equipped. Though the effects of such infrastructure equipments have been remarkable, the following aspects have been discussed as current issues: Flood disasters cannot be classified into simple patterns as treated in flood protection plan. Recently we have to focus the excess of design level floods, extraordinary weather events may be caused by global warming. Global warming may change the flood protection plan. The economic situation is degrading and we cannot expect remarkable progress of flood protection infrastructures. The infrastructure equipments have also some contradiction against ecosystem conservation and other restrictionfor sustainability. And, maybe we are facing to the change of decision making. On the other hand, preparedness of people against floods has become vulnerable by the change of life style which may caused by urbanization. The urbanization has changed not only the life style but it has brought the structural vulnerability.

In this study, flood patters are classified into several categories based on the statistics. Here we consider the plan for infrastructure must be prepared by using a “standard statistic population”. Usually the data length is short and sometimes the marginal behavior of distribution should be reasonably treated. Then we discuss the plan level for design by using the return period and successively we can discuss the excess of the design and the extraordinary events. Thus, we categorize three patterns of floods: (1) statistically standard rainfalls, (2) excess of design flood, and (3) extraordinary rainfall (such as locally concentrated heavy rainfalls). And then depending on them we have to consider the proper countermeasures: flood protection plan for category (1), wide-area evacuation plan as risk management action plan for (2), and careful watching of dangerous spots for (3). In addition we have to prepare the situation that the flood protection plan is not in progress. Recently, software based on hazard map is promoted, but here it must be more refined. Here we have to face to the vulnerability of the citizen against flood disaster, and here we discuss how to overcome the vulnerability depending on the above-mentioned disaster categories.

When we can categorize flood risks as mentioned above, we can clearly discuss the responsibility to the respective categories of disasters. Furthermore, we discuss the possibility of integrated flood risk management. At the present they can be categorized clearly and the respective countermeasures are effective, but if the global warming proceeds, we have to integrate them properly and discuss about such an integrated risk management.

DECISION SUPPORT SYSTEM FOR LOCATION SPECIFIC EARLY WARNING SYSTEM FOR FLOOD RISK REDUCTION

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Early warning is a key element of disaster risk reduction. All the advances in research in generating hazard risk information is not incorporated into operational forecast system and not all operational forecasts are integrated into decision making process to reduce disaster risks. This research paper aims to design location specific user need based weather and flood forecast products of different time scales for reducing disaster risks in vulnerable sectors. Based on the downscaled WRF forecasts and 1-15 days multiple weather ensembles (EPS) forecasts by ECMWF, integrating hydrological tools combining with GIS and social conditions, the DSS will be able to interpret, translate and communicate science based risk information into user friendly early warning information products to assist emergency managers and decision makers to prepare for appropriate response. Two sets of indicators have been defined for the DSS- the resources based indicators (RBIs) which represent the state of the local resource base and the decision support indicators (DSIs), which represent to improve livelihood conditions to cope with disaster. Relations between these two sets of indicators can be visualized though a cross-reference matrix, which, in fact, is considered as a conceptual framework for analyzing how the state of the local resource base affects livelihood conditions to cope with disasters. In a monitoring mode, indicators would allow following year-to-year developments and thus “measure” performance of interventions. In a predictive mode, they could contribute to a ranking of alternative interventions by measuring the extent to which objectives are met. DSS interface invites the users in an interactive way to specify the objectives and criteria that are involved, the management options (strategies) that are possible and the exogenous influences (scenarios) that should be taken into account. At the same it may be able to provide damage monitoring specifically to agriculture to estimate loss on agricultural output and quickly assess and report damages in agriculture sector with appropriate response mechanisms.

URBAN RAINWATER UTILIZATION AND ITS ROLE IN REDUCING OF URBAN WATERLOGGING DISASTERS –A CASE STUDY IN NANJING, CHINA

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With the acceleration of urbanization process in Nanjing, China, the urban waterlogging disasters became more and more serious. In order to mitigate the urban waterlogging disasters, it is necessary to reduce surface runoff from the source by roof rainwater harvesting and utilization. A residential sector with an area of 0.58km^2 in Nanjing was selected as the study area, by using large scale topographic map data and a long series of rainfall data (1951-2008), the ground surface types and building types of the study area are classified, and the potential of collectable roof rainwater and the reduction volume of ground surface runoff were calculated. The results showed that the construction areas occupied 55%, roads, green spaces and other areas occupied 45% of the total study area; among construction areas, the residential, commercial and other types of buildings accounted for 51%, 37% and 12% respectively. About 11.5% of the average annual rainfall can be collected by roof rainwater harvesting, this can reduce 8.6% of ground surface runoff in the study area. In addition, there are about 55% of construction areas available to set up cisterns, and among the construction areas, about 77% of the residential and the other types of building areas available to set up cisterns, only 16% of the commercial building areas available to set up cisterns.

EXPERIMENTAL STUDY OF RESPONSE TO INUNDATION CONDITION IN PADDY FIELD

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According to the meteorological, hydrological conditions in the test area and inundation sensitivity of rice in different stages, the test studies on response and adaptation of rice to inundation depth and duration during typical growth periods. To select suitable depth of storm water storage in paddy field, four stages of rice growth period are introduced in inundation test, namely Tillering Stage, Jointing-booting stage, Heading Stage, Grain Filling Stage.

The test is designed as a double factors experiment. The effects of different inundation depths and inundation duration on typical rice growth stage are the two main experimental factors. Four ratio of the inundation depth accounted for rice plant height are chosen, that is 1/4, 2/4, 3/4, 4/4, meanwhile inundation lasted for 3 days, 6 days, 9 days are selected. The results showed that inundation ratio of 2/4 and 3/4 in each stage of growth period have little effect on yield reduction, instead, product increased to some degree, especially in tilling stage. Through measuring the photosynthesis of rice during Jointing-booting stage, Heading Stage under the four inundation depths, the photosynthesis was not inhibited obviously with respect to increasing depth and longer duration except for 4/4 inundation ratio, and the rice performed compensation action and adaptive capacity responding to inundation threat. Experiment indicates that inundation obviously leads to yield reduction in Heading Stage and the starting of Grain Filling Stage, whereas yield decreases lightly in Tillering Stage, Jointing-booting stage caused by inundation. In the later two stages, the rice plant height and the time of tasseling and blooming were inhibited respectively; Tillering Stage and jointing-booting stage were delayed. The sensitivity for four rice growth phases are sorted in order as follow : Heading Stage>Jointing-booting stage> Grain Filling Stage > Tillering Stage. With the limit of 10% yield reduction and 6 days inundation, the up limit water inundation depth in each stage of rice growth is 45cm, 65cm, 60cm, 65cm respectively.

According to these, using 0.2 million hectares rice field along the Huaihe River for collecting heavy rain can not only ease the flood pressure to the downstream river, but also reduce the pumping energy consumption. Therefore, the experiment results give a reference for making use of storm water resources, moreover, it is helpful for drainage system design and operation & maintenance in Huaihe drainage area.

Key word：experimental study；inundation；paddy；storm water utilization

SUSTAINABLE LAND USE STRATEGIES OPPOSITE TO DEFENSE WORKS IN THE FLOOD PRONE AREAS (NORTH SPAIN)

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The river network in the north of Spain has 28,000 km distributed in 25 drainage basin systems over a 23,177 km^2 surface area. This area is located in the Cantabrian Range, a mountain chain that runs parallel to the northern coast of Spain in an east-west orientation, with heights up to 2,600 m and a maximum distance from the sea of 60 km, giving rise to a hydrographic network that is highly sloped. The combination with an average rainfall between 1,000 and 2,000 mm per year results in rivers with high erosive capacities and large bedload transport rates. Around 85% of the network has bedrock rivers and many of then display a behavior dominated by torrential phenomena, such us debris flows and flash-floods. Only 3,200 km of the river network have developed floodplains, where is located most of the population.

In order to reduce the flood risk, river channelization was carried out, parallel to an increasing demand for urban space and the area where the water is able to run off was limited to narrow channels. As a result fifteen percent of the alluvial rivers have been channeled during the last 40 years, especially during the 1980s and 1990s decades. As a result of this process, these modified rivers show retention of bedload, the flood protection has been reduced and the stream power has increased. In addition, the natural rivers connected to the channeled stretches show development of erosion processes and have evolved to narrower and incised channels. The cost of protection by dredging is too high, besides the known environmental problems.

Recognizing the inherent impacts associated to these constructions, the aims of the European Floods Directive 2007/60/EC and Spanish legislation are focused on the need for implementing sustainable measures in order to reduce further increase of flood risk. The protection provided by the Preferential Flow Zone (PFZ) assures a natural distribution of the bedload by the river and supports the floodplain capacity to remove the flood energy.

To reach this integrated flood risk management, five years ago the Water Authority in the north of Spain began to promote agreements with land use planning administrations. These actions are being essential in order to keep inundation areas free of settlement. Today, almost 13% of the flood network holds protection tools. The passive flood controls are an effective measure for flood risk mitigation, preserving the natural capacity of floodplains for flood retention, reducing the power flood and promoting the ecosystem potential with a low cost of maintenance.

HYDROECONOMIC ANALYSIS OF ALTERNATIVE INTERVENTION PLANS IN A RECLAIMED BASIN IN ITALY

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While updating its Hydraulic Risk Management Plan, the Consorzio di Bonifica Pianura di Ferrara developed, in collaboration with the University of Ferrara, a project aimed at creating and analyzing the flood maps associated with potential breaches in Reno river dykes – a river constituting the southern boundary of the reclaimed basin of Argenta.

The reclaimed basin of Argenta extends over 80 km^2. Its territory, mostly agricultural land with the presence of a few urban centers, is fairly flat with an average altitude of -4 m below the sea level. A well-organized hydraulic system, recently further developed and now made up of 131 km of canals, 60 control manufactures, an extended detection basin of 400.000 m3, and a pumping station of 23 m^3/s located at the basin outlet, constitutes an efficient hydraulic defence for the area with respect to heavy rainfall events.

The analysis of the simulations, summarized through several specifically designed flood maps, is a starting point for relevant decisions for both the Civil Protection and the Consorzio di Bonifica. In fact, they in particular consent to predict the behavior of the hydraulic system consisting of channels, control manufactures and pumping stations in the drainage phase that can happen only through such a system.

Another goal in the development of our study was the determination of the optimal level of planimetric and altimetric knowledge of the land, in terms of cost-benefits ratio. In fact, a detailed characterization of the land requires a large investment in terms of time, machinery and personnel, and not always all these efforts lead to an effective gain in terms of accuracy of the results.

The study starts with a definition of the territory with respect to land usage, presence of urban areas and infrastructures and with a description of the protection hydraulic system managed by the Consorzio. The study moves then to a definition of different models used to represent the land, applied with an increasing level of detail. As regards the Reno river, an analysis of observed flood events is performed which leads to the identification of the baseline critical event, together with the characterization of its frequency.

The hydrodynamic simulation of such an event allows for the analysis of all the aspects connected with the formation of the dyke breach in the area of interest and thus to define the various possible waves deriving from the opening of a breach in the dyke..

THE subsequent phases of the project are (A) the two dimensional modeling of the floods generated by the selected breach waves and the realization of the maps of flood risk; (B) the analysis of the extent to which different levels of detail (used for representing the land and the infrastructures) affect the results.

The conclusions summarize the results in terms of physical impact of the simulated phenomena and residual efficiency of the land reclamation infrastructures. Considerations about the optimal level of land representation to be used in the hydraulic simulation models are also developed.

VULNERABILITY TO TIDAL SURGES OF COASTAL LIVELIHOOD IN BANGLADESH

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The occurrence of the storm surge during the cyclone in Bangladesh is very much regular. Furthermore, mean global temperatures are predicted to increase by between 1.4-5.8°C over the coming century which will cause changes in temperature, distribution of rainfall, the frequency and intensity of extreme weather events, and sea-level rise. As a result, it is an imperative to establish a logical ground where the extent of the impact of cyclone disaster is correctly predicted. This research focuses on this particular aspect of future disaster mitigation planning in Bangladesh under the consideration of empirical evidence of cyclone Aila of 2009 along with available climate data from secondary sources.

Climate data includes wind speed, height of the storm surge, human causalities, number of affected people, affected area and its elevation. The empirical data was collected through key informant interviews, focus group discussions and a household questionnaire survey in cyclone Aila affected southwest coastal villages of the country. By assuming a 95% confidence interval, the total sample size for household questionnaire survey was 1678 out of 25782 households. Samples were drawn proportionately from 44 villages.

Adoption of a particular set of coping strategies depends not only the magnitude, intensity and possible impacts of cyclone hazards, but also on the socio-demographic characteristics. The social indicators used here are: age, gender, religion, monthly income, land ownership, having early warnings, damages and losses information, having emergency supports both internal and external sources, plinth-level and construction cost of residential house, and distance from rescue shelters (i.e. cyclone shelter). Geographic Information System (GIS) software (ArcGIS 9.3) was used to overlay the critical impact elements within the catchments zone of cyclone shelters.

The methodology involves in the analysis has found a strong correlation between the wind speed during the cyclones and the tidal surge height. The historical data shows that the value of correlation between these two variables is 0.74. The value of correlation between storm surge and casualties is found to be 0.46. There also remains a strong correlation (value 0.71) between the wind speed during the cyclones and human casualties. Average wind speed during the cyclone period of last 50 years (1960-2009) was 166.368 km/h and the average storm surge height is 4.80 meter. The number of affected people due to the storm surge is also related with the extent of the affected area and population density.

Accordingly, it was observed that more than two-third respondent could not reach in a safer place due to rush of water-intrusion and also because of inundation of road-network. The nearness to the available cyclone shelter, and place of taking shelter during cyclone is positively correlated ($r=0.38$; $p<0.001$). However, the poor people had less opportunity to take shelter in cyclone shelters, although none of the respondents groups whose monthly income is above 75USD stands without any infrastructural supports. Some important observation may hint the influence of local elites on the local disaster mitigation planning practice in Bangladesh. Finally, we also discuss existing coping strategies in the study area and recommended ways in which may be mainstreamed into the local level development planning agenda.

A RISK APPROACH FOR MITIGATION OF RIVER FLOOD DISASTERS USING HEC SERIES AND GIS

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Management of river floods and reduction of disaster risk associated with them are of high importance in the world. For this purpose, flood inundation maps are usually prepared for river encroachments which are traditionally based on fixed return periods of floods and neglect land use and soci-economical considerations. Therefore, there is a need for development of flood risk maps which can be applied for efficient land-use as well as mitigation of river flood disasters.

In this paper, a risk analysis for estimation of flood damage due to rainfall has been conducted with especial attention to measures for mitigation of flood disasters. For this purpose, a series of simple available software which were directly linked together were used. This comprised of HEC-RAS for flood hydraulic computations, HEC-FDA for economical analysis of flood damages and Arc-View for entry of the initial topographical data as well as presentation of the output maps in GIS. This approach was studied in the area of the Goragnrood River, located in North-East part of Iran, which has been prone to severe flood damages.

The flood risk analysis was conducted in the study area for different types of land-use (i.e. agricultural, residential and garden) and the flood damages were estimated in each case and for combination of them. The results were produced in the form of flood vulnerability maps which can be used for different purposes. Items such required for flood Emergency Action Plan (e.g. escape routes) were specified on the maps. It was concluded that the flood risk approach is not only efficient and effective for land-use planning but also for mitigation of river flood disasters.

RISK SHARING IN PRACTICE TOWARDS INTEGRATED FLOOD MANAGEMENT

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Under the Integrated Flood management (IFM), which aims at minimizing loss of life from flooding while maximizing the net benefits derived from floodplains, the management of flood risk should be a combination of measures that address risk reduction, retention and transfer through a strategic mix of structural and non-structural measures for preparedness, response and recovery. Practical flood management depends on how to share the cost of taking risk placed on society among governments, interested parties, communities and individuals. This study analyzes the actual flood management in a local basin along Rokkakugawa and Matsuuragawa basins from the perspective of risk sharing.

Risk management calls for identification, analysis, assessment, control, avoidance, minimization, or elimination of unacceptable risks through policies, procedures, and practices under three strategies for risk management: risk reduction, retention and transfer.

Risk reduction is the first step in risk management process. Flood risks can be reduced either through decrease of flood magnitudes; or the exposure of the economic activities; through structural or non-structural measures. The reduction can be also achieved by reducing the vulnerability of those exposed to floods.

However, there is always the possibility of residual risks by a flood greater in magnitude than the design flood. Risk retention, as the second step, includes the efforts that are made to reduce the residual risk that involves spatial planning, early warning, evacuation and preparation for disaster relief and flood proofing. Emergency response actions are undertaken to keep the materialized risk to a minimum. Individuals take the responsibility by reducing their own vulnerability and implementing proofing measures. With all the efforts in place, flooding results in losses due to damage to properties and interruption of economic activities.

While some of the materialized losses are absorbed by the element at risk, called retained risks, the other should be transferred, which entails passing a part of the materialized risk to the public at large through national scheme or another financial mechanism, like insurance.

An efficient solution requires a judicious combination of risk reduction, retention and transfer. In Rokkakugawa and Matsuuragawa basins, the national government bore the cost for emergency recovery for 1000 million yen after the 1/20-year flood in 2009, which can be considered as risk transfer. Annual budget has been traditionally allocated for risk reduction, but should include more risk retention, such as “Saga-Plain” emergency plan and communities’ activities for vulnerability reduction. Takeo Office of River, MLIT has facilitated

- emergency planning by coordinating national government (self defense, coast guard, meteorology, river), prefecture, municipals, private organizations (road, power, telecommunication, media, gas, construction) in Saga Plain, and
- communities’ participation through community risk management, based on its long tradition of communities’ mapping, called “My Disaster Map”. Around Takeo area, 57 communities have developed the map while eight communities are in the process of the development as of January 2011. The construction of new signs is based on such tradition and frequent communication with the communities.

Such collaborative activities contribute to flood risk sharing flood so as to implement IFM practically in actual fields.

OPTIMAL OPERATION OF FLOOD CONTROLLING RESERVOIRS: A COMPARATIVE ANALYSIS OF GA AND PSO ALGORITHM

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Application of optimization algorithms to flood controlling reservoirs volume has focus on flood controlling planning and management. In this paper application of Evolutionary algorithms including Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) algorithms have been investigated for flood controlling reservoirs volume. The used fitness function is minimizing the total loss of resulting from insufficient empty volumes of flood controlling reservoirs for flood controlling. The decision variables are monthly empty volume of reservoir for controlling of flood volume for every month in long term reservoir operation longevity. Also, the constraints considered for this optimization are reservoir constant capacity and the limited output of water volume for every month. Results of this paper show that, even during the low flow condition, the PSO if applied to the Mirzakhanloo reservoir in Zanjan State, Iran, can satisfy empty reservoir volume for flood controlling and downstream demand. Hence based on the present case study it can be concluded that PSO has the capability to perform efficiently, if applied to real world operation of the flood controlling reservoirs. Also, in this present study, a real coded multi-objective PSO and multi-objective GA combined with simulation of reservoir constraints show that those could be applied efficiently to optimize the volume of flood controlling reservoir. Finally, by comparison of loss value from application result of two mentioned algorithms, application of PSO is preferable to GA; and in PSO, optimization procedure improves the performance of reservoir volume for flood controlling better than the GA.

COLLABORATIVE FLOOD RISK MANAGEMENT IN THE UNITED STATES THROUGH THE SILVER JACKETS PROGRAM

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The Silver Jackets is an innovative program that provides an opportunity to consistently bring together multiple Federal, State and sometimes local agencies to learn from one another and apply that knowledge to reduce risk. This program acknowledges the importance of effective and continuous collaboration between state and Federal agencies to successful reduction of risk of flooding and other natural disasters in the United States and enhancing response and recovery efforts when such events do occur. No single agency has all the answers, but often multiple programs can be leveraged to provide a cohesive solution. The Silver Jackets program provides a formal and consistent strategy for an interagency approach to planning and implementing measures to reduce the risks associated with flooding and other natural hazards.

The program is a partnership of the U.S. Army Corps of Engineers, the Federal Emergency Management Agency (FEMA) and state agencies. Silver Jacket programs are developed at the state level with support from the Corps, FEMA and other Federal agencies. The Silver Jackets teams focus on the priorities of their individual states, with the ultimate goal of the program being to offer teams to each state. Currently there are either active or developing teams in 49 states. There are several desired outcomes for this program. The first is to reduce flood risk. A second desired outcome is to improve the ability of various agencies to understand and leverage each other's programs. Third, the program should improve collaboration between the various agencies involved in flood risk management, to coordinate programs and create cohesive solutions. Silver Jackets teams should also provide multi-agency technical resources to assist state and local agencies, and they should provide a mechanism for establishing relationships to facilitate integrated solutions after a disaster occurs.

The Silver Jackets program has several primary goals. The first of these is to create or supplement a mechanism to collaboratively address risk management issues, prioritize those issues, and to implement solutions. The second goal is to increase and improve flood risk communication through a unified interagency effort. Third, the program would like to leverage information and resources to assist in flood risk management. Another primary goal is to provide focused, coordinated hazard mitigation assistance in implementing high-priority actions such as those identified by state mitigation plans. A final key goal of the program is to identify the gaps among the various agency programs and the barriers to implementation of flood risk management, and to provide recommendations for addressing these gaps and barriers.

This presentation will discuss the efforts to establish and implement the Silver Jackets program, including the challenges that were faced. Examples of successful collaboration efforts to reduce flood risk provided by Silver Jackets teams will also be provided. Finally, the future direction for the Silver Jackets program and teams in using collaborative solutions to manage flood risk with limited resources will be discussed.

Parallel Oral Sessions

Topic 2

Flood Disaster Management (Preparedness, Emergency Response and Recovery)

- Flood disaster preparedness
- Flood hazard mapping
- Emergency management and recovery
- Risk communication and damage assessment
- Social capital and community defense

VARIABILITY OF THE URBAN VULNERABILITY AND RESILIENCY FACE TO WATER RELATED RISKS.

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After the urban ecosystem's vulnerability, may be argued the vulnerability of one ore more of its components coming both of the environment natural features and the social interventions. Those designate the exposure to the water related hazard, the urban intrinsic sensitivity, its adaptation ability or flexibility and transformability face to the potential danger. In spite of the climate change impact by term, the exposure indicates a heavy geographical determinism while the other factors sometimes successfully express of its very antithesis.

Within the context of al-Harrash municipality in Algiers, the urban vulnerability-resiliency reminds closely tied up with a sum of relevant indicators confirmed by the diagnosis items concerning the local urban and hydro systems. This sum results from a classifying process amongst tens of factors potentially implied in the water related risk level. They form here the purpose of a multicriteria analysis with the objective of assessing the urban vulnerability-resiliency index and then of orientating the preventive strategy towards some sustainable measures.

As a result, the urban vulnerability level seems to be highly dependant on each indicator's mark. With regard to its implication in the local vulnerability, the sensitivity obtains the most important note in relation to the exposure. Besides, concerning adaptation ability and transformability, the notes are very low. Thus, it may be argued that al-Harrash municipality shows a critical vulnerability and a minor resiliency level. Referring to the risk datum line, the marks obtained designate a mean term risk zone.

The present paper aims to develop a vulnerability-resiliency indicators' multicriteria analysis showing their variability and implication rate with regard to the local water related risks' level.

AN APPROACH TO FLOOD RISK MANAGEMENT IN LOW-LYING AREAS BY USING A DIURNAL RAINFALL PATTERN GENERATOR

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An increase in flood risk, especially in low-lying areas, is predicted as a result of global climate change. Immediate measures are needed to minimize the damage (e.g., inundation of paddies) caused by more-frequent floods. The capacities of drainage systemsin paddy areas are planned on the basis ofdesign rainfall. For example, design rainfall may be represented by a 3-day rainfall event with a 10-year return period. However, design rainfall parameters used in Japan have not been reviewed for a long time, and changes in rainfall patterns associated with recent climate change are not reflected in current drainage planning. The aim of this study was to developa diurnal rainfallpattern generator and to use it to evaluate the effects of changing patterns of heavy rainfall on drainage systems in Japan.

Our study area was in the Kaga three-lagoon basin, which is a low-lying area thatincludes Komatsu and Kaga cities in Ishikawa Prefecture. There are two lagoons in the lower reaches of the basin. First, heavy rainfall events during which rainfall exceeded either 70 mm each day for 3 days or a total of 100 mm over 3days were extracted from rainfall data obtained by the Kanazawa Meteorological Observatory (near the study area) from 1940 through 2008. These data were used to determine the long-term trendof rainfall data. Next, we developed a Monte Carlo based heavy rainfall pattern generator,which took into accounthistoricalrainfall data andwas used to simulate various patternsof heavy rainfall. The duration of rainfall was fixed to 3days, and the data were generated for 100 years. The statistical characteristics of simulated events such as frequency, distribution, and internal structure of heavy rainfall were compared with the historicaldata. We also developed a drainage analysis model that incorporated kinematic and diffusive runoff models for upland (non-inundation) and inundated areas, respectively. The model was adjusted in accordance with observed discharges and water levels for heavy rainfall events. Flood routing analyses from the model were consistent with observed hydrographs, and the impacts of heavy rainfall events on the drainage system were evaluated with this model.

Comparison of the hourly data of the observed heavy rainfalls showed that the average maximum 6-, 12-, 24-, and 48-h rainfalls increased a little over the 69 yearsand that the distribution of the maximum amount of 6-h rainfall also changed. In the future, rainfall intensity might increase more than indicated by our modeling.Our simulations generated various patterns of rainfall data, including heavy rainfall eventsofmore 300mm precipitation. The characteristics of these eventswere consistent with observed events. Thesimulated rainfall data were input to the drainage model, which showed that the resultant water levels at the lagoons in the study area exceeded design high water levelsin some cases. Additionally, serious inundation of paddieswas found, indicating that countermeasures such as increased pumping capacity are needed.

URBAN FLOODING MANAGEMENT BY USING THE NATURAL DRAINAGE SYSTEM CASE STUDY: TEHRAN, CAPITAL OF IRAN

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Tehran, capital city of Iran is located on Jajroud, Kan, Karaj and some small basins and it area has been grown during 20 past years and reached to about 620 Km2 with its basins up is reached 1000 km2. Due to the flattening of the urban land, landuse changes and expanding of the urban transportation, the drainage channels were developed and it caused to the natural drainage system was changed to artificial drainages and also become useless. Consequently Tehran is not able to gather the runoff during the intensity rainfall; thus flood phenomena are frequent in Tehran. This study was purposed a hydro-geomorphic zoning method as a strategy to manage flooding in Tehran.

The elevation data was taken out from the Topographical maps 1:10000, climatic data from Synoptic stations, landuse from Tehran municipality, aqueducts network and tunnels network map from Tehran Watershed Management Organization. At first Tehran was divided to three systems that included east and northeast, west and northwest and central zones. Natural drainage system for each zone was extracted of the elevation model by using HEC-HMS and Hydro Model (Agree DEM) and corrected by field researches. Then natural drainage system was compared with artificial tunnels network.

the result was shown the existence spatial variances between the networks. More than 50 percent of east and northeast drainage system with over 120 Km are not matched with the tunnels. West and northwest zone which its length140 Km at 65 percent does not coordinated with the artificial network. The central drainage system is covered and although it is according to natural drainage, but it is not able to gather the runoff of Tehran. Therefore Modified the tunnels network based on the natural pattern drainage is an appropriate strategy to manage and control flooding in the capital of Iran

MULTI-OBJECTIVE OPTIMISATION OF FLOOD RISK MITIGATION MEASURES

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Flooding is a global problem and there have been numerous cases of extreme flood events over the last decade. One of the most recent events has seen major damage, disruption and loss of life in Eastern Australia, Queensland and Victoria, where insurance claims are estimated to be in excess of ? Quantitative flood risk analysis methods are often used to support flood risk management decision making. The models are typically deployed to understand the benefits, in terms of risk reduction, afforded by flood risk management actions (sometimes referred to as mitigation measures or interventions). It is now widely recognised that effective flood risk management requires consideration of a range, or portfolio, of different measures. Depending on the location, these could include a range of structural (flood defences, barriers, etc.) or non-structural measures (flood proofing of properties, improved flood warning etc.). For existing flood defence systems it is also necessary to consider the benefits associated with different maintenance regimes.

To demonstrate the value of implementing the measures, economic appraisal is often required, highlighting the benefits of the measures, in terms of risk reduction, when compared to costs. It is also frequently necessary to demonstrate the proposed solution offers the greatest return for the investment made. This task can be complex. There are a wide range of different mitigation measures that could be made and the timing of making these interventions can also be of importance. For example, for existing ageing infrastructure, the most opportune time to undertake major refurbishment, rather than continue with a maintenance programme that becomes increasingly costly, is not always immediately apparent. Which measures offer greatest value for money, non-structural or structural measures?

Whilst the risk analysis models are able to quantify the benefit of introducing different measures, further investigation is required to identify the most appropriate solution to implement. Automated search algorithms are the most efficient methods for doing this.

This paper describes the development of a decision support system that couples a multi-objective optimisation algorithm with a flood risk analysis model and a cost model. The framework has the capability to generate potential mitigation measures that are implemented at different points in time. It then evaluates the performance of the mitigation measures in terms of costs and benefits and iterates until it finds solutions that are optimum. The system is capable of defining solutions that are optimal with respect to a single objective (eg. benefit/cost ratio) or multiple objectives (ie benefits and costs) and hence a trade off curve or (Pareto Front) is generated. These trade off curves offer decision makers greater insight into the implications of different solutions. Whilst the modelling system currently operates in terms of benefits and costs it is readily extendable to facilitate trade off curves of different output measures of interest, eg. environmental enhancement or carbon cost, for example.

ANALYSIS ON THE EFFECT OF DISASTER MANAGEMENT TAKEN AFTER RECORD RAINFALL IN SHINANOGAWA -RIVER

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Shinanogawa –River basin was hit by 1000mm -over rainfall caused by rainy season front in Jul. 2011. Quite serious flood damage has occurred, but the damage was minimized by structural and non – structural countermeasures installed after the record rainfall which hit same river basin just 7 years ago. This paper is the introduction of the disaster management countermeasures taken in Shinanogawa River basin, and flash report on the effect of disaster management including river improvement, river management, flood prevention and evacuation.

PARTICULATE STUDY OF SEDIMENT TRANSPORT IN GRANULAR DEBRIS FLOWS

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Understanding the characteristics and mechanics of granular debris flows along slope channels are fundamental and vital for the study of different geophysical flows in field. By using the Discrete Element Method (DEM), three-dimensional (3-D) granular (mass) flows along slope channels are numerically modeled and the contact behavior between solid particles is fundamentally studied. Through the numerical simulation, the evolution of the 3-D unsteady granular flows, from quasi-static to inertial flows, is systematically investigated. By capturing the velocity profiles along the flowing height and utilizing the definition of the Savage number and the granular temperature, the variation of flow regimes and the vibration of solids inside a granular body along the slope channels can be captured, respectively. Furthermore, the numerical results are compared to the field measurement, and the channel confinement effect on the solid discharge of granular debris flows is analyzed. This particulate study illustrates that the granular temperature (degree of solids vibration) is influenced by the Savage number, and their combination is a good way to clearly identify the flow regimes of different granular flows. Also, the channel width as a confinement to the granular debris flows can affect the sediment transport significantly.

FLASH FLOOD ANALYSIS IN URBAN AREAS

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Floods in Alginet (Valencia, Spain) are a recurrent problem in which relevant agencies have worked for years. Several classic protection hydraulic infrastructures (channelling, cut-off) can be seen as a glance beside others which settle local problems. Alginet has an urban planning which shows an specific urban zone arrangement and kind of buildings. This is third analysis because it is necessary to detect origin of the problem and to quantify it exactly if possible.

Alginet is in foothills of Sierra Falaguera and extent its lands as far as the marsh of Albufera de Valencia. The central area is located at the confluence of four gullies (Señor, Agua, Forca and Belenguera), as well, it collects runoff from Sierra Falaguera. The A-7 road makes a border of the city and forms a pool with the infrastructure. Downstream terrain slopes are nearly zero.

After an analysis of the zone and the precedents, the determining factors for hydrologic and hydraulic evaluations were the next:

- These studies are not the objective itself. The objective is to identify hazard of Alginet floods, identify and value the risks, plan mitigation measures and project some structural solutions. It is necessary a whole simulation to included the specific territorial distribution of buildings, infrastructures and farms and industry to fulfil the contract.

- Upstream the city there is an irrigation channel (Canal Júcar-Turia) which shows a difference between natural and channelized rivers. There are also levelled stretches to agricultural exploitation. It makes contribution flow calculation difficult with a semi-aggregate hydrologic models so, it is necessary to make it with a distributed ones.

- Flow distribution within the city, runoff analysis and a big pool prompted by several drainages needs a two-dimensional simulation model.

- Half basin, from A-7 road to Albufera is a plain zone without bed-river good defined. This part needs a distributed hydrologic and hydraulic models.

The domain has been divided in several hydraulic and independent models which have overlaps to avoid surrounding area problems because big area, little slopes, many drainages and high precision. The simulation has been made with GUAD2D which can calculate simultaneously in each triangle of calculation mesh.

With these simulations it has been possible to analyze the flow which produces damages in Alginet surroundings. The results identify overflow zones in gullies or urban area, capacities of drainages, velocities and flow ramifications, runoff and rain hydrographs and values per unit area for every territorial item and distinguish between river overflow damage or rain damage.

EFFECTIVE FLOOD CONTROL THROUGH INTGRATED AND COLLABORATIVE DAM OPERATION AT THREE DAMS IN THE UPPER NABARI RIVER

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Heavy rain with the 18th typhoon threatened the NabariRiver Basin, Kansai region with causing inundation early in the morning on 8th October, 2009. The NabariRiver is a tributary of the Yodo river basin which contains Osaka and Kyoto and runs through NabariCity which is a residential zone as commutable distance area from Osaka city. In the upper reach of the Nabari, there are three multi-purpose dams; Shorenji Dam, Hinachi Dam, and Murou Dam, which are operated by Kizugawa Integrated Dam Control and Management Office (KIDCMO), branch office of Japan Water Agency (JWA). Since it rained heavily in the downstream of the three dams, the regular operation by three dams complying with the given flood control regulation seemed not to be able to prevent NabariCity from inundation. Therefore, JWA and Ministry of Land, Infrastructure, Transport and Tourism (MLIT) conducted collaborative operation of the three dams to avoid the inundation in the city area.

In this case, flood control operation of three dams commenced in early stage before the inflow reached the defined flood discharge in consideration of the water level of the NabariRiver, rainfall condition and capacity of the reservoirs. During the operation, discharge from the dams was changed timely and appropriately through the collaborative work of the three dams in order to maximize the effectiveness of all flood control capacities of the reservoirs according to the latest rainfall forecast technology and runoff analysis.

The use of improved rainfall forecast technology and runoff analysis model enabled the effective application of this flexible operation protocols. It is estimated that this operation has resulted in 1.5 m decrease of the water level at Nabari design control point, and prevented approximately 1200 households from inundation.

Considering the recent climate change, it is possible to have extreme rainfall more often. The proof of adaptability of this flexible operation is quite meaningful not only for flood damage mitigation in the downstream, but also for future prospects of flood control by dams.

THE VARIABILITY OF ENSO AND PREDICTABILITY OF SEASONAL FLOODING

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Background: This study is an overview of the science of El Niño--Southern Oscillation (ENSO) climate cycle and its correlations to flood management in different climate conditions and geographic zones. The ENSO climate cycle—which is the largest source of year-to-year climate variability—is of central importance in this study for its global nature, strong signal, interannual time scale, and inherent lag relationships to the climate system.

Objective: The purpose here is to visit some “hotspots” of climate hazards [i.e., the U.S.-Affiliated Pacific Islands (USAPI) and Bangladesh] and emphasize the role of an operational framework for forecasting, warning, and response opportunities. Based on ENSO and sea-surface temperatures (SSTs) in the tropical Pacific Ocean, the prime objective is to discuss about the forecasting schemes for local climate indicators with lead times of several months or longer.

Methodology: Broadly, issues discussed here are: (i) El Niño, La Niña, and ENSO Cycle; (ii) climate hazards “hot spots”; (iii) the correlation between ENSO and sea level variability in the USAPI and flooding in Bangladesh; and (iv) an operational forecasting model. The source of predictable, accessible climate indicators (i.e., sea level, flooding) and its relation to large-scale oceanic variability, as predicted by ENSO, has been identified. Correlation analyses are conducted between these climate indicators and tropical SSTs. This process described the robustness of the relationship between ENSO and local climate variability by analyzing the composites of seasonal variations and correlating the SST time-series at each geographical grid-point. Finally, a canonical correlation analysis (CCA) is used to develop an operational forecasting scheme on seasonal time-scales.

Results: Findings revealed that climate extremes (i.e., sea level in the USAPI, flooding in Bangladesh) are correlated to tropical Pacific SSTs with lead times of approximately several months or so, and the corresponding CCA model forecasts are skillful.

Conclusions: These results conclude that climate variability and change in the USAPI and Bangladesh are sensitive to ENSO. Based on this hypothesis, potential prediction schemes for a real-time response plan can be drawn by using ENSO and local climate data.

Disclaimer: The views expressed herein are those of the author and do not necessarily reflect the views of PEAC, NOAA, or any of its subdivisions.

HARD AND SOFT MEASURES IN THE KISO THREE RIVERS BASIN FLOOD MANAGEMENT ～MAINLY AGAINST STORM SURGES～

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The Kiso Three Rivers originate in the mountainous district surrounding the vast Nobi Plain. The Catchment area of the three rivers covers 9,100 square kilometers. From about 100 years ago, the Kiso River, Ibi River and Nagara River, which flowed as one turbulent river, were divided into the three rivers.

The estuaries of the Kiso Three Rivers suffered serious damage the Ise Bay Typhoon in September 1959. The damage in the area at sea level resulted in 4,600 fatalities and 61,700 injuries. The area flooded by seawater totaled 310 square kilometers, and 230 square kilometers of that remained under water for more than two months. The levees at that time were weaker than that of the current structures. Then, levees have been developed to withstand the Ise Bay Typhoon. And overcoming regional ground subsidence, these levees have been completed in sight. However, the excessive force that is what happens. In fact, it is feared that the larger the typhoon by climate change. The same can be said that in these levees completed in sight.

To confront such a large force of storm surges, of course, hard measures are needed, such as maintenance of embankments. However, the hard measures, raising the force is not immediately planned and is not easy. In addition, Facilities can not support more than facilities subject to external forces. Thus, Our office has an emphasis on, not only development of the line levees, construction of facilities for the restoration work including levees breaches, and initiatives that raise awareness of evacuation.

Since Ise Bay Typhoon, residents of the Kiso Three River mouth has not experienced such a large flood levees breaches. Raising awareness about the evacuation has been promoted to assume the storm surge disaster. On the other hand, we began to consider building a network of wide-area disaster recovery for the levees. We have a policy of building the network was organized. The principal target of this policy is not only a storm surge, but also a flood, an earthquake and a tsunami. In this presentation, we introduce these initiatives.

HYDROLOGICAL ANALYSIS OF THE SITU GINTUNG DAM FAILURE

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In the early morning on March 27, 2009, the Situ Gintung dam, located just near Jakarta-Indonesia, failure occurred. This disaster has awakened most of Indonesian people especially those who have concern with hydraulic structures, disaster and sustainable water resources management. During the disaster, about 100 people died and a number of people were missing. There are hundreds dams like the situ Gintung dam and other big dams in Indonesia. Most of the dams pose a high or potential hazard to life and property if failure or levee breech occurs. Dam failure can occur with little warning. Based on the Situ Gintung dam failure and realizing that there are a lot of such dams in Indonesia, study on the possible causes of dam failure is essential as a lesson for disaster risk reduction of other dams.

Dam failure may occur at different location such as spillway, embankment and foundation. This failure occurs as a result of number of problems such as overtopping, surface erosion, piping. For instance, dam failure due to spillway problem may occur as a result of inadequate spillway capacity (overtopping) or loss spillway by erosion (surface erosion). Thus in this study, the Situ Gintung dam failure will be analyzed based on hydrology and hydraulic analysis.

Results show that heavy monsoon rainfall was not the main cause of the situ Gintung dam failure. The daily rainfall on 26 March 2009 is 112mm equaled to 10 years return period. Reservoir routing shows that there was no overtopping during 27 March 2009 flood, the maximum water depth on the spillway is 0.60 m Even the spillway is still safe under 100 years return period with maximum water level is +98.95 m. It means that the embankment still safe with 1.05m freeboard. However, due to high water flow velocity (more than 12 m/s) surface erosion occurred at the end of chute spillway that consists of silt, clay and sand type of soil. Since the continuous scoring/erosion happened throughout the spill over the spillway that started at around 06:00 pm till 03.00 am, resulted a big pond at the chute spillways and surrounding area. This phenomenon affect to the instability of the spillway structure. This instability increased due to houses build just near the embankment crest and spillway. As a results loss of spillway occurred resulted high flow discharge that reach more than 300 m^3/s.

2D NUMERICAL COMPUTATION FOR FLOOD FLOW IN UPPER RIVER BASIN WITH TRIBUTARY ENTRIES BY USING WATER LEVEL HYDROGRAPHS OBSERVED AT MAIN STREAM

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Recently, many upper river basins in Japan are suffering from flood damage due to localized torrential rainfalls. The frequency and intensity of the rainfall is estimated to be increased by the climate change. So, river management and maintenance method in upper river basin are required. However, it is difficult to clarify characteristics of flood flow in upper river basin, because of data insufficiency of tributary riversand flood flow. Because water level can be observed in low-cost and high-accurate,one of the authors has developed the unsteady two-dimensional numerical analysis method by using observed water surface profiles. The method has been applied to various flood events and phenomena in rivers, including river bifurcation, retarding basin and dike break. In many Japanese major rivers, water level hydrographs in the main stream are being observed. So, the application of the method is expected for the management and maintenance of the upper river basin.

The objective of this study is to develop the unsteady two-dimensional numerical analysis method for a river with tributary channels in upper river basin by using water level hydrographs at few observed stations in the main stream. Our computational target is the flood flow at August 2009in the Asa River of the Tama River basin. The longitudinal length of the computational domain of the Asa River is 13 km from the junction point with the Tama River. In the computational domain, there are three tributary channels and five water level observation stations, which include two discharge observation stations. The hydrographs from tributary entries have to be estimated by observed water level hydrographs. However, the water level observation stations are installed far from the junction points of tributary channel for the Asa River.

First, we develop an estimation method of discharge hydrographs from tributary entries by adjusting computed water level to observed one at observation stations, considering propagation time between the junction point and water level observation point. We demonstrated that the discharge hydrographs of main and tributary streams can be estimated by the present method. Second, we develop a flood water tracing method. Weinvestigated that the deformation of the discharge hydrograph and its composition ratios of main and tributary streams. The generation mechanism of discharge hydrograph of the Asa River flood is discussed. Third, the installation method and interval of water level observation stations are discussed. We indicated that a water level observation station is necessary within about 5 km downstream from a junction point of a tributary channel to compute flood flow for the computation of the Asa River flood.

BED VARIATION ANALYSIS USING THE SEDIMENT TRANSPORT FORMULA CONSIDERING THE EFFECT OF RIVER WIDTH AND CROSS-SECTIONAL FORM IN THE ISHIKARI RIVER MOUTH

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In estuaries, the grain size of bed materials are small and the difference of water level between the river and the sea become large during floods. Therefore, a large bed variation tends to occur during floods at river mouth. For flood control in estuaries, it is important to estimate the amount of sediment discharge rate and the degree of bed variation during floods.

Many of the sediment transport formulas proposed in previous studies are based on results by experimental channels. Therefore, they cannot estimate well the amount of sediment discharge rate in rivers because of the complicated channel shapes and bed forms.It is necessary to calculate the amount of sediment discharge rate appropriately for improve the accuracy of bed variation analysis. The determination method of the amount of sediment discharge rate at upstream boundary is also important issue for the bed variation analysis.

Fukuoka (2010) thoughtthat stable cross-sectional forms of rivers (such as width and depth) are determined by physical quantities which indicate characteristics of basins (such as discharge, river bed slope and river bed material). Then, he derived equations between dimensionless quantities of width, depth and discharge using field observed data by the dimensional analysis. Based on the above idea, he also derived the sediment transport formula considering the effect of river width and cross-sectional form using field observed data.

In this study, we develop a bed variation analysis to 1981 flood of the IshikariRiver which caused a large bed scouring at the river mouth and we investigate applicability of the Fukuoka's sediment transport formula.

During 1981 flood, temporal data of water levels were measured at many observation points in the reach 15km upstream from the river mouth. The effect of bed variation appeared on the temporal changes in water surface profiles. In this study, to clarify the flood flow and the bed variation during 1981 flood, we develop the unsteady quasi-three dimensional analysis of flood flow and bed variation using observed temporal changes in water surface profiles.

We compare the amount of sediment discharge rates during the flood and the bed forms after the flood calculated by the sediment transport formula of Fukuoka (2010)and the previous formulas of Ashida and Michiue (1972) and Sato, Kikkawa and Ashida (1958).As a result, we show that Fukuoka's sediment transport formula improves the accuracy of bed variation analysis compared with the previous sediment transport formulas. In particular, the reproducibility of cross-sectional bed forms at meandering channel in the IshikariRiver mouth are improved.This indicates that Fukuoka's sediment transport formula calculates the amount of sediment discharge rate appropriately in the IshikariRiver and the amount of sediment discharge rate at upstream boundary can be determined by Fukuoka's sediment transport formula.

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JAPANESE EARLY-WARNING SYSTEM FOR DEBIRS FLOWS AND SLOPE FAILURES

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In Japan, about 1000 sediment-related disasters happen and about 20 people are killedannually. Because it is important for residents to evacuatebefore a disaster occurs, residents have to know when they should evacuate. MLIT (Ministry of Land, Infrastrucuture, Transport and Tourism) has developed a early-waring system since 1984. In 2005, a new nationwide early-waring system was established by SABO (Erosion and Sediment control) department of MLIT and JMA (Japan Meteological Agency), NILIM. A nationwide initiative for disseminaton ofearly-warninginformation (sediment-related disaster warning infomation) was implemented at the end of March 2008.

The main methodolgy of system is to set a criterion of disaster occurrence line (Critical line, CL) for occurrence of debris flows and slope failures based on two rainfall indecies (60-min cumulative rainfall as short time rainfall index, soil-water index as long time rainfall index) in each 5-km grid mesh covering all of Japan. Because many of record of debris flows and slope failures are lacking in precision on timing and location, the system applies RBFN (Radical Basis Function Network) to set the criterion based primarily on rainfall data recorded as not triggering disasters. RBFN make response surface of the grid by using non-occurrence rainfall data. The range ofRBFN valueis from 1.0 (no rainfall) to 0. Contour lines at0.1 intervals are potential candidates for CL. CL is selected from various potentialcandidates on response surface by checking that particular large occurrence rainfall events are below the CL.

This early-warning system is aimed atfacilitating the evacuation of residents in advance of theoccurrence of disasters, and at assisting the decision-makers suchas mayors to judge the timing of when to disseminate evacuationinstructions or orders.The main players who send out early-warning informationto the residential population are JMA and local government. When torrential rain is expected or falling, the timingof the issuing of early-warning information is determined bythe expected values of the 60-min cumulative rainfall and soil-water index calculated using the forecast rainfall for 1-3 h intothe future. The progress of the actual values of the two indicesis logged graphically as a snake lineso that the likelihood of exceeding the CL in the nearfuture can be anticipated to provide enough lead time toevacuate residents before the actual rainfall causes the CL to beexceeded. This allows JMA to initiate the early-warning ofdebris flows and slope failures. The weather news on a TV,radio, and the Internet then deliver the early-warning information.

On 21st July, 2009, in Yamaguchi Prefecture, 14people died due to 65 debris flows and 105 slope failures. CL adequately captured the timing ofthese disasters occurrences.

The merits of this method are easy to apply any areas with no prior record of disasters, to updateand to revisethe criteria while the system is operating.

PREDICTION OF POTENTIAL OUTBURST FLOODS FROM GLACIAL LAKE DUE TO MORAINE DAM FAILURE

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Due to impact of climate change, flood/sediment disasters caused by Glacial Lake Outburst Flood (GLOF) are frequently occurred in the Himalaya of South Asia. Global warming has accelerated glacier retreat, which results the formation or expansion of glacial lakes and constitutes a major hazards in the Himalaya.GLOF typically occurs due to moraine dam failure caused by seepage and lake water overtopping and eroding the dam. The moraine dams are comparatively weak and can breach suddenly, leading to the sudden discharge of huge volumes of water and debris.The GLOF events can cause catastrophic flooding in downstream areas, with serious damage to lives and properties. To avoid or minimize loss of life and property, there is a pressing need mechanism approaches to investigate the GLOF events and their downstream impacts.

The studies of GLOF events and their downstream flooding are very limited. The researches on GLOF are mainly focused on satellite observations, accounts of past events and preventive measures. The failure mechanism and erosion process of moraine dam are still not thoroughly understood. However, some empirical relationships and also physically based models are established to compute the characteristics of breaching of morainedammed glacial lake, but their limitation is that they do not consider the actual mechanism of dam surface slope failure and headcut and dam surface erosion. In this context, a numerical model has been developed to compute the characteristics of glacial lake outburst due to moraine dam failure by seepage and overtopping. To compute the pore water pressure in the dam and slope stability of the dam, a seepage model and a slope stability model are incorporated into a numerical model of flow and dam surface erosion. A numerical model is verified with the experimental results. The simulated results of the outburst discharge and dam surface erosion are consistent with the experimental results.

By using developed numerical model, the potential outburst floods from Tsho Rolpa Glacial Lake of Nepal have been predicted and have been analyzed with various multi-scenarios. TshoRolpaGlacialLake is located at an altitude 4580m in the Rolwaling valley. The lake has been developed only in the last 50 years, as the glacier feeding it has begun to melt rapidly. Due to temperature rising, the trakarding glacier above the lake is retreating at a rate 20m/year. The lake is 3.45km long and 0.5km wide, and 1.53km^2 surface area and contained 85.94 millionm^3 water. The lake is considered one of the most dangerous glacial lakes in Nepal. To examine the potential outburst of the lake, the field investigation at the lake was also carried out in August 2010. The grain size distribution of the moraine dam of the lake is also prepared.

If the moraine dam of TshoRolpaLake is breached, the resulting flood from the lake outburst would cause serious damage for 100km or more downstream, threatening as many as 6000 lives, hydroelectric projectsand other infrastructures. The current risk of a failure is considered to be high and increasing rapidly.

PERFORMANCE OF A CONSTRUCTED WETLAND IN REMOVING CONTAMINANTSFROM STORMWATER UNDER TROPICAL CLIMATE

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Urbanization has increased the construction of impervious area and significantly altered the hydrology and hydraulic characteristics of catchments. Due to that the flash flood has occurred more frequent in the urban area. In the long term, the urbanization has also deteriorated the water quality in the urban area.There are various Best Management Practices (BMPs)techniques which can be used as“control at source” methods to control stormwater runoff from the aspect of quantity and quality to achieve zero development impact contribution.The constructed wetland is widely used in developed countries for the stormwater quality improvement. In Malaysia, constructed wetland has been suggested in Stormwater Management Manual (SWMM) and the topic of constructed wetland can be referred in Chapter 35, Volume 13. The treatment of stormwater in constructed wetland is the result of a complex interaction between the physical, chemical and biological processes that occur within the system.

The objective of this study was to determine the removal efficiency of contaminants in urban stormwater by a wetland constructed in the USM Penang catchment. Samples of stormwater influent and effluent were obtained during rainfall events between 2003 -2004 and 2005 - 2006. Samples were collected at the inlet and outlet to the wetland during each event and analyzed for BOD, DO, TP and turbidity. Water quality parameters (temperature, dissolved oxygen, pH, turbidity, conductivity) were measured concurrently.

The average removal efficiency of BOD was 9.7% to 80%, DO was 6.5% to 17.8%, turbidity was 25.9% to 30.0% and TP was 24% to 46%. The correlation between rainfall and water quality data for BOD and DO showed the negative correlation while for turbidity and TP showed the positive correlation. In addition, the correlation between inflow and water quality concentration at inlet point are also considered and the result indicated the positive correlation for BOD, DO, turbidity and TP. A Paired Sample Test was chosen to determine if there are any significant values for water quality at inlet point and at outlet point. The confidence level used in this analysis was 95% and the finding suggested that there are no significant differences ($P > 0.05$) for BOD, DO, TP and turbidity. The analysis proved that the water quality at inlet point has no significant effect to the outlet point.

In conclusion, the results showed that most of the parameters such as DO, BOD, TP and turbidity comply with Class IIB, Interim National Water Quality Standard for Malaysia (INWQS). The study indicated that the suitable design features of the constructed wetland, suitable plants and details monitoring are important elements to achieve the objectives of constructed wetland as water quality improvement.

FLOOD CONTROL AND MANAGEMENT SOFTWARE SYSTEM -- TOWARDS A SUCCESSFUL DECISION SUPPORT APPLICATION

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Flood control and managementsoftware systems are developed to support the discussion, analysis and decision making processes when a flood occurs.So they are now quite popular applications in big river authorities. However, some of these systems have been frequently said not so useful in real practices. The end-users of these software systems and decision makers, who are the direct or indirect users of such systems, are still not satisfied. That’s why the river authorities are still working hard to build new ones. Therefore, it is very important to figure out the exact reasons which prevent the systems from being useful and practical.

The questions are: what is the general process of flood control and management practice? What are the typical problems which prevent the present system from being useful?What should be the efficient way to support flood control and management operation?What kind of software system do we really need for real-time operation?What kind of architecture and operational mechanism should be used to build the software system? This article focuses on exploration of the causes and introduces the authors’ research and new approach to develop a real useful and advance system. Firstly, the general flood control and management decision-making process is studied with cases from the big river in China. Then, the main problems with existing systems are examined in depth. Next, research on new approach is introduced, including the new system architecture with adaptive features, internal execution mode and user operational mechanism for developing a next generation software system, including the interaction between man and machine, especially for decision support; lastly, conclusions are made and recommendations are given for future development.

PALEOFLOOD SIMULATION IN THE KAMO RIVER BASIN BY USING A GRID-CELL DISTRIBUTED RAINFALL-RUNOFF MODEL

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The Kamo River Basin (KRB) is located in Kyoto city and was frequently attacked and damaged by flood disasters during the past 1300 years.This paper tries to study the uncertainties of flood disaster events, which are not yet fully identified and may be increased under the impact of climate change. The main purpose of this paper is toestimate the discharge during the extreme rainfall events under the historical environment by usinga grid-Cell Distributed Rainfall Runoff Model Version 3 (CDRMV3), which is a physically-based hydrological model developed at Innovative Disaster Prevention Technology and Policy Research Laboratory, DPRI, Kyoto University.

This paper collects the historical geographical maps (HGMs) of KRB to identify the paleo-environment condition, from the old books and Japan Map Center. Based on the HGMs, the historical land use maps are made by using the software of IDIRIS as the input data for CDRMV3. The rainfall, temperature and discharge from Japan Ministry of Land, Infrastructure, Transport and Tourism (MLIT)are used to analyze the correlationamong the climate, old environment condition and discharge.

Theresolution of Digital Elevation Model (DEM) and land use for CDRMV3 is 100 meter. The time scale of paleoflood simulation is hourly. The result of paleoflood simulation shows a very good trend with the rainfall events. The estimation result of discharge under the historical land use shows lower and the arriving time of peak discharge is slower than under the present land use. Theresults of paleo-flood simulation under the extreme rainfall events highlighted a better understanding on the climatic change, paleo-environment and its potential impact on the flood management.

RISKASSESSMENTONDEBRISFLOWDEPOSITION FANS:A CASE STUDY IN WENJIA GULLY,SICHUANPROVINCE, CHINA

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The paper explores the system approach of debris flow in piled sectors which includes three aspects: the analysis of debris flow hazard in survey region based on numerical simulation, fragility analysis of synthesizing the features of hazard bearing body, risk assessment about accumulated region of debris flow with qualitative and quantitative researches.With remote sensing and GIS (geographic information system), the research achievementis conducted forthe severe debris flow hazards in Wenjia gully on Aug. 13th. 2010.The findings are accordance with the actual distributions and survey datum; therefore, it suggests that these risk analysis methods of debris flow have great theoretical value and practical significance, which can provide useful scientific evidences for analysis methods of debris flow and management on disaster prevention and mitigation.

RESEARCH ON RAINSTORM-INDUCED FLOOD RISK ASSESSMENT IN CHINA BASED ON 1KM GRID DATA

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Based on the 1961-2008 daily precipitation data from 560 meteorological stations in China, SRTM 90melevation data and 1:1,000,000 vector data of river and lake, 1km grid data of rainstorm factor, elevation factor, elevation variation factor and river and lake factor were calculated. Then rainstorm-induced flood hazard in China was assessed with weighted sum method. 1km grid crop percentage factor, population factor and GDP factor were calculated by using 1km grid data of landuse, population and GDP. Then rainstorm-induced flood vulnerability in China was assessed with weighted sum method. Finally, rainstorm-induced flood risk in China was assessed on 1km grid with the risk assessment model of ‘Risk = Hazard×Vulnerability’.

Rainstorm-induced flood risk assessment in China based on 1km grid data can overcome the limitationof homogenized socio-economic factors in the same administrative unit which existed in previous researches on flood risk assessment and reveals spatial pattern of flood risk in more detail.

PROSPECTS OF INDIGENOUS LAND USE SYSTEMS FOR URBAN FLOOD RISKS REDUCTION IN NORTHERN NIGERIA

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In the recent years, sustained bouts of flood incidences characterize Kano city in northern Nigeria. The floods create large-scale devastation of houses, infrastructure and occasionally loss of lives. While climate change is not ruled out, the patterns of flood damage suggest more to urban land use change and abuse. Kano city is one of the most populous African drylands cities. Few decades ago, destructive flooding was not a noted and recurrent event for the over three-million people city. Now, very often aid-deliveries for the victims meet another cycle of floods.

In this paper, we investigate urban floods in the context of human induced risk through climate and land use changes. We identify the trends of climatic change as well as patterns and drivers of urban land use changes in Kano. We analyzed the meteorological records of the city for four decades for the precipitationpatterns, and analyzed older aerial photos and maps fordocumentation of relevant land use changes over time. We also map out flood hotspots from field based surveys and records.

Our findings revealed that, flood incidences correspond with increased rainstorms. Similarly, the efforts of the state and local governments through dredging of waterways and construction of more drainage ways are increasingly becoming unsatisfactory. This is attributed to the rapid disappearance and blocking of open spaces and ponds within and around the ancient city. Our study revealed that the city's modern drainage system were planned and developed independent of the traditional drainage system and urban landscape characteristics. Similarly, the concepts of *harim* and *hima* have significantly lost their significance. *Harim* is concerned with buffer zones for built up phenomenon, while *hima* are reserve spaces within and around built up areas. Observance of these principles had tremendously helped in controlling perennial urban floods in the past.

The traditional land use tools are understandable, observable and implementable by the urban folks. The loss of application of the concepts was triggered by the contemporary land laws. Climatic uncertainties are becoming more pronounced through more floods occurrence. This makes it imperative to look for ways to reintegrate the traditional land use system into solution frameworks. The paper recommends redirection of the flood waters into the city ponds and drainage system in order to turn around the risks of floods to fortunes. In addition to flood control,other benefits include urban cooling, recreational services, urban agriculture and wastewater management.

A FAST RESPONSE ANALYSIS SYSTEM OF HIGH-SPATIAL OPTICAL SATELLITE IMAGERIES AFTER NATURAL DISASTERS

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In recent years, the scale of the natural disasters unfortunately tends to enlarge and their occurrence frequency seems to increase. Thus, environmental sustainability of the globe is under serious jeopardy and the lives of the human beings are facing more fatal threats as the disasters occur. In order to conduct timely assessment in damage losses and perform disaster mitigation and reduction management effectively, a rapid disaster response system of integrating geoinformatics resources is needed after the occurrence of the disasters where remotely-sensed imagery is a key component of the geoinformatics resources.

In this paper, it is our intention, as an example, to present a satellite image analysis of the landslide following the 2008/5/12 Wenchuan earthquake and its consequences. We will demonstrate how the remote sensing techniques can be used for civilian crisis-management purpose and disaster relief. Two dimensional and three dimensional information of structural deformation of land surfaces, including the directional changes of rivers, creation of new lakes, and the water levels in rivers and lakes in the earthquake affected area, will be derived by using the high-spatial FORMOSAT-2 and SPOT-5 satellite images. Possible flooding and rupture of natural dams during post earthquake period can be identified. It is subsequently possible to make suggestions of disaster mitigation and reduction for the purposes of immediate recovery of the bereaved persons, further destruction avoidance…etc. It is clearly shown that near real-time high-spatial resolution satellite images can be an efficient and useful resource for decision-makers to prepare rescue and post-event recovery operation plans. Such satellite imagery analysis system is especially important for some isolated earthquake areas where damage distribution is often very uneven and hard to reach in time. Note that such response system has been successfully implemented to estimate the disaster losses in rice field and yield in Fukushima and Miyagi, the most severely damaged coastal prefectures of the Tohoku region, after the 2011/3/11 Tohoku Earthquake/Tsunami, in which the specific system is named as Rice field Identification and riCe yield Estimate (RICE) model.

STRATEGIES OF FLOOD HYDROGRAPH RESTORATION IN URBAN AREA

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In increasingly urbanized area, water surface ratio descends and storage capacity of water decreases rapidly associated with lakes, branches, wetlands and floodplains buried. In addition, land surface impermeability enlarges runoff coefficients and runoff velocity. Urban flood, with higher peak discharge, larger volume and shorter concentration time, brings higher risk than rural area.

Flood hydrograph restoration is to restore the flood hydrograph after urbanization by specific strategies, by compensating water surface ratio and pervious surface proportionfor peak attenuation, volume reduction and concentration time increase. This paper presentsCompensativeWater Surface Ratio (CWSR) increased by new rivers, lakes and municipal ditches, and Compensative Pervious Surface Proportion (CPSP) increased by enlarging the detention storage and enhancing rainwater utilization. Impact of each strategy or strategy profileis assessed by comparison of flood hydrograph with the one before urbanization according to unsteady flow calculation. Minimum control indexes of CWSR and CPSP are proposed to reduce effect of urbanization on flood hydrograph.

USE OF RISK ANALYSIS FRAMEWORKS IN URBAN FLOOD ASSESSMENTS

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In the period 1960 – 1990 rapid urban development took place all over Europe, and notably in Denmark urban sprawl occurred around many cities. Favorable economic conditions ensured that the urbanization continued, although at a lower rate, until recently. However, from 1990 to present a increase in extreme precipitation has been observed, corresponding to an increase of design levels of at least 30 %. Analysis of climate change model output has given clear evidence, that further increases in extreme precipitation must be expected in the future due to anthropogenic emissions of greenhouse gasses.

The design guidelines for urban sewer drainage capacity allow surcharge approximately 1 in 2 years. Studies in the 1980ies indicated that that is close to the optimum in socio-economic calculations. Recent developments in simulation software using detailed digital elevation models have confirmed these results. However, they have also highlighted a shortcoming of the design practice that jeopardized the entire design process: the floods occur the same places every time, meaning that the losses are not equally distributed. Other key players in society are now starting to react upon this knowledge, primarily insurance companies and mortgage providers, but also politicians and media are highly interested.

Presently two very different approaches are being followed in both research and practice. One is the introduction of risk analysis and risk management tools to provide professionals and politicians with better decision support tools. Some of the developments are risk frameworks that encompass economic and/or ethic evaluation of climate change adaptation options and improved risk management. This line of development is based on a societal-based evaluation of maximizing the outcome for society and accepting losses that are outweighed by benefits to society as a whole.

Another, very different approach is to apply more stakeholder driven approaches, much in the line of Integrated Water Resources Management. The key difference is that it is recognized that the costs and benefits of both existing and planned urban drainage solutions are shared between very different stakeholders and that current practices are leading to personal bankruptcy by those bearing the highest costs. Therefore solutions must be developed that are understandable and can be communicated between different stakeholders and be acceptable also to the ones who bears the costs.

Denmark has supported research in both approaches by supporting a wide strategic partnership with many stakeholders covering all aspects of urban design, planning and ulilization as well as two research projects on developing tools for risk assessments and decision support with time-varying loads and preferences. Time will show which of these approaches will be most predominantly used in the future.

The presentation will outline the two research projects and the pros and cons of each approach as well as the preliminary findings of each of them. Both are being carried out in real-life applications combining researchers, practitioners, and NGOs.

QUANTITIVE ASSESSMENT OF DEBRIS FLOW HAZARD ALONG ROAD IN WENCHUAN EARTHQUAKE AREA

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The debris flow induced by the rainstorm in August 13th,2010 caused several roads blocked. This paper take the Xiaojia gully located in S303 road line as the typical example, combined with remote image and GIS technologies, anglicized the basic environmental and geology background of the research area. The basic parameters such as area and the gradient of the gully has been acquired. Through the wild investigation and fetching the deposit sample, the character of the debris flow has been judged, the capability and the scale has been calculated by the formulawhich based on the clay content and the rain-storm and flood method. With the climatologically, hydrologicaland road reconnaissancedata, the section parameters of the road and the river can be obtained, Then a quantitative analysissystemwith the debris flow harm the road beside river has been established. The case study of Xiaojia gully’s calculation result shows that the total amount of once debris flow process is 41*104m^3 ,the barrier dam can completely buried the road sub grade and blocked the Yuzi River. It seemed that the analysis results of case study were basically coincident with the actual hazard situation, which confirmed the methodology in this study is suitable for the risk analysis of debris flow on road in alpine area.

DEALING WITH DISASTERS: DEVELOPING AN INTEGRATED REGIONAL RESILIENCE STRATEGY

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Public-private partnerships can serve as an effective mechanism to collectively strengthen community disaster preparedness and critical infrastructure resilience. This process may involve multiple intersecting elements, including Federal, State, regional, local, and private stakeholders, each with unique operating conditions within their own environment. These conditions call upon collaborative actions at various levels to jointly address a wide array of critical issues. The 2010 Dams Sector Exercise Series – Green River Valley (DSES-10) represents an example of the type of public-private efforts that could lead to enhanced resilience at a regional scale. The primary goals of DSES-10, which focused on the Green River Valley in the State of Washington, aimed at achieving a greater understanding of the potential impacts associated with significant flooding events, identifying critical infrastructure interdependencies that influence local and regional disruptions, and assisting stakeholders in improving recovery strategies and business continuity plans. This paper discusses the findings and outcomes resulting from the DSES-10 effort, which culminated in the development of a Regional Resilience Strategy. The strategy was designed to assist public and private stakeholders in the identification of integrated post-disaster recovery solutions, prioritization of actions to improve regional disaster resilience, and development of sustainable public-private partnerships to enhance planning and multi-jurisdictional coordination for a wide range of potential threats and hazards.

COMPRISON BETWEEN RUNOUT DISTANCES OF LANDSLIDE— AND TORRENT—INDUCED DEBRIS FLOW IN WENCHUAN EARTHQUAKE ZONE

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The runout distance of debris flow is one of the most important factors in hazard assessment and determination of proper parameters for mitigation structures, which has been studied deeply and widely. However, the behaviour of runout distance is distinctive for the different types of debris flows, and a single model cannot account for these distinctive runout processes. In this paper, we selected a series of debris flow events happened in the following years after Wenchuan earthquake in order to investigate runout distance of different types of debris flows. The landslide— and torrent— induced debris flows were picked out from these events. The runout distance of landslide-induced debris flow is defined as the longitudinal distance of the front from the landslide scarp while that of torrent-induced debris flow as the distance from the outlet to the lowest point of the deposition. The key factors which affect the runout process were compared for these two types of flows, and two different models for predicting runout distance have been established with closely related factors such as: return period of triggering rainfall, drainage area, slope gradient, relative altitude and effective channel length, etc. The models obtained are applicable to hazard assessment, land plan etc in the earthquake zone.

LANDSLIDES AND FLOODS: THE ROLE OF HILLSLOPE HYDROLOGY AND THE NEED FOR INTEGRATIVE ASSESSMENT

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Landslides and floods are responsible for considerable loss of lives and property in mountainous areas all over the world. Global changes influence the occurrence of landslides and floods and increase the societal costs greatly. Both hazards are often triggered by abundant precipitation or snow melt, and it is not uncommon that these hazards occur at the same moment or trigger each other. In mountainous regions, the two are linked via the hydrological processes acting on hillslopes and the river hydraulics. This results in numerous interactions between landslides and floods, but can also lead to trade-offs when protecting society against one or the other hazard.

The unsaturated soil will buffer precipitation and thus attenuates the precipitation before entering the stream system. This generally reduces the (local) stream discharge in mountainous region. However, more infiltration leads to higher (perched) groundwater systems reducing the internal strength of the soil and thus increases the potential for slope failure. Therefore, there is a trade-off that more precipitation ‘loss’ due to soil infiltration reduces the discharge peak but at the same time increases the landslide risk. Second, large river discharge coincides with important bank erosion, undercutting slopes and increasing landslide risk. As a negative domino-effect this can result in (temporarily) damming of streams, and consequently the so-called landslide lake outburst flows, local levee breach and subsequent inundations. This stream damming can also occur with landslides taking place higher upslope with a run-out reaching the stream channel. Third, the more landslides occurring with a flooding stream the higher the sediment yield within the stream resulting in bed level rise or (temporarily) water density increase.

The role of (non-)structural prevention measures for hazard and risk prevention for floods can have quite unforeseen effects on the landslide/debris flow risks and vice-versa. This presentation will focus on the need for combined hazard and risk assessment of both floods and landslides and the role of hillslope hydrology herein.

FLOODS: TRIPOD SCHEME IN FLOOD DISASTER MANAGEMENT IN JAPAN

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Japan has suffered from natural disasters but sustained economic activities on limited islands. This social resiliency takes its stand on a time-honored risk management scheme which consists of self-help, mutual-help and public-help, like a tripod. This study confirms its background from Japan's disaster fighting history. The first political documents tell that people broke ground on floodplains to develop paddy and underwent repeating water-related disasters after Nara era (the 8th century). Then people had to deal with flood and commence risk management to survive on their flood-prone area. During Edo era (the 17th-19th century), people expanded paddy on all arable field on the islands and tried to protect rice production from endless flood disasters at the same place. Then an effective flood fighting scheme was invented and popularized in all regions. Some writings explain that the essence was coalition among people, a primary community and a local government. In Japan's modernization (since 1868), traditional social rules were enshrined into laws. Up to now, the indigenous scheme for flood fighting has been translated into 3 major acts, Disaster Management Basic Act, Flood Fighting Act and River Act. However, Japan's society itself has been qualitatively transforming due to industrial restructuring, rapid urbanization, population fluidity, etc. After downpour disaster in 2009, MLIT Himeji Office has conducted a pilot program for an inundated community to innovate the local flood fighting actions. The outputs indicate importance of strategic coproduction of people, the municipality and the river managing authority. The advanced "tripod scheme" has suggestions to live with flood not only in Japan but also in the world.

PREPARING FOR DISASTER THROUGH SIMULATION MODELING

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The US Army Corps of Engineers has launched a suite of modeling applications titled “SimSuite” that provides the emergency management community of practice a valuable tool to assist in simulating realistic disaster scenarios and apply modeling methodology in a power geospatial environment to assist with tactical decision making. The program resides on powerful ARC GIS servers that enlist multiple GIS services to form as the backbone for programming Adobe FLEX viewer software to analyze data, predict impacts and assess geospatial information in one portal. The SimSuite program consists of four separate venues of focus; SimStorm (Hurricane predictive modeling), SimQuake (Earthquake predictive modeling), SimFlood (Flood scenarios) and SimTerror (IND predictive modeling for major metropolitan cities in the US).

The four categories above allow for specific data sets and modeling methodologies to be employed as they relate to the scenario. For example with SimStorm the focus is on the hurricane prone cities in the continental United States. Users may select a site location, select a storm strength, and observe the predictive impacts that accompany the storm. Of special interest are Corps of Engineers response and recovery mission predictions (temporary power, debris clearance and removal, commodities distribution, temporary housing and temporary roofing). In addition, spatial queries on structures, populations at risk, critical infrastructure damage, social impacts and economic impacts may be made. The viewer is programmed with algorithmic information to compute the outputs based upon census track data, HAZUS data, and Corps for Engineers modeling methodology as well as with research provided by various academic institutions to produce accurate information to assist the emergency management community, whether federals state or local entity, to understand the complexities of event scoping and readiness planning.

The near and long term focus of the USACE Simulation and Modeling program is to complete the SimStorm Suite of applications, which currently has 3 completed scenarios and will consist of at least 8. Add the “on the fly” functionality of allowing the user to select a storm path and intensity of their choosing and accurately create unique predictive modeling based upon the users defined path. Complete the SimQuake suite for CONUS to include New Madrid (currently complete), and San Andreas earthquake faults. Provide an automated flooding environment where scenarios may be created based upon historical data, hierologically precise modeling of specific flood prone areas and the use of the data sets already incorporated in the program to predict the effects of the various scenarios related to rain fall, snow melt, and catastrophic flooding due to storm and terrorist events. The SimTerror suite takes the extensive work already done in the area of nuclear blast modeling and brings it to simulated life using the program viewers built by the program staff.

The SimSuite was produced by the USACE Readiness Support Center under the guidance of program manager Dr. Steven Diaz. The Readiness Support Center is a HQ-USACE entity aligned under the Directorate of Contingency Operations, Karen Durham-Aguilera, SES and Chief.

Parallel Oral Sessions

Topic 3

Flood Forecasting and Early Warning Systems
- Observation, monitoring and forecasting of precipitation and discharge
- Hydro-meteorological processes
- Rainfall-runoff modeling, flood routing and inundation modeling
- Prediction in ungauged basins
- Flood warning visualization and dissemination

EVALUATION AND ESTIMATION OF PEAK FLOOD DISCHARGE IN TOROQ DAM WATERSHED USING HEC-HMS APPROACH

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Today, control and management of surface run off is one of the most important purposes in national policy of each country, and a large amount of money is spent to reach this purpose every year. In the other hand, as hydrological analysis and estimation of flood discharges is an important factor to design and evaluate the efficiency of water related projects, small error in this regard can cause considerable risks for the related investments. Therefore, specification employment of an accurate method to carry out hydrological analysis and estimation is quite important. This research was carried out to evaluate the applicability of HEC-HMS model and geographic information system data in flood flow modeling in Torogh dam watershed of containing 131.34 km^2 in area located in Mashhad, Khorasan Razavi province. First, hydrographs and the related hyetographs of 15 events were evaluated, and then a number of 6 events were selected to calibrate the model. In the next step, sensitivity analysis was carried out for three parameters including initial loose rate, Curve Number (CN), and the lag time. In sensitivity analysis of lag time (calculated by Snider method and SCS method) it was understood that the model is more sensitive to the variations of SCS lag time. Then calibration of the model was carried out to find the most appropriate values of the model parameters. In the next step, verification of the model was carried out using the data of new rainfall events. The results showed that this software has appropriate ability to estimate peak discharge with acceptable error (less than %1) comparing to observed values. The results also indicated that using SCS time lag causes in results with higher accuracy in comparison to the use of Snyder time lag. Another evaluation was optimization of initial loose for this catchment, and the optimized value obtained for this parameter was 0.22.

ENSEMBLE SHORT-TERM RAINFALL-RUNOFF PREDICTION AND ITS APPLICATION FOR URBAN FLOOD RISK MAPPING

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Short intense rainfall over small urban river basin leads to the flash-flood event. This event is distinguished from other events types by the small time and spatial scales, and thus its prediction is subject to high uncertainty. In this study, ensemble prediction is employed to account for the uncertainty in both short-term rainfall and hydrological prediction. Considering the small scale of storm event, radar echo extrapolation by translation model is used for predicting rainfall from X-band polarimetric radar. An ensemble rainfall short-term prediction is built by perturbing initial condition of the extrapolation model. The ensemble members are subsequently considered as uncertain input of the distributed hydrological model. Uncertainty of the hydrological model parameter is assessed by the GLUEmethod. The set of behavioral simulation would develop an ensemble of flood prediction. This approach allows a cascading of uncertainty from rainfall prediction uncertainty through rainfall-runoff model to the flood prediction. The methodology is demonstrated throughout case studies in Kofu urban river basin, Japan. Having demonstrated the plausible results, this approach could serve as a reliable method for estimating the uncertainty range of short-term prediction of runoff dynamics. We also demonstrate the range of probabilistic products generated by ensemble prediction and their potential for obtaining estimates of flood risk. When utilized along with flood damage model, we highlight the value of ensemble prediction for deriving flood risk information through a risk map.

RAINFALL-RUNOFF MODELLING WITH DATA DRIVEN TECHNIQUES: CONSTRAINTS AND PROPER IMPLEMENTATION

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Data driven techniques (DDTs) are widely recognized as being an important tool for decision support systems. Nonlinear time series forecasting methods are therefore extensively applied for hydrologic process emulation. Prediction improvement of DDTs has been much discussed in the literature. Data driven models are primarily based on observations, therefore, particularly sensitive to the strong autocorrelation of time series data. This constraint may deteriorate the forecasting accuracy. In this study, we address the effect of autoregressive components on forecasting accuracy of nonlinear time series forecasting methods. The performance of artificial neural networks (ANNs) and linear stochastic models in predicting runoff of a watershed is examined for different data time intervals. We found that forecasting accuracy of ANN is slightly better than that of linear stochastic models. This is attributed to the fact that both models learn the hydrologic rule for generating low runoff. This suggests that a single model is not sufficient to predict high runoff events accurately.

THE STOCHASTIC FLOW FORECAST - CREATION, INTERPRETATION AND OTHER APPLICATION

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The deterministic discharge forecast calculated by hydrological models is a common product of the Flood Forecasting Service in the Czech Republic nowadays. However, deterministic forecast does not describe the indetermination which must be taken into account not only during the creation of the flow forecast, but mainly in the interpretation of the final predicted hydrograph.

Deterministic forecast is the great simplification of the real conditions in the catchment taking into account only one possible (although the most probable) scenario of the future development of the meteorological and hydrological situation. The stochastic flow forecast based on simulation of all probable meteorological scenarios (all members of the meteorological ensemble) aims to describe the spread of the possible flow developments within the predicted period.

The paper describes the generator of the random fields of meteorological quantities – the inputs of the hydrological model. The sets of precipitation, temperature and snow fields cover the estimated uncertainty of the measured and predicted quantities. The coinciding set of discharge forecasts is then evaluated.

The case studies of floods which hit the Dyje catchment in 2002 and 2006 show the application of the proposed method. Whereas the stochastic flow forecast is not very common in operation, the attention is paid also to the correct interpretation of the stochastic flow forecast and to other use of this product. The method has been tested in operation on the Dyje catchment since 2009 within the Flood Forecasting Service ensured by the Czech Hydrometeorological Institute.

MERGING GSMAP WITH GROUND RAINGAUGE DATA AND EFFECT OF DENSITY OF RAIN-GAUGE STATIONS ON THE ACCURACY OF MERGED GSMAP-CASE STUDY OF TYPHOON MORAKOT IN TAIWAN IN 2009-

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Satellite-based rainfall data are widely available for public use, and research has been in progress to apply this type of data to a broad range of areas including flood management in ungauged basins. In particular, a near-real-time rainfall product called GSMaP_NRT (provided by JAXA, hereafter GSMaP) has drawn much attention because of its high spatial and temporal resolutions and short data latency.

However, the previous researches have found that satellite-based rainfall products in general tend to underestimate observed ground rainfall especially for heavy rainfall, which poses a problem in their use for flood forecasting and warning. Thus, a correction method for satellite data to improve the accuracy is necessary to use them for flood runoff analysis.

In some ungauged basins, a few real-time rain-gauge stations have been installed recently. In these basins, merging method for satellite-based rainfall rain-gauge data can be applied such as Inverse Distance Weighted interpolation (IDW), Co-kriging. These merging methods are expected to improve the accuracy of satellite-based rainfall with rain-gauge data. If engineers in ungauged basins can recognize the accuracy improvement of satellite-based rainfall data by merging, their motivation of increasing the number of rain-gauge stations in ungauged basins is expected to be inspired.

This paper will describe the relation between the density of rain-gauges and the accuracy of merged satellite-based rainfall data. In this paper, GSMaP provided by JAXA is used as a satellite-based rainfall data and IDW interpolation is used as a merging method and the target rainfall event is the typhoon “Morakot” in Taiwan in 2009.

As a result of the experiment in the typhoon in Taiwan, the following are the summary of this paper:
In comparison of raw GSMaP and Merged GSMaP with rain-gauge by IDW,
1. Merged GSMaP has a higher accuracy than raw GSMaP in higher density than one rain-gauge station in 5,000km2 (hereafter, 1/5,000km2).
2. In some cases of light rainfall period, merged GSMaP has a lower accuracy than raw GSMaP since the correction coefficient calculated as GSMaP / rain-gauge is overestimated in very light rainfall of GSMaP. This result shows the necessity of threshold for correction coefficient.
In comparison of Merged GSMaP and rain-gauge data interpolated by IDW,
3. Merged GSMaP does not have higher accuracy than rain-gauge data interpolated by IDW in higher density than 1/5,000km2. However, in most cases of lower-density more than 1/10,000km2, merged GSMaP has a higher accuracy. This is because the target rainfall type in this paper is typhoon whose scale is several thousand sq km. While the rainfall distribution can be represented by high density rain-gauge data in higher density cases, the distribution can not be represented by low density rain-gauge data in lower density cases. Then merged method can improve the accuracy in lower density cases since the rainfall distribution of GSMaP can represent the macro-scale rain distribution. However, since the layout of rain-gauge stations are limited (only several cases) in this paper, it is necessary to note that all cases should be experimented in the future.

APPLICATION OF MULTIPLE ADDITIVE REGRESSION TREES (MART) MODELING IN REAL-TIME RIVER STAGE FORECASTING

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Taiwan, located in the subtropical monsoon region, has steep and short rivers. Plum rains from May to June and typhoons from July to October bring excess rainfall to this island every year and often cause serious flooding. To establish an accurate rainfall-river stage forecast model is extremely important for the decision-maker to implement flood warning, flood evacuation and disaster contingency measures in Taiwan. However, rivers in Taiwan are usually short in length and steep in slope. Besides, there is estuarine circulation and fractured surface with drastic changes. All these factors coupled with the dense precipitation, flash flood is easy to form about 3 to 6 hours and cause significant casualties or damage in the downstream region which is densely populated.

In the past, researchers commonly used rainfall-runoff models and rating curve to predict the river stage. However, this method easily increases the error of river stage prediction during the conversion process. At present, most researchers use the concept of data driven to forecast river stage for the upcoming several hours. However, they are still facing problems such as variable selection, variable weighting, observed value anomalies/missing and coefficients routing that are complicated and time consuming. In order to overcome problems mentioned above, this study adopts a new data driven methodology, the Multiple Additive Regression Trees which is a robust, fast learning speed, capability of variable selection and establishes variable importance to develop a real-time river Stage forecasting model.

In this study, using the related rainfall and river stages data of the sixteen typhoon flood events in Bajhang River basin during the 2005 to 2009 years. The evaluation indicator of RMSE is used to compare the performance about MART for the 1 to 3 hours forecasting river stages. Taking the Jun-Hui Bridge, the RMSE was 0.373 m, 0.592 m, and 0.688 m respectively. As for the routing time is about 2 seconds. The results reveal that the river stage flood forecasting method MART has better efficacy and could provide more accuracy and effective data in the river basin's flood response decision-making.

THE STUDY OF UNCERTAINTY AND COST-BENEFIT ASSESSMENT METHOD FOR FLOODPLAIN MAPPING

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The floodplain mapping is a key item of the flood management. There are many theory of hydrologic and hydraulic in the floodplain mapping process. Each theory and method has different boundary conditions and parameters. Because the limitations of rationale and data accuracy. The parameters and conditions are included with the uncertainty and sensitivity. In order to understand the affect and relevance of each parameters in the mapping process. This paper will describe the floodplain mapping process sensitivities of various parameters, for example, the discharge, water level and floodplain boundary. After floodplain mapping area was confirmed. The floodplain area will have subsidy and land-use restrictions. We suggest that the floodplain mapping processes combined with cost-benefit assessment. To select the appropriate solutions in the floodplain area that use non-engineering measures to improve flood control capacity. We wish this method as a follow-up of floodplain mapping designated reference.

DEVELOPMENT OF A REAL-TIME FLOOD FORECASTING SYSTEM BY COUPLING A SNOW-ACCUMULATION AND SNOW-MELT MODEL WITH A DISTRIBUTED RUNOFF MODEL

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Since snowmelt can be a significantly contributor to winter flood in a snowy cold region, it is necessary to take account of the snow-accumulation and snow-melt contribution in runoff analysis of a real-time flood forecasting system which is established in such watershed area.

In this paper, an integrated flood forecasting model is developed by coupling a rigorous snow-accumulation and snow-melt model with a composite distributed runoff model based on a structure of unstructured triangle mesh. The procedures of snow-accumulation and snow-melt are separately simulated by a consolidation settlement model and a full energy balance formulation. Using input data including distributed rainfall derived from C-band radar, observed temperature and velocity of wind, a temporal-spatial variation of distribution of both snow depth and snowmelt rate can be continuously calculated by this model. The output of the snow-melt model, namely, snowmelt rate, is then seamlessly transmitted to the runoff model as its input data to do the subsequent runoff calculation, which composes of a saturated-unsaturated infiltration, a surface flow, a sub-surface flow, as well as a river flow using dynamic wave method. Evaluation of simulated snow depth and calculated stream flow during past storms showed a good agreement with the observations (Figure1).

From the evaluation, it is seen that the usage of the snow-accumulation and snow-melt model in flood forecast can not only enable a prediction of snowmelt flood occurs in snowmelt season, but also avoid incorrect prediction of stream flow caused by only considering precipitation, such as overestimation in snow-accumulation season, or underestimation in snowmelt season.

The integrated model has been applied to a real-time flood forecasting system which is established for the Hii River basin of Japan, by using the C-band radar predict precipitation as well as other observation data that are acquired online from the integrated river information system of Japan. This system now is operating 24 hours a day, 365 days a year,. to make 6 hours ahead forecast with an interval of 10 minutes.

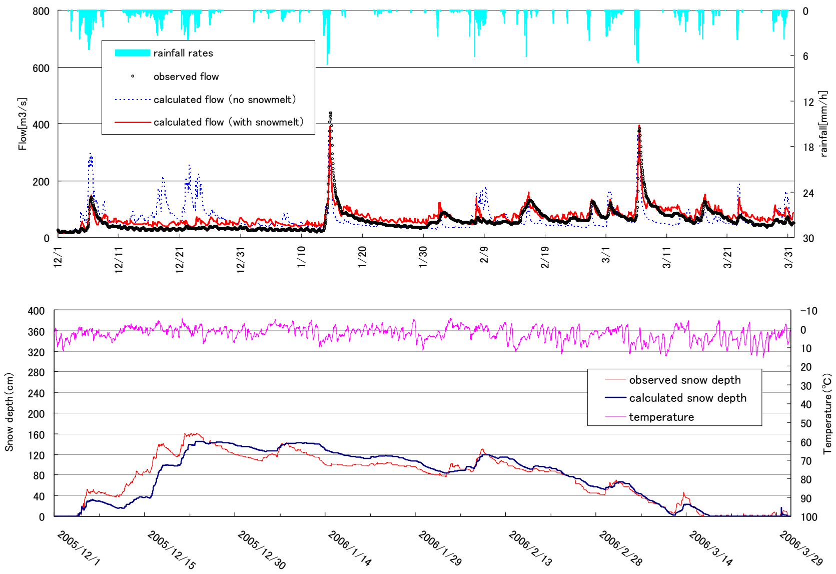

Figure1. Validation of flow and snow depth between observations and simulations

SMART LEVEES

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Whenever disastrous floods along rivers happened improved or additional dams are requested. Indeed, such dams reduce risk of flooding. More precisely, the probability of flooding is reduced but the worst case scenario of flooding – despite improved dams – becomes more and more severe. People believe in stability and reliability of flood embankments in general, so that homes, industrial production and public infrastructure are established in regions which were considered as flood regions in the past.

However, levees are weakening over lifetime. Regular inspections might not be sufficient or might be too late to detect significant changes in time. Sensor networks for continuous condition monitoring overcome this problem. Siemens started in the early nineties to analyze such sensor measurements on hydro-electrical dams by statistical means. Neural networks improved the classification performance.

Recent approaches, e.g. the early warning system (EWS) developed in the project UrbanFlood (http://www.urbanflood.eu) are making use of artificial intelligence in order to properly evaluate the information provided by sensor networks installed inside the levees. Moreover, such an EWS provides a fully integrated approach including virtual dike model, expert system for decision support, flood spreading modeling and alarming over Internet. Results are presented via different user interfaces: a multi touch table for interactive disaster analysis and interface by web browsers on standard PCs and smartphones. Reliability and robustness is secured by a redundant approach using virtual machines and load balancing over servers in Netherlands, Poland, and Russia. Experiments of dam and dike breaches by the IJKdijk consortium (http://www.ijkdijk,eu) provided the necessary information to calibrate the dike breach models in the EWS. Sensors in three dikes in the Netherlands are connected to this EWS. Two more dikes in United Kingdom and in St. Petersburg / Russia will follow within a few months.

In this paper, key findings of integrated early warning systems based on sensor networks will be presented. For instance, reliability of sensor information and early warning system has to be monitored as well. False alarms are not tolerated. Possible integration into other warning systems and combination with additional information (weather, traffic) will be discussed.

In the conclusion, a comparison of different approaches for integrated early warning systems will be carried out. Advantages and drawbacks will be discussed not only on a technical level, but also regarding the perspectives for stakeholders such as operators of levees, municipalities and cities, local government, industries and general public.

EFFECTS OF RIVER MORPHOLOGY ON PROPAGATION CHARACTERISTICS OF FLOOD FLOWS THROUGH RIVER VALLEY IN THE GO RIVER

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Frequency and intensity of floods are predicted to increase due to the global warming. In recent year, excessive growth of vegetation, distinct gut formation and riverbed degradation are decreasing discharge capacity and safety of river in Japan. In response, considering proper river improvement and management are required for increasing the discharge capacity and safety. For above requirements, it is important to grasp effects of planar form, longitudinal form and cross sectional form (river morphology) of present river channels on it.

Flood propagation through rectangular channels has been studied by many researchers and its properties have been revealed. On the other hand, it was reported that flood propagation speed in natural rivers is smaller than that in rectangular channels due to storage effects of river channels. But, there are few studies on the storage effects on flood propagation with relation to river morphology.

Objectives of our study are to understand the storage effects on flood propagation with relation to river morphology and to propose its evaluation method. First, we discuss propagation and transformation characteristics of water level hydrographs and discharge hydrographs by one dimensional equations for flood flow. And, relationships between storage volume of flood and propagation and transformation of discharge hydrographs are explained. From above discussion, we define “retarding storage volume of flood” which is the storage volume of flood when velocities are decreasing during rising period of water levels.

The Go River has a river valley at downstream of the Miyoshi Basin which continues until near river mouth. And, observed data were obtained in the river valley at large floods in 1997 and 1999. By using unsteady two dimensional flow analysis, we estimate water level hydrographs and discharge hydrographs at the both large floods in the section between Kawamoto observation station (36.3km) and Kawahira observation station (9.2km) in the river valley. From this analysis, propagation and transformation characteristics of water level hydrographs and discharge hydrographs are explained with relation to river morphology, storage volume and retarding storage volume of flood in this section. The primary conclusions in this paper are indicated below.

・Water level hydrographs are easily affected by river morphology than discharge hydrographs. And propagation speed of water level hydrographs is smaller than that of discharge hydrographs at the large floods in river valley of the Go River.

・The higher the ratio of the retarding storage volume (R_s) to the storage volume (S), propagation speed of discharge hydrographs (C_Q) becomes smaller compared to the speed of moving water in channel (U_{ave}). In the section in the river valley where cross sectional form is simple and almost uniform, R_s/S is less than 0.5 during the floods and values of C_Q/U_{ave} approaches the value indicated by kinematic wave theory for simple cross-section (1.33～1.67). On the other hand, in the section just upstream from contraction, R_S/S reaches almost 1.00 and C_Q/U_{ave} falls below 1.00.

Finally, we discuss application of the results of our study for river management.

REAL-TIME MONITORING OF DIKES AND LEVEES: A COST-BENEFIT APPROACH

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Recently, much work has been done in the Netherlands on developing sensor and satellite based systems for monitoring of dikes and levees. The full scale tests in the IJkdijk facilities in 2008 and 2010 on several failure modes have led to a suite of monitoring solutions based on different technology. The last two years saw many small pilot projects, where these monitoring systems have been used for operational monitoring of dikes. However, large scale adoption of this technology has not yet happened. In order to facilitate this, research was done on the interpretation of the various monitoring signals in terms of dike safety indications.

In parallel, a practical cost-benefit analysis tool was developed with which flood risk managers can objectively evaluate the financial rationale for investing in a monitoring and warning system compared to investing in structurally improving the dike or taking other measures to prevent flood casualties and damage. In this paper, the latest developments related to dike monitoring will be summarized. Additionally, the background of the cost-benefit analysis will be discussed and its usefulness will be evaluated in several case studies in the Netherlands.

MULTI-FREQUENCY ADCP SURVEYS OF FLOODS IN ASIA

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Each summer large regions of Asia experience catastrophic floods. National hydrological agencies conduct in-situ river surveys to search for subtle trends in discharge that represent increases or decreases in magnitude. Such information is important to decide whether to divert flood water to agricultural fields or to store in dams & reservoirs. These surveys were previously challenging as flood waters also covered the shallow and vegetative floodplains. To make comprehensive surveys the hydrologists either operated several ADCP units of various frequencies or manually switched operating modes so as to capture flows in both the main channel and the floodplain. These extra procedures created discontinuous surveys and increased measurement times significantly. To improve data quality, a multi-frequency ADCP was recently introduced which enables continuous surveys to be conducted from 0.3m to over 40m without needing to stop a survey boat. In this paper, flood surveys from the Red River (Vietnam) and the Yangtze River (China) will be described, illustrating this new capability for rapid and comprehensive surveys of flooded rivers in the Asian region.

PROPOSAL OF WATER DISCHARGE MEASUREMENT WITH ADCP IN MOUNTAINOUS AREA AND ACCURACY EVALUATION METHODS

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In 1981, Acoustic Doppler Current Profiler (ADCP) developed, and it has been applied by many river engineers for water discharge measurement. From the beginning of 2000s, United States Geological Survey (USGS) have reported criteria for Quality Assurance (QA) as well as guidelines associated with ADCP measurements. However, they are not easy to apply to the flood flow, such as Japanese rivers, whose characteristics are highly unsteady condition, loose boundary condition, wide distribution of bedload velocity, and etc. Furthermost is water surface conditions with drastic vibration. Therefore, we have studied the methodology for appropriate measurement with implementing three peripheral devices such as nonoscillative tethered ADCP platform, external compass and RTK-GPS with VTG information in severe flood condition.

The authors also have promoted the standardization of ADCP-associated techniques in measurement, data processing, and quality assurance (QA) for Japanese rivers. The main reason for such promotion, particularly for developing QA for Japanese field engineers, is due to a highly unsteady flood flow in Japanese rivers, where flood waves pass through a section within a shorter period of time compared with floods in continental rivers. Considering this flow characteristic, QA should be maintained based on results not from multiple traverse measurements but from a single measurement. Ideally, the grid size, which is usually determined by the boat speed and the period of a single ensemble, should be consistent during a traverse measurement to maintain the same level of QA despite many disturbances in a river channel, such as flow behind bridge piers, vegetation and strong shear, which prevent the boat from traveling with a consistent speed. Therefore, in this paper, we propose an accuracy evaluation method as described in the following paragraph.

Under fixed measurement, random errors observed at a single ping can be estimated by calculating the standard deviation of error velocity, since the random errors depend on measurement conditions including measurement mode, depth cell size, and the number of pings. To apply such random errors to traverse measurement, the authors propose to compile a set of indexes (e.g., the functions of velocity, the standard deviation of velocity errors in a single ensemble, the distance of each ensemble) to create modified random errors as “Deviation Velocity”. Then, “Deviation Discharge” can be obtained by integrating the Deviation Velocity in a cross-section. To evaluate the accuracy of flood discharge measurement as a final judgment of QA, “Deviation Discharge Ratio” is calculated as the ratio of Deviation Discharge to measured discharge value.

To finalize the development of the accuracy-evaluation methods, the authors conducted field measurements under severe conditions with highly sophisticated devices and verified the methods with high-quality datasets. They were also applied to flood observation results obtained in the Shimanto River.

TRANSBOUNDARY COOPERATION IN FLOOD FORECASTING AND WARNING SERVICES WITHIN THE INTERNATIONAL MORAVA RIVER BASIN

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The **Morava River basin** lies on the territories of three countries: the Czech Republic (CZ), Austria (AT) and Slovak Republic (SK) (since 1.1.1993). The major part of this catchment belongs to the Czech Republic. The river Morava is a left-hand tributary of the Danube river entering it at the border cross-section between Austria and the Slovak Republic. The Morava river forms the border between both countries from the point of confluence with the river Dyje (Thaya).

The forecasting system HYDROG has been set up for the whole Morava river basin, containing 25 forecasting profiles. The lead times of the forecasts are 24 and 48 hours. It includes also reservoir operation routines for optimization of possible future operations. The model is running every day. There is a close cooperation with Austria in place; in the regional Brno office of the Czech Hydrometerological Institute a discharge forecast is produced daily for the Austrian gauge stations at Raabs and Schwarzenau in the Dyje river basin. In return, Austria provides extended meteorological data for Austrian part of the Dyje/Thaya river basin.

Within the framework of the European Territorial Co-operation 2007 – 2013 (AT, CZ), a project **Flood forecasting in the Confluence Area of the Rivers Morava and Dyje** was adopted. As a result of this project the extended upgrade of the forecasting model HYDROG for the Morava river basin was prepared and since the February 2010 in the test operation the forecasts for the profile Hohenau (AT), Moravský Sv. Ján (SK) on the river Morava have been daily disseminated. Work on this project will continue also in the year 2011.

ROLES OF NATURAL LEVEES IN THE ARA RIVER ALLUVIAL FAN ON FLOOD MANAGEMENT

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There are many alluvial fans in Japan and people who lived there had suffered from flood damages time and time. Natural levees are a kind of micro-topography produced by the inundation of flood flow. Natural levees are formed on flood plains in ordinary circumstances, but many natural levees are seen on the Ara river alluvial fan, because of its gentle inclination and large amount of sediment movement. The Ara river alluvial fan's natural levees are surrounded by back marsh and they are over 0.5m taller than the surrounding ground level. It is required to understand the effects of natural levees on flood flow behavior in the alluvial fan. But there are few studies about the roles of natural levees from the point of view of flood control and management.

The objective of this study is to clarify the roles of natural levees on the Ara river alluvial fan for the flood control by using a topographical classification map, the positions of remains of communities since the Paleolithic-period until the Heian-period, the Jinsokuzu(a map made in the early Meiji-period) and a hazard map.

We plotted positions of the remains of communities on the topographical classification map, and we clarified that many remains of communities on the Ara river alluvial fan had been developed on the natural levees. And most of the shrines and temples had also located on them. It is thought that people at that time had known empirically that the natural levees were safe from flood attacks.

Next, we used the classification map of Japan. Almost all of roads and railways traced on the map are found on the natural levees. Many communities are also located on the natural levees. People have used natural levees not only for the housing, but also for farms and mulberry plantations. Roads and railways are running so as to connect natural levees.

From the Ara river hazard map, flood depths on the natural levees are small on the natural levees compared with surrounding low land areas. Flood inundation area is restricted by the banks of roads and railways on the natural levees.

We clarified in the present paper that the natural levees had roles for development of communities, and decrease flood damages. Natural levees with roads and railways may make possible to become economical and flexible flood control measures.

FLOOD HYDROMETEOROLOGY OF THE TAPI RIVER (INDIA)

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Abstract

The main objective of the analysis of the hydrometeorological data in this paper is to broadly identify the major meteorological conditions associated with large floods in the Tapi Basin. The predominant cause of floods and large floods on the Tapi River and its major tributaries is low pressure systems (LPS). These systems either originate over the Bay of Bengal or the adjoining coastal belt, and move in a west or northwest direction, either parallel to the basin axis or through the upper reaches of the Tapi Basin. However, not all such LPS produce large floods. Large floods are not produced unless the following conditions occur: 1) 1-day to 3-day heavy rainspells that produce high rainfall totals and are widespread in nature and contribute sometimes up to 25% of the basin's average rainfall. 2) Heavy rainfall extends westwards up to Surat. This situation usually occurs when the LPS move parallel to the basin axis through the Narmada Basin. 3) The contribution to the floods is from the source as well as the lower parts of the basin. 4) A high rainfall-producing LPS is preceded closely by another LPS, which provides favorable antecedent precipitation conditions. The chances of large floods are generally higher during above-average rainfall years and during long duration above-average rainfall periods. These situations, therefore, suggest that the meteorological conditions associated with infrequent, large-magnitude floods on the Tapi River are very complex.

FLOOD FORECASTING AND RIVER FLOW MODELING IN MOUNTAINOUS BASIN WITH SIGNIFICANT CONTRIBUTION OF SNOWMELT RUNOFF

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One of the main challenges of flood management in mountainous areas is snowmelt runoff analysis with lack of snow observation data. In particular, it is very important to have an accurate inflow estimation to dam reservoirs located in mountainous basins with significant snowmelt runoff. The estimation of Snow Water Equivalent (SWE) provides a key basis for runoff modeling and estimation of river flow.

In the recent years, the availability of satellite-based data and the development of Distributed Hydrological Models (DHM) have made it possible to improve simulation of snowmelt runoff. This study tested if lack of conventional ground-based snow observation (e.g. snow depth and density) can be overcome by using Temperature-index snow models coupled with rainfall-runoff models. Satellite-based data has been used for deriving land cover/use, soil data, Digital Elevation Model (DEM) and Snow Covered Area (SCA).

For this purpose, three hydrological models (HSPF, SWAT and WinSRM) were applied to a mountainous river basin of Iran. The Talar river basin is one of the major river basins in Mazandaran Province located in the northern part of Iran close to Caspian Sea. The basin area is 2100 km^2 and its dominant land cover is forest land.

HSPF model is physically-based, semi-distributed hydrological model to simulate basin-wide hydrological process. SWAT is also a physically-based, semi-distributed hydrological model that has been developed to simulate effects of land use management practices on rainfall-runoff generation including snow melt runoff contribution. WinSRM has been developed specifically for snow melt runoff analysis by using-degree-day method. The NOAA Advanced Very High Resolution Radiometer (NOAA-AVHRR) channel 3 satellite images in UTM projection system with resolution 1.1 x 1.1 km has been used for SCA.

All three models could reasonably simulate Talar river basin runoff considering the amount as well as inter-annual variation of SWE. It was found that simulated runoff correlated well with the observed natural discharge at Shirgah hydrometric Station. The high correlation suggests that a reliable SWE estimation and snow melt runoff simulating can be constructed using DHM and satellite-based SCA. However, it was observed that the uncertainty of using DHM to estimate SWE (using HSPF and SWAT models) is higher than degree-day snow model (WinSRM). WinSRM showed a better performance in monthly river flow simulation in comparison with two other models. Using estimated SWE it is possible make reliable simulating of runoff generation in the mountainous basins with lack of snow observation for a better dam operation and flood mangamnet.

REAL TIME RAINFALL FIELD INTERPOLATION USING GEOSTATISTICAL TECHNIQUES FOR FLOOD EARLY WARNING PURPOSES

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Flood early warning systems can help reduce human and economic losses of flooding. Developing cities represent a challenge for flood early warning, taking into account the persistent lack of data, limited resources and often complex climatic, hydrologic and hydraulic conditions. In this environment, radars are not common and rain gauges networks constitute the basic source of data for the inference of rainfall fields.

Rainfall constitutes the main input for flood forecasting, with its spatial distribution being of high importance for accurate prediction of flood events in these cities in space and time. This poses challenges in defining a robust interpolation procedure that meets the requirements of real time operation. The main focus of this study is the identification of geostatistical interpolation methods for flood forecasting purposes under complex topographic and meteorological conditions using daily precipitation data from rain gauges. The city of Bogotá (Colombia) was chosen as the study area and the geostatistical methods chosen for the analysis include ordinary Kriging (OK) and Kriging with external drift (KED)..

Interpolation of rainfall fields applying OK and KED was carried out for daily datasets previously classified according to extent and location of maximum precipitation recorded. The relationship between secondary variables and precipitation was analysed in order to establish the added value of including these in the interpolation procedure, as well as the influence of smoothing windows in the treatment of the secondary variables. The skill of the interpolators was assessed through cross validation, which allowed the identification of an optimum smoothing window for KED, which in the case study ranged from 2.5 Km to 15 Km depending on the class under consideration.

In order to automate the interpolation that would allow its use in an operational forecasting procedure, climatological variograms and average residual variograms were developed and a comparison using cross validation was carried out, identifying the most suitable procedure for interpolation in real time. The analysis allowed the definition of limitations for the use of KED through the comparison of adjusted R for the correlation between secondary variables and precipitation with the percentage of variability explained of OK, as well as the identification of a simplified and robust interpolation procedure for real time operation that was verified through the analysis of simulated rainfall fields. The results show that OK using a climatological variogram and KED with an average residual variogram can be used successfully for interpolation in real time operation in the study area.

Impact of climate and land use changes on the flood hazard of the middle Brahmaputra reach, India

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Being the highest specific discharge river of the world, the Brahmaputra has a large floodplain area of 700 km long in its middle reach falling under high flood vulnerability category. The floods generated in the upland Himalayan catchments are mainly controlled by the land use and land cover, storm characteristics and vegetation dynamics. The floods propagate through the floodplain region consisting of wetlands, paddy agriculture, braided river reach with natural constraint points (nodals) to make the reach more vulnerable for flood hazard. In this study, a macroscale distributed hydrological model has been used to obtain the flood characteristics of the reach. The model considers the hydrological processes in wetland, paddy agriculture, vegetated hillslopes and grasslands which are the major land use land cover classes in the basin and primarily control the generation of rainfall-induced floods.

The hydrological model with spatially distributed input parameters and meteorological data was simulated at (1 km x 1 km) spatial grids to estimate the flood hydrographs at the main river and its major tributaries. The model was calibrated and validated for 9 wet years having the highest flood lifts. After validation the "*best guess*" land use change scenarios were used to estimate the potential changes in flood characteristics. The results show that at the middle reach of Brahmaputra the peak discharge would increase by a maximum of about 9% for the land use change scenarios. It was also found that the paddy agricultural fields of the valley would significantly alter the flood characteristics at the reach.

The same model with bias corrected climatological data from a regional climate model (RCM) simulation (PRECIS) has been used to obtain the future changes of the flood generation and its propagation through the basin under the projected climatological scenario. The hydrological time series obtained through this simulation was analyzed to obtain the changes in the flood characteristics like flood duration, time to peak, maximum lift and number of waves in a season. The changes in the flood characteristics with reference to the baseline period show that the average duration of the flood waves would increase from 15.2 days in the present period(1960-1990) to 19.3 days in future(2070-2100). However the number of flood waves per season is expected to decrease from 3-4 waves per season to 2-4 waves per season. Peak discharge would increase by an average of 21% in future under the projected climate change scenario.

After obtaining the hydrological time series and the statistics of the changes of flood characteristics under the projected climate change scenario (2070-2100), a 2-D hydrodynamic model has been used to obtain the flood inundation and velocity distribution in the floodplain. The model has been simulated with discharges of different return periods. The distributions of velocity and inundation depth have been spatially analyzed to obtain the flood hazard zones under the projected climate change. The results show that the spatial variation of flood hazard zones would significantly alter under the projected climate change scenario as compared to that change due to probable land use/land cover changes.

FLOOD FORECASTING MODULE OF THE DISTRIBUTED HYDROLOGICAL MODEL EASYDHM

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A flood forecasting module of the independently-developed distributed hydrological model EasyDHM, is developed mainly aiming for supporting the flood operational management specially.

In general, EasyDHM model has the following characteristics: a) In the horizontal scale, the structure of EasyDHM is made up of sub-basins and internal units; b) it adopts the method of modularized programming, which ensures the readability of its codes and achieves the expansibility of its functions; c) it offers a choice from multiple computational algorithms of runoff-generation and flow conflux; d) it supports global parameter sensitivity analysis and parameter automatic calibration; e) it proposes the concepts of parameter partition and computational partition. There are four runoff-generation algorithms for chosen: EasyDHM, WetSpa, Xinanjiang and Hymod. Amongst, EasyDHM is a runoff-generation algorithms developed by our research group independently.

In the flood forecasting module, the accuracy of hydrological simulation is the most important task. In order to increase the accuracy, some new techniques, like adaptive interpolation of real-time weather information data, auto-calibration of parameters, real-time flood correction and multi-model combination techniques, are introduced to this module.

Computing zone and parameter zone were designed to conquer the low computation efficiency and the difficulty of distributed hydrological model parameter auto-calibration. And several parameter sensitivity and auto-calibration algorithms include SCE-UA, LH-OAT, MOPSO were integrated into EasyDHM model to make parameter auto-calibration of distributed hydrological model easier and more efficient.

In the flood forecasting module, AR series method is chosen for the real-time correction of the simulated flood (Ding, 2010). In this method, the error sequence between the simulated and the observed discharge quantity is seen as an AR time series. By using the historical error sequence, the coefficients of AR series can be attainted, thus, the newly error could be calculated.

As no single model can perfectly simulate the real system, the simulated discharge generally differ in various respects from the observed ones, the errors between them are compensated for through the use of implicit or explicit error updating procedures. Multi-model combination techniques of adaptive simple average/weighted average method are therefore introduced in the flood module of the EasyDHM model.

The flood forecasting module is then applied to Tao River basin of Nen River in Northeast China for validation. It is revealed that the accuracy of simulation results from flood forecasting module is obviously higher than that from regular simulation in EasyDHM, and this independent flood module is of great importance for flood forecast and management projects.

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NUMERICAL PREDICTION OF FLOOD RAINFALL IN PAKISTAN

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Several unprecedented flood disasters occurred in recent years, such as in Pakistan, Australia, and Indonesia. Damages of human lives, buildings, and farms were more than we've ever experienced. Those floods were caused by record breaking rainfall events that we could hardly imagine. It is vital to know rainfall amount in the river basin for flood warning, flood manages, and flood control. However, in developing countries, raingauge network is sparse compared to the vast river basin. It is hard to capture rainfall distribution from ground observation required for flood prediction. Currently satellite observation is only the method to provide rainfall distribution. GSMaP (Global Satellite Mapping of Precipitation) operated by JAXA provides rainfall distribution in best spatial and temporal resolution, 0.1 x 0.1 degree and hourly, using seven polar orbital microwave radiometer satellites. However, currently the best product of rainfall by GSMaP has limitations. The satellites passed once in a few hours over certain location, data processing takes four hours after observations, and the measured rainfall amounts have considerable underestimate.

Numerical weather predictions (NWP) could be another choice of providing rainfall data, since NWP has been improved in accuracy of rainfall forecast in developing countries. To examine its validity for flood management, we conducted rainfall forecast experiment using regional weather prediction model, WRF (Weather Research and Forecasting). Then, we applied the predicted rainfall data into a rainfall runoff inundation (RRI) model developed by Sayama et al. (2010). The target was a flash food in Kabul river basin (92,605 square kilometer) in Pakistan during July to August 2010. Global forecast data provided by NCEP (National Center for Environmental Prediction, USA) were used as initial and boundary conditions. The model reasonably predicted rainfall accumulation around Peshawar 28-29 July 2010. However, the rainfall distribution center was shifted a little southward compared to GSMaP rainfall. As a result, maximum rainrate within Kabul river basin was smaller than corrected GSMaP rainfall. Using the predicted rainfall data, the RRI model reproduced similar inundation extension in Peshawar Valley as obtained from a calculation based on corrected GSMaP rainfall. But, it didn't reproduce inundation extension in upstream valley area as that based on corrected GSMaP rainfall did. It reproduced runoff about half of that based on corrected GSMaP rainfall at Peshawar in the end of the Basin.

The combination of the numerical prediction model and RRI model rather underestimated inundation area and runoff. However, it predicted main inundation extension in Peshawar Valley correctly in correct time. It could have a great possibility in flood warning and management.

COUPLING OF WEATHER FORECASTING MODEL WRF AND DISTRIBUTED HYDROLOGICAL MODEL WEP AND APPLICATION IN THE WEI RIVER BASIN

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Frequent disasters of floods and droughts have brought huge losses to people's lives and property, and big impacts on socioeconomic development in China. Hydrological forecasting plays an important role in basin-scale flood management system which includes both engineering and non-engineering measures. However, the effective period of flood forecasting is restricted by basin average time of runoff convergence due to the limitation of traditional hydrological forecasting methods which take the falling-to-ground time of precipitation as a starting point. As a result, it’s necessary to research on the coupling of meteorological and hydrological models so as to further extend the effective period of flow forecasting and improve the forecasting accuracy by comprehensive simulation of the whole water cycle process.

In this paper we studied on the coupling of numerical weather forecasting model WRF (Weather Research and Forecasting) and distributed hydrological model WEP (Water and Energy transfer Processes), and a comprehensive application of modern technology on quantitative predictions of precipitation and discharge, which may extend the effective forecasting period of flood and improve the accuracy of hydrological forecasting to provide reliable basis for decision-makings in basin-scale flood management.

We established an integrated hydro-meteorological simulation platform by unilateral coupling of numerical weather forecasting model WRF, scale-transferring model CAM (Coupling Assistant Model) and distributed hydrological model WEP. We first successfully achieved the localization of WRF in the basin of Wei River (the biggest tributary of the Yellow River with a catchment area of 135000 km^2) based on the optimization of nesting district and physics program. To consider the scale matching between WRF and WEP and reflect the topography effect, 3-level nesting gridding was adopted for the computation domain of WRF with the gridding sizes of outer, middle and inner levels as 45km, 15km and 5km respectively, and the interactions considered among the 3-level computations. After that, we established and validated the distributed hydrological model WEP in the Wei River Basin. Finally, we successfully accomplished the coupling of WRF and WEP and its application in the Wei River Basin. The coupled simulation results of precipitation and runoff between Sep. 23rd and Oct. 31st in 2000 in the Wei River Basin showed satisfying accuracy and future potentiality. The forecasted precipitation was evaluated using Threat Score (TS) and Bias Score (BS) methods, and the daily discharge was evaluated using hydrographs comparison and the Nash-Sutcliffe efficiency.

In a summary, in addition to studying in-depth on the theory and method of hydro-meteorological coupling, we successfully carried out quantitative precipitation prediction and hydrological forecasting in the Wei River Basin based on coupling of numerical weather forecasting model WRF and distributed hydrological model WEP, which achieved valuable results both in the theoretical exploration and modeling practices.

AUTOMATIC WATER DISCHARGE MEASUREMENT FOR MOUNTAINOUS AREAS

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Water discharge measurements in river, as well as storage of the values, are very fundamental in terms of designing the river-infrastructure, such as levee, dam, and etc. For conducting the measurement, the current meter with a depth sounder has been employed in many countries, especially in continental rivers. In the case of Japan, float-type measurements, which established in 1940s, have employed since then, because of character of Japanese rivers which is high unsteadiness, loose boundary, and, above all, rough water surface.

Recently, many devices have developed with different principles, such as acoustic, video images, erector-magnetic, and etc. Those are classified as fixed/non-fixed type measurements. Firstly, representative of the non-fixed type measurements is acoustic Doppler devices with a profiling technique loaded on boats, which are the only tool capable of water discharge measurement without any hydraulic assumption, though the method requires human labors. Secondly, the fixed type measurements, which are usually automatic measurement without human labors, can be listed as non-contact current meter with erector-magnetic, Particle Image Velocimetry (PIV) with video images, Horizontal-Acoustic Doppler Current Profiler (H-ADCP), and etc. They could measure water-velocity at points wherever assigned by each device. Using the fixed type water velocity measurements, the water discharge values require additional information such as water depth during flooding, as well as a correction coefficient which is an estimator of averaged water velocity. Certainly those two parameters are necessary to be fixed type measurement for completion of an automatic water discharge measurement system, as explained in the following paragraphs.

The river-bed elevation during flooding, for obtaining water depth, is mostly un-prevailed, though few reports show monitored data of river-bed elevation changes during flooding. So far, four methods have been shown, such as 1) Echo sounder or ADCP mounted on the boat with traversal measurement, 2) Echo sounder fixed on H-type steel in the middle of river channel, 3) Samenkei: riverbed detecting devices with light-emmiters/receivers, and 4) Ring methods. Most of reports except first method show the river-bed elevation changes at the exact points of measurement, though not much discussion about changing of cross sectional area has been done. Only second and third methods have possibility to contribute to the automatic measurement system. In addition, to take into account the correction coefficient, the authors employed water gauges to estimate the water slope.

Authors have conducted water-discharge measurement in the mountainous area with several devices, such as 1) non-contact current meter with erector magnetic type for measuring water velocity at water surface, 2) few water gauges for measuring water surface slope, 3) the echo sounder fixed on H-type steel for monitoring the river-bed elevation change, and 4) ADCP traverse measurement mounted on a tethered boat for verification purposes. Though flow condition during flooding was not easy to conduct the ADCP measurement, measurements were successfully done. As a matter of fact, river-bed elevation changed in the magnitude of 1m. In this paper, authors explained about phenomena observed by devices, as well as how the bed-elevation change affects to water discharge values.

DECISSION SUPPORT SYSTEM FOR FLOOD FORECASTING IN THE EBRO AND GUADALQUIVIR RIVER BASINS

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The Decision Support System for flood forecasting basin of the Ebro river and Guadalquivir river basins, includes all the scope of its corresponding river watersheds (Ebro: 85.000 km^2 ; Guadalquivir: 58.000 km^2).

It is made up of a set of models - hydrologic and hydraulic – and computer tools that allow users to simulate, in real time, the evolution and behaviour of the water all along the basin. The aim is to feed the system with meteorological and hydrologic inputs obtained automatically by a complex network of sensors (including meteorological radar) distributed trough the river basin that will provide information, at least, every fifteen minutes, as well as with any meteorological forecasts, including ensemble prediction systems (EPS).

The DSS, has been conceived as an open system which will be able to elaborate forecasts independently of the hydrologic and hydraulic models used. This will allow the users to adjust the system to the accuracy they need at a given moment and compare the output of the system with those of the different modelling programs used.

The system will use different hydrologic and hydraulic models. From simplified kinematic wave models to bidimensional unsteady models with full Saint Venant equations, including classical one-dimensional models.

Considering the characteristics of the River basin of Ebro and Guadalquivir, the DSS also incorporates the operation of existing regulation dams, whose routing capacity has a great importance when mitigating the magnitude of flood peak and volume which would take place in the river basin in their absence.

APPLICATION OF STATISTICAL DOWNSCALING METHOD IN ASIAN COUNTRIES FOR DAILY PRECIPITATION AND TEMPERATURE VARIABLES

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General circulation models (GCMs) provide plausible simulations of weather variables at global scales, but cannot generate local climate details at a basin scale for studies of the impact of climate change on water resources. Downscaling of the global climate model output is therefore necessary for local scale hydrological impact studies. In this study, the Statistical Downscaling Model (SDSM) was used for downscaling precipitation and air temperature (T) in both the present and future climate scenarios (IPCC scenarios A2). It was applied to four river basins in Asian countries (Thailand, Sri Lanka, Vietnam, and Philippines) by projecting the local scale daily temperature and precipitation. The large scale atmospheric variables including National Centre for Environmental Prediction (NCEP) reanalysis datasets (1961-2000) and a general circulation model (HadCM3 GCM) outputs (1961-2099) with a coarse spatial resolution of 2.5º latitude by 3.75º longitude were used in this application. The performance of the downscaling method is compared for both calibration period and validation period. The downscaling models' performance show that SDSM is efficient for downscaling average daily air T and the extreme maximum air T with high R^2 index. However, SDSM did not produce good results for downscaling the daily precipitation. The extreme maximum, minimum and seasonal precipitation and air temperature were then analyzed for both current and future climate scenarios. The simulated yearly average air T (1961-2000) by using HadCM3 datasets also reproduced well the observed ones in the local station. Average and maximum air T in future scenarios (2070-2099) predicted by the SDSM are generally found to be larger than those observed values (1961-1990). This study shows the applicability of SDSM downscaling techniques in evaluating the reliability of the downscaled GCM data for climate scenarios development.

LARGE SCALE RAINFALL-RUNOFF-INUNDATION ANALYSIS IN THE INDUS RIVER BASIN

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Pakistan suffered from a devastating flood disaster that killed more than 1,700 people and affected 18 million people between the end of July and August 2010. The flooding struck first the northwest part of Pakistan, where torrential downpour caused severe flash flood damages. As the flood water travelled southward, large-scale riverine floods caused severe damages of houses, crops and livestock along the Indus River. To recover from this devastating flood disaster and to reduce flood risk for the future, Integrated Flood Management (IFM) must be practiced based on the structural understandings of flood hazards and their links to flood damages.

This study particularly focuses on characterizing the distributions of flood hazard and damages caused by the Pakistan Flood 2010. Our approach here is to simulate rainfall-runoff and inundation simultaneously over the large areas to characterize flood hazards in this region. Then actual flood damage information was overlaid over the simulated flood hazards to discuss the relationship between them. First the model was applied to the Kabul River Basin (~92,605 km^2), a tributary of the Indus River Basin. The results demonstrated the high performance of the model to identify potential flash flood affected areas as well as large scale flood inundation areas. The simulation result was then compared to the housing damage distribution maps produced OCHA.

The developed Rainfall-Runoff-Inundation (RRI) model was then applied to the entire Indus River Basin (~930,000 km^2). The model successfully simulated the flooding area including the one about 100 km apart from the main Indus River. The proposed approach can be useful for understanding flood hazard and damage characteristics, which are essential for IFM.

ARCHITECTURE OF REAL-TIME FLOOD FLOW FORECASTING SYSTEM CONTRIBUTION TO EVACUATION ACTIVITY AND FLOOD FIGHTING

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Real-time flood flow forecasting system is developed due to supporting evacuation , flood fighting, flood prevent activities during flood event. In this paper, issues of architecture and structure of Real-time flood flow forecasting system is described. This system gives much effective information in inundation area for residents. We architected user-interfaces for residents and municipal officers, which is integrated with WEB GIS. Flood flow in inundation area is automatically computed in this system.

Many flood forecasting system have been developed, which compute water surface level and discharge at check point in basin managed MLIT and Local Gov. Recently flood forecasting system change from manual operation to automatic computation, because developed unified river information system give much observation and prediction datum to flood forecasting system. In particular, prediction precipitation datum which is given to system is a mesh size of 1km X 1km and every 10min. Real-time flood flow forecasting system is in operation by connecting with unified river information system

Real-time flood flow forecasting system make a possible to develop on background above mentioned. This system is to contribute to early evacuation preparation, warning and caution for municipals, and assist the activity and timing of flood fighting. Moreover not only resident can require the important information to evacuate to refuge , but also public officers can plan to strategy of restoration for disaster damage of embankment and structure broken by flood.

This paper is consisted three parts of the following.

1) Application of flood flow analysis model

Flooding flow from breach point is calculated by two dimension depth-integrated governing equation in inundation area which is dispersed with unstructured mesh.

2) Architecture of system

Requirement method from unified river information system

Design master table and relation in Data Base

Time schedule of computation

Dealing method of deficiency in observation datum

3) Development of system

Assemblage sub-program into this system

Connection with Web GIS, DB, hydrodynamics model and GUI

Correspondence with several system on network

Specifications complied with roles of Server, PC and softwear

INVESTIGATING THE EFFECTS OF RAINFALL TIME DISTRIBUTION ON RAINFALL THRESHOLDS FOR FLOOD FORECASTING

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Being economical and having environmental acclimatization, flood forecasting systems have been implemented to reduce damages in last few decades. Different methods for flood forecasting in the target areas are used in these systems. From simple regression equations between upstream and downstream river discharges to complex systems combining meteorological, hydrological and hydraulic models. Rainfall threshold (RT) method is one of the evolving flood forecasting approaches which is considered as an emerging forecasting tool. Rainfall threshold is the cumulative rainfall depth, for a given initial soil moisture condition, which causes critical water level (or discharge) in a particular cross-section of the river. This approach seeks to reduce the available information to a level which non-technical people can interpret them directly and make a decision.

In this study, after the calibration of the HEC-HMS rainfall-runoff model (SCS-CN method for infiltration, Clark unit hydrograph to transform excess rainfall to runoff and Muskingum method for routing flow were set up in the model), RT curves were extracted for Walnut Gulch watershed, USA. According to watershed area (144 km2 approximately), rainfall spatial distribution was assumed to be uniform and Huff method was employed for rainfall temporal distribution. The RT curves were calculated for Huff's 10, 50 and 90 percent distribution curves. The critical discharge was assumed to be 20 cms for watershed's outlet. Results revealed that for a same duration, the rainfall thresholds for 10 and 90 curves are very similar and these values are both greater than the 50 percent one. For instance, rainfall threshold values obtained for 6-hr duration are 26.1, 26.5 and 24.6 mm for 10, 90 and 50 percent curves respectively. With increasing rainfall duration, the differences between 10 and 90 percent curves with the 50 percent one will increase. For example, the value of rainfall thresholds for 10, 90 and 50 percent curves are 40.1, 37.8 and 26.5 mm, respectively for 24-hr duration curves.

PROBABLE MAXIMUM PRECIPITATION IN JAJROUD BASIN OF IRAN USING SYNOPTIC MODEL (PMP)

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The Probable maximum precipitation is the maximum amount of precipitation that may occur in a basin. It is very important factor in designing many hydrological structures such as irrigation canals, and dams. Therefore it is very important to analyze the PMP in any developmental projects.

The Jajroud Basin in north of Tehran is important for the agricultural activities of the area and the urban planning of Tehran city. Therefore the main objective of this research is to determine the Probable maximum precipitation in this basin using synoptic model.

In this model the most attention is paid to the moisture and thermal characteristics of the rain storms. In order to achieve the objective of the study, eight intensive and widespread storms with one to four days duration were selected.

The results showed that the intensive rain storms of the basin are intensified by the merging of the Mediterranean cyclones with the Sudan lows. Through the maximization of the rainstorms the maximum probable precipitation of the basin was computed as 102 millimeters. The result of the study is the main input for the calculation of the probable maximum flood of the basin.

EXPERIMENTAL STUDY ON SCOUR OF CONSOLIDATED BED BY FLOOD

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The characteristics and the process by flood erosion of cohesive sediment after consolidation were studied experimentally both in a closed conduit system and open channel. The test samples investigated in this study are mixtures of sand and clay with variable compositions and different consolidation times. The main concern of this study is the effects of flood process on scour rate. A scour rate formula is derived and further interpreted based on the experimental results.

USE OF EMERGING NON-INTRUSIVE TECHNIQUES FOR FLOOD DISCHARGE MEASUREMENTS

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In order to assess the performance of emerging non-intrusive techniques available for measuring stream discharges during fast floods, comparison tests were conducted at four experimental sites for a range of hydraulic conditions. Discharge was simultaneously measured using concurrent surface velocity measurements conducted with a mobile radar velocimeter (Ott Kalesto v sensor operating at 24.1 GHz), with a conventional mechanical currentmeter deployed from a hydrometric van, and in some cases with an image-velocimetry technique (Large Scale Particle Image Velocimetry).

Surface velocity measurements were converted into depth-average velocity using a velocity coefficient, α. The value of this site-specific velocity coefficient was derived from the vertical velocity profiles measured with the current-meter. Values obtained for α in our tests range from 0.75 to 1.10, according to the relative roughness and the non-uniformity of the flow. The highest value, greater than 1, corresponds to a specific situation with an accelerated and almost confined flow under the bridge. The velocity coefficient was also used to back-compute surface velocity from the current-meter depth-average velocity (computed with the 3-point formula following the ISO748 standard). The discharge yielded by the stage-discharge relationship of the gauging station was also considered as a reference discharge.

In all our tests, velocity distributions across the section produced by the different techniques are in acceptable agreement, within 10% typically. The surface velocity measured with the current-meter shows more scatter, likely due to surface waves and the vicinity of bridge pier. Some tests over a smooth free-surface confirm the minimum radar gain indicated by the manufacturer (50 dB) under which velocity measurements are erroneous. When available, LSPIV velocity fields are used to explain the discrepancy between radar and current-meter velocity profiles.

Our results show a decisive potential of both non-intrusive techniques for gauging flood discharge within 10% or less, mainly depending on the accuracy of the velocity coefficient α. When measured vertical velocity profiles at the site are available, α may be derived experimentally. Alternatively, it can be calibrated against concurrent discharge measurements or estimates. Theoretical considerations based on the relative roughness, or roughness height to flow depth ratio, at a given site provide guidelines for estimating α and its variability.

Image velocimetry is a powerful technique for measuring instantaneous 2D velocity fields throughout the whole filmed area, hence discharge. However, its implementation and configuration remain complex since the measuring process involves image recording and processing, topography measurements and image orthorectification, image pattern correlation and velocity sampling over the gauging transect for discharge computation. Radar velocimetry only provides surface velocity at fixed positions and, though faster than traditional techniques, it requires successive measurements of several minutes. However, it is easy to deploy in the field, and data can be processed as easily as any other velocity-area discharge measurements. Flood discharge measurements using a mobile radar velocimeter would be valuable to disseminate to hydrological services, provided that further validation tests bring more guidelines on the technique limitations, error sources and calibration.

USE OF LARGE SCALE PARTICLE IMAGE VELOCIMETRY TO ESTIMATE SURFACE VELOCITY IN WIDE AREAS

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The application of the Particle Image Velocimetry (PIV) technique to large-scale parts of open-channel flows is nowadays widely used in riverine environments (Muste et al., 2009). In this paper, we attempt to apply the Large Scale PIV (LSPIV) to estimate the surface velocities in wide domains such as a river flood plain. The application of the LSPIV to this domain is constrained to several limitations and difficulties: the direction and magnitude of the flow are varying spatially; the far field cannot be studied similarly to the near field; effects of wind may be not negligible and tracers may be lacking.

In order to estimate the potential of this method for large-scale flood mapping, an application was achieved in a large reservoir during a flushing event. The reservoir flushing was completed on 25th and 26th September 2008 in the Longefan reservoir (Arc en Maurienne River, France). This reservoir (approximately 300mx500m) is part of the EDF (French Electricity company) hydropower system. It is mainly used for the sedimentation of the water released from the upstream hydropower plant and for temporary storage for the next plant.

LSPIV measurements were completed using three cameras covering the main zones of interest (entrance, main channel and exit). For each movie, biologically degradable chips were injected to produce visible patterns at the surface of the flow and to facilitate the LSPIV processing. However, most of the chips were visible by the first camera only. Dark patterns on the surface due to fine sediment bursts were used successfully for the LSPIV processing for the camera 2 and 3. A relatively good velocity field throughout the reservoir was obtained though partial. In particular, recirculations next to the main flow have been characterized. Some uncertainties still remain in the estimation of the flow magnitude, which depends on the accuracy of the velocity coefficient α (ratio between the surface velocity and depth averaged velocity), especially in presence of a strong wind.

A 2DH hydrodynamic model (Rubar20, Cemagref) was applied to the system and its results were compared with the experimental data. Advantages and limits of the model were discussed together with the validity of the LSPIV measurements. In particular, the effects of water level and wind were studied as well as the direction of the jet entering the system. These results confirm the interest of the LSPIV technique for monitoring flood processes over large areas, and evaluating hydraulic simulation results for overbank flows.

Muste, M., Fujita, I., and Hauet, A. (2009).Large-scale particle image velocimetry for measurements in riverine environments. Water Resources Res., W00D19:14 p.

DETAILED FLOOD FORECASTING AND EARLY WARNING IN BELGIUM: CASESTUDY OF THE YSER BASIN

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During the past decade the Flemish Environment Agency (VMM) has developed different detailed flood forecasting and early warning systems for the non navigable waterways in Flanders, the Flemish speaking part of Belgium. In addition to warning water managers and emergency services, the systems are successfully used to mitigate the psychological and material damages of floods. In order to create growing awareness, the most relevant information of the system is made available to the public through a website. Real time flood forecasting maps aredisplayedand interpreted in a comprehensive and multilingual website (www.overstromingsvoorspeller.be). In short, it is an ideal instrument in flood disaster management. An operator monitors 24/7 the underlying systems and checks if or when a warning should be broadcasted.

The flood forecasting system of the Yser basin covers more than 200 km of hydrodynamically modeled waterways. All structures as well as river sections every 50 metersalong the course of the waterway, are measured on the field. These data are used to build the hydrodynamic model. Hydrological models that use rainfall data (either detected by radar and rain gauges, or forecasted by the Royal Meteorological Institute (of meteorological models)) supply the input flow of the hydrodynamic models. Water level measurements at gauges and weirs are used to correct the hindcast which makes the forecast more reliable. Every hour, the model generates stages and discharges for more than 6000 nodes and 700 structures, as well as flood forecasting maps, up to48 hours ahead.

In order to evaluate the severity of the forecasted inundations, alert and alarm thresholds are defined all over the modeled area. An exceedance of the alert threshold implies non critical inundations of meadows; the alarm threshold is set at the level at which infrastructure will start to inundate. For each risk zone, the lowest doorsteps are measured in order to correctly define the alarm threshold of the area. When thresholds are exceeded, the operator is notified automatically by an alert or alarm message (SMS). An observed and predicted flooding will be highlighted on the website by a changing color of the point that represents the flooded area.

The website provides a closer look at the forecasted inundated areas. The real time interpretation of the operator on the website gives detailed information that can help emergency services and civilians to take the necessary precautions or people can be reassured that no critical flooding will occur.

The flood forecasting system of the Yser has been online since November 2009. There have already been two significant flooding periods where it proved to be useful. Together with the other newly developed flood forecasting systems in Flanders it provides a very high degree of forecasted flooding information and it is an indispensible tool to diminish damage, to stimulate awareness and to serve the emergency services.

EVALUATION OF A REAL-TIME FLOOD FORECASTS IN THE CZECH REPUBLIC 2002-2010

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Czech Hydrometeorological Institute (CHMI) is responsible for flood forecasting and warning in the Czech Republic. To meet that issue CHMI operates hydrological forecasting systems and publish flow forecast in selected profiles. A real-time flood forecast is a result of system that links atmospheric and river network observations, data processing, weather forecast (especially NWP's QPF), hydrological modeling and interaction of the forecaster. Each part of the system introduce uncertainty (and errors) to the whole proces and final output. However forecast users are interested in final output without separating uncertainties of separate steps of described process.

Therefore an evaluation of final operational forecasts was done for 103 forecasting profiles in the Czech Republic covering the period 2002 to 2008. Effects of uncertainties of observation, data processing and especially meteorological forecasts were not accounted separately.

We have focused only to cases of forecasted and/or observed increase above the flood levels thresholds during the 48h of forecasting period (peak over the threshold). Hit-Miss-False Alarm ration and some common derived criteria were evaluated together with peak flow and volume difference and Nash-Sutcliffe for each time step (1 to 48 h) of forecasting period.

Evaluation found significant differences of forecast skill between forecasting profiles, particularly less skill was evaluated at small headwater basins due to domination of QPF uncertainty in these basins. The average hit rate was 0.34 (miss rate = 0.33, false alarm rate = 0.32, CSI= 0.34). However explored spatial difference is likely to be influenced also by different fit of parameters sets (due to different basin characteristics) and importantly by different impact of human factor. Results suggest that the practice of interactive model operation, experience and forecasting strategy differs between responsible forecasting offices.

The expected result was the decrease of performance with increasing lead time as well as performance increase with increasing basin area, on the other hand there was no performance decrease with increasing flow threshold. Observed Nash-Sutcliffe decrease with forecast lead-time illustrates well the high dependency of hydrological forecast on QPF, based on our result we can estimate QPF is responsible for about 70 % of the total forecast uncertainty (error).

DECISSION SUPPORT SYSTEM FOR FLOOD FORECASTING IN THE EBRO AND GUADALQUIVIR RIVER BASINS

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The Decision Support System for flood forecasting basin of the Ebro river and Guadalquivir river basins, includes all the scope of its corresponding river watersheds (Ebro: 85.000 km^2 ; Guadalquivir: 58.000 km^2).

It is made up of a set of models - hydrologic and hydraulic – and computer tools that allow users to simulate, in real time, the evolution and behavior of the water all along the basin. The aim is to feed the system with meteorological and hydrologic inputs obtained automatically by a complex network of sensors (including meteorological radar) distributed through the river basin that will provide information, at least, every fifteen minutes, as well as with any meteorological forecasts, including ensemble prediction systems (EPS).

The DSS, has been conceived as an open system which will be able to elaborate forecasts independently of the hydrologic and hydraulic models used. This will allow the users to adjust the system to the accuracy they need at a given moment and compare the output of the system with those of the different modeling programs used.

The system will use different hydrologic and hydraulic models. From simplified kinematic wave models to bidimensional unsteady models with full Saint Venant equations, including classical one-dimensional models.

Considering the characteristics of the River basin of Ebro and Guadalquivir, the DSS also incorporates the operation of existing regulation dams, whose routing capacity has a great importance when mitigating the magnitude of flood peak and volume which would take place in the river basin in their absence.

OBSERVATION AND FORECASTING OF PRECIPITATION OVER THE SOUTH PENINSULA REGION DURING DECEMBER 2010

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Observed rainfall activity over the south peninsular Indian during the post-monsoon season 2010 as a whole was more than 155 % of Long Period Average (LPA). In particular it was observed as 181 % of LPA during the month of December 2010. The post-monsoon season region comprising subdivisions (i) Costal Andhra Pradesh (ii) Rayalaseema (iii) Tamil Nadu & Pondicherry (iv) South Interior Karnataka (v) Kerala. During this season, all the five subdivisions of south peninsular received excess rainfall. The subdivisions of peninsula and the Indian islands received excess rainfall -flood like situation occurred. The amount of rainfall which occurred nearly one and half times of their respective normal rainfall. This study project the spatial pattern of rainfall received during the season in particular the extreme South peninsula and parts of east coast received rainfall of the order of 40 to 60 cm. Rainfall over eastern parts of Tamil Nadu exceeded 80 cm.

The cumulative rainfall departure was negative till the first week of November. Thereafter it became positive and remained so till the end of the season. The rainfall over the south peninsula for the season was observed as 155 % of its Long Period Average, which is the second highest since 1901 after 2005 it amounts to 164 %

The ‘cyclonic storm (JAL)’ of the season formed over the Bay of Bengal in Nov, 2010. It was first observed as a ‘low pressure’ area over the south Andaman Sea and neighborhood on 02 Nov . It concentrated into ‘depression’ on 04 Nov at 8˚ N/92˚ E and then ‘deep depression’ on 05 Nov moved in a northwesterly direction, it intensified into a ‘cyclonic storm’. It further intensified into a ‘severe cyclonic’ storm on 05 Nov and moved in a northwesterly direction. in the end it weakened into a ‘cyclonic storm’ then into a ‘deep depression’ on 07 Nov moving in a northwestward, it crossed north Tamil Nadu-south Andhra Pradesh coasts close to Chennai in the evening hours of 07 Nov. One more ‘depression’ formed over the southwest and adjoining west central Bay of Bengal on 07 Dec.

The above rainfall observations have been examined with the analysis and predictions made with (i) Global Forecast System (GFS) with the resolution T382L64 (NCEP version) installed at the National Center for Medium Range Weather Forecasting, India (ii) Japanese Reanalysis datasets (JRA25), JMA, Japan. The low pressure system/s are verified with the above two analysis and forecast systems.

ENSEMBLE SHORT-TERM RAINFALL-RUNOFF PREDICTION AND ITS APPLICATION FOR URBAN FLOOD RISK MAPPING

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Short intense rainfall over small urban river basin leads to the flash-flood event. This event is distinguished from other events types by the small time and spatial scales, and thus its prediction is subject to high uncertainty. In this study, ensemble prediction is employed to account for the uncertainty in both short-term rainfall and hydrological prediction. Considering the small scale of storm event, radar echo extrapolation by translation model is used for predicting rainfall from X-band polarimetric radar. An ensemble rainfall short-term prediction is built by perturbing initial condition of the extrapolation model. The ensemble members are subsequently considered as uncertain input of the distributed hydrological model. Uncertainty of the hydrological model parameter is assessed by the GLUEmethod. The set of behavioral simulation would develop an ensemble of flood prediction. This approach allows a cascading of uncertainty from rainfall prediction uncertainty through rainfall-runoff model to the flood prediction. The methodology is demonstrated throughout case studies in Kofu urban river basin, Japan. Having demonstrated the plausible results, this approach could serve as a reliable method for estimating the uncertainty range of short-term prediction of runoff dynamics. We also demonstrate the range of probabilistic products generated by ensemble prediction and their potential for obtaining estimates of flood risk. When utilized along with flood damage model, we highlight the value of ensemble prediction for deriving flood risk information through a risk map.

DETERMINATION OF INITIAL INFILTRATION RATE FOR REAL-TIME FLOOD FORECASTING

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Infiltration rate in the early stage of a storm is less if the soil pores are filled from previous storms. However, a large quantity of water will infiltrate into soil for a prior dry period. The infiltration rate reaches to a maximum value at the beginning of the storm and decreases to a low constant rate as the soil profile becomes saturated. Selecting an adequate initial infiltration rate is considered important for a real-time flood forecasting because the storm runoff depends on the volume of rainfall abstraction deducted from the observed rainfall. Since infiltration rate is inverse proportional to soil moisture, the antecedent soil moisture at the beginning of the storm should be an index link to the initial infiltration rate.

In this study, Horton infiltration equation was applied to estimate the rainfall excess and then substitute into a geomorphology-based runoff model for real-time flood forecasting. A current precipitation index (CPI) was used to represent the time-varying soil moisture of the watershed. A nonlinear inverse-proportion relation can be expected between the CPI and initial infiltrate rate (fo) in the Horton infiltration equation. Hydrological records and watershed geomorphologic information from Kaoyi watershed in north Taiwan and Goodwin Creek Experimental Watershed in America were collected for verification of the proposed model. Through a series of tests, a regressed equation was developed to describe the relationship between CPI and fo for rainfall abstraction estimation. Consequently, the rainfall excess was used as an input of the watershed rainfall-runoff simulation. More than twenty storm events in these two watersheds were used for rainfall-runoff simulations, and good agreement between the recorded and simulated hydrographs was found. Results from series of tests also show that significant errors can be found in using inadequate initial infiltration rates for rainfall abstraction estimation.

DEVELOPMENT OF MULTI-MODEL ENSEMBLE FLOOD WARNING

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On August 7–9, 2009, the Typhoon Morakot hit Taiwan with record-breaking rainfall and catastrophic damage, making it the deadliest typhoon to visit Taiwan in the last 50 years. In preparation for weather extremes like the Typhoon Morakot, the enhancement of flood warning modeling has drawn more attention than ever before in Taiwan. However, most physical models are very computation consuming and impracticable for real-time warning; statistical estimation easily leads to bias since flood triggering factors are various and interplay complexly with each other; empirical approach is often criticized due to lack of theoretical reasoning and data base. In light of the limits of individual model, this study appeals to a multi-model ensemble warning that integrates the results of several conceptually different hydrological models. The results indicate that the ensemble warning shows better accuracy than individual models by giving higher hit alarms, revealing the fact that hydrological ensemble is no less important than meteorological ensemble in acquiring better flood warning performance.

APPLICATION OF RADAR-GAUGE INTEGRATED METHOD TO FLOOD FORECASTING MODEL

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Flood forecasting is fundamentally important for many non-engineering flood control methods. However, special natural environment factors in Taiwan have often made it difficult to produce real-time flood forecasting, as emergency operations personnel are unable to issue timely warning and take necessary measures due to the lack of proper information. Therefore, the only way to effectively enhance decision-making and reduce flood damage is by establishing an efficient and accurate flood forecasting model. To improve the existing technology for real-time rainfall estimation, recently government agencies have used the QPESUMS (Quantitative Precipitation Estimation and Segregation Using Multiple Sensors) data to develop the technique of integrating radar estimation and surface gauge observation. Therefore, the purpose of this article is to first integrate the rainfall using the radar-gauge integrated method and establish through artificial neural networks methods such as recurrent neural networks, self-organizing maps, and back-propagation neural networks. This article then explored the simulation results of 1~3 hours water level forecast by looking at the three different rainfall-water level forecasting models established through the methods mentioned above. Simulation of several flood incidents showed good results in all three types of rainfall-water level forecasting models in the use of radar technology for monitoring medium to small scale time and space changes in rainfall within the river basin during the flood. By feeding the water level forecasts back into the equations on river and flood, it not only improved the credibility in flood forecasting, but also provided water level forecast for each section along the entire river system.

COMPARISON OF DIFFERENT METHODS OF REGIONAL FLOOD ANALYSIS (MULTIVARIATE REGRESSION, HYBRID REGRESSION AND INDEX FLOOD) IN THE ARID AND SEMI ARID AREAS

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Rate and frequency of unexpected event in hydrology is of importance. Today, necessity of economical planning of projects needs to use analysis methods of unexpected events in hydrology.In regions with deficient or lack of statistics, to estimate peak flow, indirect methods (methods of regional flood analysis) can be applied. From presented methods for analysis regional flood in arid and semi - arid areas, there are Hybrid regression, multivariate regression and Index flood methods.

Purpose of this study was to test these methods to estimate peak flow in Northeast of Iran (Khorasan - Razavi province). To conduct the mentioned methods, 19 hydrometric stations were studied. At first, by selecting the best regional distribution (lognormal distribution type II), rate of peak flow with different return periods were estimated. Then, by using factor analysis method, important independents of variables including area, mean annual rainfall, mean elevation of watershed and its slope were determined. Then, by testing homogeneity with the method of cluster analysis, two Homogeneous hydrologic regions were determined and sets of model were presented for the each region.

To compare models, relative error index were used. The results showed that Hybrid method with return period of 50 years had more accuracy relative to multivariate regression and index flood method. Also,the results showed that the index flood method (except the return period 50), had more accurate and better results. Multiple regression and hybrid methods have similar accuracy in return period of 25 years.

DEVELOPMENT OF HYDRAULIC AND HYDROLOGICAL SIMULATION PLATFORM REALIZING HIGH FELXIBLE COMBINATION OF VARIOUS ANALYSIS ELEMENT MODELS – COMMONMP –

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This paper reportsmethodologies to realize both flexible combination of various analysis element models by development of a hydraulic and hydrological simulation platform and protection of model developer's intellectual propertiessimultaneously.

National Institute for Land and Infrastructure Management, Ministry of Land, Infrastructure, Transport and Tourismhas developed and is now revising hydraulic and hydrological simulation platform, which is named "Common Modeling Platform for water-material circulation analysis"; CommonMP for abbreviation. One of the main purposes of developing CommonMP is to promote broader utilization of hydraulic and hydrological simulation and to stimulate research and development of hydraulic and hydrological analysis models. First version of CommonMP was released in March 2010. We equipped CommonMP with features shown below to realize these purposes.

First, CommonMP has a feature that different developer's element models can be combined on it and enables concurrent data exchange between element models during simulation, even if each element model has different time step and other computational conditions. CommonMP has an interface which synchronizes each element model's calculation, translate data and send them to combined element models. Thanks to this feature, you can combine your rainfall runoff model with a flood routing model developed by someone else, and conduct hydraulic and hydrological simulation for example without tedious effort.

Second, CommonMP has several features to promote more element model development and to activate hydraulic and hydrological simulation by reducing laboring programming work. One is a function to automatically generate source codes of element model's interface. Another is a function to secure the portability of element models and simulation project between different computers. These models and projects consist of a number of files so that it is usually troublesome work to deliver and set up them on other computers.

Furthermore, these is a feature to protect model developer's intellectual properties without giving up the compatibility between element models. Model developers do not need to provide source codes of the element model, but only compiled codes when they release their element models on CommonMP. This encourages model developers to release more element models.

FLOOD WARNING FOR INFRASTRUCTURE: TAILORED FLOOD WARNING SERVICES

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The summer floods of 2007 in England and Wales were the most expensive in terms of flood damage anywhere in the world during that year, with around 50,000 properties flooded, water supplies to 350,000 homes disrupted and insurance industry costs of £3.2 billion[5].

In England, an estimated 14% of electricity infrastructure, 20% of railways, and 10% of major roads lie within the floodplain[6].

The Sir Michael Pitt Review of the 2007 floods encouraged the development of a specialised flood warning service for infrastructure operators (Pitt Recommendation 33). During this Review, the Environment Agency received feedback from infrastructure operators indicating that the volume of non relevant flood warnings they received compromised their flood response.

Infrastructure operators wanted notification of when they need to monitor flood warnings, flood warnings that are related to assets or networks, a digital to view warnings and assets spatially and produce reports. A pilot web-based infrastructure warning service, using a commercial supplier, was implemented in July 2009 with Western Power Distribution, an electricity distribution company covering South Wales & South West England. The pilot project, providing targeted flood warnings to specific infrastructure assets, has received positive feedback from infrastructure operators.

This service ensures infrastructure operators only receive flood warning information that directly concerns their business and provides them with the appropriate information needed to take action on warnings that are directly related to their assets. The Environment Agency intends to offer an infrastructure warning service based on this pilot to Category 1 and 2 Responders[7] in Spring 2011. The pilot also demonstrated that a web-based application is one method of delivering these types of services and that there are many possible end user requirements for a tailored warning service.

It was evident that the 'live flood data' held by the Environment Agency could be used to develop a range of specialised and tailored products and services for both the public and businesses by providing this information securely to third parties or Value Added Resellers (VARs). Providing our data feeds to VARs enables this data to be integrated into existing applications or allows the freedom to develop bespoke or standalone services.

From January 2011, any organisation can be licensed to access Environment Agency live flood warning information retrieving this from a secure data distribution hub. Whilst the Environment Agency retains the core and high quality flood warning service, VARs are now actively developing specialised and enhanced services for particular customer groups.

Tailored warning services for transport operators, specialist insurance products, and smart phone applications are now all being developed. These services result in more people receiving flood warnings and accessing them in the way they want to receive this information.

The Environment Agency plans to release more live information including river level, rainfall, river flow and forecast data that will enable even greater specialisation of products and services. The adoption and use of these services will improve flood response and reduce the impact flooding on communities through the loss of essential services and key infrastructure.

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IMPACT OF URBANIZATION ON FLOOD VULNERABILITY IN SHALLOW GROUND WATER CATCHMENT

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The rapid urbanization of the modern cities around the globe has been created vast amount of changes to the urban hydrology and causes urban flood risks, inundating the cities while destroying valuable assets even threatening the human lives. Assessment of flood vulnerability considering the urban hydrology for catchments is more complicated with the features of the urbanized lands. Except for very simple systems, analytical solutions of hydrological behavior are rarely possible. Numerical modeling is widely using to evaluate the complex hydrological characteristics of urban catchments.

The present study combines the 2D overland flow elements and the 1D drainage networks to represent urban hydrological system. Canning Vale which is one of the rapidly urbanizing cities in Western Australia was selected as the case study. Assessment of urban hydrology of Central Catchment within Canning Vale which is size of 248 ha was carried out using a numerical model. The developed catchment model of the study area was used to investigate the impact of the land use changes and shallow groundwater level of the area and urban city's features like open channels, underground drainage network, multiple user corridors, detention basins, roads and their features, parks and foot paths on the urban hydrology. Results show that shallow ground water plays a main role in urban flood process in Caning Vale. Therefore ground water level was treated as one of the main calibration parameters while comparing model output with observed storm water flow at observation locations. Several rainfall frequency scenarios were used to identify the flood vulnerable areas of the catchment. Results of the study were used to develop flood vulnerability maps while recommending the necessary improvements to the urban storm water system according to the best management practices and water sensitive urban design concepts. Output of this study will assist local city council officers, planners and decision-makers in coming up with better land management concepts and urbanization procedures to ensure long-term sustainability minimize natural and anthropogenic impacts on urban flooding

EVALUATION OF FLOOD DISCHARGE HYDROGRAPHS THROUGH A NETWORK OF CHANNELS IN THE OTA RIVER DELTA

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A network of channelswhich consists of the Ota River Floodway and five branched rivers is formed in the Ota RiverDelta. Each channel flows into the HiroshimaBay where the tidal changes are relatively large. Hiroshima city which has a population of about one million is located on the Ota River Delta. To estimate and understand flood discharge hydrographsthrough the channels in the Ota River Delta is important for proper river management.

The effects ofriver conditions such as vegetations, river bifurcations, river structures and bed variations during the flood appear in the time series of water surface profiles observed in each channel. Fukuoka, Watanabe et al. (2004) proposed the unsteady 2D flow analysis method using time series of observed water surface profiles. The calculation method makes possible to evaluate the temporal changes of hydraulic conditions during the flood (e.g. water levels and discharge hydrograph). This idea can be applied to estimate flood discharge distributions and bed variations during a flood in a network of channels ina delta area.

The objective of this study is to make clear the flood discharge distributions and bed variations during the flood with a network of channels of the Ota River Delta by developing unsteady quasi-three dimensional flood flows and bed variations analysis method combined with time series of the observed water surface profiles.

For estimating the flood discharge distributions, we installed the water level gauges along the channels in the Ota River Delta. In2010’s flood that is middle scale flood in the OtaRiver, the time series of water surface profiles were observed by these gauges.

We develop the calculation method which uses the time series of observed water surface profiles to compute the flood flow in a network of channels of the Ota River Delta at 2010’s flood.In the network of channels, a fixed weir and movable weirs are installed at the river bifurcation point of the KyuOtaRiver and the Ota River Floodway. And, there are a number of bridges with piers in the branched rivers. Since these structures cause to raise water surface of the flood flows, effects of a fixed weir and piers of bridges and movable weirs are considered in this method. And, three dimensional flows develop around the river bifurcations due to the divergent flow and weirs. It is important to evaluate these flows for estimating bed variation around the river bifurcations. Therefore, the calculation method employs quasi three-dimensional flood flow analysis method (Uchida and Fukuoka, 2010).

As a result, the unsteady quasi three dimensional analysis of flood flows and bed variations using time series of observed water surface profiles is found to provide good results for theflood discharge distributionsof a network of channels in the Ota River Delta.

This research provides the idea to evaluate and understand flood flows (e.g. flood discharge distributions) and bed variations for river managements of a network of channels through a delta area.

URBAN FLOOD INUNDATION MODEL FOR HIGH BUILDING DENSITY AREA

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Urban flood has been an unavoidable problem in many cities around the world. Discharge propagation from upstream catchments causes river over flow in the downstream part particularly if the area is flat. Furthermore, local rainfall makes inundation area expand. In relation to water resources planning and management especially in disaster mitigation, decision makers often rely on flood studies which usually use numerical model to simulate flood inundation. Therefore, it is necessary to have an appropriate model for urban areato provide estimation of inundation due to flood.

Flood in urban area has different characteristic compare to flood in rural area.Urban flood has its own challenge which researchers have to deal with. The presence of buildings particularly in high density urban area changes flow path and pattern due to the blockage which lead to affect flood inundation. This phenomenon needs to be accounted in urban flood model to accommodate the physical process in real condition.

The objective of this study is to develop flood inundation model considering buildings effect in high density urban area. 2D overland flow model is coupled with 1D channel model to simulate flood inundation with exchange of flows between the river and surface floodplains. Momentum equation in overland flow model is modified in order to consider urban flood characteristic. Sharing ratewhich is defined as occupancy area of buildings in each grid of model domain is applied to accommodate the effect of buildings. Furthermore, drag force which is occurred due to the reaction of the force acting on buildings is included.

The model is applied to the downstream part of CiliwungRiver basin where Jakarta, capital city of Indonesia, is located. Flood often occurs in this city which is well known with its high building density area. Upstream discharge and local rainfall have been considered to cause flood in Jakarta.In February 2002, this city experienced one of the most severe floods in history which is recorded as one of the worst in the city history. This event is used for flood simulation in this study. Comparison of inundation between observation and computation shows good agreement. It means that the model approach can be used to support decision makers regarding flood prediction and mitigation.

IMPROVED DISCHARGE ESTIMATION WITH 2D DYNAMIC WAVE MODEL AND PARTICLE FILTER

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River discharge data is essential for water resource management and hydrological model calibration. In contrast to such an importance, river discharge is generally estimated by using observed water stage data and a rating curve. As an alternative to get more precise discharge data, hydraulic model simulation has been considered in some cases. However, hydraulic model simulation with a deterministic model condition also has limitations in consideration of the time variant river characteristics, and thus it is difficult to predict the prospective state of river flow. In fact, natural river flow conditions, such asManning's roughness coefficient and lateral inflow to the river channel, are the subject to change continuously. Especially, the variations of river flow conditions during flood events are extremely fluctuating, and this phenomenon has been reported many times.

In this study, we attempted to find away to consider the natural river flow characteristic(time variant Manning coefficient) into a hydraulic model simulation for more exact analysis and prediction of river discharges. In dealing with this problem, we introduce a simple 2D dynamic wave model, which can reflect the geomorphologic effect, and Monte Carlo sequential data assimilation scheme (or Particle Filtering scheme), which is adequate to non-linear system and able to reflect the time variation of state variable and parameters. Based on the Sequential Importance Resampling (SIR) method within the Particle Filtering scheme, the parameters and state values of the dynamic wave model are sequentially updated to consider the observed water stage information every hour. However, the fluctuation of estimated river discharge was too large to present the value in accordance with the noise magnitude of state variable and parameter in updating step. Therefore we quantify the magnitude of noise by using a synthetic experiment.

The method was applied to the middle reach of the Kastura River in Kyoto, Japan. The length of the modeled river channel is about 10km, and there are 3 water level stations and 4 weirs within the channel. The study shows that the difference between the estimated river discharge from the method and the river discharge estimated from the rating curve is not negligible in this study area.

SEQUENTIAL DATA ASSIMILATION FOR STREAMFLOW FORECAST USING A DITRIBUTED HYDROLOGIC MODEL: PARTICLE FILTERING AND ENSEMBLE KALMAN FILTERING

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Streamflow forecasting is an uncertain task. As hydrology community has analyzed, there are structural, input and measurement uncertainties in rainfall-runoff modeling. If the forecasting is implemented without considering these uncertainties, potentials of the forecasting become very limited and it is hard to be used properly for decision making.

Data assimilation is a way to integrate information from a variety of sources to improve model accuracy, considering the uncertainty in both a measurement system and a modeling system. Applications of the sequential data assimilation methods have been increasing in hydrology to reduce uncertainty in the model prediction. The main idea is to update model states (and parameters as well in some cases) when a new measurement is available. The Ensemble Kalman filter (EnKF) is one of the widely used sub-optimal filters implementing an efficient computation with limited number of ensemble members. However, the estimation via EnKF may lead to biased results when the nonlinearity of the system increases. The sequential Monte Carlo methods, known as particle filters (PF), can be an alternative in which the propagation of all uncertainties is carried out by a suitable selection of randomly generated particles without any assumptions about the nature of the distributions involved. Unlike the Kalman filter-based methods, particle filters have an advantage of being applicable to non-linear and non-Gaussian state-space models.

In this study, we discuss the implementation of sequential data assimilation methods based on two filtering schemes; particle filtering and ensemble Kalman filtering. In case of PF, new particle filtering scheme is introduced to consider the lagged system response of a distributed hydrologic model when the state variables are updated. Advanced particle regularization scheme is implemented together to preserve the diversity of the particle system. In case of EnKF, modified versions such as the square root scheme are implemented. Each filtering method is parallelized and implemented in a super computer system using MPI (message passing interface). A distributed hydrologic model, the water and energy transfer processes (WEP) model, is applied for the Katsura River catchment (887 km^2), Japan. Forecasted results via PF and EnKF are compared and analyzed in terms of the prediction accuracy and the probabilistic adequacy. Discussions are focused on the prospects and limitations of each data assimilation method.

ANALYZE THE "NEEDS" OF THE USERS FOR THE NEWLY INTRODUCED X BAND MP (MULTI PARAMETER) RADAR

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It is envisaged that the newly introduced X Band MP (Multi Parameter) Radar will provide higher precision rainfall information compared to the conventional radar, contributing to river and disaster management in Japan. However, the procedure for rainfall estimation, the operational structures and the ways of effectively utilizing the rainfall information have not yet been established.

The objective of this research is to analyze the "needs" of the users (e.g., what type of information is needed at what timing?) for the MP radar from the perspectives of river managers, municipalities, general public, etc. It aims to propose the operational procedures to realize the functionalities demanded by the users, and to make recommendations for developing disaster evacuation support systems.

Based on the general requirements by users for radar and disaster information identified in the first year of the research, the second year of the research involved the following elements:

- Conduct interviews with wide variety of users to analyze their needs for radar rainfall and disaster information
- Develop a prototype system for flood/inundation forecasting and flood disaster evacuation support system which disseminate information to mobile phones

The simple questionnaire surveys and interviews were conducted targeting the users of flood information in order to determine the types of information needed during flood events. Potential users of flood information include such entities as organizations related to disaster-prevention, administrators of rivers, sewerage, or roads, managers of underground facilities, river-users, recreational users and the nearby residents.The survey revealed the needs of and the information required by river, sewerage and disaster prevention managers, and also the key issues regarding flood information that are considered important to resolve.

The prototype system which provides flood/inundationforecasting and flood disaster evacuation support information using X-band MP radar was designed and developed. The system provides information such as current and estimated rainfall, water level and inundation depth at any given locations and ranges, and can be accessed through mobile phones. Pilot testing of the system will be conducted this year in order to verify the effectiveness of the system and to refine its specifications.

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FLOODINUNDATION SIMULATION USING HYDRO-BEAM IN RED RIVER BASIN, VIETNAM

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Flood hazard is a major concern for many people and the governments around the world. The threat of flood risk is likely to increase with growing population, urbanization andglobal climate change. It has become even more important to develop countermeasures strategies to cope with flood disasters. Such countermeasures rely on flood prediction capabilities, and especially, the delineation of potentialflood inundation areas becomes very important. An effective flood modeling and prediction system could help mitigate the worst effects of flood disasters through the rapid dissemination of information in areas under threat. Hence, it is important to obtain information on flood characteristics, study the hydrological system and simulate different extreme events to visualize the probable floods that would exceed the flood control design standards for disaster mitigation. Flood hazard maps can be a tool to communicate flood problems in the region and enhance the awareness of people. This could help community to be proactive and prepared towards such events and reduce loss from flood disaster.

This research develops a distributed model for simulating flood inundation integrating with rainfall-runoff processes. A physically distributed model Hydro-BEAM (Hydrological River Basin Environment Assessment Model), has been used as hydrologic model. In the model, it takes a one-dimensional diffusion wave representation for channel flow and a two dimensional diffusive wave approximation of inundation flow solved with the application of fully implicit finite difference scheme. Two dimensional Navier-Stokes equations-based flood propagation model is used considering the suitability in complex urban terrains. The discharge that overflows from each stream segment to the flooded area is calculated from the difference between the water level of the channel and the grid section connected to it by assuming that Honma's overflow formula of a trapezoid dam is applicable. Zero extension theory has been used here to solve a free boundary problem as this theory easily treats moving boundary with the analytic domain expanded outside (Fig. 1). Here, a hypothetical domain adjoined to the analytic domain along the boundaries is provided and then that variable is assumed to have a constant value of zero over the hypothetical domain.

Hanoi, the capital of Vietnam, which is vulnerable to flood, has been selected as the study area. It is located in the floodplain of Red River. Flood problem has been compounded in recent years by a number of changes, such as environmental degradation, worldwide climate change, and sedimentation.

The outcome of this study is the preparation of flood hazard maps for discharges corresponding to various year return period to assess the area likely to be inundated due to potential flooding. Various scenarios such as reservoir operations, dyke failures, future climate change will be evaluated. Finally suitable flood disaster mitigation policies will be found out with the developed scenarios for flood hazards.

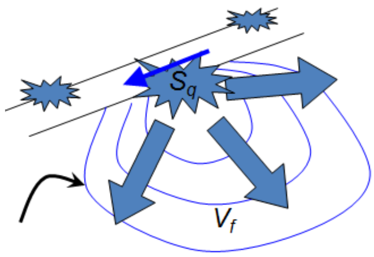

Fig. 1. Moving boundary of flooding/inundating area

RAINFALL-RUNOFF MODELING AND FLOOD ROUTING OF UPPER MARIKINA RIVER FLOODS FOR 2009 TROPICAL STORM ONDOY (KETSANA) AND LOWER RETURN PERIOD EVENTS

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Tropical Storm Ondoy (Ketsana) crossed Metro Manila and the adjacent river basins in a late wet-season episode of 2009, starting in the evening of September 25, 2009 and continuing into the next day of September 26, 2009. TS Ondoy brought very intense and heavy rainfall to the region - record amounts of rains fell over a very short time period of 12 hours to 24 hours, which are estimated to occur at an average annual frequency of 1 in 100 years or even higher, depending on the measuring location in the region. The rains generated record-magnitude flood flows and inundation in the Pasig-Marikina River Basin in Metro Manila, and the Laguna de Bay region. The paper starts by briefly explaining the present situation in the flood management in Metro Manila and covers the various government flood-mitigation projects; describes the temporal and spatial pattern and statistics of the rainfall and flood flows associated with the major storm and their resulting physical impacts, risks and damages to the metropolis; and finally, provides recommendations, both in terms of structural and non-structural mitigation measures, for all stakeholders to consider and adopt.

This paper also describes the application of the distributed watershed rainfall-runoff model SWATCH in order to simulate the TS Ondoy floods and other floods of lower return periods (2 years to 100 years) in the upper Marikina River Basin, using as input the spatially-interpolated rainfall network data and available topographic, soil/geology and river-geometry data. The SWATCH model consists of a tree-network of several variable rectangular surface/soil/aquifer storage nodes and overland/channel flow links, with accounting of soil moisture, evapotranspiration, infiltration, and recharge to groundwater, and routing of overland and channel flows, interflow and baseflow into aggregated total streamflows. Using the model-computed inflow flood hydrographs, the options of single or cascade of flood-control storage dams (with selected reservoir-storage and spillway capacities) for attenuation of floods peaks and volumes, and downstream flood hazard reduction are initially evaluated by flood-routing studies.

OPERATIONAL HYDRO-METEOROLOGICAL SIMULATING AND 3D DISPLAYING SYSTEM

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This study aims to develop an Operational hydro-meteorological simulating and 3D displaying system. The predicted rainfall data from Weather Research Forecasting (WRF) are used as our meteorological forcing on watershed modeling. Fifteen members are included in this research for Ensemble Quantitative Precipitation Forecasts (QPF). The hydrology and hydraulic modeling are conducted by WASH123D (WaterSHed Systems of 1-D Stream-River Network, 2-D Overland Regime, and 3-D Subsurface Media) numerical model. And the WRF/WASH123D coupled system is applied to simulate floods during the typhoon landfall periods. The daily operational runs start at 04UTC, 10UTC, 16UTC and 22UTC, about 4 hours waiting time for data downloaded from NCEP GFS. This system will execute 72-hr quantitative precipitation forecasts, then WASH123D will sequentially trigger after receiving quantitative precipitation forecasts data. The simulation results are further display by a 3D GIS web service system. This system is established following the Open Geospatial Consortium (OGC) standardization process for GIS web service, such as Web Map Service (WMS) and Web Feature Service (WFS). The traditional 2D GIS data, such as high resolution aerial photomaps and satellite images are integrated into 3D landscape model. The simulated flooding and inundation area can be dynamically mapped on Wed 3D world. The final goal of this system is to real-time forecast flood and the results can be visually displayed on the virtual catchment. The policymaker can easily and real-time gain visual information for decision making at any site through internet.

RADAR HYDROLOGY: NEW Z/R RELATIONSHIPS FOR KLANG RIVER BASIN, MALAYSIA

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The use of Quantitative Precipitation Estimation (QPE) in radar-rainfall measurement for hydrological purposes is significantly important. For more than 50 years, radar has been deployed to monitor and to estimate the precipitation routine in several countries. However in Malaysia, radar application in QPE is still new and need to be explored. This paper focuses on the Z/R derivation work of radar-rainfall estimation. The work developed new Z/R relationships for Klang River in Selangor area for three different classes of rain events, namely low (<10mm/hr), moderate (>10mm/hr, <30mm/hr) and heavy (>30mm/hr). Looking at the high potential of Doppler radar in QPE, the newly formulated Z/R equations will be useful in improving the measurement of rainfall for any hydrological application especially for flood forecasting.

SNOWMELT RUNOFF PREDICTION IN THE UPPER EUPHRATES BASIN, TURKEY

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Snowmelt runoff in the mountainous eastern part of Turkey is of great importance as it constitutes nearly 2/3 in volume of the total yearly runoff during spring and early summer months. Therefore, keeping track of snow dynamics and forecasting the amount and timing of snowmelt runoff in the headwaters of the trans-boundary Euphrates River, where large dams are located, is an important task in order to plan dam regulations, control flooding and optimize water resources.

Upper Euphrates Basin in Turkey with an area of 10275 km^2 and an elevation ranging from 1125-3500 m is selected as the study area since it is one of the main branches feeding the Keban Dam Reservoir (first dam in the series of large dams in Euphrates Basin). Automatic snow-meteorological stations are installed at various locations and altitudes in the Upper Euphrates Basin operating in real-time. Since ground based observations can only represent a small part of the region of interest, spatially and temporally distributed snow cover data are acquired through the use of Moderate Resolution Imaging Spectroradiometer (MODIS) optical satellite. Daily 500 m resolution MODIS satellite images on Terra and Aqua platforms are used to determine cloud free snow depletion curves using certain combination and filtering techniques. Snowmelt Runoff Model (SRM) is applied in the basin to forecast runoff with a 2-day lead time for 2011 snowmelt period. Meteorological input data of precipitation and temperature are provided from numerical weather prediction models and snow extent data is estimated through stochastic modeling using MODIS images. In conclusion, promising results indicate the possible operational use of runoff forecasting in the Upper Euphrates Basin for future flood events.

HYDROLOGICAL MODELING AND RESERVOIR SIMULATION OF FLOOD EVENTS IN YUVACIK DAM RESERVOIR, TURKEY

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As the world's water resources become increasingly stressed, effective tools for management become more important. Effective management deals with how much water will be released and stored especially in urban lands where flood event occurs.

Yuvacık Dam Basin, located in the Marmara region of Turkey and has a 248 km^2 drainage area, is selected as the application basin and accordingly Yuvacık Dam Reservoir is taken as the application reservoir. The dam reservoir, having a total volume of 56 million m^3, is designed to provide 142 million m^3 of domestic and industrial water annually for 1.5 million populated City of Kocaeli.

The reservoir operation of Yuvacık Dam is very crucial especially for the periods of flooding and drought since it has to meet the need for drinking water of Kocaeli City, despite the relatively small capacity of its reservoir. The drainage discharge conditions set for the downstream of the reservoir is 100 m^3/s, despite the spillway capacity of 1560 m^3/s, therefore, the motivation of the study is to improve reservoir operation conditions especially during flood events.

Basin/hydrological model integrated reservoir modeling system, in the most common form include the integration of a hydrologic simulation model and a reservoir simulation model. Hydrological model is to be used for establishing a relationship between rainfall and runoff and to calculate the inflow to the reservoir and reservoir model is to be used for creating reservoir operation scenarios according to specific operation rules and current priorities of runoff. Basin is divided into four sub-basins. Hydro-meteorological data are collected via automated rain gauges in and around the basin and a semi-distributed rainfall runoff model is calibrated for sub-basins that drain into the lake using HEC-HMS. Finally modeled inflows are used as main inputs in HEC-ResSim for the hourly and daily reservoir simulation of flood events.

In this case study, Yuvacık Dam reservoir operation for 19 March 2008, 26 February 2009, 6 April 2010 flood events during which spillway was operated are selected and simulated with different scenarios to analyze the operation and release decisions and to propose an improvement in decision support system. Model parameters calibrated for several flood events can be used in real time forecasting studies with the aid of these simulations and several scenarios can be used to improve management of the reservoir.

THEORY VERSUS PRACTICE IN SEASONAL APPROACH TO FLOOD FREQUENCY ANALYSIS

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The annual peak-flow series of Polish rivers are mixtures of summer and winter flows. In the paper the practical aspects of applicability of seasonal approach to flood frequency analysis (FFA) of Polish rivers are discussed. Taking Two-Component Extreme Value (TCEV1) model as an example it is shown that regardless of estimation method, seasonal approach can give profit in terms of upper quantile estimation accuracy that rises with the return period of the quantile and is greatest for no seasonal variation. Then, the assessment of AM (annual maxima) versus SM (seasonal maxima) approach to FFA is carried out with respect to seasonal and annual peak-flow series of 38 Polish gauging stations. Having the samples of summer and winter maxima, (i.e. the AM ones), one can estimate the TCEV1 parameters and hence AM quantiles both by the seasonal approach and then by the AM approach when all parameters are jointly estimated from AM sample. For the mutually independent seasonal peak flows of the Gumbel form, the AM upper quantile estimates of the two approaches should not differ much asymptotically converging so the magnitude of difference may serve as the measure of goodness-of-fit to the data. With a help of this criterion it is found that the TCEV1 model with seasonally estimated parameters is not appropriate for most Polish data. Moreover, the TCEV1 considerably underrates the skewness of AM distributions as well as upper quantile values. It is shown also that the asymmetry of summer maxima is more spatially stable than that of annual or winter maxima. Moreover, the trends for winter and summer may differ when the non-stationary case is considered. According to Polish seasonal data summer is barely affected by time-variability, and winter shows decreasing trend in first two moments. In such a case the seasonal approach is recommended. Dominating season in AM series was confronted with predominant season for extreme floods. When seasonality is pronounced, the AM upper quantiles should be derived from the predominant season and the other season should be ignored. In the case study for Warsaw gauging station, the upper quantile estimates got by means of classical annual and two-season methods happen to be fairly close; what's more they are nearly equal to the quantiles calculated just for the season of dominating extreme floods.

SHALLOW WATER FLOW SIMULATION USING QUADTREE CUT CELL MESH

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Numerical modeling of flow governed by nonlinear shallow water equations has been widely performed to simulate shallow water flows. In practice these equations have provided with reasonable model results in various applications such as flood/tsunami propagation, river flows and lakes simulation, even though the shallow water equations cannot address the vertical movement of flow. A lot of numerical schemes have been developed and applied to the equations. Among them, the adaptive quadtree approach has a quite attractive feature in terms of grid generation. This approach allows models to refine a mesh dynamically tracking flow features or where high resolution is required, which makes the models efficient and accurate in many applications. For example, in a dam break simulation the front propagation should be calculated with high resolution while lower resolution is enough to describe the flow after the dam break shock wave. The adaptive quadtree approach enables numerical modelsto handle such problems efficiently and has been successfully applied to the shallow water equations.Curvilinear boundaries, however, are represented by a staircase-type approximation on the quadtree grids. The approximation makes high resolutions obtained in the vicinity of curvilinear boundaries whereas it requires mesh refinement and causes additional computational costs. Cartesian cut cell method can alleviate the restriction of fitting grids to complex boundaries, and moreover it is well compatible with adaptive quadtree grids.

The river module of Gerris Flow Solver (Popinet, 2003), which is open source free software, provides the adaptive quadtree grid generator and a finite volume shallow water solver.We adapted the cut cell method in the Gerris' river solver and implemented the well-balanced scheme on cut cells, given that the current river solver does not support the cut cell method. We notice that one of the important issues in shallow water modeling inrecent years is the preservation of the well balanced property. The issue is derived from the fact that the hyperbolic form of the shallow water systems treats the gradient of bathymetry as a source term while the gradient of fluid depth as a flux,and they are independently computed. There is no guarantee that the discretization errors caused by those two terms compensate each other unless those are treated properly. To correct the imbalance between flux and source terms in the discretized equations in case of irregular bathymetry, a number of “well-balanced” numerical schemes were proposed. Among these, the hydrostatic reconstruction technique proposed by Audusse et al. (2004) has been proved to be effective and robust even in the case of wetting and drying. We implemented Audusse et al. (2004)'swell-balanced technique on the quadtree cut cell mesh in this research.

THE BEST-PRACTICE METHODOLOGICAL FRAMEWORK OF AT-SITE FLOOD FREQUENCY MODEL SELECTION IN THE VIEW OF FRENCH RUNOFF DATASETS

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Benjamin Renard[1], Michel Lang[1], Eric Sauquet[1]
Federico Garavaglia[2], Emmanuel Paquet[2]
Jean-Michel Soubeyroux[3], Sylvie Jourdain[3], Jean-Michel Veysseire[3], François Borchi[3]
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In frequency analysis (FA), a probability density function (pdf) is selected more or less subjectively from among asymmetric continuous pdfs. The selection of a correct or best-fitting distribution can have a significant effect on the reliability of risk assessment and hazard quantification procedures. Ironically, the abundance of the methods of pdf selection (including statistical tests and graphical methods) developed over years does not help the practitioners to make the right decision (if any) about the model selection but gives rather the room for vacillation.
The French National research project EXTRAFLO aims, *inter alia*, to perform a comparison between pdfs currently used in France, select the most promising models and recommend them for practical applications. The analysis is based on a dataset of long series of runoff. This work provides a deepened description of the objective and best-practice methodological framework of model selection and presents results of its application to a large runoff dataset. The proposed methodology involves analysis of descriptive and predictive ability of models as well as uncertainty and reliability of the models' predictions. The novelty of the proposed approach stems from the fact that it enables the application of the predictive distribution to assess the stability and reliability of the central estimate and thus evaluate the stability and reliability of estimated uncertainties.
The models are selected from among the pdfs recommended in the hydrological legislative literature in European countries and the United States.
The framework applied to the French runoff data pointed to the Generalised Extreme Value pdf as the most promising model of at-site FA, under condition that uncertainty is included. However, when uncertainty is ignored, at-site flood estimation by the GEV leads to misinterpretation, in the sense that some validation data are regarded as 'impossible' in about 15% of the stations. Still, accounting for uncertainty by predictive distribution lets to overcome this effect.

Parallel Oral Sessions

Topic 4

Flood Management in Different Climate Conditions and Geographic Zones

- Urban floods, flash floods, riverine floods, storm surges
- Landslides and debris flow
- Floods in deltas and estuaries
- Floods in arid areas and seasonal rivers,
- Floods in cold regions
- Trans-boundary rivers floods
- Glacial lake outburst floods (GLOFs)
- Dam malfunction flood, dam break and natural dams after earthquake, etc.
- Reports on recent floods (lesson learned and the best practices)

A METHODOLOGY FOR RAPID INUNDATION MAPPING FOR A MEGACITY WITH SPARSE DATA: CASE OF MUMBAI, INDIA

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Nikam, V.[1]

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Many cities in Asia are facing flooding due to increased habitations in flood plains/low lying areas, loss of pervious surfaces and natural detention ponds and increased rainfall intensities.This trend is also seen in Mumbai, India,an island city with a population of 17.7 million (2001) residing in an area of 437.71 sq. km. Mumbai extends for about 40 km from North to South and 5 km to 12 km from East to West. The average annual rainfall is 2050 mm in South and 2300 mm in North Mumbai. Over 95 % of the annual rainfall occurs primarily during June to October in the monsoon season and 70 % of this in July and August; moreover, 50 % of this occurs in just two or three events. During these two or three events, it usually rains uniformly over the city and severe flooding occurs in many parts of the city. Mumbai experienced its worst floods on 26th July 2005 due to 727 mm rainfall in 8 hours which caused an almost total shutdown of the city.

A Disaster Risk Management Master Plan integrating various disasters like floods, earthquakes and cyclones has been initiated by the Municipal Corporation of Greater Mumbai and is in final stages of completion. As a part of this plan, a rapid Flood Risk Assessment (FRA) of the city has been carried out using best available data. This paper describes the development of the FRA methodology and it's application to the L -Ward which was one of the worst affected wards in Mumbai during 26th July 2005 flood.The Shuttle Radar Topography Mission digital elevation model data has been used for contour generation and delineation of the catchment using software. The catchments contributing to the ward has been identified and runoff volume has been computed. The flood risk assessment has been carried out for two scenarios - continuous rainfall at 50 mm/h for one hour and 100 mm/h for one hour corresponding to return period of 2 in 1 year and 1 in 1 year respectively. The depth of inundation due to runoff from these rainfalls has been computed and the areas submerged have been delineated (Fig. 1).Subsequently the flood spread and number of people likely to be affected by flooding in the ward has been estimated (Fig. 2 and 3). This map is being used to formulate mitigation measures like identification of safe shelters on high ground, evacuation paths and planning for transport route diversions during heavy rainfall.

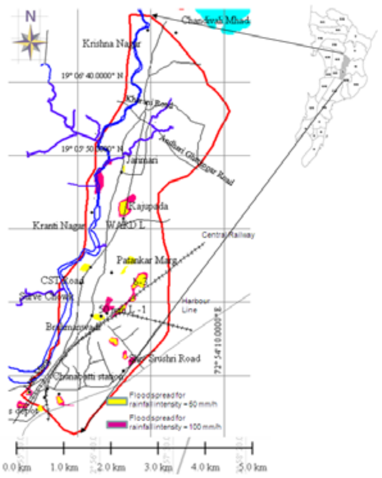

Fig. 1 Flood spread for rainfall intensity of 50 mm/h and 100 mm/h for L- Ward.

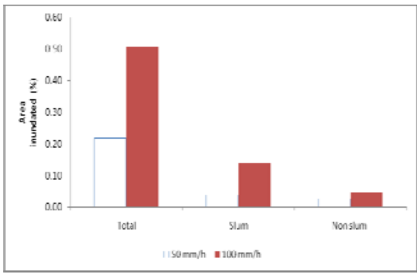

Fig. 2 Percentage of area inundated in L- Ward for rainfall of intensity of 50 mm/h and 100 mm/h.

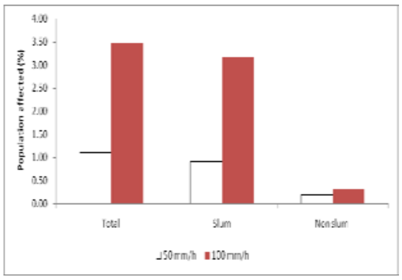

Fig. 3 Percentage of population in L- Ward affected due to rainfall of intensity of 50 mm/h and 100 mm/h.

FLOODS: EMERGENCY ACTION PLAN IN KOREA

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Many nations already made it mandatory to draw up some reports like a analysis of flood wave and a predicting map of flood caused by destroying dam to protect life, property and water structures because the damages caused by unexpected destroying water structures that store a lot of water like a dam or a reservoir is serious more than expectation. In Korea, establishing Emergency Action Plan(EAP) is also obligated.

The field of establishing EAP are followings: EAP for a possible collapse of dam or reservoir, EAP for a tsumani and EAP for an earthquake. Among them, we will introduce the establishing procedure of EAP plan assuming collapsibility of Imhadaem and Andongdam, both are located upstream of Nakdong river, and Taechongdam located upstream of Geum river. This is one of the most interesting case in Korea for the establishiment of EAP to prevent dam or reservoir collapse.

In Taechongdam, WMS model using GIS is used for calculating the amount of flood. DEM is created by vector of basin. We set up the possible virtual collapse scenarios in dam-site and then DAMBRK model from U.S National Weather Service is used for identifying electronic characteristics. The result forecasts changing value of flooding and water level in main points of downstream following the width and time of collapse. Flood area is set by TIN configured by using DEM on WMS and Arc-View, and then draw up the 2D and 3D map of flooding inundation. EAP is utilized for examining population in a expected flood area while destroying a dam and for calculating flooding elevation and times of flooding wave to reach each area. Shelters with drawing sheet about a expected flood area will be provided to quickly evacuate residents.

In Imhadaem and Andongdam, for setting virtual collapse area(width, time and side wall slope of collapse aspect), we use spec of those dam as basic and also refer to existing survey data. The inflow PMF curves for the virtual collapse of the runoff was derived. To calculate decreasing tendency of flood runoff, peak flow, highest flood level and flood wave arrive time occuring by flood wave propagation due to the virtual collapse, DAMBRK model is used. Flood attenuation characteristics are analyzed in regard to the collapse of a Imhadaem upstream runoff and downstream of the Nakdong River estuary for design flood conditions, the variation of the main point in the flood is probed and we consider Peak flow, high water, flood arrival time, the highest level and simulated time of occurrence by cases of extream flood collapse following each main points of downstream. The maximum possible flood was also created in conjunction with ArcGIS and ArcView as a appendix to the simulation results.

FLOOD CHARACTERISTICS AND MANAGEMENT IN THE LOESS PLATEAU OF CHINA

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Loess Plateau, the uniquephysiognomy unitscovering an area of about 640,000 km2, lies in arid and semiarid northern China and covers the drainage basins in the middle reaches of Yellow River. The Loess Plateau is well known to the world for its intense soil water erosion which is caused by flood and rainstorm.

Flood destroy the roadsand farmlands, and form the cavities in the Loess Plateau because of the collapsibility characteristics of loess, causing severe soil water erosion. The area with erosion modulus greater than 5,000t km-2a-1 covers about 145,000km2 in the region, being 37.1% of the Plateau's area; that greater than 10,000t km-2a-1 covers about 50,000km2, or 12.8% of the Plateau's area[1-3]. The silts which were eroded and carried from the Loess Plateau by flood accounts for more than 90 percent of the annual average silt rechargingto the Yellow River. The flood is great relative to the rainfall intensity, land coverage and human activities. With the climate change in the Loess Plateau, the uncertainty and potential risk of weather disaster and the paroxysmal rainstormis increasing [4-5]. In addition, with the development of urbanization in Loess Plateau, most of the rainwater-harvesting catchments were asphalted and extended. Consequently, the harms of flood have an increased tendency and influence not only on soil water erosion, but also regional economic development. Thus, it is very important to understand the flood characteristics and manage the flood to prevent severe soil water erosion and destruction of roads and building from flood.

In this paper, the spatial-temporal variations of rainstorm and flood occurring in the Loess Plateau were investigated on the basis of the observed data of daily precipitation at 50 stations for the period 1960 – 2010.The characteristics of flood induced by different precipitation and in different surface conditions were researched. The river sediment data observed from 9 main hydrological stations, such as lanzhou, toudaoguai, longmen, tongguan, sanmenxia, xiaolangdi, were analyzed. The relationship between land use change and river sediment carried by flood were also analyzed using GIS technology. Finally, strategies and measures to improve the conditions and decrease the flood were given.

According to the analyses results, the precipitation of rainstorm showed anincreasing trend in Loess Plateauin the past 50 years, though the annual precipitation has decreased.Thespatial distribution of rainstorm and flood showed an increasing tendency from northwest to southeast. The river sediment of 9 main hydrological stations is significantly correlative with the rainstorm and urbanization. More rainwater was harvested from the asphalted and extendedrainwater-harvesting catchments, resulting in intensive flood and severe soil water headward erosion of the gully, causing collapse of roads and farmland, and flooding the buildings of towns. The risk of flood and rainstorm has an increase trend in the Loess Plateau. In order to relief and prevent the harm from flood, it is urgent and necessary to build the flood management system. In addition, based on landforms and precise calculation of flow concentration, the projects of building minor dam and water-cellar in different branch of the catchments should be constructed, and the vegetation should be planted largely.

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ANALYSIS ON THE EFFECT OF DISASTER MANAGEMENT TAKEN AFTER RECORD RAINFALL IN SHINANOGAWA -RIVER

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Shinanogawa –River basin was hit by 1000mm -over rainfall caused by rainy season front in Jul. 2011. Quite serious flood damage has occurred, but the damage was minimized by structural and non – structural countermeasures installed after the record rainfall which hit same river basin just 7 years ago. This paper is the introduction of the disaster management countermeasures taken in Shinanogawa River basin, and flash report on the effect of disaster management including river improvement, river management, flood prevention and evacuation.

FLOOD VULNERABILITY OF KARUN RIVER SYSTEM AND THE SOLUTIONS

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Karun river basin in south west of Iran has accommodated a large number of hydro projects including reservoirs, hydropower plants (HPPs), water convey systems, and irrigation networks. Extreme floods of the basin not only have inundated the vulnerable areas but also devastated under construction dam site in few last years. Two extreme floods of 2006 and 2007 successively breached Karun4 cofferdam and wiped out under construction dam and HPP site. Since then structural and nonstructural approach was followed to reduce vulnerability of region in flood events. This paper discusses the events of 2006 and 2007 and introduces the structural and nonstructural solution which implemented in the basin in recent years. However, overtopable cofferdams in along with early flood forecasting system (EFFS) and emergency action plan (EAP) has been identified as the most adoptive solution for the basin. For instance, cofferdams of rehabilitated diversion systems and new projects are mostly armored soil or roller compact concrete (RCC) type. Implemented EFFS contains regional numerical weather forecast system, rainfall-runoff models, reservoir flood control simulation model, flood routing and two dimensional inundation models. Maximum lead time of forecast is 3 to 4.5 days depend on the location of the sites which is sufficient to evacuate the area and damage centers. Reliability and errors of forecast change with lead time, however, the average error has been less than 20% based on assessment of past 3 years results of the system. In addition to EFFS, EAP of dam break and flood events has been defined after determining potential damage areas and hazard zones in along with clarifying the responsibilities of the relative organizations. Meanwhile there was not reliable data for recoded damages, potential damages have been determined based on inundation depth, flow velocity, and properties of the region. However, EAP includes guidelines of warning for different hazards and accessing to safe zones as well as planning maps of surviving service.

COMMUNITY-BASED DISASTER PREPAREDNESS AND SOCIAL CAPITAL

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Japanese coastal areas are inherently vulnerable to typhoons and tsunamis, all the more so if they are rural. These areas have become increasingly vulnerable in recent years, in part due to social factors such as the aging of society and depopulation. Following the Kobe earthquake of 1995, the Japanese government promoted Voluntary Disaster Preparedness Organizations (VDPO) to help build communities that are more sustainable and resilient to natural disasters. However, studies indicate that VDPO activity has stagnated in some areas. The present study focuses on a specific rural coastal area in a remote region of Japan. It examines whether the presence or absence of a VDPO impacts residents' awareness of disaster preparedness, and examines ties among members of the community.

In particular, this study focuses on Tosashimizu city in Kochi prefecture, on the island of Shikoku. It is located about 170 km southwest of Kochi city, the prefecture's capitol.

The survey was conducted from July to August 2007. The questionnaire consists of two sections, which are divided into several parts.The *Residents' Awareness of Disaster Preparedness*section consists of the following four elements: "*Perception of Risk*," "*Preparation for Self-Help*," "*Perception of Mutual-Help*," *and "Changes through Participation in Evacuation Drills*."The other section consists of three elements regarding bonds in the community.

The questionnaire survey was conducted in July and August of 2007, and targeted residents of Tosashimizu city.The number of valid respondents was 447. Of these, 158 residents were identified as being "without" a VDPO in their community (Group A) and 289 residents were identified as having a VDPO in their community (Group B). The groups are compared using χ^2 tests to test for a general association among items (the level of statistical significance is 5% (0.05)).

Though there is no perception gap between Group A and Group B regarding floods, Group B does more self-help type preparation. In the *"Perception of Mutual-Help"* element,there is a statistically significantdifference in 17 of the 18 activities listed. In addition, the response by participants in the evacuation drill element implies that participation in evacuation drills might provide opportunities for residents to recognize the necessity of disaster preparedness as well as the existence of intra-community bonds.
With respect to these bonds in the community, Group B evaluates neighborhood associations positively. Further, Group B reports stronger community tiesrelative to Group A. This means that being active in the VDPO contributes to an increase in the sense of trust in their neighborhood association.

The results of this survey reveal that the presence of a VDPO contributes to improving residents' awareness of disaster preparedness (perception of risk, self-help, and mutual help), and that collective action through a VDPO contributes to deepening communal bonds. In light of these effects,how should VDPO activitiesbe promoted to build resilient communities? Let us take the example of two communities in Tosashimizu city. Shimokawaguchiura community and Kainokawagou community were greatly affected by a torrential downpour in 2001. The former had a VDPO, the latter did not. Different actions were subsequently taken by the communities during the catastrophic disaster of Typhoon 23 in 2004. A comparison of the two communities' actions (2004)suggests that VDPOscan be used both to generate a discussion about risk within a community (internal organization) and as a bridge to other stakeholders (external organization).
In addition, the residents in Shimokawaguchiura community have come to feel "bonds in the community". VDPOs appear to be an effective measure for enhancing a community's capacity for disaster response and bonds in the community.

INTEGRATED FLOOD EVACUATION SIMULATOR CONSIDERING TIME-SPACE DISTRIBUTIONS OF FLOOD RISK

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Floods continue to pose a major challenge in both advanced and developing countries. During the International Decade of Natural Disaster Reduction, from 1990 to 1999, the previous paradigm of flood protection was recognized as being not wholly appropriate. Absolute protection is both unachievable and unsustainable, because of high costs and inherent uncertainties. Therefore, a new paradigm of flood risk management has been recommended as being more suitable, and the new paradigm is now attracting attention.

Flood risk management includes flood prevention using hard defenses, but it also requires that society learn to live with floods, and that stakeholders living in flood-prone areas develop coping strategies to increase their resilience to the impact of floods. Thus, in accordance with the new paradigm, flood disasters are considered not only physical processes, but also as being equally shaped by socio-economic factors. When putting the new paradigm into practice, it is important to do so with the division of roles clearly define, involving the cooperation of self-, mutual-, and public-help efforts. There has been a significant shift in flood risk management, from a top-down decision-maker approach to a cooperative approach between local residents and government.

It is now widely recognized that flood risk communication among residents, regional communities, and administrative authorities is central to effective community based flood risk management. The representative tools of conventional flood risk communication are the publication anddissemination of flood hazard maps. Flood hazard maps are made as the maps that graphically provide informationon inundation, as well as evacuation in aneasy-to-understand format. Flood hazard maps arerecognized as instruments for disaster management in many countries. In Japan, the effectiveness offlood hazard maps was verified in August 1998, when a huge flood disaster occurred in KoriyamaCity,FukushimaPrefecture. According to the questionnaire survey conducted immediately after the flood,among the residents who evacuated, those who had read and understood the flood hazard map inadvance were 1.5 times greater in number, and they started to evacuate 1 hour earlier than theircounterparts who had not read the map. In the case of a flash flood, in particular, evacuation timingis very important because delays in evacuation could lead to fatal consequences. However, there arestill some problems with flood hazard maps related to community-based flood risk communication.

The aim of this study is aiming for developing an integrated flood evacuation simulator taking into account the time-space distributions of flood risk. The numerical simulations for Shirakawa river flooding were conducted using an unstructured grid model. The calculated time-series data for inundated water depth, flow velocity, and specific force per unit width were analyzed and their frequency distributions and probability density functions were obtained. The flood risk during the flood evacuation was performed using the threshold value of the specific force taking into account phase lag between inundated water depth and flow velocity. The flood risk map during flood evacuation by walk was proposed and examined.

TORRENTIAL RAIN DISASTERS AT AMAMI ISLAND ON OCTOBER 2010

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Inundation of river flow and sediment disasters due to the torrential rain at the Amami Island, Kagoshima, Japan at October, 20, 2010 cause 3 casualties and 485 total and half collapses of houses. 94% rivers in the island were flooded. Landslides and slope failures are occurred at 58 places such as Sumiyou in the central part of the Amami Island, and Tatsunogou in the north part of it. Length of the rivers in the Amami Island is very short. Hence, produced sediment was transported to coastal area rapidly. As a result, some sightseeing resources are damaged in the Sumiyou bay and the Tatsunogou bay; some parts of mangrove forests are lost and corals are filed with sediment. In this study, the torrential rain disasters at Amami Island on October 2010 are studied on the focus on sediment dynamic state and the disaster characteristics of islands in the subtropical region are discussed.

Stationary front which was affected by Tyhoon MEGI causes the torrential rain from October 18, 2010 to October 21. Precipitations are measured at Naze and Sumiyou. The distance between the cities is only about 15km, but the precipitation characteristics were different. The maximum precipitations at Naze and Sumiyou were 78mm and 131mm, respectively. The hyetograph has one large peak at Naze. However, the hyetograph at Sumiyou has two peaks. Cumulonimbus clouds due to the local ascending air current tend to be produced in subtropical Islands and cause the large spatiotemporal change of precipitation.

Mangrove forests were damaged along the outer banks of rivers. The mangroves were washed out under the two kinds of conditions. One is bank erosion. Another is the increase in drag force due to the accumulation of drift woods on the mangrove wood itself. The distance from the production area of the drift wood which is in mountainous area is short in the island. Hence a lot of drift woods are transported to the coastal area and increase the washout number of mangrove woods. Furthermore, a lot of coarse gravels were transported to the mangrove forestduring the heavy rain. In general, bed of mangrove habitat is composed of fine materials. Hence, it is considered that these coarse materials cause the transition of the vegetation type in the future. As a result, the area of the mangrove forest will be decreased. The transition of the vegetation type can be observed after some decades and tends to be neglected as a disaster.

The torrential rain disasters at Amami Island on October 2010 are studied on the focus on sediment dynamic state and the disasters characteristics of islands in the subtropical region are discussed. Characteristics of disasters in subtropical island, such as large spatiotemporal change of hyetograph and rapid sediment and drift woods runoff to the coastal area, are observed. Furthermore, the transition of the vegetation type is expected due to deposition of the coarse gravels. It is considered that we have to take care of these long term sediment disasters.

NEW APPROACHES TO FLOOD MANAGEMENT IN PAKISTAN

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Pakistan's climate varies from tropical to temperate with arid conditions existing in the South coastline characterized by a monsoon season (July to September every year) with sufficient rainfall and a dry season with lesser rainfall. Strategically it is located in a position between the important regions of South Asia, Central Asia and the Middle East. It is composed of seven administrative units (Gilgit-Baltistan, Federally Administered Tribal Areas, Khyber Pakhtoon Khawa, Punjab, Azad Jammu Kashmir, Sindh, Balochistan).

Floods in Pakistan have caused enormous damage over the time span. Flood problems differ greatly from one area to another depending on physiographic and hydrologic conditions. The most severe flood problems, however, occur generally in the flat plains of the Indus River Basin. Floods result from heavy monsoon season rainfall in the upper catchments of the tributary rivers, often augmented by snowmelt, the Arabian Sea Seasonal Low and the Mediterranean Sea Westerly Waves besides cloud bursts, flash floods, and artificial damming . In the Indus River Basin reoccurrence of floods of varying magnitudes is almost an annual feature. However some 17 high flood eventshave occurred since 1947 the year of independence. The recent floods of 2010 were the most devastating one in the living history of the region.
The total losses attributable to floods in the country have been estimated as about US$ 20 billion including over US $ 10 billion alone due to 2010 floods, while nearly 10,000 people lost their lives.

Traditionally flood management in Pakistan has mainly been focused on placement of river training works (embankments, spurs, dykes etc.) on the main Indus River and its tributaries with a specific purpose to stop river land erosion, loss of cropping land and river-side communities. Besides there exists flood forecasting and warning system primarily composed of two 10 CM QPM weather radars, five 5 CM weather surveillance radars, flood telemetry system and high frequency radio telecommunication system.

The 2010 monsoon rains coupled with western weather jet streams manifested occurrence of exceptionally high flash floods in upstream smaller river tributaries resulting in sporadic and unprecedented flooding in the main Indus River system with continuous influx of flashy flows from northern tributaries. Massive and continuous inflows consequently caused: major breaches in the river embankments, highlighted need of revisions in dam operation rules, inadequacy of accurate computerized flood forecasting, absence of last mile information dissemination and effective system to record discharges of secondary and tertiary rivers, complete absence of flash flood monitoring and now-casting system and dire necessity of urban flood control measures.

The prevailing flood management situation suggests the reality of adopting new approaches for effective, real time and more resilient flood management approaches with special emphasis on: effective River legislation to stop river course inhabitation by low lying communities, registering of discharges of secondary and tertiary rivers for improved main river system flood forecasting and warning, real time flood information dissemination from districts to the communities at Union Council levels, revisions in the dams operation rules, urgent measures to construct mega reservoirs to mitigate floods and to ensure greater water availability during water scarcity periods, immediate placement of flash flood guidance system in the upper provinces of Gilgit Baltistan, Khyber Pakhtookhawa including more 10 CM QPM weather radars, remote area flood discharges coverage by adequate provision of flood water gauges, coastal flood management through addition of weather radars in the provinces of Balochistan and Sindh, exhaustive construction of water diversion and water dispersion structures in the provinces of Balochistan and Punjab to account for the havocs created by the hill torrent floods, urban flood management in cities of Lahore, Peshawar, Karachi, Peshawar, Quetta, Hyderabad etc. including Kalpani and Deg Nullahs (streams) similar to the pattern of Islamabad-Rawalpindi Lai Nullah flood forecasting and warning system established through Japanese technology besides flood management education to the communities and students would be the hallmark of new approach to flood management in Pakistan.

INUNDATION ANALYSIS OF 2009 CHIKUSA RIVER FLOOD AND COMPARISON OF EVACUATION CRITERIA

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The Typhoon No.9 generated in the Pacific Ocean south of the HonshuIsland in August 2009 induced intensive rain throughout Japan and, as a result, many river basins flooded caused severe damage via inundation. The ChikusaRiver in HyogoPrefecture is one of such rivers suffered from extremely heavy rain in its central part; especially in Sayo-cho area the inundated flood claimed more than twenty lives. This is because of the record-breaking torrential rain with hourly rainfall intensity of 87mm and 327mm per 24 hours which is 1.75 times greater than the previous maximum record.

In the present study, we pay attention to two regions, Kuzaki district and the MakuyamaRiver area. The MakuyamaRiver is one of the small-scale upstream tributaries of the SayoRiver which a major branch river of the ChikusaRiver. Kuzaki district is located upstream of the confluence point of the ChikusaRiver and the SayoRiver. In Kuzaki district, most of the area was flooded due to a levee breach of the SayoRiver but with no casualties. On the other hand, in Makuyama district, there were more than eight casualties while they were evacuating towards the evacuation center during nighttime hours.

Firstly, to examine the difference of the two cases, we performed detailed inundation simulations using the Laser Profiler (LP) data obtained by the Kinki Regional Development Bureau as the information of ground topography. The LP data has a highest resolution of one meter. We applied two-dimensional inundation simulation models based on structured and unstructured grids. In the simulation of Kuzaki district, discharge hydrographs estimated from the gauging data of the Chikusa and Sayo Rivers are applied at the upstream ends of each river in the simulation range. Meanwhile, the discharge hydrograph of the MakuyamaRiver was estimated from a runoff analysis because gauging data is not available. The simulated data for the two cases can reproduce the elevation of various flood marks and the range of inundation. In addition, distribution of fluid forces acted on a person can be calculated from the local velocity distributions with a spatial resolution of about 1m.

Secondly, to examine the possibility of evacuation of a person through inundated flow situation, several criteria for walking difficulty proposed so far are compared in a form of water-depth versus velocity relation. Adding to the previous criteria, we proposed a new formula taking into account of the fluid force and compared it in a form of fluid force versus water-depth relationship. It was made clear that a limiting fluid force escapable from inundated flow is about 100N through a comparison of various formulae.

Finally, we can conclude from the simulation that the people who failed to evacuate should have subjected to the fluid force more than 100N and it must have been difficult to escape from the situation once being trapped into the local fast flow. In addition, the difference of the two cases can be attributed to the people's previous knowledge and experience of inundation in the local area.

EVER EXTREME 2010 FLOODS IN PAKISTAN AND THE LESSONS LEARNT

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Pakistan is facing many risks emanating from a number of natural and man-made hazards and flood is the most devastating natural disaster among these hazards. Floods have caused enormous losses to human lives, property, infrastructure, and has affected the overall economic growth in past six decades. The monsoon rainfall activity is normally significant in July - August, while the snow melt is highest in or before July. Difference is normally there in the timing of rain-fed and snowmelt flood peaks in the Indus Basin Rivers. Therefore, the peak flows on the various Indus Basin rivers do not synchronize generally and are often confined to one or two rivers only. Occasionally, however, flood peaks do synchronize, creating widespread flooding. During 2010-Floods also, flood wave of Indus River released from Tarbela Dam and the unprecedented flood wave of the Kabul River and its major tributaries (Swat, Panjkora rivers and other local nullahs) got superimposed which resulted in the exceptionally high floods situation in the River Indus all the way to the last control structure, i.e. Kotri Barrage.

The unprecedented rains in Pakistan during monsoon season 2010 caused countrywide massive and large scale flooding, which is being termed as the worst ever flooding in the living memory of the entire region. This was mainly on account of major and severe rain spells over Pakistan which had first hit country's southern Province of Balochistan in the third week of July 2010, followed by a second spell of very heavy monsoon rains over Khyber Pakhtunkhwa, in the last week of July 2010& in the first week of August 2010. These rains generated unprecedented flood flows in major, secondary and tertiary rivers including nullahs in Khyber Pakhtunkhwa followed by Punjab and Sindh.

The exceptionally high flood flows of 2010 caused extensive damages to the Irrigation, Drainage & Flood Protection Structures, besides other private as well as public sector infrastructure in the country. Floods affected an area of about 160,000 sq.km (one fifth of the country), claiming about 2,000 lives, damaging 1.6 million homes, wiping out cropped area of about 2,093,000 hectares and a population of about 20 million had been displaced.

Year 2010 has witnessed the significant increase in intensity & frequency of flood disasters in Pakistan. Ever extreme 2010 flood-event urges for devising more flood mitigation measures in order to minimize the anticipated losses in future. This paper expounds various aspects of flood management practices adopted by the flood related organizations during 2010-Floods in Pakistan including early flood forecast, flood risk assessment and other mitigation as well as adaptation measures in vulnerable areas. This is an excellent opportunity to share the experience of 2010 floods with international community and evolve strategies for integrated flood management approaches, with lessons learnt during 2010 floods, this paper also highlights future needs for a broader understanding of how we can collectively cope with flood risks and plan for and respond to flood events.

THE FLOOD CONTROL STUDY OF POYANG LAKE CONSIDERING THREE GORGES RESERVOIR OPERATIONS

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Operations of the Three Gorges Project has a potential impact on flood protection situation of Poyang Lake and Tail of the “five rivers”.In this paper, multidimensional Copula joint distribution function is used to establish the joint distribution and conditional probability distribution of the elements from hydrological system consist of “the Yangtze River−Poyang Lake−five rivers” before the Gorges Projectoperation, and then assumethe conditional distribution relations remain unchanged after the Three Gorges project operation; by analysing the probability distribution of hydrological elements of the Yangtze River after Three Gorges Projectoperation, with the conditional probability distribution , we can estimate the probability distribution of the study variablesafter the Three Gorges project operation ; comparison analysis of probability distribution of study variables before and after the change , we can assess the change of flood protection situation of the Poyang Lake and tail of the “five rivers”considering the Three Gorges Projectoperationformthe probability level. The results show that the change of thelakewater levelwas greater than thatof the"Five Rivers" tail,the pre-discharge of the Three Gorges in may and june will increasethe water levelof Poyang Lake, where the increase of the averagewater levelis greater thanthat of themaximum water level,and the low wateris greater than the highwater;Corresponding to Different water levels ,the change of "five rivers" tailwater level caused by the pre-discharge is almostno difference.

A CASE STUDY ABOUT THE INFLUENCE OF SMALL RETARDING BASINS ON FLASH FLOOD RETENTION IN HEADWATER AREAS – CENTRAL EUROPE

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The concept of decentralised flood protection measures is based on the idea to localize and use 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.

Due to the fact that common flood protection management mostly focuses on the downstream catchment regions the question arises if for headwater areas any opportunities exist to mitigate flash floods for example by implementing or using small retarding basins or ponds along the valleys of the headwater areas for a downstream flood protection.

The headwater areas of the Ore Mountains, a low mountain range in south-eastern Germany, are often one agent triggering flash floods in downstream valleys since precipitation is distributed over large areas of the upper sub-catchments before the run off concentrates in the steep receiving water courses.

Against the background of severe damages on infrastructure and buildings caused by flash floods in that region in the past the hydrological effect of small retarding basins on flood generation was analysed for the case study of the Natzschung creek. The rainfall-runoff simulation was operated with the software package NASIM. As one result the analysis of calculated scenarios indicates that the use of those small basins has a distinct and also local impact on the reduction and time shift of peak discharge. The results of this case study will show the opportunities and limitations of this concept.

DEPRESSION FILLING AND PARTITIONING PROCESSING FORDIGITAL ELEVATION DATASET

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A digital elevation model (DEM)—composed of depression fillings, flow directions, and flow accumulations—is usually used to extract watershed geomorphologic parameters in hydrological analyses. With the development of aerial surveying and remote sensing techniques, the resolution of the DEM dataset has been evolved from 40m×40m to 5m×5m or even more fine-grid; the high-resolution data can show a detailed description for the landscape of terrain. However, the dataset of 5m×5m is 64 times in size that of 40m×40m— resulting in a poor performance of the algorithm proposed by Jenson and Domingue (1988), the analytical procedure most widely applied currently.

A Personal Computer is generally incapable of handling a high-resolution DEM dataset of large size; there being a systematic processing developed through repeatedly “partitioning” and “assembling” the data not presented in previous studies. When the algorithm of partition is applied, the digital elevation data are divided into a few parts, each of which is processed within the DEM; subsequently, all parts of the data are assembled to an intact one for junctions.

To analyze the high-resolution DEM dataset efficiently, this study develops a package of new algorithms. The algorithm for depression fillings is applied repeatedly to detect the new cell code and the change of cell elevation. The algorithm for flow directions, then, is applied to individual cells, which can be divided into “normal cells,” and “flat areas”. In the former, water will flow to the cell that has maximum distance-weighted drops in eight neighboring cells; in the latter, the dilation algorithm is employed to determine the flow direction. Lastly, to accumulate the flow of cells, which a traditional DEM cannot run efficiently, we present an algorithm with the concept that water flows from a high place to a lower place to calculate the flow accumulation number. The application of the whole package of algorithms takes only one percent time; the DEM proposed in this study, comparing to a traditional one, can evidently promotes the efficiency of the analytical procedure.

Moreover, the high resolution DEM dataset was used to delineate the inundation regions under extreme rainfall conditions directly, which is based on the characteristics of the determined depression cells and their surrounding cells to alleviate lots of computation time required in performing a conventional 2-D inundation model.

FLOOD EARLY WARNING SYSTEM: SENSORS AND INTERNET

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We present the UrbanFlood flood early warning system (EWS): a system that monitors data from sensor networks in flood defenses (embankments, dikes, levees, dams, etc.), detects sensor signal abnormalities using artificial intelligence, calculates dike failure probability given the actual dike strength and load, and models scenarios of dike breaching, the resulting hydrograph and flood spreading and characteristics in near real time.

The relevant information and model simulation results are used in an interactive decision support system that assists dike managers and public authorities in makingtheir often difficult decisions during flood events. It reduces uncertainties and offers relevant information through an accessible map-based interface residing on a multi-touch table, suitable for use by multi-person emergency units.'What-if' scenarios are easily set up and quickly calculated, while access to libraries of pre-calculated detailed flood scenarios is provided for reference and comparison. The EWS will also offer an on-line 'dashboard' giving access to a selection of the functionality.

The system will be designed to also support dike managers in routine dike quality assessment and management. In this way it supports an important part of their responsibilities and becomes an integral part of the daily work, which ensures that staff members have the necessary routine and practice to use the EWS effectively and with confidence whenever infrequent flood emergencies occur.

The flood EWS is built on a generic Internet based EWS, and able to use virtually all types of digital (sensor) information. It can run computational demanding applications like near real time (flood) modeling in the 'cloud', allocating computational resources according to priority and requirements. For dependable use during flood emergencies the right combination of its advanced Internet computing options and the robustness and reliability of running parts of the system on traditional local computing resources clearly needs to be deployed.

For advanced research into dike stability and failure mechanisms and for training the EWS artificial intelligence module on signals related to dike instability a Virtual Dike computational module has been developed.

This paper describes the UrbanFlood EWS design and functionality,the main stakeholder requirements, the workflow, the individual modules and their integration and the first results of EWS monitoring and performance benchmarks. It also describes the pilot sensor network installations in the Netherlands and in the UK.

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ASSESSMENT OF RAINSTORM CLIMATE RISK AND RAINSTORM-INDUCED AGRICULTURAL DISASTERS RISK IN EAST-CENTRAL CHINA

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Using the 1961-2008 climatic observation data from 292 meteorological stations in east-central Chinaand thehistorical information about the agriculture disaster of each province in east-central China, an climatic risk index and a relative disaster index of heavy rain and their risk evaluation modelwere constructed by principal component analysis, soft histogramestimation, grey relational, normal information diffusion to analysis rainstorm climatic risk and agriculture relative disaster risk. The results show that the distribution of rainstormclimatic risk take on decreasing tendency from south to north in the study area, and the high value area almost is Hainan, Guangdong ,Guangxi province in southeast coastal area of China, secondly is Guangdong and Guangxi province north-central, Anhui, Hubei province inJianghuai Region and the middle region in Hunan province. The low value area is Northeast China except coastal area in Liaoning province and Shanxi, Hebei province in North China. The high value area of relative disaster risk is Anhui, Hubei, Hunan and Guangdong province, and the low value area is Hebei, Henan, Liaoning province. Except Guangdong province, the correlation coefficient between the rainstorm climatic index and the relative disaster index for each typical province is above 0.6 and pass the 0.01 confident level. Combining with actual disaster verified for years, rainstorm climatic risk index and relative disaster index could respectively better assess actual rainstorm strength and the possible agriculture loss degree affected by rainstorm.

FLOOD HAZARD MAPPING AND ASSESSING USING RADARSAT REMOTE SENSING AND GIS

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Remote sensing is the science and art of obtaining information about an object or phenomenon through the analysis of data acquired by a device that is not in contact with the object or phenomenon under investigation. This study examined large inundation areas in the MaghnaRiver Basin, around the northeastern Bangladesh, as determined from passive sensor LANDSAT data and the cloud-penetrating capabilities of the active sensors of the remote imaging microwave RADARSAT. This study also used passive sensor LANDSAT wet and dry images for the year 2000. Spatial resolution was 30 m by 30 m for comparisons of the inundation area with RADARSAT images. RADARSAT images with spatial resolution of 50 m by 50 m were used for frequency analysis of floods from 2000 to 2004. Time series images for 2004 were also used. RADARSAT remote sensing data, GIS data, and ground data were used for the purpose of flood monitoring, mapping and assessing. A supervised classification technique was used for this processing. They were processed for creating a maximum water extent map and for estimating inundation areas. The results of this study indicated that the maximum extent of the inundation area as estimated using RADARSAT satellite imaging was about 29, 900.72 km2 in 2004, which corresponded well with the heavy rainfall around northeast region, as seen at the Bhairab Bazar station and with the highest water level of the Ganges–Brahmaputra–Meghna (GBM) Rivers.

A composite of 5 years of RADARSAT inundation maps from 2000 to 2004, GIS data, and damage data, was used to create unique flood hazard maps. Using the damage data for 2004 and the GIS data, a set of damage maps was also created. These maps are expected to be useful for future planning and flood disaster management. Thus, it has been demonstrated that RADARSAT imaging data acquired over the Bangladesh have the ability to precisely assess and clarify inundation areas allowing for successful flood monitoring, mapping and disaster management.

The main objective of this study was to demonstrate the capability and usefulness the RADARSAT remote sensing and GIS for early identifying the potential inundation area, which in turn will allow flood forecasting and warning center to identify regions of flooding. It can be deduced that RADARSAT data is acquired over the northeast region. It is revealed that very often and in all kinds of weather condition, RADARSAT satellite provides images data. Consequently, the results presented in this paper suggested that the RADARSAT image data provide useful information for flood hazard mapping the extent of inundation around northeast region.

Therefore, we can conclude that the RADARSAT data have the ability to clarify questions relating to the inundation area, flood monitoring, mapping, and assessing. For the inundation areas and for the severity of flood damage, the RADARSAT data can be objectively mapped. Thus, this study clearly demonstrated that the impact that RADARSAT satellite-based measurements of water body in conjunction with ground data generate confidence that the results are useful for flood disaster management. Finally, the results achieved here could also be expected to be very useful for flood disaster management, and hazard mapping services, which may reduce the cost of a general survey.

INFLUENCE OF DETAILED TOPOGRAPHY WHEN MODELING FLOWS IN STREET JUNCTION DURING URBAN FLOODING

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When flooding occurs in an urban area, most of the water flows in the street network. Crossroads play a major role in urban flood dynamics: they govern the flow distribution to the downstream streets and the flow regime in the upstream streets. When modeling urban flooding, it is thus important to compute with accuracy flow pattern in each crossroad, as well as to estimate the related uncertainty. Moreover, the representation of the domain is usually extremely simplified and details of the street topography are usually neglected (sidewalks, obstacles, façade irregularities etc…). Indeed, measuring and including such topographical details in the numerical mesh is time-consuming and should be considered only if the computed flow pattern is noticeably improved. We thus aim at studying the impact of the local topographical details on the junction flow in order to assess of their importance for urban flooding management.

In this study, flows in crossroads are studied with both experimental and numerical approaches. Experiments are performed on a 90° junction of two inlet and one outlet horizontal glass channels, 0.3 m wide and 2 m long each. The three controlled parameters are the flow-rate entering each inlet and the water depth at the downstream section of the outlet. LSPIV (Large Scale Particle Image Velocimetry) and ADV (Acoustic Doppler Velocimeter) measurements allow a fine description of the flow at the free-surface and within the water column. The same flow configurations are computed using a 2D shallow-water equation numerical model to validate the use of such model for urban flooding simulations and to assess the resulting uncertainties.

Both experimental and numerical data result in a fine description of the flow pattern which is consistent with the literature. A stagnation area appears on the upstream corner of the junction, which limits the width of the lateral branch flow when entering the junction. A mixing layer is observed within the junction at the frontier between both inflows. Finally, a recirculation zone is observed just downstream of the junction along the lateral side wall, which accelerates the flow in the contracted section along opposite side wall.

A reference flow configuration is extensively measured experimentally and serves as calibration data for the 2D model. The model shows a good agreement with experimental data, provided that appropriate turbulence diffusion coefficient is selected. The impact of sidewalks and generic obstacles (representing possible bus-stops, stores etc…) on the flow is then studied numerically for different flow configurations. The presence of sidewalks mainly affects the recirculation area (the width of this area increases about 20 % for a 6 cm by 2 cm sidewalk) and can increase local velocities in the contracted zone (up to 10% for the same sidewalk). Their influence remains limited but can grow with other flow configurations, especially for lower water depths. On the other hand, inserting generic obstacles strongly affects the flow pattern, which can results in significant differences in the velocity field.

MONITORING AND FORECASTING GLACIER DAMMED LAKE OUTBURST FLOODS IN THE UPPER YARKAND RIVER, CHINA-KARAKORAM

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Abstract :Glacier dammed lakes play a prominent role in both the landscape-shaping and flood processes of the Karakoram. Glacier dammed lake outburst floods (GLOFs) have been a source of many local and some regional disasters and remain a serious hazard. Hydrological records at the downstream gauging station on the Yarkand River in the China-Karakoram show that GLOFs now frequently repeat from the glacier lakes 500 km upstream, after being inactive for 10 years (1987-1996). This paper proposes a method tomonitor and forecast a huge glacier dammed lake and its outburst flood using imagery of China Environment and Hazard Monitoring Satellite (HJ1)with 30m resolutionand a period of every 2 days in summer of 2009 and 2010. The lake change and a great surge of its dam were observed at the upper side of the damming glacier during Mayto July and August 2009 respectively, with 2500m of maximum surge distance and water volume of51 x10^6 m^3, but a small flood recorded at the gauge stations along the downstream, the former is first finding of glacier surge in China-Karakoram and the latter does not exceed the potential capacity of the glacier lake estimated on images. Repeated damming, caused by glacier advances at the lake basins, and the increasing number of GLOFs results from the ice dam's thinning about 20m than that in 2002. Growing glacier and the dam surge in 2009 suggests that a potential huge dammed lake and GLOF will be like near future.

COMPARISON OF STRATEGIES USED TO MAP RIVERINE FLOODING: THE TOWN OF FISLIS, IN FRANCE, AS A CASE STUDY

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Flood risk is the major natural hazard in the world, and in France. Flood hazard maps are the principal base for studies related to flood control and management. For better decision-making process, better understanding on the flood phenomenon is required. Uncertainties in flood maps can generate several losses in terms of flood management. Several studies have been carried out in order to study uncertainties in hydraulic modeling and hazard mapping. This concern have also induced different institutions to investigate the quality of flood mapping, e.g. the Federal Emergency Management Agency's Map Modernization Program in U.S. and the EU Floods Directive 2007/60/EC. Topography is considered the most important source of uncertainty contributing to the overall mapping uncertainties. However, the choice of what kind of hydraulic model that should be used for different purposes is still vague. Another source of uncertainty is linked to the human-factor uncertainty behind modeling processes. This concern is less discussed in literature.

This study focuses on the comparison of different strategies used to model riverine flooding. The differences between strategies consist of two aspects of the modeling process: (1) the type of hydrodynamic model used to simulate flood events (1D, 1D/2D or 2D models) and (2) the choices made by the modeler when representing the geometry, bathymetry and topography of the studied system (cross-sections for 1D and 1D/2D models and grid resolution for 1D/2D and 2D models). Our main objective is to identify how hazard maps can be affected by strategic choices in the hydrodynamic modeling process. With this purpose, we compare hazard maps based on different modelling approaches in terms of: flood extent boundaries and water depth distributions.

In order to compare the strategies used to model floods, we built several modelling scenarios using different hydrodynamic models and different geometry and topography considerations when building the flood scenarios. HEC-RAS 4.1 (U.S. Army Corps of Engineers) was used for accomplishing 1D simulations, and MIKE by DHI Group for 2D simulations (MIKE 21) and coupled 1D/2D simulations (MIKE FLOOD). This comparison is based on a real case study: the town of Fislis, in eastern France. A digital elevation model with 0.5 m horizontal and 0.2 altimetric precision; and results of field measures for structures and bathymetry were used for constructing the different models.

The flood hazard maps produced using the different strategies to simulate floods show us the relevance of this concern. The choice of the scale is determinant for the flood hazard maps construction. However, the choices made by the modeler when describing geometry and topography of the models also play an important role on the final result of the simulation. Several criteria should be studied before making these choices, including technical capacity of dealing with them. Data and resource availability as well as theirs quality can be determinant to the way the model is built.

DAMAGE AND RECOVERY FROM TYPHOON DISASTER IN PHILIPPINES 2009

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Luzon Island in Philippines was suffered by two continuous tremendous typhoon disasters in 2009.

Tropical Storm Ketsana, called Ondoy in Philippines, dumped huge amount of rainfall, such as 92mm in one hour and 512mm in one day on September 26 in Science Garden gauging point in Quezon city. Almost 500 people died and 4.2 billion Philippine Pesos of public damage were estimated. The most severe aspect of the disaster was that Metro Manila that is the population and economic center of Philippines was severely damaged.

Typhoon Parma, called Pepeng in Philippines, hit on the northern part of Luzon Island several times from the end of September to the beginning of Octobar. Agno river basin that is the main agricultural area in Philippines was damaged because more than 6000 m^3/s of discharge run over the Agno river where the capacity of discharge was 2,340 m^3/s.

The Tropical Storm Ketsuana revealed the vulnerability of Metro Manila. Both sides of bank of Mangahan flood way that diverted the flood from the Marikina River to Laguna de Bay have been occupied by unauthorized settlers. It reduced the effective width of the river. Evacuation shelters were provided by the government. However, many amounts of evacuation reliefs were seized by less damaged people during the delivery, according to the interview. At an evacuation shelter which was originally built for Basket court, privacy and sanitation were less cared. For example, people had to stay with coffins. Some infection diseases were worried to spread. Neverthless the outbreak did not happen. On the other hand, rapid growth of population and development of river side areas increased the amount of damage.

Dam operation during Typhoon Parma was strongly discussed after the Typhoon Parma disaster. San Rouque Dam was located at the upper stream of the Agno river. The dam stored the water at the first strike of the typhoon. However, the typhoon moved in an irregular path, and it hit the Luzon Island three times. Therefore, the dam did not have an enough capacity to reduce the discharge of the second and third strike of the typhoon. The dam released almost 6000m3/s during the peak time. It also was affected by the communication network among National Power Corporation (NPC), Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA), and dam operating company.

The community action was wonderfully operated in the rural area. In Philippines, there are several levels of government. The bottom level, neighborhood self-governing body is called “barangay” in Philippines. There are several evacuation shelters, which are usually used as play field and wedding party holl. Before the inundation happened, barangay captain received the evacuation order from municipal government, and they led the villagers to the shelters. These strong communities decreased the casualties.

At the conference, detailed explanation of the disasters as well as the effect of climate variability is discussed.

FLOOD DAMAGE MODELLING ON A GLOBAL SCALE: EXPOSURE AND TRENDS, 1970 - 2050

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Flood damage modelling has traditionally been limited to the local, regional or national scale. Recent flood events, population growth and climate change concerns have increased the need for global methods with both spatial and temporal dynamics. This paper presents a first global estimation of exposure to river flooding for the period 1970 - 2050, using existing flood extent data and two different methods for damage calculation. The first method is based on population data and the second is based on land-use data.

The population based method of damage estimation is based on a combination of population density data and national income per capita. By analysing the population living in flood prone areas on a country basis, taking into account their normalised average income per capita, we calculated the assets at risk over time. Extrapolation to 2050 was carried out using population growth and GDP per capita forecasts. The highest exposure values in 2010 are in China and the United States, with ca. 10 trillion and 0.8 trillion USD assets exposed to river flooding, respectively. In terms of assets per capita in 2010, the highest exposure is in the Netherlands and Austria, averaging 70,000 and 42,000 USD per capita respectively. Towards 2050 we see a strong geographical shift, with India taking over second place in terms of total exposed assets and Russia following the Netherlands in per-capita exposure.

The land-use based method of damage estimation assesses the area of urban development within flood prone areas over time. For each country, this urban area is multiplied by a GDP-normalised damage estimation, derived from existing depth-damage relationships and assuming maximum inundation levels. Extrapolation to 2050 is carried out using scenarios of GDP per capita, total population growth and changes in relative urbanisation. Total estimated maximum damage in 2010 is highest in the United States, followed by Germany (2 trillion and 0.2 trillion USD, respectively). On a per capita basis exposure is again the highest in the United States (55,000 USD), followed by the Netherlands (46,000 USD).

More important than the absolute estimates are the changes of exposed population and assets over time. The largest absolute exposure changes between 1970 and 2010 are found in the United States, India and China. In relative terms we the largest increases are in the Middle East and Sub-Saharan Africa, where exposed population growth is often 120% - 160% of total population change.

Over the period 1970 to 2010 the damage estimates derived from the two methods are very close to each other. Towards 2050 the gap is expected to grow, whereby the results of the population-based approach are in general higher than the estimates from the land-use method. Recommendations are made for future research, both in terms of the use of flood prone areas and damage estimates.

THE GLACIER LAKE OUTBURST FLOOD IN HIMALAY : A CASE STUDY OF TAM POKAHRI GLACIER LAKE OUTBURST FLOOD IN THE INKHU VALLEY EASTERN NEPAL .

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The Glacier Lake Outburst Flood (GLOF) is the phenomena constituting a sudden breach Glacier lake and discharging huge volume of water and debris flow in short time affecting catastrophic flooding to downstream devastating property, agricultural lands, eco-systems, Socio-economic infrastructure/assests. The hydrological regime of the basin could change, with increased frequency of floods and draughts.

There are 3252 glaciers in Nepal covering a total area of 5323 sq. km. The Nepalese glaciers provide good opportunity to study the impact of global climate change in this region. In Nepal, Glacier study in a regular basis started in early-1970s. There are 2315 glacier lakes of varies sizes, the total area of which is 75 sq. km. The formation and growth of glacier lakes is a phenomenon closely related to the deglaciation in Nepal .Nepal has experienced more than a dozen GLOFs in the past.

Tam Pokhari Glacier Lake is located in the upstream of the Inkhu Khola in the Solukhumbu district of Sagarmatha zone, Nepal. The Tam Phokari GLOF of Inkhu valley occurred on September 3, 1998 and discharging about 18 Million Cubic Meters of water in the Inkhu Khola due to ice avalanche. The Tam Pokhari GLOF caused few human casualties and serious destruction in the agricultural land and infrastructure such as houses, bridges, trails and hydro met stations in the downstream. The stream bed level of Inkhu khola and Dudh Khosi River is raised due to sediment deposition and river bank erosion.

PAKISTAN FLOODS 2010: AN INSIGHT INTO CAUSAL EFFECT RELATIONSHIP

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Pakistan lies on the forefront of world's most disaster prone region; the Asia Pacific, where 40% of globe's natural catastrophes occur annually. Trends reveal that frequency of natural hazards and consequent disasters is readily increasing. Pakistan, prone to almost any species of hazard that takes place across the globe, has been hit the worst by floods in its short history. Since its independence, it has witnessed 17 major floods, the worst of which is Floods 2010. This paper describes how the Floods 2010 has been caused by a number of meteorological factors exacerbated by momentous anthropogenic factors, combination of which had never been seen before. Prominent amongst the causal factors are formation of Omega Block at Ural Mountains of Russia and consequent movement of active jet stream into the western parts of Pakistan, rapid development of La-Nina cycle, and redistribution of concentrated rainfall away from Punjab towards Khyber Pakhtunkhwa. The unusual high rainfall caused flashfloods in the western tributaries of the Indus, which ultimately led into the worst-ever river flooding in the mighty Indus. Besides this, anthropogenic aspects have served as intensifying factors, significant of which are encroachments in downstream river causing increased level of vulnerability; narrowing down of water channels and other dry torrents; rapid deforestation followed by slope instability and landslide issue; lack of appropriate early forecast and warning dissemination system; and inadequate coordination amongst the key stakeholders.

The paper also gives an insight into the damages caused by this unforgettable deluge. The damages of Floods 2010 stretched to an area of more than a hundred thousand sq.km victimizing 78 out of 141 districts of Pakistan. Around 21 million people have been affected by this worst inundation, which is almost one-tenth of the total population. Economic damages worth US$9.5 billion have been recorded, which is approximately one quarter of financial outlay for 2010-11 and 5.8% of nation's GDP. The worst affected sector by floods has been agriculture in the aftermath of this catastrophe. As a result of these unprecedented floods, a number of macroeconomic indicators have been set back. Country's fiscal deficit and balance of payment deficit are expected to rise. In addition to this a decline in GDP growth and industrial slowdown are anticipated. Apart from this, Floods 2010 has already implied a negative impact on labour market, which may lead into a probable issue of food security. This paper is divided into four sections. The first section, gives an idea about the disaster trends across the globe in general and Pakistan in particular. Section two addresses the causes of Floods 2010, followed by third section of the paper, which sheds light on extensive damages caused by the floods. Recommendations and conclusion follow the fourth section, which describes the reconstruction strategy and humanitarian response in perspective of Floods 2010.

EXPERIENCE OF TYPHOON MORAKOT RECOVERY AT TAIWAN

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Taiwan hit by a huge disaster by Typhoon Morakot two years ago. Southern part of Taiwan sustained heavy losses, yet the resilience and soft power of Taiwan have also become even stronger as a response. Governmental departments and different social firms spared no efforts in the rescue, restoration, and reconstruction efforts for minimizing the damages. A reconstruction council was established soon after the incident. Special Act and funding of 116 billion NTD was approved almost without any boycott at the Legislative Yuan in the mean while.

More than 30 commissioners participates Reconstruction Council those from the administrative departments, experts and scholars, civil groups, officials in the counties and cities suffered by the disaster, representatives of victims, and representatives of aboriginal groups. At the end of first year after the disaster, 1600 permanent houses have been completed that benefit 4000 individuals. On the infrastructure, six major road systems totaling 653 km and eight loop railway tracks have been restored. In terms of economical restoration, plants and agricultural production has been restored more than 80%. Related departments are also assisting in the promotion of the restoration of the culture, life, and industries in the permanent-housing communities and regulated supplementary industrial and tourism packages in the wish of achieving sustainable communities and economic recoveries in the disaster areas.

Reconstruction plan is implemented in three levels: the Regional Reconstruction Master Plan, Departmental Reconstruction Plan, and Local Reconstruction Plan. With the Regional Reconstruction Master Plan being the policy guideline under the premise of conserving national land, related central government agencies should follow it to propose approaches and plans to implement the reconstruction in the three phases of “Infrastructure Reconstruction,” “Community Reconstruction,” and “Industry Reconstruction.” Local governments, on the other hand, may divide disaster areas into several reconstruction separate sections and propose and implement individual reconstruction plans for those sections.

The reconstruction effort is a race against time as many projects must be completed before the season of floods, plum rain, and unpredictable typhoons. The disaster also made the government realize the importance of teaching the public about disaster prevention, minimization, and preparation as the power of nature should never be underestimated. However, regarding those living in hazardous areas and not willing to relocate, the governmental firms will take the "pre-emptive preparation and 24-hour standby" measures once the government announces any disaster alarms.

This paper intends to review and share the experience for disaster recovering for such a tremendous catastrophe. Setting up reconstruction council is introduced at first, and coordination of governmental and NGO’s resources is discussed at the second part. Victim’s consociation is also the main work since people expects to speak out their mind and no one dares to stop it. Finally, we know that reconstruction is only not an engineering process; it might be more likely a new town planning with many investors having different opinions. Most of the precious records to complete the reconstruction work will be summarized by categories as engineering, finance, administration, cultural etc. at the end of this paper.

SOCIAL NETWORKS IN TIMES OF DISASTER

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This paper presents an analysis of a case study of the emergency responses, public as well as governmental, during the Queensland Flood in Australia. Significant flooding occurred in many areas of Queensland during late December 2010 and early January 2011, with three quarters of the state declared a disaster zone and 35 deadly victims. The floods forced the evacuation of thousands of people from towns and cities. In Brisbane and surroundings, the community responded immediately and effective: circa 60.000 volunteers made their way to the city of Brisbane to help cleaning up. Obviously this would logistically have wheeled out of control without an adequate response of the government officials. But people were well informed; using modern technologies like Twitter and the interactive floodmaps on the website of the Brisbane City Council.

The guiding research question for this study was “How to identify the informal dynamics of social (flood) resilience of a community, and nurture and enhance those in a coherent and potentially even institutionalized manner”. Since the course of events during the flood response in South East Queensland was largely influenced by (informal) community action and the dynamics of social media, this case study contributes to our general understanding of informal, social (flood) resilience in a modern, developed, society.

Members of the public were already known to improvise in disaster situations, and to be able to, for instance, take ad hoc responsibility for leading important rescue and relief activities (Tierney, et al. 2001; Kendra and Wachtendorf, 2003; Palen and Liu, 2007). And (in)formal social networks have always been important for finding and providing information outside the official response effort (Stutton et all, 2008). But the fact that nowadays, due to modern media, these social networks are more noticeable, better organized and may be even larger than before, gives a whole new perspective on the potential of these networks and the usability of community actions in the realm of formal governance.

The Queensland study is build around the definition of social resilience as the ability of communities to recover from shocks to their social infrastructure. Resilience can be measured in terms of the time it takes the community to respond to the event, self organize and incorporate the lessons learned. Using this conceptualization, the demonstrated resilience of different communities during the flood, can be quantified. The activities in the selected communities before, during and after the flood disaster are studied and analyzed to quantify their shown resilience and to measure their performance on other characteristics that are known to enhance social resilience. The analysis shows in what extend the use of social media catalyses these network characteristics and how social resilience can be enhanced or nurtured through governmental channels. The results of this study add to existing knowledge on the dynamics of public participation and interactive governance. Connecting interactive governance to social resilience has not been done before. It provides essential insights in how environmental influences can determine the outcome of governance processes and on how the existing models perform under pressure.

OPTIMAL URBAN FLOOD MANAGEMENT USING SPATIAL MULTI-CRITERIA DECISION MAKING APPROACH

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Water management in urban areas is including wastewater control and modification of drainage systems. The rapid growth of cities with their population increasing has many problems in the management of runoff during flood events.

High-intensity rainfall, reduced permeability due to urban development and old drainage systems existence, are the main reasons for the occurrence of floods in urban areas. Regarding the mentioned issues, the maps indicate the areas with high flood potential; can be the appropriate tool for urban planning in the future. Vulnerability Analysis in different areas of urban environment is a complex process because it depends on several spatial and temporal parameters and criteria.

The purpose of this paper is to prepare flood hazard maps to determine more accurate decisions in urban flood management, using a combination of Multi-Criteria Decision Making and Geographic Information System as a Decision Support System.

In this paper, the following objectives have been considered. 1) Evaluate the flood potential in different urban areas which lack primary information. 2) Evaluate the spatial multi criteria decision making model using the capability of spatial modeling by intelligent models like Artificial Neural Networks. 3) Assessment the suitability of the proposed routes in order to collect urban runoff in high hazard areas.

In order to generate criterion and final hazard maps, a new toolbox is produced in Arc GIS 9.3 software environment. In this Toolbox, all data, input variables, necessary processing on these variables, selected multi criteria decision-making approach which includes the production of the main criteria, sub criteria and weighting them, is included.

Also sensitivity analysis is implemented based on the generation of weighting scenarios with producing flood hazard maps that has been done in the several runs of model.

RECENT EXAMPLES OF FLOOD RISK MANAGEMENT IN THE UNITED STATES

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The last several years have seemed to have a particularly high number of natural disasters worldwide. The United States has not been immune from this disaster activity. In particular, there have been a number of significant and highly publicized flood events in the United States in recent years. These events have required the United States, particularly the United States Corps of Engineers (USACE), to reconsider their approach to flood risk management.

This presentation will provide case studies of some of the significant and widely publicized flood events that have occurred in the United States in recent years. One of these case studies will focus on the flooding in 2005 caused by Hurricane Katrina in New Orleans, Louisiana, and other regions in the along the Gulf of Mexico. Hurricane Katrina and the resultant flooding was a disaster for the city of New Orleans, resulting in massive damage and over 1800 deaths. The city was “protected” by levees, floodwalls, and pump stations, but many problems with the performance of this system surfaced during Hurricane Katrina. First, these levees and floodwalls did not actually perform as a system. The water overtopped many levees and floodwalls, which is not an outright failure, but this did result in erosion and collapse of many of the structures that were supposed to provide protection. Thus, USACE reconsidered the design of floodwalls and levees, and adopted a design that was believed to be more secure. USACE also undertook an extensive construction effort to provide 100-year protection to the city, which was completed in June 2011.

Another case study will examine flooding at the confluence of the Mississippi and Ohio Rivers in April 2011. Due to the magnitude of the flood hazard in this case, USACE considered intentionally breaching approximately two miles of levees to reduce the threat of flooding to downstream urban areas and to prevent a potentially catastrophic overtopping event. Breaching the levee would flood approximately 140,000 acres of farmland located in the floodway. Though USACE has the authority to operate this floodway in this manner, they have not done so since 1937. Thus, there was significant public backlash over the plan, including a lawsuit filed against USACE by the state of Missouri. The results of this flood event, and any changes made to USACE procedures for operating levees to avoid catastrophic overtopping during flood events, will be discussed in this presentation.

The spring 2011 flood season promises to be quite significant. Many watersheds are saturated by previous rainfall and snowmelt, and many areas of the country have received significantly more rainfall and snowmelt than typical. It is possible that further case studies will also be developed and presented based on events that occur over the next few weeks.

Parallel Oral Sessions

Topic 5

Cross-cutting and other topics

- Flood risk index (assessment and indicators of exposure, vulnerability and capacity)
- Integrated flood management approaches
- Uncertainty analysis and management
- Role of training, information networking and public awareness
- Tsunami Hazard Map
- International cooperation and assistance
- Indigenous flood management knowledge

OVERCOMING OBSTACLES TO INTEGRATED FLOOD MANAGEMENT: A CASE STUDY OF THE COWICHANVALLEY, BRITISH COLUMBIA, CANADA

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Given the weaknesses of traditional flood protection, a better practice is Integrated Flood Management (IFM). This method adopts a basin-wide, multidisciplinary approach to flood management that maximises the net benefits from floodplain areas while reducing vulnerability and risks due to flooding, promoting community involvement, and preserving and enhancing natural ecosystems.

In 2007, the Cowichan Valley Regional District and its partners initiated the development of an IFM Plan for the CowichanValley with the goal of reducing flood risk to all communities, while protecting aquatic and riparian habitat and addressing the cultural values of the valley's rivers. The plan makes use of modern engineering tools, including two-dimensional numerical modelling and GIS, and incorporates biological data and the traditional knowledge of the Cowichan First Nation. The plan promotes innovative methods of flood hazard management including flood zoning and development controls in order to minimise short- and long-term economic, environmental and social costs, and where possible, increase the environmental and social capital of the region. The plan was released to the stakeholders in September 2009. Since this time, significant efforts have been made to implement the actions and strategies outlined in the plan.

This paper outlines obstacles encountered and lessons learned during the development and early implementation of the plan. The main obstacles are outlined below.

Obstacle	Problem
Inter-jurisdictional complexity	Three local level governments and a First Nation are directly involved and Provincial and Federal agencies are important stakeholders.
Planning under uncertainty	1. Physical uncertainties such as the timing and size of the next flood, and the impacts of climate change 2. Political uncertainties relating to level of interest in flood hazard in the short and long-term
Funding	Limited funding is available for flood management and is earmarked for structural flood control.
Lack of basin organisation	The plan was developed without inputs from a basin organisation. No group is in place to implement the suggested actions.
Decision analysis frameworks	Economic based decisions rarely favour IFM strategies as the time-horizon is short, and non-monetized externalities are not included.
Property rights	The majority of the floodplain is currently 'owned'; particularly complex ownership is seen on First Nations land. Flooding of the land is not considered a common-property resource.
Knowledge gap	Understanding of riverine processes, flood management issues and engineering jargon was difficult for some stakeholder groups. Outside technical consultants may not understand local issues.
Responsibility and liability paradigm	In Canada, post-disaster payments are assumed by Federal and Provincial governments; planning decisions that affect flood risk are made by local level governments.

Understanding the obstacles facing IFM projects and making use of lessons learned in the CowichanValley will hopefully help other flood-prone regions develop and implement IFM strategies in order to build healthy rivers and communities for the future.

CAN WE DETECT THE IMPACT OF CLIMATE CHANGE ON FLOOD REGIMES?

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Climate change has not only an impact on the water cycle in general it also impacts the hydrological extremes. There is an indication that climate change affects the flood regime. The study aims to assess the impact of climate change on flood frequency and severity in a meso-scale catchment in France. The research was conducted on the catchment of the Yzeron River in western Lyon. The Yzeron catchment area is 130 m^2 and characterized by a rapidly expanding, scattered periurban development.

First statistical tests showed that both flood frequency and severity increased, between the two distinct periods in the 1970s and 1990s. During the same period an increase in rainfall frequency was detected. A more detailed analysis of the daily rainfall regime showed an increase of 10 to 20 mm in maximum rainfall in the 1990s, with a decrease in the number of rainfall events at the same time.

In order to assess the influence of climate change as result of a change in rainfall a diachronic approach was used with rainfall and land-use data from the two periods 1970s and 1990s. The data were used to calibrate a distributed hydrologic model and to simulate the urban, periurban, and rural hydrologic contributions.

The simulations showed the respective effect of both, climate change (through rainfall regime change) and urban development on flood frequency.

INVESTIGATION OF RIVER ENGINEERING CONSTRUCTION WORKS OPERATION IN RIVER MORPHOLOGY (CASE STUDY: GHEZEL-OZAN RIVER)

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River morphology is the science of river system aspect of shape and overall form, size and hydraulic geometry, direction and bed longitudinal profile and also its process and changes. Groins and Dykes are one of the important river structures that can protection lands near the rivers from floods and damages and also river rehabilitation can happen between them by trapping sediment. Hence morphology change will impacted by constructed these structures. In this research, engineered reach in Ghezel-Ozan River have initially been identified, studied and classified. Groins and Dykes are the most kind of structures have been used in training works of Ghezel-Ozan River. Studies and field investigation of river training works in Ghezel-Ozan River and assessment constructed structures showed that the river training studies of this river are based on technical principles and standards and proper construction of structures has caused high efficiency, performance and land rehabilitation with high fertility. Economic estimates showed that river training works on Ghezel-Ozan in addition to reducing flood damage and sediment deposition in Sefidroud Dam's reservoir; it has had frequency effect on employment and increasing income of local farmers.

WHOLE SYSTEM MODELLING AND UNCERTAINTY CASCADES

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The increasing trend towards the coupling of complex model systems in a cascade is a particular feature of future 'Whole System Modelling' approaches. Major advances in numerical weather prediction (NWP) have made it possible to provide rainfall forecasts along with many other meteorological data fields at high spatial and temporal resolutions. The incorporation of high-resolution mesoscale model output directly into real-time flood forecasting systems provides extended lead-times and also allows the development of a 'Whole Systems Approach' to the treatment of uncertainty. The uncertainties inherent in the NWP can be propagated into hydrological and hydraulic domains and may be magnified by the scaling process. As ensemble weather forecasts become operationally available, it is of particular interest to note the potential and implications of ensemble inputs to real-time hydroinformatic modelling systems in terms of uncertainty propagation. This paper discusses the use of ensemble forecasts from a short-range high-resolution mesoscale weather model (WRF). The results include a special study of extreme flooding in the Thames Coastal Domain focussed on wave state and storm surge in relation to 'extreme' storms. The importance attached to emerging techniques for uncertainty handling in complex model cascades acknowledges the recently completed National Environment Research Council (NERC) Flood Risk for Extreme Events (FREE) Programme and the Ensemble Prediction of Inundation Risk and Uncertainty arising from Scour (EPIRUS) Consortium.

THE RISK CULTURE IN TALCAHUANO, CHILE: THE SOCIAL PERCEPTION OF FLOOD RISK AFTER THE EARTHQUAKE-TSUNAMI ON FEBRUARY 27TH, 2010.

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In Chile floods are considered one of the main natural hazards, especially in the province of Concepcion. One of the most important cities of this area is Talcahuano. During the last years, this place has suffered consequently flood episodes; it could increase for the frequency of extraordinary atmospheric events even and a higher exposure to the flood risk for intensive urbanization process developed. However after the February 27th 8.8º earthquake (Richter scale) that affected the center-south of Chile and originated the tsunami which flooded a big percentage of the residence area and military base of the Talcahuano city, and affected a population higher than 180.000 people, (including 23 casualties and invaluable economic and environmental losses) changing the risk, vulnerability, resilience and copy capacity concepts.

Continuing with the project line developed in Canada (HEROS Program), The Netherlands (through the water boards institution), the new approach about Integrated Flood Risk Management, the European Directives (2000/60/EC; 2007/60/EC) about water framework and on the assessment and management of flood risks, respectively, and the results of different scientific research about the role of local community in disaster manager, which could be summarized in this sentence "if community planners and disaster managers ignore the local community, then they decrease their chance of providing reasonable solutions to disaster-related problems" (Pearce, 2003). This research look the social perception and social knowledge, of Talcahuano residents affected by the earthquake-tsunami emphasizing which is their risk, vulnerability, resilience and copy capacity concepts and what kind of measures they proposed to improve their flood vulnerability after having suffered the natural disaster that changed their lives. The final objective of this research is to become a framework for future local flood polices and a tool that could be review by specialists in other regions that might be affected by this hazard. This social assessment has been carried out through surveys for permanent residents where the endogenous and exogenous characteristics of them have been significant to explain their perception. One of the results drawn from the opinion polls was the perception that they are living with fear to be flooding again, the importance of structural measures, especially for older people and the general feeling that the government and disaster managers ignore the local community for design measures as a whole of reconstruction process.

EDUCATION ACTIVITIES FOR URBAN FLOOD REDUCTION USING UNIQUE FACILITIES

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Here, we introduce our recent education activities for urban flood using a real scale model and a miniature model, and discuss about their effects.

Many cities in Japan are located in alluvial plains, and the vulnerability of urbanized areas to flood disaster is emphasized by flood attack due to heavy rainfall. Underground inundation inflicts severe damages on people. In a similar way, underpasses under highway and railroad bridges are also prone to floods and passengers in a car become in a dangerous situation.

In underground inundation, people must evacuate immediately via staircase against a swift inflow. And people caught in basements must attempt to evacuate from doors held shut by hydrostatic pressure. When we consider a suitable evacuation way from underground space in flooding, it is very important to understand the critical condition of evacuation via staircase or by opening a door. We executed evacuation tests using real-sized models. We found from the test using a staircase that the evacuation is difficult for adults when water depth on the groundexceeds 0.3m, while from the test using a door, the critical water depth in front of the door is about 0.4m for men and 0.35m for women.

The underpasses are common sites of accidents of submerged vehicles, and severe damage including human damage occasionally occurs under flooding conditions.We also executed evacuation tests from a real scale submerged vehicle. Through the experiment, we found that the water depth of 0.7-0.8m from the ground surface is the safe evacuation limit.

We could obtain the evacuation limit for inundated underground space or submerged vehicle. At the same time, we found that these experiments are very effective for education for urban flood reduction. Testees feel how severe the flow is when its velocity is over 4m/s in a staircase, and how big the hydrostatic pressure is acting on a room door or a car door. The experience of evacuation test reminds testees of the strength of water and importance of prompt evacuation. As the above evacuation tests are very effective to enhance disaster prevention awareness, we try to make people experience them in a university event such as open campus as much as possible.

Also, we made a miniature model of urban area with river which can express urban inundation by river overflow or heavy rainfall by a small pump. The miniature model includes underground space and underground storage pond. The former part can express the configuration of underground inundation and the latter part can show the good effect of underground storage. Not only children but adults can study the urban flood mechanism and its countermeasures with interest.

MULTIAGENT-BASED FLOOD EVACUATION SIMULATION MODEL CONSIDERING THE EFFECT OF CONGESTIONS AND OBSTRUCTIONS ON THE PATHWAY

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Comprehensive flood risk management, one of the policies of Japan, is combination of facility-based and non-facility-based countermeasures. Appropriate combination is getting more important in the changing world. Social change has brought the concentration of population and capital into lower lands, which has extremely increased the exposure to water disasters. It is important to try keep flood water within the river channel by dikes and reservoirs, but it is not possible to cope with exceed floods only by these facilities. Therefore integration of facility-based and non-facility-based countermeasures is crucial for us to cope with the flood disasters in changing social and water environment.

It is still difficult, however, to estimate the performance of non-facility-based countermeasures. One of the reasons is that the non-facility-based countermeasures are always closely related to human response to disasters and then contains so many uncertainties. Even to the same flood condition, individuals act in different manners according to their residential areas, generations, life styles and other attributes. In order to estimate the human response to various flood conditions, simulation study can be one of the powerful tools. From this viewpoint, several attempts have been done to simulate the residents movement to the shelter under flood situations (Takahashi *et.al.*(1982) , Katada *et.al.*(2000)). The authors also developed the micro flood evacuation model which simulate people's decision process based on numerical expression of mental factors such as danger recognition rate (Takasao *et. al.*(1992) , Hori *et. al.*(2004)). Paying attention to the considerable burden required expressing the street network on a computer and the importance of information, Hori (2008) developed a flood evacuation simulation system based on digital modeling of street network considering distributing process of information. Those models expressed street network by the combination of nodes and arcs.

On simulating evacuation in urban area, we should mention the effect of congestion on evacuee's speed. But in order to simulate these situations, node and arc expression of street network is not enough because this expression cannot deal with actions of passing and avoiding the other evacuees.Moreover, it should be noted that evacuees use cars instead of walking to shelters in some cases. Cars are rather indispensable to help vulnerable people to evacuate. But once a car comes into the flooded area it might get stuck and become an obstruction. So we should also express actions of avoiding obstacles on the road.

Therefore in this study, new versions of evacuation simulation model which express the streets as polygons are developed and have been tested. One can describe the effect of congestion and obstructions on the pathway on moving evacuees. The other one can describe rule-based collision-avoiding actions of evacuees. The performances of those two models have been compared in the several simulation results in actual flood-plain areas in Japan.

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MODELLING TSUNAMIS: DEVELOPMENT OF A NEW TSUNAMI GENERATOR

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Methods to prepare for, to resist, and or avoid / mitigate damage to buildings and/or infrastructure caused by tsunamis depend critically on understanding the damage that can be done onshore by tsunami waves. Unfortunately, whilst methods to model the propagation of tsunamis across oceans are well established, models for transformation processes at the shoreline, and for wave / structure interaction onshore, are weakly supported. In part this is because of the absence of robust data on those processes, either from the field or laboratory, exacerbated by the difficulties in simulating the very long wave lengths of tsunamis.

At early stages in the knowledge life-cycle, most wave / structure processes have historically been modelled using scale models. For some simple interactions, such modelling has been sufficiently comprehensive to allow the routine use of numerical codes based on equations refined / calibrated / validated by those earlier physical models. But for many interactions, the processes are too complicated to be yet described by such equations, and physical modelling is still routinely used in the analysis / design of shoreline structures all around the world, indeed the use of physical modelling tools has probably increased in the last 5-10 years.

Conventional flap, piston or wedge wave generators have a serious limitation in producing tsunamis. Their limited stroke simply cannot produce waves with the required wavelengths and periods to match that of a realistic tsunami (2 to 200min periods…). A very small number of piston paddles (perhaps only one in Japan at PARI) have long enough stroke to make moderate period tsunami waves. Furthermore, generating trough-led waves, an important feature of many sub-duction zone tsunamis, still pose considerable stability issues.

The new HRW / UCL Tsunami Generator is based on the concept of the Pneumatic Tide Generator developed in the 1950s (e.g. Wilkie & Young, 1952). A fan extracts air from a closed-top tank with a submerged opening, drawing water from the test flume into the tank. This water is then released in the required wave shape by controlling the opening of an air valve on top of the tank. This system handles both crest-led and trough-led waves, and multiple tsunami waves. The bathymetry and shoreline installed in the flume allow the study of the nearshore behaviour of the generated tsunami wave.

Testing by UCL / HRW has shown that this new tsunami generating device can produce various controlled wave shapes (sine, solitary waves, N-waves), including trough-led waves, with consistent repeatability (see Rossetto et al, 2011). It also reproduced at scales of up to 1/50 at reasonable accuracy the profile of the 2004 Indian Ocean Tsunami as recorded close to shore (Mercator time series).

Testing by the UCL team has already measured forces on example buildings (see Allsop et al, 2009).

This paper will present the development of the Tsunami Generator and test results so far. The paper will also highlight developments underway to expand the range of wave conditions that can be generated. Numerical modelling of the generator will provide guidance on improving the current set-up by changes in tank height, outlet size / position, valve and pump requirements. Moving the Tsunami Generator to a longer flume is being planned as it will enable longer waves to be generated without corruption by waves reflected back to sea from the shoreline. The results previously obtained are very promising and further improvement of this unique tsunami generation technique will enable a better understanding and therefore mitigation of effects of tsunami-induced flooding.

NEW FORMS OF DATA AND KNOWLEDGE SHARING IN FLOOD MANAGEMENT, CASE STUDY JAKARTA

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Ask any audience at a seminar: “Would your sector’s effectiveness increase, if people would cooperate better?” Without a doubt the majority would raise hands and most of them may contemplate how they have always advocated it themselves. Ask any forum of principals: “Do you think that your hired capacity can improve their services, by picking the fruits of worldwide R&D?” and their answer would be a convincing YES! Apparently we all think that combining forces has enormous potential. So why don’t we push for it a little more?

The Netherlands has a long history in cooperation. Dutch consensus models originate from the Middle Ages when farmers, city-dwellers and aristocrats cooperated to build and maintain the dikes on the basis of shared value. The Dutch have since become famous for their *poldermodel* and elaborate hearing of all stakeholders in any government undertaking. Advocates praise the consensus model for its unmistakable democratic and transparant character. Opponents observe that *to polder* - it has become a verb - ultimately leads to semi-solutions that are far less effective.

Meanwhile, new forms of cooperations take front stage: Apple sold an astounding 12 million IPads during its year of launch, offering nothing more than connectivity to eachother (email, internet) and eachother ideas (sharing of applications). We see the birth of concepts as ‘corporate social value’, promoting increased value for companies by improving the lives of the people and companies that surround them. We observe outsourcing of services growing from simple algorithms in the financial and engineering sector, to complex, conceptual cooperations in the creative industry. Apparently, we have found some new forms of communication and cooperation, and thrive by them.

The question is whether flood management can pick the fruits of new developments in cooperation and IT. Let’s take Jakarta, a city facing a grim future when it comes to floods. The international community stepped in and assists the Indonesian people the best they can, producing countless studies and projects on climate change and flood management. When asked, all involved answer to the first question exactly the same: “Yes, better cooperation would help!”. What if we could truly combine our thinking and implementation power to the problems that we face?

In Jakarta, the partnership Flood Control 2015 developed a flood information portal called *Dashboard BanjirOnline* (www.banjironline.com), in cooperation with the province DKI Jakarta. BanjirOnline enables to link flood management data and information sources to specific demands from end-users, by means of an open service bus architecture. The architecture is designed in such way that an indefinite amount of suppliers and demanders of data and knowledge can be connected, without their systems having to be centralized. The portal BanjirOnline searches for the best available information and produces user defined output to a Client. With multiple parties now working on specific elements of a problem, we have opened a new possibility for enhanced cooperation in flood management, following the good example of flood management history and as we have witnessed in other successful industries.

MACHINE LEARNING AND MODELS OF UNCERTAINTY IN FLOOD CONTEXT

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In flood management the necessity for adequate handling of models and data uncertainty has been clearly articulated. Majority of studies studying propagation of uncertainty through models to outputs are based on representing various types of uncertainty using probabilistic approaches, and then sampling parameters or inputs from prior distributions and running models multiple times. Uncertainty analysis techniques based on such Monte Carlo (MC) simulation have been applied in hydrologicalsciences successfully in the last decades, but for complex models they are computationally expensive, even if “economical” schemes are used. Another issue is that the distributions of output variables represent average behavior of a model across the whole range of input and state variables, and not the output uncertainty characteristic for a particular combination of these variables.

In the framework of the EU-funded FLOODsite project, two methods to encapsulate uncertainty in a machine learning model have been developed: 1) UNEEC method (Solomatine and Shrestha, 2009) and 2) MLUE method (Shrestha et al., 2009). This paper deals with the new results associated with the second one, a method to encapsulate the results of MCruns in a fast-running model. MC simulation is firstused to assess the parameter uncertainty of the conceptual rainfall-runoff model. A machineslearning (non-linear regression) model is trained to encapsulate the uncertainty (distribution quantiles) estimated by the MC method using the historical input data. Inputs to this model are variables representing the hydro-meteorological situation. The trainedmachine learning models are then employed to predict the uncertainty of the model output for every time step.

This method has been applied to two catchments. The experimental results demonstrate that the machine learning methods arereasonably accurate in approximating the uncertainty estimated by MC simulations. An advantage of the proposedmethod is its efficiency to reproduce the MC based simulation results; it can thus be a tool to assess theuncertainty of flood forecasting models in real time.

We discuss also some aspects of how uncertainty is perceived, which is the main theme of a EU-funded KULTURisk research project (Knowledge-based approach to develop a cULTUre of Risk prevention). In the context of the presented study it appears that in practice (when the number of model runs is inevitably limited) using different sampling methods (e.g., standard MC, Markov chain MC, or LHS) may lead to different distributions of output (streamflow). This may create confusion among different stakeholders involved in flood-related activities, and thus undermine the whole principle of explicit use of uncertainty analysis studies in flood management. This is an issue that still needs further research.

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INVESTING IN THE DEVELOPMENT OF FREELY AVAILABLE NATIONAL FLOOD TOOLS AND INFORMATION

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Floods are Australia's most expensive natural hazard with the average annual cost of floods estimated at AUD$377 million (BITRE 2008). This figure is likely to have risen following the widespread and devastating floods across eastern Australia that occurred over the summer of 2010-11. The development of tools to support the identification and analysis of flood risk is an important first step in reducing the cost of floods in the community. The Australian Government through Geoscience Australia (GA) has been leading the development of tools which assist in flood intelligence, modelling and damage assessment. An overview of three of these tools will be provided in this presentation.

The Australian Flood Studies Database

Government and industry expend considerable resources to define areas affected by flooding in an effort to reduce the impacts of floods. This work typically involves the development of reports describing the methodology used, data sources and results of the modelling. While numerous reports are developed each year, there was no centralised record of what studies had been undertaken in Australia at a state/territory or national level. This was remedied by the development of the Australian Flood Studies Database in 2004. Two years later, the database was made freely available from GA's website. In 2010 GA developed a web-based Data Entry and Maintenance Tool to make future data entry efficient and readily accessible to stakeholders. The tool is now providing registered stakeholders with the ability to add information on new studies remotely, edit existing information and upload attachments to the database via the internet.

The inundation modelling tool ANUGA

GA has also been leading the development of an open-source software tool for modelling the impact of hydrological events such as floods, storm-surge and tsunamis. The software tool can be used to predict where water will go, at what speed and over what duration, information critical for drafting evacuation plans and land use planning. ANUGA is a collaborative effort of GA and the Australian National University (ANU) and is being continually developed with input from the open-source community. The numerical scheme behind ANUGA is suitable for modelling complex flows in shallow water involving hydraulic jumps (shock waves), rapidly changing flow regimes and flows into dry beds.

Flood damage functions

Flood damage functions are an important input into calculating the direct economic cost of flood events. They also enable the economic benefits of various mitigation strategies to be assessed. GA has developed flood damage functions for residential buildings as a parameter of water depth over floor level. Flow velocity is equally important for assessing building damage. GA has also developed functions which estimate the likelihood of a dwelling being moved off its foundations based on a combination of water depth and velocity.

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CALCULATING AND VISUALISING FLOOD VULNERABILITY AND RISK: A UK CASE STUDY INTO FLOOD EMERGENCY MANAGEMENT

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It is widely accepted that increases in the magnitude and frequency of fluvial flooding over the coming century is likely to be exacerbated by severe pluvial flooding in urban areas. In light of these growing concerns, the EU Floods Directive (2007) requires member states to develop and utilize flood hazard and risk mapping to inform flood risk management plans by 2015. The purpose of these plans is to steer strategies towards prevention, protection and preparedness, in attempts to alleviate future costs from flooding. Furthermore, there has been a significant attempt in the UK to shift societal expectations of future risks – a strategy that has been underscored by key policies, such as Making Space for Water (Defra, 2004). It seems there is a need to readdress the traditional emphasis on structural measures designed to alleviate flooding, with greater stress on the 'need to learn to live with floods', and advocates devolution of risk management to more localised activities. While this approach seeks a more sustainable future, it crucially transfers the burden of flood management to a broader base of practitioners, with less formal training in flood science.

In response to this, the flood research community is encouraged to facilitate knowledge transfer and communication across this scientific-practitioner interface, with the explicit objective of grounding research outputs. This interface is however, a frequently contested space, where fundamentally different perspectives collide. This paper reports on current FRMRC (Flood Risk Management Research Consortium *www.floodrisk.org.uk/*) research and discusses the experience of developing an end-user-tailored, GIS-based tool to support the assessment and visualisation of flood vulnerability and associated risk.

Drawing from professional stakeholder interviews conducted before and after tool completion, we review how stakeholders engaged with the tool to construct their own vulnerability indices, selecting the scale of assessment and applicable context. The conception of 'who is vulnerable' is subjective and variable across stakeholders, as such, we provide a feature for end-users of the tool to select indicators according to their individual opinions and decision making needs; users can balance this with an in-built, expert-declared rationale accompanying each indicator. Furthermore, we address the value of qualitative indicators typically neglected in the 'classical index' approach to vulnerability assessment (such as hazard experience and household perception of vulnerability). Additional feedback is presented with regards to the interactive nature of the tool, hazard presentation (e.g. animation) and how end-users negotiated the risk equation (aggregating and weighting hazard and vulnerability data). Flexibility in the tools' design is necessary to suit the needs of multiple stakeholders involved in flood emergency management, whose decisions are confined by different geographical scales and purpose.

The interactive and user-friendly tool constructed in this project served as a facilitator to knowledge transfer at the scientific-practitioner interface and as well as exploration into vulnerability assessment, typically neglected in hazard-centric views on risk. This UK-based case study is presented here to shed new light on the utility of social vulnerability assessment within the context of flood emergency management in the UK. While it is not a tool designed to roll-out into practice, stakeholder feedback is used to inform recommendations regarding vulnerability and risk appraisal.

FROM "DUAL FUNCTIONS" TO "TRIFUNCTIONS": A CASE STUDY OF FLOOD DETENTION AREAS IN HUAIHE RIVER BASIN

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Huaihe River Basin, locating in east China, covering an area of 270,000 km^2, and having a population of over 170,000,000, is the first river that received national management after the founding of People's Republic of China in 1949. Since the first use in 1950, and until 2007, those areas, as an indispensible component of flood control, have been put into utilization for 206 times, protecting hundreds of millions of residents living along Huaihe River from flood deteriorations.

However, due to restrictions of national conditions, such as economy and population, migrated people are limited within areas or abilities, while, the population of those who are still living inside those flood detention areas is whereas increasing rather than decreasing. In light of these trouble, flood detention areas in Huaihe River Basin have to bare "Dual Functions"—function of flood control and function of places of living and human development. Suffering greatly from flood disaster, people are living far below the poverty line.

In view of fast-completing of hydraulic projects and accompanied by national adjustment on flood management strategies, "Tri Functions" has been receiving more and more attentions. "Tri Functions", based on "DualFunctions", adds eco-environmental function into consideration. Flood is a double-edged sword, and when causing disasters to people, it is also bringing forward an extraordinarily abundant of water supply. If taken into proper use, flood can be a valuable treasure for local people. For example, on the grounds of using frequency of these flood detention areas, we can try to make better adjustment over these areas, change certain detention area into wetland and exploit the feasibilities of wetland breeding and planting. In this way, not only do flood problems be solved, but also economic value is gained.

Similar problems also occurred in Japan. As early as 1902's, with the purpose of handling flood and water contamination problems, Japanese government proposed to build a flood detention area in Watarase River, Tonegawa River Basin. Until now, more than 100 years have passed, contemporarily Watarase, covering an area of 33 km^2, is the largest one all over Japan, with the functions of not only previous flood prevention and water supply, but also other functions like ecological restoration, stream flow maintenance and eco-tour as well.

Therefore, for the purpose of perpetuation and optimization, this article, taking the experiences of Japanese Watarase flood detention area, is aiming at exploring proper and effective solutions to flood issues in detention areas of Huaihe River Basin. In a nutshell, we can conclude that: (1) Flood detention areas in Huaihe River Basin should develop from previously "Dual Functions" to contemporarily "Tri Functions" which adding eco-environmental function as an indispensable consideration for prosperous development in this age; (2) By summarizing and analyzing the strengths of flood detention areas in Huaihe River Basin, we should shift our focus of work to eco-environment build, so as to maximize this strength and benefit the whole region; (3) By taking the advantages of wetland and other eco strengths, constructive plan for develop local eco-environment function in flood detention areas of Huaihe River Basin can be put forward.

CHARACTERISTICS, IMPACTS AND RISK OF DAMMED LAKES INDUCED BY DEBRIS FLOWS AT THE SERIOUSLY HIT AREAS BY THE WENCHUAN EARTHQUAKE

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Debris flows extensively develop and frequently occur in the seriously hit areas by the Wenchuan Earthquake, which block rivers, generate dammed lakes, and result in flash flood when dammed lakes outburst. This paper mainly discussed the formation model, outburst, impacts and risk of dammed lakes induced by debris flows. The field investigation and remote sense identification showed that the dammed lakes are created by gully debris flows, large-scale slope debris flows and the combination of debris flow and landslides, and distribute step-by-step along river after the Wenchuan Earthquake. Dammed lakes outburst immediately along the front of debris flow deposits or the suture between debris flow and landslide, however, most only partly outburst due to the dam structure and deposition geomorphology. Moreover, frequent debris flows continuously increase the magnitude of debris flow deposits and the height of the dams, which not only increase the stability of a single dam, but also rise the outburst danger of dammed lakes under the condition of intensive rainstorm. Dammed lakes produce steep rage in the sites of dams and rise the upper riverbed due to alluvial sediment so that the vertical profile of river channel abruptly change. Under the condition of local intensive rainstorm, the risk derived from the outburst of step-dammed lakes increase remarkably. After the analysis of formation, characteristics and impacts of debris flow dammed lakes at the whole Wenchuan Earthquake areas, the dammed lakes at the section from Dujiangyan to Wenchuan along Min River, seriously hit by Wenchuan Earthquake, were analyzed, the impacts and risk of dammed lakes are assessed based on the evaluation of debris flows hazards and magnitude, and some countermeasures against dammed lakes outburst are recommended to protect local reconstruction and security.

STUDY ON SPATIAL AND TEMPORAL DISTRIBUTION OF RAINSTORM IN CHINA IN RECENT 48 YEARS

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Using daily precipitation data of 552 stations from 1961 to 2008 in china, the Spatial and temporal distribution of rainstorm(daily precipitation≥50mm), heavy rainstorm(daily precipitation≥100mm)and extremely heavy rainstorm(daily precipitation≥200mm) were analyzed based on mathematical statistics. The mainly results showed that the days of rainstorm , heavy Rainstorm and extremely heavy rainstorm during 48 years decreased gradually from southeast to northwest in china, and the rainstorm days were 0-713; the heavy rainstorm days were 0-252; the extremely heavy rainstorm days were 0-47, and the days in China's western region were 0.In recent 48 years, the rainstorm days decreased in most areas of the North China plain and the loess plateau, east of the Inner Mongolia, west of the Northeast and the Sichuan Basin, and the heavy rainstorm days decreased in most areas of the Northeast, north of the North China plain, east of the loess plateau and some areas of the regions south of the Yangtze River, and the extremely heavy rainstorm days decreased in the North China plain mainly. The annual curves of the rainstorm days in most areas of china were unimodal except for the Tibetan Plateau, and reached the maximum in July in the Northeast, the Inner Mongolia, the North China, the SichuanBasin, the loess plateau and the XinjiangProvince and in June in the South China, the JiangNan and the Yunnan-Guizhou Plateau. Some research results could be important for the analysis and evaluation of mud-rock flow disaster.

KNOWLEDGE SHARING IN INTERNATIONAL COOPERATION PROJECTS: EXPERIENCES FROM A DUTCH-ROMANIAN FLOOD MANAGEMENT PROJECT

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Floods represent one of the major natural risks in many countries around the world. The (international) sharing of knowledge on flood management methods, concept and technologies may help to reduce these risks. The flood information and warning system FLIWAS is an example of what can be achieved in international cooperation projects. This internet-based application was developed in a European project that involved partners from the Netherlands, Germany and Ireland. It aims to provide water managers and decision-makers with adequate information before, during and after floods. FLIWAS was developed in such a way that it could be transferred to other countries as well. In 2009, the application was implemented, with the financial support of a Dutch governmental agency, as a pilot in Romania. We analyzed this project to gain more insight in knowledge sharing between experts of different countries.

Knowledge can be defined as information possessed by an individual. Knowledge that is relevant in flood management projects includes both content-related (substantive) knowledge and process-related (procedural and political) knowledge. Knowledge sharing is an important aspect of these projects, especially if it concerns an international project. This includes the sharing of explicit knowledge that can be expressed in words and numbers andof tacit knowledge that is based on experiences. Tacit knowledge resides in an individual and is therefore hard to formalize and communicate. Tacit knowledge is also essential for sharing explicit knowledge as it provides the necessary background to interpret words or numbers. Knowledge on a particular subject that includes the experiences and skills to use this knowledge is also referred to as expertise.

The pilot implementation of FLIWAS in Romania basically involved: (1) the creation of a Romanian FLIWAS application; (2) implementation of FLIWAS for a pilot area; and (3) communication and training activities. The project was implemented by experts of a consortium (representing Dutch, German and Romanian consultancy companies) in cooperation with experts of Romanian water authorities.Knowledge was shared on distance (email and telephone) and through face-to-face meetings (joint working sessions and meetings, trainings and workshops). Some of the Dutch and Romanian experts involved already cooperated with each other before, which enhanced the knowledge sharing process. One of the major bottlenecks was the installation of a Romanian server. Knowledge was shared on distance and experts involved had difficulties in relating the knowledge to their own context.

The case study confirms that successful knowledge sharing largely depends on the existence of a shared knowledge base and shared previous experiences. If experts lack a shared knowledge base they will have difficulties to arrive at a mutual understanding of data or information. If experts have positive experiences of a previous joint project, they are more willing to trust the other expert, which increases the opportunities for sharing tacit knowledge. The case study also shows that projects should involve experts that can contribute to the project content (contributory expertise) and experts that are able to interact with experts and combine expertise (interactional expertise). The case study further highlights that successful knowledge sharing does not necessarily lead to knowledge application. Although FLIWAS was successfully implemented in Romania, additional steps are still needed to put FLIWAS into use.

ASSESSMENT OF UNCERTAINTY OF STAGE-DISCHARGE RELATIONS THROUGH HYDRAULIC AND BAYESIAN APPROACH

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Continuous river discharge data are crucial for the study and management of floods. They are used to estimate flood return periods, but also as input or calibration data for prevention or forecasting models. In most river discharge monitoring networks, these data are obtained at gauging stations, where stage-discharge relationships are used to derive discharge from the measurement of water level in the river. A key element to improve the relevance of flood studies is therefore to quantify the uncertainty associated with stage-discharge relations, in particular for high flow values. Stage-discharge relations are usually established against individual ratings (or gaugings). Due to the lack of gaugings, they often have to be extrapolated for the highest floods, inducing large uncertainty in the computed discharges, even when extrapolation is based on hydraulic simulation.

We use the Bayesian framework to estimate this uncertainty. For a given station, the first step is to estimate the uncertainty of each gauging, according to the gauging technique (e.g. velocity-area method, tracer dilution, ADCP, etc.) and operational conditions (e.g. number of verticals, number of point velocity measurements per vertical, flow variation during the measurement period, etc.). The uncertainties of the gaugings are taken into account individually. The approach also uses priors on the formulations of rating curve equations and on the values for the parameters. These priors are based on the hydraulic analysis of the station site (geometry of the section, identification of hydraulic controls), that can be performed with little data.

The method was applied to several stations in France, corresponding to a wide range of contributive catchment sizes (from 23 km² to 2340 km²), configurations (natural sections, weirs, flumes), gauging availabilities (from 15 to more than 180) and gauging uncertainties. The results show that the introduction of hydraulic priors improves the control of extrapolation and controls uncertainty in the high flow parts of the rating curves. They also demonstrate the interest of more uncertain, yet high flow contactless (remote) discharge measurements (LS-PIV or radar techniques) for reducing the uncertainty of extrapolated rating curves.

COLLABORATIVE FLOOD RISK MANAGEMENT IN THE UNITED STATES THROUGH THE FEDERAL INTERAGENCY FLOODPLAIN MANAGEMENT TASK FORCE

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In the United States, no single Federal government agency is responsible for flood risk management. The Federal Interagency Floodplain Management Task Force (FIFM-TF) brings together twelve of the Federal agencies with missions and responsibilities related to flood risk management. The purpose of the FIFM-TF is to provide Federal leadership in flood risk management efforts and to develop a vision for flood risk management in the United States.

The FIFM-TF was established in 1975 to develop a "unified national program for floodplain management." The group became inactive in 1997, and was re-established in 2009. In re-establishing the FIFM-TF, it was recognized that the costs of flooding disasters in the United States continued to rise while the natural functions and values of floodplains continued to be degraded. It was further recognized that the 21st century would bring increasing challenges, such as increased population and climate change, which would make reducing loss of life and property caused by floods and restoration of the natural resources of riverine and coastal floodplains more difficult.

Members of the FIFM-TF created a work plan that included 10 activities to pursue over the next several years. These activities will identify and develop opportunities for the Federal government to be more effective in promoting and encouraging good flood risk management decisions that reduce the loss of life and property caused by floods and restore the natural functions and values of floodplains. The activities included are primarily long-term activities, so members have identified additional activities to address in the short-term to improve flood risk management in the nation. The FIFM-TF has initiated several of these long-term activities already. One such activity is an evaluation of Federal programs and policies that impact flood risk management, to identify those that impede good flood risk management. FIFM-TF has also begun an assessment of the state of knowledge related to environmental services of floodplains, including natural and beneficial functions and ecosystem goods and services. The FIFM-TF is also considering methods to update the strategic national framework for flood risk management, known as the Unified National Program for Floodplain Management, and Federal guidance for agency actions in flood hazard areas, currently included in Executive Order 11988.

The FIFM-TF recognizes the importance of interacting with other stakeholders, including lower levels of government and non-profit groups, to create a more balanced national approach to flood risk management. In the United States, the Federal government has little control over land use decisions, which are primarily the responsibility of local and state governments. Therefore, to truly improve flood risk management, collaboration across all levels of government will be necessary. The FIFM-TF has developed a communications strategy, key messages, and communications products to assist in future collaboration with stakeholder groups.

This presentation will discuss the efforts to re-establish the FIFM-TF and the anticipated benefits to be obtained through this collaborative process. The current and future activities of the FIFM-TF to improve flood risk management will be discussed in more detail, as will examples of recent successful coordination efforts.

RISK ASSESSMENT FOR INTERCONNECTED CRITICAL INFRASTRUCTURE SYSTEMS IN COASTAL AND DELTA REGIONS

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Coastal and delta regions are characterized by the presence of large population densities and various vital infrastructure systems. These infrastructures include flood defences, power, water, telecommunication and road and rail infrastructure systems. These systems can be characterized as highly interconnected. Failure of one system could increase the probability of failure or consequences for the other system. For example, a flood event could damage power and water supply for a larger area. In addition, the interactions could also affect the consequences of failure. For example, failure of telecommunication systems could limit the possibilities for warning and evacuation and thereby enhance the consequences of flooding. These interconnected systems are threatened by various (coastal) hazards, such as windstorms, storm surges, floods, earthquakes and tsunamis. Existing approaches for risk assessment mainly focus on a single system and often on a single hazard. However, the extent and spatial profile damage of a flood disaster could be more extensive than predicted in existing damage models that mainly focus on economic damage and sometimes on loss of life. Recent experiences after tsunami in Japan (2011) and hurricane Katrina (2005) have shown that these domino or chain effects can occur during and after disasters. Neglecting interactions between systems could lead to an underestimation of the risk.

The objective of this work is to develop and demonstrate methods for the assessment of risks in for systems characterized by interconnected infrastructure systems and the threat of multiple hazards.

A general framework will be presented that can be used to assess dependencies in failure probabilities and consequences between systems. Specific issues related to these dependencies will be addressed. For example there are geographical scale issues, as the area affected by coastal hazards may be smaller than the area affected by the consequent infrastructure failure. In addition, the nature of hazards, the vulnerability of systems and the interconnections may change over time due to processes such as population growth, sea level rise, subsidence etc.

The applications to coastal and delta areas will be demonstrated by means of case studies. The first case focuses on the vulnerability of the infrastructure systems in the Rotterdam harbor (Netherlands) under the influence of coastal windstorms and floods. It is found that a storm surge can have significant effects at a national and even European scale due to the regional function of the port. The chemical facilities that are located in the port are found to be specifically vulnerable during storm surge events. The second case study will focus on interdependencies in the systems in the Sacramento San Joaquin delta in California and will demonstrate findings for a specific island. General implications for risk management and risk reduction strategies in coastal and delta areas will be discussed.

THE GENERATION AND MOVEMENT OF SURGE IN ZIPINGPU RESERVOIR RESULTING FROM LANDSLIDE DURING 5.12 WENCHUAN EARTHQUAKE

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Landslides can cause rocks and soil falling into water at high velocity, causing large surface waves, which will threaten navigable vessels, stability of the reservoir dam, and the lives and property of residents along the shore. The 5.12 Wenchuan earthquake triggered high-velocity landslides along the shore of Zipingpu reservoir, 30 km from Yingxiu town in Wenchuan County. The resulting surges killed more than 70 fishermen and swept away more than 10 vehicles. This paper describes the landslide-triggered water waves in Zipingpu reservoir as follows: (1) the fall velocity of the landslide was calculated according to basic dynamic principles. (2) Laboratory modeling of the water waves enabled us to calculate their initial height. Eight factors, such as water depth, sliding impact velocity, slide volume, slide width and so on, are chosen as key parameters in model experiments. The calculated value is compared with the measured data and the values calculated with the practical empirical formulas presented by Edward Noda and the China Institute of Water Resources and Hydropower Research (IWHR). (3) Analysis of wave attenuation was based on model test achievements. (4) Considering the base of the slope and the climbing direction of the surge, we calculate surge run-up and the compare the simulated value with the actual value. By analyzing the process of landslide-triggered water waves in Zipingpu reservoir, the analysis methods may provide a scientific reference for the design of major water projects and disaster prevention and reduction in the future.

DEVELOPING A FLOOD VULNERABILITY INDEX FOR COASTAL CITIES

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Coasts are highly dynamic and geo-morphologically complex systems, which respond in various ways to extreme weather events. Many of the world's densely populated urbanised areas are found in low lying vulnerable coastal areas. Here floods become more and more frequent and amongst the most dangerous and harmful of natural disasters. Worldwide there is a need to enhance our understanding of vulnerability and to also develop methodologies and tools to assess vulnerability. One of the most important goals of assessing coastal flood vulnerability, in particular, is to create a readily understandable link between the theoretical concepts of flood vulnerability and the day-to-day decision-making process of coastal populations and to encapsulate this link in an easily accessible tool to assess flood vulnerability.

The fore-work of Connor and Hiroki (2005) within ICHARM, flood vulnerability index for river basin scale, is taking into consideration to build on earlier work on a flood vulnerability index on different spatial scales (Balica et al., 2009) to establish a coastal cities flood vulnerability index using a composite method.

The presentation focuses on developing a Coastal City Flood Vulnerability Index (CCFVI) based on exposure, susceptibility and resilience to coastal flooding, combined with three interdependent subsystems in the water resources system: (i) the natural river system is delimited by climate and (hydro-geo) physical conditions (catchment and coast), (ii) the socio-economic system is formed by the demographic, social and economic conditions of the surrounding economies and (iii) the administrative and institutional system is formed and bounded by the constitutional, legal and political system. Coastal floods distress three components of the water resources system, each of them belong to one of the subsystems described here. Their interactions affect the possible short-term and long-term damages. The components can be expressed by different indicators to understand the vulnerability of the system to coastal floods.

The index is applied to nine cities around the world, each with different kinds of exposure. The data collection was done via readily available sources through the internet.

Using the CCFVI, shows which cities are very vulnerable to coastal flooding with regard to the system's components, that is, hydro-geological, socio-economic and politico-administrative. The index gives a number from 0 to 1, indicating comparatively low or high coastal flood vulnerability. The use of the CCFVI to compare the vulnerability of a range of cities under current conditions is demonstrated. More important is that the CCFVI also indicates per individual city, which aspects need urgent action towards adaptation measures, by raising the anticipatory mentality of local populations. Actions must be undertaken to protect coastal cities in order to reduce their vulnerability to floods. Therefore, cooperation between delta cities' administrations, multiple stakeholders and organisations at international level (like delta-alliances) have to be undertaken to support the most vulnerable areas and to learn from each other (win-win effect). CCFVI's can serve the international cooperation between coastal areas, because they help to focus on the most pressing issues that such cooperations should be dealing with.

The results show that CCFVI provides a means of obtaining a relatively fast, broad overview of flood vulnerability and the effect of possible adaptation options to reduce that vulnerability. This, in turn, will allow for the direction of resources to more in-depth investigation of the most promising strategies.

FLOOD RISK ASSESSMENT IN FUJIAN PROVINCE, CHINA

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It is quite important to assess flood risk in a region for its flood management strategy, disposition of various structural and nonstructural measures. In this study, flood risk is defined as the product of hazard, exposure and vulnerability, and typical indexes were selected from the three aspects to assess the flood risk in each countries of Fujian province.

First of all, the authors developed the following model for flood risk assessment.

$$R = (W_H \sum_{i=1} H_i)(W_E \sum_{j=1} E_j)(W_V \sum_{k=1} V_k)$$

where, R stands for regional flood risk; H, E and V are instead of the elements of flood risk, hazard, exposure and vulnerability, respectively; W_H, W_E, and W_V represent the weights of the corresponding elements and were assigned according to flood management export's experiences.

Secondly, the authors selected the following seven indexes to describe the elements of flood risk. One index, peak discharge of 1% flood (Q_{100}), was selected to stand for hazard (H); three indexes, that is, population density ($P_{Density}$), urbanization rate (U_{Rate}) and fixed assets (E_{Mean}), were used to be instead of exposures (E); and other three indexes, namely, the capacity of main structural measures (F_c), urban flood drainage (L_s) and percapita GDP (P_{Mean}), were used for reflecting the information of vulnerabilities (V).

Thirdly, according to the above indexes, the authors collected and sorted out the data of 85 counties in Fujian province and computed the corresponding flood risk. The analysis was done according to the following steps. First, the data of the seven indexes were normalized to obtain the dimensionless index; second, the indexes, H, E and V, were computed as the sum of corresponding indexes in the seven indexes; third, the flood risk, R, was the product of H, E and V.

Finally, the results were classified as four levels (very high, high, medium, and low) and put into maps by means of GIS technologies. The analysis indicated that the flood risk is very serious in north and west Fujian province, and the cities of Fuzhou, Nanping, Fuan, Jianou, Changtai are heavily threatened by flood. More and special attention should be paid to these countries and cities on the flood management in the coming years.

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THE NEXT GENERATION TSUNAMI HAZARD MAP

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he Great East Japan Earthquake on 11 March 2011 characterized in that not only big earthquake and unexpected Tsunami height but also ground subsidence or some other influencing factors which expanded further damage on coastal cities in the Pacific side of northern Japan.We can grasp the reality of actual Tsunami behavior and devastating power of tsunami from news reports like that and those materials serve us as examples for improvement of disaster prevention.Now it is said that the countermeasures against Tsunami has reached at a major turning point and needs of Tsunami analysis technologies for greater sophistication and diversity are increasing.

In this study we create a tsunami analysis model including ground subsidence and collapsed houses based on our experience and suggest the next generation tsunami hazard map using virtual reality.

Nuclear power plants tend to be located on coastal area because of injecting cooling water into the reactor core. So, it is important for us to create new Tsunami analysis system for estimating a safety level on coastal area and making public to people Tsunami behavior and evacuation route etc. using hazard map and Tsunami virtual reality.

The Tsunami analysis is modeling for coastal area in Kamaishi city Iwate prefecture where had extremely serious damaged by Tsunami caused by the Great East Japan Earthquake. Tsunami behavior is calculated by finite difference method of solving shallow water equation. We tried how Tsunami behavior is changed depend on ground subsidence and collapsed houses. Considering the change of ground level make possible to estimate a true value of flood depth and true flow direction coastal land area.

We also suggest a new kind of hazard map called the next generation tsunami hazard map using virtual reality which makes people raise public awareness of disaster prevention and recognize the evacuation route etc. The next generation tsunami hazard map consists of three-dimensional visualization and provide with not only fluid analysis results but also other useful various information about disaster prevention such as houses and cars and evacuation of people. In the three-dimensional virtual space, we can display various kinds of disaster such as structure collapse and move to any viewpoint for example in house, in moving car, in moving airplane, from the viewpoint of underground. Therefore we can use the next generation tsunami hazard map for multipurpose.

We can expect these new approach (Tsunami analysis model including ground subsidence and the next generation tsunami hazard map) mitigate disaster risks.

SAFETY AND FOOD SECURITY: GLOBAL CHALLENGES OF ADAPTIVE WATER GOVERNANCE

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This paper suggests that uncertainty regarding water problems is increasing; we observe more uncontrollable and unpredictable events. Public leadership is challenged to come up with an approach to deal with uncertain risks. This requires a strategy of adaptive water governance, to explore uncontrollable and unpredictable events and to find innovative ways to cope with them.

Increasing uncertainty

The recent tsunami in Japan, floods in Australia and Brazil, cyclone Sidr in Bangladesh, hurricane Katrina in the USA show natural phenomena and related water problems which threaten large numbers of people. These phenomena are experienced as increasingly uncontrollable and unpredictable, they seem to become more complex given their enormous scale and impact. Societal losses are huge while social or political instability may increase due to feelings of un-safety and to the impact on economy especially on food availability and prices.

These events are related to natural conditions and in the case of climate change accompanied by changing weather conditions. Changes in water quantity and quality due to climate change are expected to affect safety against flooding as well as the availability of food and drinking water, the stability of food supplies, access to resources and utilisation of food production. Climate change affects the function and operation of existing water infrastructure (IPCC).

Towards adaptive water governance

To be able to preserve safety and societal and political stability on the long term, governments try to find solutions to protect citizens against severe floods and provide enough water of sufficient quality. We argue that it is important to define the kinds of water challenges and the involved risks and uncertainties on the basis of two different axis:

- predictable or unpredictable water problems ;
- controllable or uncontrollable water problems.

To develop a strategy for dealing with water problems it is important to distinguish beween the four different situations emerging from the above mentioned axis.

Based on our experience in The Netherlands and Bangladesh we explored different water problems of both countries and positioned them in the four situations.

Water problems involving ‘normal’ disturbances and risks are fundamentally different from water problems involving significant uncertainties. For the uncontrollable and unpredictable water problems, uncertainty management should be related to adaptive water governance. This needs to be elaborated and based on the awareness of serious threats, mobilization of knowledge, intentions to learn and innovate, the necessity of strategic change of thinking and acting, the importance of network organization and public leadership to guide and facilitate these over a long period of time.

The way a government responds to uncertainties depends strongly on national and administrative cultures and existing modes of water governance. The paper shows that adaptive water governance offers an additional strategy to anticipate uncertain risks, taking into account differences in culture, knowledge and experience, financial and other resources.

CULTURES AND FLOODS, RESPONSES AND ADAPTATION

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Countries around the world face various problems due to flooding, varying in intensity and frequency, but often including casualties. Although this is already the case for decades, it is surprising that the behavior of people with regard to flooding, in different countries strongly differs. Some countries prepare themselves otherwise than others do. There seems no tendency to merge in behavior, although there might be some merging in the engineering world, both in knowledge and approach, this is not strong enough to influence people's behavior.

For the first time, this paper explains the differences in flood perception and responses of people using the Cultural Theory of Risk (Thompson 1990). This theory has been used scientific in many sectors, but not in water management. In this paper this will be done.

The theory gives a powerful qualitative explanation for this behavior. Though the cultural theory is not very powerful in explaining differences in a quantitative way, the paper shows that a qualitative explanation is very useful. It directs responses in an over seeable and orderly manner with specific characteristics. Especially in understanding why people have different perceptions and how they can be supported in developing their own response and adaptation options based on their inner drives. In the light of recent worldwide debates on climate change and possible impacts on societies, this is of great value. Also in the light of the theme of this conference it offers opportunities to cope with the risk of floods.

The paper presents practical examples from different countries and cultures around the world. Basically four cultural groups of people are distinguished. The behavior of these four groups are discussed in the light of climate change and associated flood risks. The responses of the four groups differ in many respects. The extremes can be described. From the idea of governing nature on one extreme towards the idea that every disaster is unavoidable, and from the idea of being able to create your own solutions at the right moment towards the idea of equal chances and equal burdens for everybody.

It is interesting to see the connection between adaptation measures and technical solutions on the one side and behavior and social interactions of people on the other. Technical solutions, like defence constructions, evacuation routines, etc., are associated with the social interactions of the people, the way they live together within their constitutional, legal and political system.

Furthermore it is questioned and discussed whether learning-capabilities somehow are connected to the position of a country within this model of Cultural Theory. This could be related to the culture of governance, which is an issue of another paper.

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FLOOD RISK MAPPING AND SCALING: RANKING SOURCES OF UNCERTAINTIES WITH VARIANCE-BASED GLOBAL SENSITIVITY ANALYSIS

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In order to increase the reliability of flood risk assessment, we need to question the uncertainty associated with flood risk mapping (SEC 2010). Using a case study on the basin of the Orb River, France, we demonstrate how variance-based global sensitivity analysis can be used to quantify uncertainty in flood risk maps at different spatial scales and to identify the sources of uncertainty which should be reduced first.Flood risk mapping is recognized as an effective tool in flood risk management, and the elaboration of flood risk maps is now required for all major river basins in the European Union (European directive 2007/60/EC). Flood risk maps can be based on the computation of potential damage due to different flood events, estimated for each individual stake over the study area. Mean Annual Damage indicator (MAD) is a synthetic indicator obtained by averaging over time, using the return period of each event, that can be mapped too. The issue of uncertainty associated with these flood damage maps should be carefully scrutinized, as they may be used to inform the relevant stakeholders or to design flood mitigation measures.

Flood damage maps are based on the combination of hydrological, hydraulic, geographic and economic modeling efforts. Consequently, numerous sources of uncertainty propagate in their elaboration. Recent studies describe these various sources of uncertainty (Koivumäki 2010, Bales 2009). Some authors propagate these uncertainties through the flood risk modeling chain and estimate confidence bounds around the resulting flood damage estimates (de Moel 2010). It is of great interest to go a step further by identifying which sources of uncertainty account for most of the uncertainty in flood damage maps.

We demonstrate the use of variance-based global sensitivity analysis to rank sources of uncertainty in flood risk mapping, taking into account spatial scaling. We use a quasi-Monte-Carlo scheme to propagate input uncertainties through the process of flood damage map elaboration and to compute importance measures (Sobol' sensitivity indices) for each source of uncertainty. The variability of the damage or MAD indicator and the associated sensitivity indices are estimated at different spatial scales: individual stake, district, whole floodplain.

This approach is illustrated on a case study on the Orb River, France. By mapping the uncertainty of damage and MAD indicator, we identified zones – mostly urban areas – where flood damage estimates were less accurate. Then, sensitivity indices allowed ranking the sources of uncertainty at different scales. For instance, the accuracy of the digital elevation model proved to be the key source of uncertainty when estimating the MAD indicator on an individual stake (e.g. a single building), whereas return period of flood events were the most influential when examining the accuracy of total MAD over a larger zone. Finally, maps of sensitivity indices showed the spatial variability of sensitivities over the study area.

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Koivumäki, L. et al. (2010). “Uncertainties in flood risk mapping: a case study on estimating building damages for a river flood in Finland.” Journal of Flood Risk Management 3: 166-183.

de Moel, H., Aerts, J. C. J. H. (2010). “Effect of uncertainty in land use, damage models and inundation depth on flood damage estimates”. Natural Hazards and Earth System Sciences, in press.

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FROM FLOOD CONTROL TO CONTROLLED FLOODING: A RESILIENCE APPROACH TO FLOOD PROBLEMS IN THE 21ST CENTURY CHINA

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China is one of the most flood prone countries in the world, with more than 60% of its 1.34 billion population, about 50% of its most productive arable land, and close to 80% of its rapidly growing national GDP exposed to flooding of various kinds. Each year, China suffers billions on economic losses and hundreds to thousands on life losses. For millennia, China's long and rich flood coping and management experience has been one that is predominantly centered on controlling the flood through engineering structural measures either blocking or channeling the flood water. The increasing trend of flood losses, particularly during the 1990s, stimulated a profound rethinking of the flood management strategy in China, which has led to a major institutional shift that is increasingly characterized as from flood hazard management to flood risk management.

In this paper, we first set this strategic transition into the international context, arguing that it is consistent with and a refection of the overall global rethinking and paradigm shift on our relationship with floods and how flood risk can be managed in a changing climate and an increasingly interconnected world. Embracing variability and uncertainty lies in the heart of the new flood resilience centered paradigm. The fundamental and arguably most difficult change required is therefore for decision makers and society at large to accept that it is neither possible nor necessary to control all floods. A resilience strategy for managing flood risk would require human adjustment to flood, not by aiming for full protection and control but by adjusting our use of floodplain, integrating and indeed experimenting with a wide range of flood risk management options, so that a dynamic balance is maintained between exposure and coping capacity and flood risk is contained at an acceptable level.

While the resilience strategy embodies a wide range of opportunities for long term sustainable flood risk prevention and mitigation, it also raises major challenges. Using Donging Lake Area as an illustrating case, the paper then outlines a set of fundamental dilemmas faced by China in managing its future flood risks, from balancing economic development with flood vulnerability reduction, to coordination and cooperation among increasingly diverse actors and across scales. Envisioning potential impacts of climate change and continued intensification of floodplain development in China driven by rapid industrialization and urbanization, the paper argues that China will see a continued increase of exposure to floods. In order to reducing the vulnerability to flood, trade-offs and hard choices must be made. To what extent can vulnerability be significantly reduced without interfering with the progress on economic gains and improvements in overall well-being? To what extent the politicians as well as the general public are prepared to accept the major investment that is required for the transition to a resilience strategy? What is an acceptable level of flood risk and how it should be decided? Those are the critical questions to which the paper calls for further research and more importantly, science-policy-practice dialogues that are increasingly essential for the paradigm shift to happen on the ground.

DEVELOPING A COMPREHENSIVE FLOOD HAZARD ASSESSMENT FOR LOCATIONS IMPACTED BY MULTIPLE SOURCES OF FLOODING

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The traditional method of determining flood frequency and flood risk does not typically account for the fact that a location could be impacted by flooding from more than one source, where sources of flooding are riverine, coastal, pluvial, and groundwater. Providing separate probability estimates of a location experiencing a riverine flood and a coastal flood event does not provide the true likelihood of flooding at the location, it only provides partial information, which can lead to inaccurate estimates of risk. Thus, the traditional flood frequency analysis does not provide a comprehensive understanding of the flood hazard potential for the location. To fully understand the flood risk at a location, the likelihood of flooding from all potential sources must be accounted for and understood.

The goal of this research is to develop a method of combining flood probability curves from multiple sources to produce a comprehensive flood frequency curve for a given location and to show how the calculation of flood frequency or probability impacts flood risk assessment. This method will provide the true probability of a flood of a given magnitude, or a given inundation level, that occurs at a specific location of interest. The approach will account for the possibility that that the flood may be caused by one or more potential sources. This asks the question “What is the probability of experiencing a flood inundation of ten feet at a critical location, regardless of the source of the flood water?”, as opposed to the question asked by a more traditional flood frequency analysis, which is “What is the probability that a riverine flood will cause an inundation of ten feet at a critical location?” This comprehensive assessment of flood probability and flood risk will allow for more informed decision-making.

This analysis will also shift the focus of the flood frequency study from the individual source of the flooding, where the stage or discharge of the river or water surface elevation at the coast might be measured, to the level of flooding at the location of interest, where the inundation experienced because of the flood event will be measured. A flood frequency analysis that provides the probability of exceedance of a given stage or discharge at a river flow gage or coastal gage does not provide useful information to the people in danger of being flooded. By conducting a flood frequency analysis based on inundation at the location of interest, the information is presented in a manner that is both more understandable and more useful to the user.

Because this research is on-going, the presentation will provide background information on the topic, focusing on the need for this work and the potential benefits. Progress to date of the research will also be presented, including implications of the results gathered up to this point. There will also be discussion of next steps of the research.

Poster Presentations

APPLICATION OF HEC-RAS MODEL, REMOTE SENSING AND GIS FOR FLOOD MAPPING OF LOWER CITARUM WATERSHED, INDONESIA

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Citarum River Basin is considered as one of the vital and strategic river basins for the country's development, particularly for the West Java Province and Metropolitan City of Jakarta. Flooding is almost occurred annually in Upper Citarum in Bandung area, the Capital City of the West Java Province and in Lower Citarum.

The prominent issue of solutions in the flood problems is not only the structural measures, but also soft-intervention needs to be strengthened. Flood occurs within hours and can last within weeks, hampering socio-economic conditions. To reduce and mitigate the impacts of flood as part of soft-intervention actions, establishing a robust hydrological model to predict the flood, higher accuracy of data and information, and information disseminations are steps need to be developed.This article presents the flood map of lower Citarum watershed delineated using hydrodynamic model and satellite image analysis. HEC-RAS was selected to model the flood. The ArcView program and the HEC-GeoRAS module were used to extract the geometric data and export to the RAS GIS Import File in the HEC-RAS import file format. This file was then imported in HEC-RAS model. The correction of geometric data such as adjusting the location of river banks, filtering the number of cross section point, etc. was then performed in HEC-RAS model. After the correction, the maximum daily average discharge was input to simulate the flood event.

Two images of ALOS PALSAR, one taken on a dry date (January 19, 2009) and the other on a wet date (March 26, 2010), were selected to be analyzed using ENVI platform.

One Dimension Hydrodynamic model HEC RAS has been used for flood inundation mapping using two different DEMs for the lower Citarum watershed. Flooded area for year 2007 (From existing map) is 105.11 km2 and simulated area from HEC RAS is 95.63 and 25.68 km2 with DEM1 (extracted from spot height and contour data) and DEM2 (extracted from ASTER data) respectively.

ALOS PALSAR (year 2010) have been utilized for the flood extent mapping of year 2010. A threshold of -3 dB gives an area of 57.27 km2 of flooded area

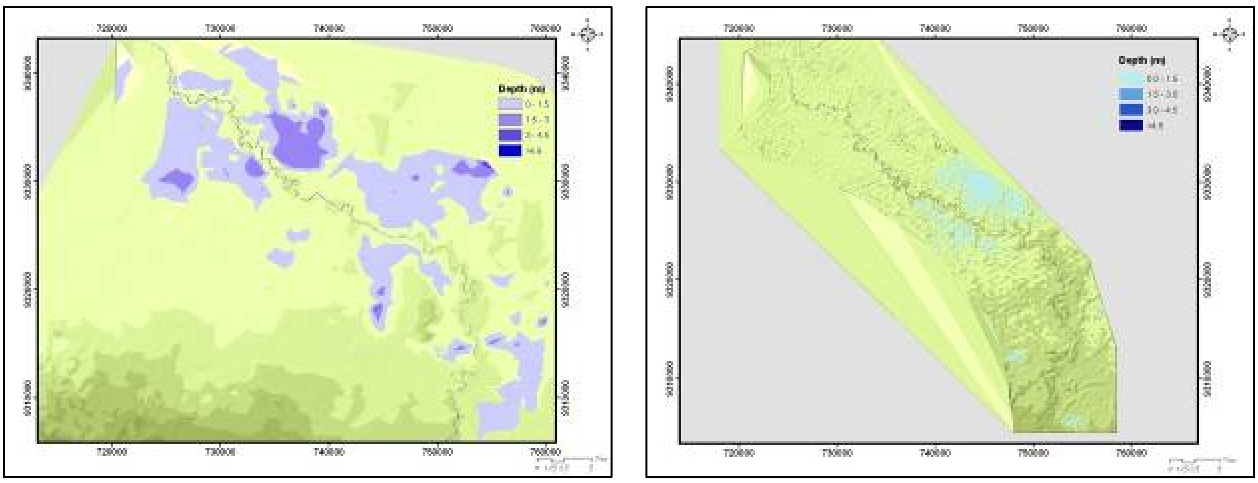

Figure 1. Flood extent simulation of Lower Citarum according to DEM-1 and DEM 2

COST-BENEFIT ANALYSIS CONSIDERING FLUCTUATION OF LOSSES FOR FLOOD MITIGATION PROJECTS

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Flood mitigation projects such as reshaping river banks and constructing dams are undertaken to protect lives and property of people residing in flood plains during floods and landslides. Because the cost of realizing such projects tends to be very high, it is necessary to validate the cost efficiency by carrying out cost-benefit analysis (CBA). CBA expresses relationships between benefit b and cost c. CBA equations include the ratio of benefit to cost (b/c) and the excess of benefit over cost (b–c). The traditional CBA evaluates the benefit of a project by calculating the reduction in annual average losses. For example, the Ministry of Land, Infrastructure, Transport and Tourism in Japan, in its flood control economics manual, presented a comparative calculation of the annual average benefit and annual average cost. Federal Emergency Management Agency (FEMA) has provided guidelines for the use of CBA and presented a comparative calculation of the future benefit of a mitigation project and its total cost.

However, the traditional CBA does not consider the effect of a reduction in fluctuation of losses. In a previous study, Okazaki et al. proposed a CBA based on the μ-VaR (value at risk) model, which considers both expectation and VaR as variables. The method can evaluate the benefit of a project by considering not only the reduction in annual average losses but also the reduction in fluctuation of losses. Okazaki et al. also validated the method by performing a typhoon simulation, selecting forest wind damage as the target for the simulation.

In this study, we used the above method to study the feasibility of a flood mitigation project in Japan. Then, we compared the method with the traditional CBA. The total cost of the project was estimated by considering both the construction costs and maintenance costs. The total benefit of the project was estimated by performing flood simulations for many scenarios. The results showed that the flood mitigation project has the effect of reducing fluctuation of losses and that the benefit calculated by the proposed method is larger than that by calculated by the traditional CBA. From the results, we confirmed that the traditional CBA underestimates the benefit of flood mitigation projects and that our method is suitable for assessing the feasibility of such projects.

PRESENT TRAGIC FLOODING SITUATIONS OF LOWER MINDANAO RIVER IN THE PHILIPPINES: FLOOD PATTERN CHANGES AND SOCIAL ENVIRONMENTS

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The Mindanao River Basin (MRB) is the second largest river basin in the Philippines. It has a catchment area of 23,169km^2 and is located in central and southern MindanaoIsland. Severe and constant flooding ever caused disruption in social and economic activities, and caused inflicted damage to lives, livelihood, and properties losing billions of pesos, especially at Cotabato City and surrounding areas.

In 1982, the Government of the Philippines (GOP) formulated flood control Master Plan (M/P) including MRB with JICA. However, no flood control works were implemented due to the unstable peace and order situation in the area.

In 2008, Typhoon Frank hit the area. The damage brought by Frank on infrastructure alone, excluding government installation and school buildings, was estimated by the DPWH at P710million (USD16million). Triggered by the havoc, the Presidential Task Force on MRB Rehabilitation and Development (PTF-MRBRD) was established.

Primary mandates of PTF-MRBRD are to coordinate the formulation and implementation of the MRB relief, rehabilitation and long-term development plan. PTF-MRBRD started the preparation of the MRB Integrated Management and Development M/P by coordinating with GOP and Autonomous Region in Muslim Mindanao, and is almost completed.

SimuayRiver with a total basin area of about 600km^2 joins the MindanaoRiver through Municipality of Sultan Kudarat. It flowed into IllanaBay before but joined directly to the MindanaoRiver at the downstream in 1970s. The reasons comes from the fact that Ambal River, presently a tributary of Simuay River with a catchment area of about 200km^2, joined Simuay River in the upstream in 1950s, and carrying down heavy sediments and depositing them in the lower sections. AmbalRiver swelled flood and sediment discharges to SimuayRiver.

Eventually in 2008, Frank breached widespread left banks of SimuayRiver, and large floods and heavy sediments were brought over to many barangays of the municipalities of Sultan Kudarat, Sultan Mastura and CotabatoCity. Floods in 2009 breached the other parts of the left bank of SimuayRiver and expanded the flood disaster area. Many barangays located along flooding course are being exposed to flood damage on a daily basis. It becomes an ordinary situation nowadays, and such floods usually inundate about knee height.

Such flooded water and sediments finally flows into the MindanaoRiver. Since heavy sediment discharge and flood water from SimuayRiver raise river bed, thus increasing flood levels of the MindanaoRiver and flood disaster risks to the areas. In CotabatoCity, flooding areas are identified over the low-lying lands extending in the east and west of the city core.

A comprehensive flood control M/P of MRB and an urgent rehabilitation plan of Simuay and AmbalRiver are needed to mitigate the flood damages and restore the ordinal life of the people to stabilize the peace and order situation in the area. Involving the local stakeholders in the planning and implementations are essential for the peace move.

The authors present the background and the steps forward to mitigatethe flood damages in the area.

GLACIAL LAKE OUTBURST FLOOD AND ITS COUNTERMEASURES IN BHUTAN

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The mountainous country, Bhutan has relatively less flood disasters than the countries with large flat lands. On the other hand, various mountain disasters occur in Bhutan because the country is completely located in the Himalayan Mountains. This presentation shows the recent status of floods from the mountain glacier and its countermeasures activity being carried out in Bhutan.

A number of glacial lakes have been recently developed due to the global warming. Most of the lakes are dammed by fragile moraine. The so-called “Glacial Lake Outburst Flood (GLOF)” comes down from breaching of the moraine dammed lake. GLOF events occurred at least 6 times in the Bhutan Himalaya since the beginning of 20th century. Among them, the 1994 GLOF from Luggye Lake struck provincial cities. Punakha Dzong, a prefectural office building founded on the lowest river terrace was isolated from the swelled river and 21 people were killed. Lake level lowering works in Raphstreng Lake, one of the biggest glacial lakes in Bhutan was conducted by the Geological Survey of Bhutan and India in 1996-98. The Economic Affairs of Bhutan with support from UNDP also implemented the lowering of the Thorthormi Lake from 2009 onwards. It involves severe labor works and the workable time is also limited to only 3 months in a year due to snow and ice. For the last 2 years only 2.2 m and 7.6 mil. cu m could be reduced in lake level/volume. However this project also creates some small job opportunities and brings positive economic opportunities.

At the same time, a glacier lake mapping and vulnerability evaluation project has been initiated by Department of Geology and Mines and Japanese researchers with support from Japan International Cooperation Agency and Japan Science and Technology Agency from 2009 onwards. Through this study, a potentially dangerous glacial lake, with the possibility of outburst was reevaluated by objective criteria using Remote Sensing/GIS techniques. Consequently, most of the 25 lakes, which have been so far identified as potentially dangerous, have been found to be not so dangerous. This result means that difficult tasks of mitigation and monitoring measures in future by focal agency can be focused only on selected several lakes, thereby reducing the cost considerably. Our field investigation also identified a small but most recent GLOF event in Bhutan. The flood was generated from a typical debris-covered glacier which was never noticed as causes of GLOF. Hence, such cases also have to be sensitized as one of the source of GLOF.

In addition to the glacial lake, there are some cases of natural dam formation by landslides and debris flow from the tributary due to heavy rain. A natural dam outburst flood occurred subsequent to a deep-seated landslide in Tshati Chhu in 2003. This event threatened a reservoir dam downstream in the Kuri Chhu hydropower station. The Hydropower generation is the main source of revenue in Bhutan which covers over 40 % of foreign currency. Hence, assessment of lake condition, flood simulation and intensified meteorological observation are urgently required.

ANALYSIS OF DRYNESS/WETNESS IN XIANGJIANG RIVER BASIN AND ITS RELATIONSHIP WITH FLOOD USING THE STANDARDIZED PRECIPITATION INDEX

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The local dry/wet condition is one of the important components of a regional climate system. It is strongly coupled with precipitation and moisture content and greatly affects local hydrologic and ecologic processes, which may trigger some extreme events with severe consequences. The occurrences of drought, flood are usually accompanied by an anomaly of dryness/wetness. it is therefore of great importance to investigate the change of local dryness/wetness in the context of global climate change, in order to better understand the future climate trend and flood risk, and thus manage flood disaster in a more effective way.

Standardized Precipitation Index (SPI) is a probability-based indicator to depict the degree to which the accumulative precipitation of a specific period departs from the average state. The deviation degree and its probability are obtained through a transformation from the original distribution of historical precipitation to standard normal distribution on the basis of same accumulative probability. SPI has been widely used in the field of drought monitoring, as it is space-independent. Meanwhile, research has indicated that SPI also has a sound performance in flood risk analysis and wet condition monitoring since it is normally distributed. Thus, the changing trend of local dry/wet condition can be detected with it.

Xiangjiang River Basin, a tributary of the Yangtze River, is taken as the study area in this paper. The advanced agriculture makes the region one of the major grain-producing areas in China. However, due to the variation of monsoon and the intensive precipitation brought by typhoon, Xiangjiang River Basin is prone to floods, which cause millions of dollar of agricultural losses every year. Strengthening the research on the change of dry/wet condition inXiangjiang River Basin in the context of climate changecan thereforepromote a better understanding of flood risk in this area and help decision-makers to take more effective measures to reduce the loss.

The work carried out in this paper mainly consists of three parts. Firstly, the spatial-temporalvariation of dry/wet condition of each season in Xiangjiang River Basin is investigated with the SPI at various time scales. Then the Mann-Kendall test is used to analyze the trend of local dry/wet condition. Finally, historical flood events in Xiangjiang River Basin are used as illustrating cases to explore the relationship between flood and local wet condition, together with SPI value series. Results show thatthe weather in spring of Xiangjiang River Basinis getting dryer and getting wetter in summer with significant level less than 0.05, while there is not any explicit trend in day/wet condition in autumn and winter.Meanwhile, a significant correlation has been found between positive SPI value series and peak flow. And a more detailed analysis indicates that the historical flood events are well explained when SPIs of different time scale (12 months and 3 months) are combined together. The method and result can be used to predict the flood risk tendency in Xiangjiang River Basin, thus corresponding proactive actives for flood risk reduction can be properly taken.

FLOOD MANAGEMNET IN COLD CLIMATE- EXPEREINCE IN NORWAY

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Cold climate regions are the regions where the mean monthly temperature of one month per year is below +1oC (Smith et al., 1996). The cold regions occupy one-third of the earth's land areas and now one-fifth of the world population resides in the cold climate. Norway is situated in the western and northern parts of the Scandinavian Peninsula in northern Europe, ranges from altitude about 57oN in the south to 71o N in the north and longitude about 10o45' E. According to a statistics of monthly air temperature during 1961-1990,13 of the 19 stations that distribute in 19 counties and have data in the statistics period have cold period from 2 to 7 months. 9 stations have 5 or more cold months.

Specific problems caused by low temperature are typicallyprecipitation in form of rain or snow, snow storage and snow melt, rain on frozen surface, frozen soil and underground, frozen in pipes (sewers) and in rivers and lakes, icing and clogging of sewer inlet and outlet, etc. These problems will induce more runoff in urban drainage systems and rivers in some periods of a year depending on the temperature, which will subsequently increase the risk of flooding and pollution problems. In temperate and dried climate flood usually occur in wet seasons; whereas in cold climate like in Norway floods may happen any time of a year, i.e. floods in four seasons.

Comprehensive flood management include data collection, modelling and forecasting, flood risk mapping and guide for development along the main rivers and floodplains, and emergency planning. In combination general flood management approaches with the specialties in Norway, this paper presents characteristics of flood management in urban catchments and river basins.Case studies of flooding in large river basins and urban catchments are presented.These case studies deal with snow-related statistics and simulations with different scales for temporal and spatial resolutions are presented in the paper.

The climate in Norway is however not unique. Regions along the coast like Bergen have mild climate, whereas regions inland have cold humid climate. Therefore modelling and management flooding related to cold climate requires both spatial and temporal diversification.

Due to its geographical location and climate conditions, Norway is very sensitive to climate change. Projected change scenarios, possible impacts and resulting challenges for flood management are addressed.

A STUDY IN TAIWAN'S KEY AREAS OF ANNUAL FLOOD SEASON

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Taiwan is a subtropical island with many typhoons and floods in monsoons. To mitigate the disaster damage, the NCDR introduces the innovatory researches and develops practical techniques for hazard reduction, readiness, response and recovery. The disaster potential of Taiwan has been analyzed by the NCDR, and strategies for hazard preventions and mitigations are proposed. The NCDR is also an assistant unit of the Central Emergency Operation Center (CEOC). During typhoon periods, the NCDR also provides flood warning information and suggestions to CEOC and help the commander to make the right decisions in disaster preparedness and response phases.However, the typhoon path and rainfall forecasts have high uncertainty, so we need inundation predictionsin order to judge early.

Thus Taiwan's key areas of annual flood season were proposed. The study decided the annual key areas according to the four items of information: last year's flood security plansof Taiwan cities and counties, vulnerable flood areas investigated by NCDR, weakness flood areas estimated by Taiwan Government, and historical flood points of Taiwan. In this study, Taiwan's key areas of 2010flood season was proposed, and verified their missed alert rate and false alert rate using Taiwan's 2010 flooding records of Typhoon Fanapi event in September and Typhoon Megi event in October. The results reveal that the key areas has better efficacy and could provide a useful information for emergency responses

TEMPORAL VARIATIONS OF SCOUR AROUND SERIES OF SPUR DIKE

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Consider to importance and necessity of river training, the use of structures to stabilize the riverbanks and shape of structure type is the very important. One of the stabilization methods with a good efficiency in river is use of spur dikes.

Spur dikes are structures, constructed transverse to the river flow extending from the bank into the river. Spur dikes are divided into two types: Permeable or pervious spur dikes and impermeable or impervious spur dikes. Impermeable spur dikes which are usually made of rock fill embankment, earth embankment or gabions, protect the bank by deflecting the current toward the axis of river. In this type of spur dikes, due to impermeability of structure, the vulnerability is so high and scouring may occurs in the nose of spur dikes. The permeable spur dikes, usually made of pile or trees, decreases the eroding ability of flow by reducing the velocity near the river banks, consequently protect the banks.

Construction of spur dike will affect the flow pattern and may cause local scour around the nose of spur dike and leads to siltation in the downstream. Review of literature shows that less attention has been paid to study the scour around permeable spur dike.

In this paper effect of parameters like: Opening ratio and Spacing of spur dikes on temporal variations of scour around series of spur dike under clear water condition are studied. Results of experiments on temporal variations of scour around spur dike are reported.

Results showed that:

1. The scouring around the first spur dike (in series of spur dikes) was similar to that of single spur dikes. For the next spur dikes, the amount of scouring was related to amount of scouring of the first spur dikes as well as the spacing of spur dikes.
2. The scouring rate in impermeable spur dikes was higher and more fast than spur dikes with greater opening ratio in all spacing. Also, this trend was reduced with increasing the opening ratio. The effect of opening ratio on scouring trend can be neglected with an acceptable approximation.
3. Increasing of opening ratio decreases the scouring rate around spur dikes.

FLOOD DISATERS CAUSED BY 2009 TYPHOON MORAKOT IN CENTRALTAIWAN: CASE STUDIES, LESSONS AND RECOVERY PLANS

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Toukeng Creek located at Sinyi Township, Nantou County in central Taiwan, of a branch for Heshe Creek, catchment area is approximately 453 hectares. Due to

Morakot brought heavy rainfall for this catchment, resulted in the occurring debris flow in Toukeng Creek approximately at 2:00 pm, August 9, 2009. The large sediments scoured the stream bed around 20m, and caused the breaking road approximately 600m, as well as the partial residents suffer injury and damages of the national forest. The debris flow converged in Heshe Creek, created the delta deposition on the confluence, and raised the riverbed of Heshe Creek.

Based on the field investigation and aero-photographs which were photoed before and after Typhoon Morakot(shooting date wasJanuary 14, 2007andAugust 25, 2009), the results showed the mainsource ofwatershed sediment was landslide. Before Typhoon Morakot, the area of landslide, which was gradually invasive with vegetation, was 3.09 hectares; however, after Typhoon Morakot the landslide area in this region increased to 28.38 hectares, and mainly spread in the upstream catchment area.

Moreover, the area of theriverflood plain theriver channel was6.13 hectares before Typhoon Morakot; the river channel areaexpanded to27.85 hectares after TyphoonMorakot because of the lateralerosionbyheavy rainfalland discharge effects. The whole stream riverbedwassignificant scoured and thestream bankerosion due to thedebrisflows. The damagecaused bydebris flow included the along houses,roads andplantations. From the aero-photograph in 2007, it indicated the originalarea of riversideforestland was 15.27hectares, however after TyphoonMorakot it reduced to9.95 hectares area due tochannelwidening, and the lossforestarea was5.32 hectares. By thefield investigation, the mainaccumulationarea of debris flow caused by Typhoon Morakot silted up on the riverbed of Heshe Creek near the outlet of Toukeng Creek catchment. Meanwhile, it resulted in the oppression to the opposite bank erosion of Heshe Creek, and affecting the left bank ofhouseholds androad safety.

In this research, a numerical simulation of debris flow will be also carried out in addition to the field investigation. The purpose is to increase the understanding on this phenomenon and compare the difference between modelling and field investigation. Finally, it will present several planning schemes and their goals are to stable the present residual sediment on the stream channel, and preventsedimentmovement intothe area of preservation target and avoiding the occurrence of compounddisasters. It is expected, after the implementation ofrelevantmanagementplans, thatit can protectnot only the forestsbut people in catchmentareas, reduce thedamagecaused bythe land lossof forestsas well as buildingrepair costs, and thusincrease protectedlandbenefits. It is assumed toprotectthe population of110 people, 36 buildings, 12.04 hectaresof forest, and 2bridges in Toukeng Creekcatchmentandthe region along the bank downstreamofthe confluence.

FLOOD FREQUENCY MAPPING IN BELGIUM USING MULTIRUN RESULTS

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Flood frequency mapping isan important tool in evaluating water managementpolicies. The effectiveness of protective measures can be weighed more effectively when the flood frequency in a certain zone is known. The Flemish Environment Agency (VMM) in Belgium has developeda new methodology to create flood frequency maps. The method allowsto make univocal flood frequency maps in which a certain frequency can be attributed to every water level and flow anywhere in the river system.

In some methods to generate flood frequency maps, frequency results at water gauges are used. These methods state that frequency results at one location (e.g. flow gauge) can be propagated throughout the catchment. In many cases this is not correct. A single event may be exceptional at one place but not at another place or vice versa. Moreover, extrapolation to higher return periods is uncertain with gauges that have a short measuring range. With this new methodology it is possible to delineate precise floodfrequencies at every node in the hydrodynamically modelled network.

In the first step of the method, a selection of independent historical events is made. For these events, calculations are performed by the hydrodynamic model. The results of these calculations provide information about the behaviour of the river along the course of the modelled network for many historical storms. Subsequently, a statistical analysis is performed on every river section and storage area in the network, from which uniform flood frequency maps are created. The automation of these steps by the software Infoworks RSmakes it possible to obtain flood frequency results in a fast manner.

INSTRUMENTING THE PERFORMANCE OF LEVEES AS PART OF REAL-TIME FLOOD MANAGEMENT: AN APPLICATION OF THE EU URBANFLOOD PROJECT AT BOSTON UK

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The UrbanFlood project will create an Early Warning System framework that can be used to link sensors via the Internet to predictive models and emergency warning systems. The data collected from the sensors will be interpreted to assess the condition and likelihood of failure; different models will be used to predict the failure mode and subsequent potential inundation in near real time. Through the Internet, additional computer resources required by the framework are made available on demand. The project includes three pilot sites to apply and validate at full scale the technology being developed in the project: Amsterdam (Netherlands), Boston (UK) and St Petersburg (Russia). Other papers will discuss the new information and communication technologies required for this project; this paper focuses on a description of the selection, design and installation of the instrumentation and the early dissemination and analysis of the results at one of the pilot sites, Boston.

Boston (UK) is a town on the east coast of England located with a long history of floods. More than 50% of homes (i.e. more than 15,000 homes) are at significant risk of flooding from a combination of high tide and storm surge in the North Sea. The main area of the town is a little inland from the coast but is affected by tidal rivers in which the spring tide range is about 6m. Levees have been constructed on superficial alluvial deposits of sand and clay beneath over glacial boulder clay. A mixture of different levees exist, but for this project a simple embankment was selected at a location with a history of instability on the riverward face.

The instrumentation was selected on the basis of previous experimentation and comparison of instruments installed in full scale dike failure tests in the Netherlands (IjkDijk). Installed in CPT holes were

- Dutch developed MEMS modules (GeoBeads) able to detect local tilt, pore pressure and temperature, the latter as a proxy method for detecting water flow
- Two types of US-Canada developed Shape Acceleration Arrays able to measure three-directional soil deformation profile and one type also able to detect pore pressure

In addition, sensor enabled-geotextile strips based on fibre optic sensing technology, able to detect soil strain by distributed light back-scattering, were installed along the entire 300m in the crest and front slope of the embankment. This technology allows longer stretches of embankment to be monitored at low cost.

The gathered data is being used to detect anomalies, supported by an Artificial Intelligence system. If an anomaly is detected, this then triggers assessment of the likelihood of levee breach. If breach is likely, the consequences in terms of flood propagation and damage in the defended urban area are assessed via high speed computer modelling.

Results are being displayed on the project website. There are also plans to set up a visitor centre in the town where this information is made available and is linked to future plans for improvement of the levees in Boston.

FLOOD LEVEL ANALYSIS IN OPEN CHANNEL USING STOCHASTIC DIFFERENTIAL EQUATIONS

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To calculate flood level in open channels, the usual assumption is that the hydrology parameters are constant. However, this is just a kind of idealized situation for stochastic effects are ignored. In fact, there are many uncertainties existing in the hydrology process. To handle these uncertain effects, the stochastic differential equations (SDE) based on the theories of probabilityand differential equations were adopted.

This paper explores the modeling ofwater level in open channels and solved it numerically by applying an Euler-Maruyama method. The initial water level and roughness coefficient in the equation are taken as random variables and assumed to obey normal distributions. A Brownian motion is considered as random entry to the equationto balance the uncertainty during the flood propagating.

The results suggest that both the mean value and standard deviation of initial water level has noticeable influence to the mean of the random flood hydrograph while to the standard deviation of the random flood hydrograph suggest little influence. The mean value of the roughness coefficient in the normal distribution significantlyinfluencesthe mean of the random flood hydrograph while the change of standard deviation substantially affects the standard deviation of the random flood hydrograph. Random entry affects the random flood hydrograph significantly, especially to the standard deviation. It is also observed that the influence of the random factors to flood routing grows larger as the flood propagatesdown.

Therefore, the random factors play an important role in the propagation of a flood and the theoryon stochastic differential equations can be used to model problems in hydraulic more realistically, which provides a better input for the risk analysis in hydrological modeling and computation.

RISKS AND DAMAGE QUANTIFICATION DUE TO FLOODINGS

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Fifteen percent of Catalonia urban area is exposed to flood risk. This situation is getting worse when infrastructurehigh density and population concentration are considered –mainly in the metropolitan area of Barcelona. For the last 10 years, the Catalonian Water Agency prepares studies and plans at different scales and objectives, which lay the foundations of Risk Management Plans development. These Plans will have to be compulsory carried out in accordance with sectorial regulation (Directory 2000/60/CE and 2007/60/CE and their transpositions to national laws).

During this period, the methodology has evolved with the data improvement (flood data, the land use data and the informatics tools), has achieved the setgoals to determining flood risk quantification and evaluation and to developing methodologies for cost benefit of mitigation measures.

First steps were taken in defining the concepts, formats and scales as a framework and assessing vulnerability. Territorial items were classified according to their use, the associated problems suffered in a flood event and to their aggregation level: class, subclass, type, subtype, item, subitem. This allows the available information reclassification regardless of the aggregation level data source and the nextstandardization depending on the chosen work scale. Updated land use layers are vector and 0,05 ha maximum resolutioned rasterGIS data models. The structure and content value per unit area are measured for every territorial item. Damage can be quantified from the 5 hazards levels that the floodplain is characterized, weighted total destruction as the unit.

These weights depend on land use so the same hazard level produces different loss ratios. Fatalities estimated have been determined from: population density assigned to different kinds of land use, people's vulnerability depending on their mobility and answering capabilities, peopleexposure and weighted coefficients associated to every hazard levels. The result is multiplied by a human being loss legally prescribed compensation cost.

In summary, to obtain a cost raster layer is needed:

- To determine the floodplain hazard level
- To determine the vulnerable territorial items from the land use map,
- To set an analysis level of data,
- To calculate costs allocation depending on the item category and
- To intersect flood area hazards raster layer and valued land use layer and to adjust weighted coefficients.

In this way a continuous map of potential damages will be obtained. This information is used for cost-benefit analysis of mitigation measures to guarantee comparative basis.

FLINKMAN; A STAKEHOLDERS' LINKING FRAMEWORK FOR FLOOD MANAGEMENT

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Natural disasters, including floods, are increasing in frequency and magnitude in Europe and all over the world. It has resulted, from the preparatory work and the consultations of EU member states, the identification of specific problems:
the lack of a consistent knowledge base regarding floods;
the limited or non existing links and/or partnerships among the various actors and policy areas involved in Flood Management.
Description
FLINKMAN project is aiming at the enhancement of collaboration and mainly coordination of stakeholders involved in flood prevention and management. The majority of stakeholders involved in the different phases of a Flood Management Plan are, usually, unaware of their involvement, the human and financial sources they have to input for effective Flood Management. It is important for flood prevention and mitigation of the consequences of a flood incident, the active participation of all level stakeholders in the planning and implementation phases of a Flood Management Plan.
The main objective of the FLINKMAN project is the development of the appropriate framework, which will promote the stakeholders active engagement during the preparation phase of a flood management plan in order to ensure their consistent and effective linking into each stage of the flood prevention-preparedness-response-remediation chain. Furthermore the proposed project intents to:
establish support tools based on Information Society applications, that will foster the collection, assessment and exchange of best practices across the EU;
initiate the proper participatory mechanisms for stakeholders sensitization and their active involvement in Flood Management issues;
promote the transnational cooperation with interested, competent bodies all over Europe.
Activities
In order to achieve the abovementioned, FLINKMAN partners (The Netherlands (region North-Brabant, Greece (region Macedonie), Germany (region Hessen) and Assembly of European Regions (AER)) will:
Identify and present effective engagement mechanisms of competent, public and private authorities involved in flood management, in order to ensure solid coordination with regional and national key actors on flood prevention.
Develop and widely disseminate Good Practices which will target at providing guidance for the engagement and linking of the stakeholders in the different phases of flood management phases.
Initialize a closer cooperation between stakeholders involved in Flood Management and other disasters via a participatory process, in order to instigate stakeholders to comprehend their roles and responsibilities in Flood Management and develop the necessary capacities in technical means and human resources.
The results of FLINKMAN will be presented on a poster.

EVALUATING THE ACCURACY OF A RAINFALL-RUNOFF MODEL IN LUMPED AND DISTRIBUTED ESTIMATION OF FLOOD HYDROGRAPH, A CASE STUDY: KAROUN BASIN

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Simulating flood hydrograph in a drainage basin has a great importance in many projects like: flood control and management, controlling flood damages and excreta. Hydrologists use hydrological and hydraulic modeling methods to simulate flood hydrographs. There are lots of hydrological models called rainfall-runoff models which can be classified based on different methods. In general, mathematical hydrological models can be classified in 2 groups called "Lumped Models" and "Distributed Models". In lumped models, all inputs and outputs are applied as total average; So that the domain of simulated data is directly affected by the domain of observed data. In distributed models, simulating is based on pixels or hydrological units. The second one is used in this research which can rout the flood wave and effective precipitation step by step, from upstream till downstream. Therefore the flood hydrograph at the outlet of a basin can be simulated by all calculated hydrographs. Usually, distribution of observed meteorological and hydrological gauges isn’t suitable. It causes the lack of required data in a large part of study area. This problem will limit the application of distributed models. In this study, the simulated hydrographs of two flood events (on 17th till 19th of March and on 1th till 7th of April in 1998 which are respectively the first and second important flood in Karoun basin because of their peak discharge) through 2 methods of Lumped and Distributed using HEC-HMS were compared to find that weather distributed model can be replaced by lumped mode. The required data for being applied in HEC-HMS model were calculated directly using observed data or indirectly by being processed in GIS environment. Extracting the needed data in GIS environment was done using a radar digital elevation model (RDEM) with pixel size of 85×85 meter. To have a distributed simulation of flood hydrograph, Gridded curve number map (CN) was extracted in GIS environment base on soil hydrological group map and land use map determined by the images of Landsat TM. As the study are is located in a place which receives a large value of snow, therefore for considering the amount of run-off caused by snow, the snow factors including degree-day factor and critical temperature have been calibrated and have been validated for the study area.

The result of calibrating the basin parameters has proved that the curve number has the lowest changes trough calibration process in compare with initial loss and time of concentration. It could be due to the high accuracy of the extracted gridded curve number map. Comparing simulated and observed flood hydrograph has demonstrated that the values of 3.2 degree-day and 2.5 degree are the best values for degree-day factor and critical temperature respectively in Karoun basin. Comparing the simulated flood hydrograph gained by lumped method with observed flood hydrograph in shaloo bridge station as the outlet of the basin, has showed that the difference between the main characteristics of these two flood hydrograph (peak discharge, time to peak discharge and discharge volume) was lower than 5% and was not significant. However the simulated flood hydrograph trough distributed method was also in a great agreement with the observed flood hydrograph in the outlet of the basin. Comparing two simulated flood hydrograph by lumped and distributed method has demonstrated that there was no significant difference in the main characteristics of these two flood hydrograph. The most difference in the characteristics of simulated hydrographs through lumped and distributed methods was in the time to peak discharge which was estimated one hour later in distributed method. It could be concluded that estimating flood hydrograph by distributed method could be replaced by lumped method in Karoun basin which needs lower data and is simpler than distributed method. Therefore a promising estimation of flood hydrograph could be done based on lumped method in this mountainous basin when there is the lack of data which is a common problem in the most of watersheds.

EVALUATION OF CLIMATE CHANGE IMPACT ON FLOOD FLOWS IN THE CZECH REPUBLIC

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Moddeling rhe expected climate change impact on extreme hydrological events demands for precise methodology using adequate temporal and spatial resolution, adequate downscaling method and simulation of sufficient length in order to cover possible variability of interaction between climate driver (precipitation) and basin state (initial saturation).

Available GCM and RCM simulations were evaluated from the perspective of its performance for the area of the Czech Republic during the refernce period within the project VaV/1a6/108/07. In addition regional climate model ALADIN-CLIMATE/CZ simulation was prepared. Selected scenarios were used in following hydrological modelling. We take into accound scenarios based on A1B, A2 and B1 emission scenarios and best performing models MIROC3_2_M; MPI_ECHAM5; UKMO_HADCM3; ALADIN-CLIMATE/CZ and median of 8 best performing GCMs. Based on expected mothly changes of precipitation and temperature (mean and variability) a 1000y daily time series of MAP and MAT were generated using stochastic generator for three target periods (2010-2039, 2040-2069, 2070-2099). We have also simulated another three scenarios representing colder climate of the end of 19th century and of course a reference scenario.

Precipitation data was distributed to 6h time step using historical analogue selection. Spatial distribution used modified Shaake shuffle approach. (Spatial-temporal distribution used an ensemble approach for selected flood events.) AquaLog modeling system (using SAC-SMA) was used to simulate runoff for 7 small to medium size basins Orlice River (1 554 km^2), Vyrovka River (265 km^2), Jizera River (2 159 km^2), upper Vltava River (948 km^2), Otava River (2 914 km^2), Smeda River (244 km^2) and Becva River (1 593 km^2).

As a result empirical flood exceedance curves were made based on simulated yearly peak flows. Comparison of climate change scenarios to reference period suggest mostly slight decrease or no change (+/- 5 %) in flood risk for the magnitude of 100y flood. However results differ significantly based on scenario used. For example MIROC3_2_M based simulations provide significant increase of flood risk due to expected increase in summer precipitation while other GCM expect decrease of summer rainfall total in the Central Europe. It suggest the antagonist efect of increased short term precipitation and lower initial saturation due to longer periods of dry will be probably of comparable magnitude from the perspective of its influence on floods. We have not fooud significant trends during the 21st century, but colder climate excersice provided generally the higher flood risk for all flood return periods.

A CASE STUDY ABOUT THE INFLUENCE OF SMALL RETARDING BASINS ON FLASH FLOOD RETENTION IN HEADWATER AREAS – CENTRAL EUROPE

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The concept of decentralised flood protection measures is based on the idea to localize and use 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.

Due to the fact that common flood protection management mostly focuses on the downstream catchment regions the question arises if for headwater areas any opportunities exist to mitigate flash floods for example by implementing or using small retarding basins or ponds along the valleys of the headwater areas for a downstream flood protection.

The headwater areas of the Ore Mountains, a low mountain range in south-eastern Germany, are often one agent triggering flash floods in downstream valleys since precipitation is distributed over large areas of the upper sub-catchments before the run off concentrates in the steep receiving water courses.

Against the background of severe damages on infrastructure and buildings caused by flash floods in that region in the past the hydrological effect of small retarding basins on flood generation was analysed for the case study of the Natzschung creek. The rainfall-runoff simulation was operated with the software package NASIM. As one result the analysis of calculated scenarios indicates that the use of those small basins has a distinct and also local impact on the reduction and time shift of peak discharge. The results of this case study will show the opportunities and limitations of this concept.

STABILITY OF CONCRETE BLOCKS AS A COUNTERMEASURE AGAINST OVERTOPPING FAILURE OF LEVEE

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Recently, the failure of levee due to overtopping increases in Korea. The main cause of overtopping is the occurrence of flood over design frequency. Since the levee failure during flood threatens human life, efforts are needed to prevent the abrupt collapse of embankment. It has known that levee break begins with erosions of inner slope surface and toe which are not protected against overflow. The reinforcement for the weak points, therefore, may be the best way to minimize the probability of levee break. In this study, experiments were carried out to investigate the flow characteristics on the steep slope of levee and the stability of concrete blocks as a countermeasure against its surface erosion. A rectangular channel used for experiments is 9 m long, 1 m deep and 1 m wide. The slope of channel is 1 in 3. As a result of the experiment, the behavior of overtopping flow on levee slope is characterized and the design curves to be able to determine stable sizes for given flow condition is proposed.

IMPACT OF VULNERABILITY ON FLOOD RISK: NILWALA RIVER BASIN IN SRI LANKA

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Flooding has been one of the most costly disasters in terms of both property damage and human casualties in Sri Lanka. Floods are observed frequently along Nilwala river in southern Sri Lanka and thus the government is compelled to spend a huge amount of national funding for the relief work during such floods. Population density, dependency, land use, road network and building conditions are considered to be important vulnerability factors that contribute to the risk due to floods in the Nilwala river basin. Usually, decisions in the mitigation of impacts due to floods before, during and after flood events are taken at the smallest administrative level in the country, which is the Grama Niladari Division (GND) level. The study investigates the impact of different vulnerability factors on the risk due to floods at the GND level. In that exercise, the flood risks were calculated at the GND level considering diverse flood hazard and vulnerability factors. Software HEC-GeoRAS and HEC-RAS were used in the determination of flood hazards at the GND level. Inundation area and inundation depth were taken as hazard factors. Flood risks were calculated and risk level maps were prepared at the GND level using the abovementioned hazard factors and vulnerability factors.

The study indicates that the different vulnerability factors considered have different impacts on flood risk of different GNDs. Thus, the identification of the most effective vulnerability factor in the mitigation of risk using the proposed methodology will be very useful for the decision makers to make right decisions on the allocation of funds for flood relief work.

STUDY ON THE STRATEGY OF FLOODING MIIGATION IN CHIAYI COASTAL ZONE

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Chiayi is an economically challenged county in Taiwan; the most residents rely on the fishery and agricultures for economic income. Since 1970, for needs on economics developing, over-pumping of groundwater for aquaculture have been caused the serious ground subsidence, near the coastal zone, many of the land has become as depressions and runoffs have been trapped or become water-logged and hence brought about damage. In addition, due to the population growing needed and the public's pursuit of quality livelihood, encroachments of the lands for waterways for urban development spaces frequently happened. Consequently, the watershed features was changed and the originally natural hydrological environment was harmed, then all of the drainage systems and flood control facilities have reduced or lost their function, and caused the coastal villages such as Budai and Tonshei became as a flood-prone area, now the most area situated within these two townships have long suffered from serious inundation, especially in heavy rain and typhoon season.

In order to find the most effectively strategy to solve the inundation disasters, based on to the regional characteristics and flooding causes, a questionnaire including two strategies (objective layer), i.e. engineering strategy (S1) and non-engineering strategy (S2) and seven sub-strategies (factor layer) for each objective layer were proposed, and four times re-corrected by modified Delphi method was performed to obtain a final version of the questionnaire. Then we begin to make a questionnaire survey, 72 copies gained from scholars and experts (including professionals from central government and local government) were analyzed by the AHP (Analytic Hierarchy Process) method, The results shows though non-engineering strategy has a smaller negative impact in environment and ecological system, we can be found, engineering strategy is still the relatively acceptable method and it was recognized by all three units. In engineering strategy, "design and planning of regional drainages" is the most recognizable methods, and "building pumping station and portable pumps" is the second recognizable approach. These two methods actually response to the needs for solves the inundation problems occurred in Chiayi coastal region. Also, "Change and restrain the land utilization" in non-engineering strategy is an important approach for solve the inundation due to ground subsidence. Methods mentioned above are the urgent need approach and they conforms to the objective of "Regulation Project of Flood-prone Areas", in addition the other methods propose in this study can be provide as a long-term demand for a reference on flooding control in Chiayi coastal zone.

INTEGRATED FLOOD PLAIN MANAGEMENT STRATEGY FOR THE KOR RIVER BASIN IN IRAN

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Using floodplain natural resource management strategies, and with the aim of reducing flood damages, river bed and bank erosion control and improving well-being and livelihood security, Iranian policy-makers have sought to mitigate the destructive aspects of floods while harnessing their beneficial aspects. To this aim an integrated flood plain management strategy has been developed for the Kor River basin in Fars province of Iran via dam construction, flood hazard map generation, floodway and flood fringe determination and river training techniques.

Fars Province with an area exceeding 133,000 square kilometers covers a large number of sub basins in Iran which the Basin of Bakhtegan Lake is one of them. The Kor is a permanent flow river and interlink of Tangeboragh and Shooreshirn streams in the upper zone of Kamfirooz Flood plain that routes to the lake of Bakhtegan After nearly 200 km long.

Mollasadra dam with 440 MCM volume of reservoir has been constructed at upstream part of basin in 2007 and 25 km river training works including flood hazard mapping, floodway and flood fringe determination and bioengineering measures has been done. The method which is used for flood hazard mapping and floodway determination is based on flood-flow frequency and hydraulic analysis of floods.

Flood hazard maps were generated based on 25, 50 and 100-years floods. In accordance with current laws and regulations for the country, 25-years flood on floodplain was punctuated as a floodway and 20 meter free boundary as flood fringe from the sides of the flood way was recognized. Flood way and flood fringe are both integral parts of the natural conveyance of a river which in this project were determined and conserved from any encroachment and manmade obstructions. In order to bed and bank erosion control, flood way was divided into bank full and 25 years limits. Channel modification system via cutoffs, groins and dikes was built on bank full limit and local vegetation and trees were planted on 25 years limit. This paper deals with the result of the integrated national flood control and floodplain management policy and specific aspects of current management in Kor river basin in Iran.

FLOOD HISTORICAL EVENT AND THEIR HYDROLOGICAL ANALYSIS OF THE PAHANG RIVER, MALAYSIA

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Pahang River is the main channel to drain off water during northeast monsoon from its upstream to their downstream at Pekan, Pahang and finally to the South China Sea. Three selected gauging stations were identified along Pahang River; Sg. Yap, Temerloh and Lubuk Paku Gauging Stations. Average monthly water level data of the Pahang River at Sg. Yap was ranged from 43.49m (July) to 45.36m (Dec), from 24.73m (August) to 26.71m (Dec) at Temerloh and from 12.70m (July) to 15.23m (Dec) at Lubuk Paku. Sg. Yap was recorded monthly rainfall from 106.67mm to 254.01mm. From 93.75mm to 219.83mm at Temerloh, and from 79.81mm to 324.57mm at Lubuk Paku. The average monthly discharge of the Pahang River at Sg. Yap was 845.78m³/s, was 1008.50m³/s at Temerloh and was 1184.46m³/s at Lubuk Paku. The average discharge of Pahang River (1980-2009) at Sg. Yap was 382.62 m³/s, at Temerloh was 494.24m³/s and Lubuk Paku was 669.60m³/s. At least five critical points were coincided with flood events from 1980 to 2009 along Pahang River.

FLOOD RISK ASSESSMENT IN KOTA MARUDU DISTRICT, SABAH, MALAYSIA

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Floods are natural phenomena which is globally inevitable. The main reason of riverine flooding is due to heavy rainfall, resulting in large volume of surface runoffs which exceeds capacity of the current drainage system. Nowadays, rapid and massive developments within river catchments has resulted in higher runoff volumes and deteriorated existing river capacity and in turn, has resulted in significant increase in the flood frequency and magnitude. Localized flooding in urban areas are generally caused by clogging of the internal drainage systems. In the coastal areas, flooding could be occasionally aggravated by high tides and storm surges.

As an effort to reduce flood damages, the Sabah government has compiled a state level water resources master plan, where a holistic flood mitigation measures are introduced involving structural measures (stream straightening, widening and deepening) and non-structural measures (land use planning, floodplain management plan, conservation of wetlands, flood forecasting, flood warning system and public awareness on flood and its consequences). While these measures have to certain extent been implemented and successfully brings down the number of deaths and flood frequencies, damages to properties and crops is nonetheless continue unabated. The main reason for this is that the non-structural measures have not yet been fully implemented due to some constraints. Detailed mapping of flood-prone areas and studies of flood characteristics in Sabah is urgently needed to be able to assist in the formulation of effective flood risk management plans.

This project presents a research on flood risk assessment, which involves the use of flood risk modelling and mapping. The main objectives of this research is to develop flood risk maps based on 10-, 50- and 100-years of flood return period. Sabah Water Resources Master Plan (SWRMP) has recommended land-use planning, zoning of flood-prone areas, gazetting forest reserves and water catchment protection areas as parts of floodplain management measures (SWRMP, 1995). Kota Marudu district are chosen as the study area due to its history of severe flood occurrences and its status as one of the poorest district in Sabah. During the latest flood in 2009, around 1,500 from 23 flood-hit Kota Marudu villages were displaced and evacuated to 12 flood centres. Due to this district's financial status, efforts in changing current land-use to improve the livelihood of the residents are aggresively introduced. However, a thorough study of flood risk has not been done, thus is not incorporated in the future districts developments. In order to setup a flood model, primary and secondary data (such as written historical data and digital terrain data) are gathered from various resources in government and non-governmental agencies. The information gathered will serve as data input in the flood model, and its output will be used to generate flood risk maps. From the maps, one can expect to see the extents of flood encroachment which are useful to be incorporated into the district's future development.

LONG LEAD FLOOD FORECAST APPLICATION TO BENEFIT SOCIETY: EXPERIENCES OF BANGLADESH FLOODS

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It has long been recognized that if society could have advance information on flood or weather, the adverse effects associated with it could be minimized. This paper describes on how a proper interpretation of probabilistic forecasts information empowers individuals and communities to respond appropriately to a threat in order to reduce risk of death, injury, and property loss and damage. A pilot demonstration project has been implemented in Bangladesh. The forecasts information interpreted, translated and disseminated to the pilot communities through established communication channels such as a flag network, SMS bulletins and flood pillars. The warning provides key information for community level responses such as the onset of flood, its duration and dates of flood recession. The forecasts system also addresses top down to bottom up scaling, linking hazard detection with warning communication, preparedness, mitigation, and response, with a feedback mechanism. For communities, the increased lead time of flood forecasts is proving to be one of the best tools for enhancing their capacity to adapt to climate change. Evaluation of the benefits of the forecast has revealed that an estimated average of USD 270 has been saved per household from getting early warning in the pilot areas. According to the World Bank study (2009), for every US dollar invested, a return of USD 40.85 in benefits over a ten-year period may be realized through this early warning system. For a flood prone country like Bangladesh, flood forecast technology plays an extremely crucial role in saving countless lives and properties. Its benefits are many but at the same time it should be remembered that there is an uncertainty factor inherent to such forecast.

CONDITIONS FOR DEBRIS FLOW INDUCED BY BREAK OF GLACIER LAKE IN TIBET

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There have occurred 21 breaks of 16 glacier lakes in Tibet in the last 70 years and they have caused catastrophic debris flows. Formation of debris flow depends on the magnitude of the break flood and also the material on the passage. A debris flow may forms when the total volume of flood is bigger than 105m^3 and the peak discharge bigger than 600m^3/s. When solid material supply is sufficient, dilute flow may occur in channel with gradient bigger than 1% while viscous flow requires a sufficient content of clay. As the materials have a high content of coarse grains, the glacier-induced debris flows in Tibet are mainly of low viscosity.

TEST OF MODELS ON VISCOUS DEBRIS FLOW WITH OBSERVATIONS AT JIANGJIA GULLY IN YUNNAN PROVINCE, CHINA

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Parameters such as velocity, discharge, and impact force are needed in debris flow control works designing and debris flow risk zoning. Determination of these parameters depends on model simulation.According to bulk density and the mass ratio of clay to water, debris flows can be classified into mudflow, water-stone-flow, dilute debris flow, and viscous debris flow, et al. Viscous debris flows are the most common in China. Researchers have founded some empirical formulas to estimate velocity of viscous debris flow based on field observations. These formulas are simple to use and have acceptable accuracy for the specific debris flow gullies. However, parameters in the formulas should be calibrated when they are applied to other gullies.Meanwhile, researchers studied the physical mechanism of viscous debris flow and have put forward some physical models. The representative ones include Bagnold's model in the viscous region, Takahashi's viscous model, Fei's non-homogeneous solid-liquid two-phase model, and Iverson's friction model with pore fluid pressure considered. In this paper these models were tested with observations from 23 surges of viscous debris flow at Jiangjia Gully in Yunnan province, China. Sensitivity of each model to two parameters– the maximum possible concentration and the internal friction angle–were also analyzed. It indicates that Bagnold's model and Takahashi's model are sensitive to the former parameter, while Fei's model and Iverson's model are sensitive to the latter one. Mean value of simulated velocities of the 23 surges agrees well with measurement for Bagnold's model and Takahashi's model when parameters are properly given. However, errors are relative large when simulated velocities are compared with measurements surge by surge. Results with Fei's model are less than measurements. It is difficult to set the initial condition for Iverson's model, so velocities were not computed in this paper. However, pore fluid pressure needed to decrease the effective stress was calculated with load balance along the flow direction. A simple analysis was performed and it indicates that the pore fluid pressure can be maintained in Jiangjia Gully.

OCCURRENCE RISK ASSESSMENT OF DEBRIS FLOWS AFTER WENCHUAN EARTHQUAKE IN SUBAO RIVER VALLEY OF BEICHUAN COUNTY, SICHUAN PROVINCE, CHINA

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Subao River valley with a drainage area of 72.2km^2 lies along the Beichuan–Yingxiu fault in Beichuan County, which was heavily impacted by the Wenchuan earthquake on 12 May 2008 and has become sources of many debris flows. The debris flows seriously threaten the post-disaster reconstruction. Therefore, occurrence risk assessment of debris flows is of great significance to post-disaster reconstruction. Based on field survey and image data of remote sensing, a case study on occurrence risk assessment of debris flows was conducted in the valley using GIS technology.

For assessment the occurrence risk, five factors were selected by analyzing the characteristics and formation conditions of debris flows after the earthquake. According to contributions to debris flow formation, they in turn were density of landslides and rock avalanches (x_1), distance to the seismogenic fault (x_2), formation lithology (x_3), ground roughness (x_4) and hillside gradient (x_5) and each of them was subdivided into five grades. The occurrence risk assessment was conducted using multi-factor superposition method which was implemented by summing the products of weight and value of each factor. The constructed assessment model of debris flow is as follow:

$$Y_i=0.511x_{1i}+0.264x_{2i}+0.130x_{3i}+0.059x_{4i}+0.036x_{5i}$$

Where subscript (i) was the grid number.

The assessment was conducted using the above model based on the spatial analysis of ArcGIS. According to the assessment results, Subao river valley was divided into three areas using high risk areas, medium risk areas and low risk areas. The high risk areas concentrated in the middle of the valley, accounting for 17.6% of the valley area. The medium risk areas were in the middle and lower reaches and some in the upper reaches, most of which located on both sides of the high risk areas, accounting for 45.3% of the valley area. The rest belonged to low risk areas. The results agreed with the activities of debris flows after the earthquake in the valley, as could provide guidance on reconstruction planning and prevention and mitigation of debris flow in this valley. According to the results, it was suggested that, in the high risk areas, human activities should avoid debris flows and should not carry out control projects against debris flows in the short term after the earthquake, at least 5 years. In the medium risk areas, human activities should try to avoid debris flows and engineering control standards should be raised appropriately if necessary. Debris flow disaster assessment must be conducted in the low risk areas to ensure no disaster threat, or must avoid debris flows, too.

FLOOD HAZARD MAPPING GUIDELINES IN CHINA

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Researches on flood hazard mapping have been carried out in early 1980s. In 1990s, especially after 1998 flood, China has been undertaking strategic adjustment in flood control and disaster mitigation. For effective flood management and land use, high attention has been paid gradually on flood hazard mapping. In 2010, flood hazard mapping guidelines was published as professional standard of Ministry of Water Resources. This paper will briefly introduce the main topics of flood hazard mapping guidelines in China. Then the categories of flood hazard maps, flood risk analysis, requirements for flood hazard map production and the nationwide management of hazard maps will be discussed.

These guidelines were issued firstly in 2005. After that, Office of state flood control and drought relief headquarters of China has carried out pilot projects during 2005-2007. In 2008, the first phase of nationwide flood hazard mapping has been started. This paper will also introduce some example flood hazard maps following the guidelines.

THE CRITICAL ROLE OF FABRIC CHARACTERISTICS OF COLLAPSE-SLIDE ACCUMULATION IN THE FORMATION OF DEBRIS FLOW UNDER FLOOD

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Tens of thousands of collapses and landslides are induced by 2008 Wenchuan earthquake in China, and it produced a large number of collapse-slide accumulation bodies which are piled up in the channels and the lower slopes. With the arrival of the rainy season, the collapse-slide accumulations are easily stimulated to form debris flow under flood after the heavy rainfall. Eventually it constitutes the evolution of collapse-slide accumulation into a debris flow. The key factors in the debris flow evolution are the fabric characteristics of collapse-slide accumulations and the flood. Based on the field trips, on-site observation test and indoor sampling analysis, the different fabric characteristics data of seismic slump-accumulation and the typical debris flow deposits have been obtained in the earthquake stricken area. Firstly, the different characteristics between seismic collapse-slide accumulations and debris flow deposits are comparatively analyzed, and then the key factors of fabric characteristics of the collapse-slide accumulations which influence the evolution of debris flow are studied, such as particle component, water content, and porosity and so on. Based on actual field data analysis, we build the simulating numerical analysis model to simulate the formation processes of debris flow under different accumulations fabric and flood intensities, Eventually we find the key roles and the key factors of physical characteristics of the accumulations in control of debris flow disaster process, and create the different debris flow formation patterns by different fabric characteristics of accumulations and intensities of flood.

STUDY ON THE EFFECTS OF DEM RESOLUTION ON BTOPMC PARAMETER VALUES

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Predictions in Ungauged Basins (PUB) is one of the research focuses in international hydrological and water resource sciences, the hydrological data are lacking in most of the regions in the world: the gauging stations are scarce, and the quality of observing data is not very high, even the same is true in developed countries. The International Association of Hydrological Sciences (IAHS) have recognized that it's very important to develop methods for predictions in ungauged basins and research for PUB have became the key topic/project of IAHS since 2003(Sivapalan).

Physically-based distributed hydrological models have, in principle, the advantages of reflecting basin changes which allow the users to analyze specific hydrological processes. However, in the current generation of such models, some fundamental problems are still far from being solved. The scale problems of model equation and parameter identification are two of the most critical variables. Such problems make the existing models inapplicable to large catchments(AO, T.Q).

At the same time, in hydrological modelling one of the most common and significant challenges faced is the reduction of uncertainty in estimation and calibration of model parameters. And, when the physically based distributed hydrological model—BTOPMC modelling for ungauged (or poorly gauged) basins, how to value the model parameters according to the physical basin features, such as topography, vegetable, soil type, land use and so on.

Model parameters should, as closely as possible, represent the main physical basin features, such as topography, soil properties and vegetation types. Even though many model parameters for existing physically based distributed models are essentially 'effective values' at practical spatial and temporal scales, the fact that the parameters do have some physical interpretation means they could be used to develop transfer functions.

In order to overcome these problems, a hydrological model is required of which parameters can be identified by physical basin features. In this study, for the purpose of applying physically based distributed hydrological model to ungauged mountainous watersheds, it is necessary to establish the quantitative relationships between model parameters and physical basin features such as topography, vegetable, soil type, land use and so on. The focus of this study is the effects of DEM resolution on runoff simulation were investigated model parameter values and consequently the transfer functions. Of course the TOPMODEL with the Muskingum–Cungerouting method (BTOPMC) model is applied to four of mountainous basins, in the southwest of china, to explore the model parameter transfer functions, if it is exist, and, we are going to find the law of the parameter of BTOPMC model variation with the DEM resolution.

OCCURRENCE POSSIBILITY IDENTIFICATION OF POTENTIAL DEBRIS FLOW INDUCED DAMMED LAKES IN THE UPPER MIN RIVER AFTER WENCHUAN EARTHQUAKE

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The 5·12 Wenchuan Earthquake resulted in a number of landslides which formed dozens of dammed lakes in the quake-hit area, and great damages were thus caused. At the same time, the earthquake caused numerous landslides and collapses that provided abundant unconsolidated materials for future mobilization as debris flows. Debris flow and its induced dammed lake will be very active and cause considerable damages for a relatively long time in the affected area. For example, on Aug.14 2010, a debris flow occurred in Hongchun gully in Yingxiu Town, Sichuan Province. The Min River was blocked by the large scale debris flow sediment, and a dammed lake was formed consequently. The dam breaking flood submerged part of the newly constructed Yingxiu Town.

The identification of the occurrence possibility of potential debris flow induced dammed lakes is very significant to post-disaster reconstruction. The potential damages of debris flow induced dammed lakes are first introduced following environmental changes after the earthquake by selecting the upper Min River from Yinxiu to Wenchuan as study area. Then, the method of combining remote sensing image processing with information from field investigations of typical disaster sites is used to obtain the distribution and volume of unconsolidated sediment following the earthquake. At last, multi-factor comprehensive identification is discussed based on the fuzzy matter-element extension theory.

According to the identification, among the 56 first-grade gullies in the study area, 23 gullies have a high probability for the formation potential debris flow induced dammed lakes, 19 gullies have middle probabilities, and 14 gullies have low probabilities. The most likely locations are in the middle-to-lower reaches of the study area, and those with middle probabilities are distributed in the upper reaches of the watershed. This is in accordance with the interpreting results of the volume of unconsolidated material as the primary factor affecting the occurrence of debris flows. In addition, among the 23 potential debris flow gullies with high probabilities, debris flows of 5 gullies formed dammed lakes during the 2010 rainy season. The remaining gullies will form dammed lakes in the future with high probability.

EVALUATION AND ANALYSIS OF THE SENSITIVITY OF SOME FLOOD ESTIMATION EMPIRICAL FORMULAE

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During the last decades flood events have caused huge damages to the communities specially in flood plains and riparian areas. In the other word, one of the most important tasks in catchment hydrological analysis is flood and flooding, and therefore estimation of river peak discharges is necessary. Peak discharge estimation as design flood is the base and necessary element of water related projects and designs. In ungauged catchments where no enough measured data is available, empirical approaches are usually applied to estimate the maximum flood discharge. They are usually based on one or more factors such as drainage area that cause flood, and most of these methods have been proposed for a certain area with specific physical and climatic conditions. To use these methods in other areas with different conditions, evaluation and analysis of the sensitivity of their parameters seems to be necessary. In this research a simple new and efficient method has been used to carry on sensitivity analysis of ten empirical flood estimation methods including Creager, Diken, Fuller, Fanning, Inglis, Coutange, Mayer, Horton, USGS and German, in which some of them are the most famous existing methods. The results show high sensitivity of all equations to area in its lower ranges. In other word, small changes in catchment area for small watersheds cause large variation in model output (peak discharge). Also in most of the equations, the role of area is decreased in comparison to the C coefficient in large watersheds. It means that as the area of catchment increases, its role on peak discharge decreases. In some equations such as Fuller, the output is also very sensitive to return period especially in the range lower return periods. To be able to check the findings of this research, field data gathered from catchments with different geometrical characteristics but located in hydrologically homogeneous regions are required.

INTEGRATED SIMULATION OF THE ENVIRONMENTAL DAMAGE CAUSED BY THE TSUNAMI AT THE GREAT EAST-JAPAN EARTHQUAKE 2011

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A catastrophic Tsunami attacked the coastal areas of Tohoku region of Japan on March 11, 2011, after the Mega Earthquake occurred far off the pacific coast of east Japan. The earthquake had changed topography of the ground by ground subsidence, liquefaction and landslide. The huge energy of tsunami had almost destroyed the whole surface structures in coastal plains and changed its land cover.

As an inevitable consequence, serious secondary damages followed and remained there, such as seawater retention and salinization of soil, seabed sludge inflow and deposition, spill and diffusion of various chemical/bio-derived materials. Furthermore, an additional damage was brought about by the leakage of radioactive nuclides from the tsunami-stricken atomic power plant.

For the reconstruction of the residential/industrial areas and activities, the multiple environmental damages as mentioned above have to be evaluated quantitatively, in order to take adequate countermeasures before and on the reconstruction processes.

Environmental evaluation of the vast damaged area necessarily requires the up-to-date hydrologic system analyses. We, therefore, have been making simulation studies for the following cases.

(1) Reproduction of the seawater inundation on land, seawater intrusion in river channels, and the seawater retention on the land, at and after the tsunami.

(2) Prospect of the change of salinity concentration in the soil by evaporation, dilution by rainfall, and infiltration of seawater into the subsurface groundwater system.

The Sendai plain which was severely damaged by the tsunami was selected as the study area. In the simulation, the observed changes of the sea level with time at the day of the tsunami, as well as the topographic change in coastal area are considered as the boundary inputs. Physically and mathematically, the mixing process of seawater and freshwater on the surface and in the subsurface are also taken into account. The wide-ranged water circulation model by 1km-mesh grid-blocks for the whole area of Tohoku region (Mori, et al., 2010) is incorporated for realizing 3D-hydrogeological setting into the model.

A comprehensive numerical simulation technique based on the surface/subsurface coupled fluid-flow model has been used to compute the transient response of flooded seawater during and after the tsunami.

The authors would like to present the simulated results and make discussions for the future design of the city and disaster prevention.

TRANSFORMATION OF FLOOD-CONTROL IN NORTHEAST CHINA BAICHENG REGION: FROM SAFETY ORIENTATION TO COMPREHENSIVE UTILIZATION

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Abstract: Aiming at solving the water shortage issue of Baicheng region in northeast China, this essay analyses two factors leading to the flood-control strategies transformation of Nenjiang and Tao'er river. One is the over-exploitation of the underground water and inadequate utilization of surface water; the other is the hydraulic engineering on the upper part of local river that paralyzes the lower part reservoir. The flood-control strategy changes from the security-orientation to comprehensive utilization, which can meet the demand of agriculture irrigation and ecology maintenance. The survey of the local natural geology, flood resource, hydrology compensation, hydraulic engineering, local weather and rainfall, etc. shows that this region has sound basis for flood utilization. By analyzing the benefits brought by the flood resource utilization in 2003-2008, this paper concludes that strategy transformation can make the flood-resource a regional natural resource that can relieve the water-shortage pressure and will benefit economy, ecology and society in future.

RESERVOIR FLOOD CONTROL OPERATION VIA MULTI-ATTRIBUTES DECISION MAKING METHOD AND GREY RELATIONAL ANALYSIS WITH INTERVAL NUMBER

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Reservoir flood control operation is generally complex in nature and involves a variety of quantitative and qualitative factors arising from environmental, social and even political concerns. However, no single alternative performs well for all performance factors. Thus, due to imprecision and vagueness in available information as well as uncertainty in modeling and subjectivity in human judgments, decision making for reservoir flood control operation can be structured in a framework of multi-attributes decision making under uncertainty. This paper presents a new approach based on multi-criteria attributes and grey relational analysis to solve complicated decision making problems. The values of quantitative attributes for each alternative are represented by interval numbers, and its qualitative counterparts and the weight of each attribute are described by linguistic terms and then converted into interval numbers in the proposed decision making. With the definition of the reference sequence and every comparability sequences, the grey relational grades are obtained for each alternative under uncertainty. The ranking of alternatives and the best one can be determined directly on the basis of the entire grey relational coefficient. The evaluation process is effective and straightforward to apply in practice. Finally, a case study of reservoir flood control operation is given to demonstrate the validity and applicability of the proposed method.

ACTION PLAN FOR RISK MANAGEMENT AGAINST LARGE SCALE INUNDATION DUE TO “SUPER ISE-BAY TYPHOON” –TOKAI NEDERLAND ACTION PLAN AGAINST EXTREME STORM SURGE AND FLOOD-

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The area around Ise Bay is a wide low land which was attacked by big Ise-Bay Typhoon in 1950 and more than 5000 peoples were killed by inundation due to storm surge. On the news of a tragedy in New Orleans by Hurricane Katrina in 2005, we strongly recognized that in Ise-Bay area we need a proper risk management action plan for evacuation against large-scale inundation. The area below the sea level is around 340km^2 with the population 0.9 million is equally matched New Orleans in serious inundation risk.

By organizing a working group among various organizations related to central and local governments, meteorological agency, river management, disaster management, energy, water supply and treatment, public transportation, telecommunication, port authorities, police, defense force, medical services and so on, we made a action plan through discussion lead by facilitators from academia. We postulated possible maximum storm surge with flood discharge in rivers by model typhoon, and extracted possible risks. At present, current development of forecasting techniques of landing timing and the amplitude of major typhoon makes possible for us to have 36 hours for preparation. Preparation means evacuation of a few hundred thousand peoples from inundation risky area of 300km^2. And, for the evacuation process and during recovery stage, we need various tasks (emergency support functions) to which various organizations are responsible. We need reasonable sharing of resources with fair negotiation and a framework to do so. The guideline for action plan was edited and tested by drill on table where various organizations tried to test their roles.

In this study, we also learned the advancement of FEMA (Federal Emergency Management Agency) in USA: particularly its role on Katrina disaster, improvement of the system after Katrina, catastrophe planning and its verification by enforcement of the new system against Hurricane Gustav in 2008.

On the other hand in Japan, we have not yet fixed the system based on the action plan. We have a system to organize a headquarter office for recovery after a major disaster happens. However, in case of risk management against typhoon, we have to prepare by a strong leadership because mass evacuation is necessary from wide area and need a headquarter office before a disaster happens. It is one of the most important points but we have no acts to support it. Certainly, the task of the earliest stage is to make various information common among various organizations and it is possible without headquarter, but without waiting long time we must face various negotiations among many organizations. It is a reason for set up of the headquarter office in earlier stage.

We experienced a big Typhoon No.18 in 2010 which was forecasted to land the west of the Ise Bay to cause serious storm surge but landed a little bit east of the site to cause less serious disaster. We had no system yet in that opportunity but some functions were in operation voluntarily and tested the system through its experience.

SEGREGATION OF PARTICLES WITH TWO DIFFERENT SIZES AT THREE DIFFERENT SLOPE ANGLES

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In this study, an experimental scheme has been developed to survey the segregation procedure induced by two different types of particles in debris flow. The steep-slope debris flow experimental channel was employed. It is important to investigate the characteristics of larger particles' movement in debris flow as it can cause major damages and casualties. This research demonstrates the debris flow development mechanism between two different particle sizes.

The experimental channel consists of three main parts: water intake, rectangular flume and the deposition table. Two different sizes of particles were used: 10 mm and 2.5 mm. The specific weight of each grain is 2.7 g cm^{-3}. This study involves three slope angles: 15º (low), 20º (intermediate) and 25º (high). A constant discharge (3.0 l/s) was supplied for the duration of 10 seconds. The particle movement was visually analyzed by using High-speed-video-camera (HSVC) to capture the movement characteristics of the individual particle grain. The HSVC was placed downstream of the rectangular flume. Four groups of time frame were carried out to understand the particle characteristics mechanism. The groups are (a) initial, no liquid-phase flow (b) starting with liquid-phase flow (c) intermediate, 2 s and (d) last, 4 s.

A numerical model entitled as the Hydro Debris 2-D Model (HD2DM) was developed based on the Lagrangian sediment particle tracing numerical experiment. This model used the Marker and Cell Method, which involves a SGS (Subgrid-Scale) model and the PSI-Cell (Particle Source in Cell) Method. The transportation processes of debris and air bubbles were simulated based on the Lagrangian particle trace by introducing air bubbles and sediment markers. Air bubble movement characteristics were also simulated by this numerical model.

The HSVC results tracing each particle movement were compared with the HD2DM simulations. Analyses using the HSVC fully demonstrated the mechanism of the debris flow. It was found that as soon as debris flow is produced on the well-graded sediment bed, larger particles move upwards while smaller particles remains in the bottom and the inverse grading in the debris flow becomes evident. Velocities in upper layers are faster than in lower layers and the larger particles move ahead. Similar characteristics can be observed in the numerical simulation using HD2DM.

RIVER MORPHOLOGICAL CHANGE DURING FLOODS OF NEWLY CONFINED ALLUVIAL FAN RIVERS

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The author presents the morphological change during the flood events in 2008 of newly improved alluvial fan rivers by earth dike, the Laoag river basin in the Philippines. The 4 tributaries in the basin, which were naturally meandering / braiding having total length of approx. 40km, were just confined by basically continuous earth dike with series of spur dike as bank protection from 2004-2007. After the construction work completion in 2008, those tributaries experienced consecutive flood events which were corresponding to beyond the design flood magnitude, resulting into the morphological change due to the flood.

Using satellite images before and after the construction works, the river conditions such as thalweg and channel width were illustrated to discuss the effect of man-made impacts such as dike confinement and sediment control dam in the upstream. Some sections of those rivers showed the tendency to enlarge the channel width due to large boulder bar.

For one of the tributaries, hydraulic model test using distorted movable bed for the entire river reach (10 km in proto type) was conducted in Manila in 2002 (before the construction) in order to design the dike alignment, spur dike layout and to estimate the scour depth along the dike. The 2008 flood event enabled the author to compare the model test results with the actual phenomenon. While the model test was distorted type using mixed bed material and some results such as local scour depth were still to be discussed, it can be regarded the model test results were practically usable to other similar design needs, supported by the 2008 phenomenon in proto type considering the test itself subject to the entire reach length.

In these days in Japan, such morphological change from natural condition to river improved condition for entire reach scale has been difficult to observe because most of the present river reach started to be confined by dike a few hundreds year ago and the data on their original, channel feature condition is very few. In this sense, the monitoring of morphological phenomenon in the Laoag river basin in 2008 and from now on is quite valuable for flood management.

URBAN FLOODING IN POLAND – THE CASE OF MUNICIPAL PREPAREDNESS FOR EXTREME RAINFALL IN POLAND

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Many studies dealing with the issue of climate change are pointing out the problem of its consequences. Extreme weather events, as an effect of the climate change, are seen as a threat for human health as well as for urban infrastructure. Heat waves, storm winds, heavy rains are projected to be more frequent and more intense. Highly urbanised areas, are definitely more vulnerable to extreme weather conditions, especially heavy rain. Due to high population density mentioned events bring a huge risk for health of inhabitants, moreover, every extreme weather event in urban area is associated with high financial damages. Furthermore, urban area vulnerability is often increased due to an effect of lowering permeability with building impervious pavements, parking lots etc.

There is a set of methods for adapting to extreme rainfall. These are traditional and innovative technological solutions, as well as legislative. One of the most popular – and most obvious – way of dealing with heavy rain is a technological mean – storm water sewage system. This is a costly but effective method in normal conditions. Nevertheless, in heavy rainfall situation it often becomes inefficient what brings large financial losses and risk for human health. This produces space for implementation of different solutions which are increasing the efficiency of traditional methods.

In this study, authors are dealing with the issue of decisions and activities of local municipalities in reactions to the risk of heavy rainfall. Cases of innovative approach are analysed, as well as those where is no activity, in order to find obstacles in introducing adaptation measures. The problems of lacking knowledge on administrated areas, unwillingness for non-traditional adaptation methods, and even failure in recognition of extreme weather events risk, are shown. The material gives an image of strong mental-model-grounded decision-makers approach to the issue of flash floods in Polish towns. The complicated situation of legislative methods introduction linked with the issue of property rights and gaps in Polish law is presented as well.

The study is based on a set of individual in-depth interviews with experts, decision-makers and practitioners from different local municipalities in Wielkopolska region in western Poland.

A DECISION-SUPPORT MODEL FOR FLOOD RISK MITIGATION INVESTMENTS

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The changes in a flood-defence system over time are dynamic in nature. There is a wide range of aspects in the system and its surroundings that evolve through time, such as climate, the available amount of knowledge, societal risk perception, structural deterioration due to subsidence, economic and demographic growth, etc. These variations are hard to predict and difficult to incorporate in the decision-making process regarding the future of the flood-defence system. For policy or decision makers it is important not to make the wrong choices. They are interested in knowing what investment should be made in the flood-protection system, where and when, as well as when it would be more beneficial to postpone an investment. For this reason this paper introduces a model that can support policy and decision making by giving rational answers to the above questions.

The objective of the suggested model is to provide a broad overview of the response of a flood-defence system to gradual or sudden changes and the effect of measures based on a cost-benefit optimization through time. As a starting point a single dike section is considered and a crest-heightening process is optimized. For a given moment in time a classical cost optimization can be elaborated with which the optimal crest level can be derived. In order to add the dimension of time, the time-variations of the aforementioned time-dependent physical and socio-economic aspects are inserted in the model. The extracted result is a two-dimensional representation of the optimization parameters, based on which the optimal dike heightening and the optimal moment to apply this intervention can be derived.

This simulation is in fact a sub-optimization within a greater flood-defence network that may be realized under specific conditions; yet can be expanded to include multiple dike sections and other flood mitigation measures besides dike heightening, such as widening of a channel or development of a floodplain. The main benefit of this analysis is that it creates a rational basis for the development of a fully integrated decision support system, whose basic elements have been explicitly indicated and classified.

SNOW PACK PROPERTIES FOR SNOW AVALANCHING IN THE CENTRAL MOUNTAIN AREA, JAPAN

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Numerous studies have been conducted on snow pack characteristics associated with snow avalanches formation, mainly in North America and Europe. In recent years, the analysis about structural weakness has developing. However, existing research on mountain snow pack in Japan is aimed at the development of water resources, with the focus on determining the amount of snow water equivalent on mountains, and doesn't pay attention to avalanche disaster. The goal of this study is to fill this gap by examining the characteristics of snow pack associated with avalanches for the purpose of prevention of avalanche disaster in the Central mountainous area, Japan. We had examined these characteristic by comparing 20 snow pit data observed at fracture line of avalanche occurred in the Central mountainous area, Japan with present study results. Results of the analysis are as follows.

-Most of avalanches had related to persistent weak layers such as layers consisted by near surface facetted crystals and depth hoar developed near the ground.

- Weak layers consisted by rime less new snow crystals are observed significant higher frequency than Canada and Switzerland.

-It suggested that critical points of fracture depth, weak layer thickness, hand hardness difference, grain size difference, are important also in Japanese snow climate.

-Both of maritime and continental climate snow pack characteristics are found in closed area (Maritime: Japan sea side of main island, Continental: Pacific side of main island).

THE VNK2-PROJECT: A FULLY PROBABILISTIC RISK ANALYSIS FOR ALL MAJOR LEVEE SYSTEMS IN THE NETHERLANDS

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Flood risk mitigation is vital to the low-lying Netherlands. There are various alternative strategies to mitigate flood risks, ranging from flood defense and safety zoning to crisis management. Given the uncertainties related to, amongst other, the performance of flood defences and emergency response organisations under extreme conditions, evaluating the effectiveness and efficiency of alternative risk management strategies is not an easy task. Quantitative risk analysis (QRA) provides a means for dealing with relevant uncertainties in an explicit and consistent manner, by the quantification of flood probabilities and damages.

In 2007, the Dutch Ministry of Public Works and Water Management, the Dutch Provinces and the Union of Water Boards commissioned a study to gain insight into the probabilities and consequences of large-scale floods. The so-called FLORIS-II project (Flood Risks and Safety in the Netherlands II) aims at quantifying flood probabilities and consequences for all dike rings in the Netherlands. The project draws upon three decades of research and development in this field. In this paper, we discuss the methodology used in the FLORIS-II-project, as well as its applications in the Netherlands.

In the FLORS-II project, flood probabilities are quantified in a Bayesian framework, taking into account the uncertainties related to loading conditions, resistances, and empirical models. The infinite range of potential flood scenarios is characterized by a limited set of scenarios that are mutually exclusive and collectively exhaustive. Probabilities are calculated for each of these scenarios. The consequences per flood scenario are estimated using flood propagation models, loss/probit-functions, and land-use data. The various possible outcomes of evacuation attempts are estimated on the basis of event trees, taking into account the results of transportation models and the uncertainties related to weather and water level forecasts. Economic and fatality risks are calculated by combining the probabilities of flood scenarios with the consequences associated with these scenarios. Various risk metrics are considered in the VNK2-project, ranging from expected values per hectare to cumulative distributions and individual exposures.

The results of FLORIS-II project can be used to prioritize actions, evaluate alternative solutions for mitigating risks, inform investment decisions, support the political debate about new safety standards, and (re)direct research efforts to reduce important sources of uncertainty. We illustrate this by practical examples from the FLORIS-II project.

HYDROLOGICAL MODEL DEVELOPMENT AND TESTING IN UNGAUGED BASIN : A CASE STUDY OF QINGHAI LAKE BASIN

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Remote sensing (RS) and Geographic information systems (GIS) technologies and data can provide potential information in spatial and temporal domain for hydrological modeling has been recognized since the last two decades. Especially, remote sensing and GIS technologies have been identified as useful tools in the ungauged or data-limited basin in hydrological related research area.

Qinghai Lake, located in Northwest China, is the largest saline lake in China. Because of climate change, population growth and fast economic development, water environment of the Qinghai Lake Basin has changed obviously, and it has experienced severe water shortage and water level decline in recent decades. The purpose of this paper is to predict the dynamic water level tendency in Qinghai Lake in the future and to provide a scientific basis for future water resources allocation. A hydrological model was originally developed and tested based on remote sensing and GIS technologies and data in the Qinghai Lake Basin. The water areas of Qinghai Lake in the past thirty years had been identified using Landsat images and other satellite data. The relationship between water levels and water areas built up firstly. The data of remote sensing data and daily maximum and minimum temperatures and daily precipitation from six meteorological stations around Qinghai Lake as well as the hydrological records of daily lake water level, daily streamflow of Buha River and Shaliu River in recent 50 years were analysis as input data for the water balance model in this study. For other three ungauged tributaries rivers, the flow duration curve (FDC) employed in this paper by using the relation of streamflow and watershed characteristics acquired from remote sensing data.

The results indicate that the water balance model has the potential to be used to predict streamflow for the Qinghai Lake Basin. The water level of Qinghai Lake will continuously descend and reaches the lowest level in 2030. After that, the water level will rise slowly and tends to a stable level.

DAM DE-SILTATION IMPACTS ON WETLAND WATER QUALITY –A CASE STUDY

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The total storage for irrigation and power generation in the basins of rivers draining into the Vembanadu wetlands (South India) is of the order of about 6000 Mm^3, which is nearly half of the average flood flow to the wetlands. The reservoirs help in containing the floods to the wetlands to a larger extent and act as sediment and nutrient traps. The increasing human intervention in these rivers has changed their physical and chemical structure in such a way that it might sound the death knell of these rivers, if the authorities continued to be indifferent. Indiscriminate sand mining and check dams across the rivers are the reasons for the degradation of the rivers. One of the major victims of these activities is the River Periyar (part of wetland system). Flushing out huge quantities of mud and silt collected in one reservoir for 18 years into the Periyar without advance public notice has raised concern on safety and quality of drinking water as this river is the only drinking water source for 40 lakh people. It had flushed down tones of decomposed bio-waste and sediments into the river and the river water got discolored with its taste and smell changed. More critically, the sediments got into several rural water supply pumping systems in the downstream. Pumping of the muddy water and distributing the same employing the traditional treatment methods seemed to be insufficient for human consumption. The turbidity level in the river had varied between 58 and 68 ntu. After treatment with alum and lime, the water quality level reached to the acceptable limits between 4 and 7 ntu. Though the present crisis occurred by non-cleaning the reservoir once in two years and such cleaning was never for many dams- resulting in accumulation of sludge; similar openings of other dam's can occur with climate changes. It is time to examine the water quality changes and the public reaction to the alarming situations of the spreading of waterborne diseases. To pre-empt eutrophication, the authorities were forced by NGO to step up inflow to stabilize the pH factor and oxygen content in the estuary. Any future de-silting of a reservoir has to be carried out only during the monsoons as the silt would get flushed down to the sea quickly. The environmental groups advocate against large dams and wanted only small local water harvesting structures to harness the monsoon flows. However, the storage requirements indicate that even to hold half of the available monsoon flows, at least a million tanks would have to be in position. When the rains fail, these tanks submerging about two million hectares would also dry up, negating the very purpose for which they are built. Hence a combination of major, medium and minor storages has to be further constructed to utilize the monsoon flows.

A STADY OF DESIGN FLOOD DISCHARGE IN THE TONE RIVER ON A POINT OF VIEW DIFFERENCE FROM GEOMORPHLOGYICAL DISTRIBUTION OF RAIN-FALL AND EFFECT OF CHANNEL STORAG

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Recently, it is a main subject that flood control measurement is not depend on dams, therefore, verification of design flood discharge is required for river planning from public opinion. In 1980 year, in the Tone River, flood control planning have been carried out by storage function method that concentrated model on flood runoff analysis under a technical standard. In 1947 year, Catherine Typhoon hit Japan iland, and its flood did expensive damages. At this time, Dam was not existence in the upper river basin from Yattajima standard point of observation, and also hydrological data was not sufficiently. Then, we found that safety of river management is increasing every year with measurement of dams after the post warld war Ⅱ using the same model. In this study, flood runoff analysis carried out under large rainfall events that Catherine Typhoon was included, and also effect of channel storage at the confluence point and river channel was estimated. Runoff analysis due to inspect dischrage under a diference spatial distribution of rain fall was required. In this results is following, geomorphologic factor influenced characeristics of rain fall distribution, and According to compare accumulated discharge method with 1D model method at the confluence point in the Tone river,effects of channel storage and reduction at confluence point was cleared by runoff analysis.

FLOOD RISK MANAGEMENT OF LOWLAND RIVERS – A CASE STUDY OF LIELUPE RIVER IN LATVIA

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Lielupe River is the lowland trans-boundary river with total drainage area 17600 km2, only 8800 km2 or 50% of them are in Latvia territory. This paper describes development, causes and effects on Lielupe River flood during spring 2010. The objective of the study is to determine possible measures of integrated trans-boundary flood risk management.

There are many flood-intensifying factors. It is possible to separate these factors in two large groups: environmental and anthropogenic. Environmental factors such as rain, snowmelt intensity are unpredictable and it is impossible to change or avoid them. However, anthropogenic factors could be minimized by measures of flood risk management.

Mathematical model METQ (Ziverts, A & Karms, M.1993; Zakis, G. & Ziverts, A. 2004) was used to understand the impact of environmental conditions on Lielupe River during spring floods in 2010. After the transformation process of discharges to water levels there was a significant difference estimated between measured and simulated water levels in Lielupe River near the city Jelgava. Anthropogenic flood - intensifying impacts could be divided into direct (infrastructure, buildings, dams etc) or indirect impacts (change of land use proportions). Anthropogenic flood – intensifying factors was identified impact amount on flood in case study area. Assessment of recommended flood risk management measures was made according to changing social, economic, and environmental contexts.

In the conclusion part research points out possible development directions and benefits of integrated trans-boundary flood risk management. Finally this paper describes further developments that are required to enable integrated flood risk management to be realized in practice.

RESIDUAL FLOOD RISK ANALYSIS FOR BANDA ACEH FLOOD CONTROL PROJECT

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Banda Aceh is the capitol city of Aceh Province located in the northern tip of Sumatra Island, Indonesia. The city has experiences in annual riverine floods due to an over capacity of flood flow for Krueng Aceh River which flowing through downtown of the city. To overcome the flood problems in the city, the Krueng Aceh Flood Control Project was created. By introducing some technical flood protection systems such as river reach normalization, the construction of floodway, and the reconstruction of city's drainage system, the city is already protected from a 20-year return period of flood. It means that the city is proved for flood with magnitude less than 1200m3/s.

It is noted that the flood protection systems are limited in their resistance that the city is still exposed to a residual flood risk especially for the floods for greater return periods. This paper aimed to demonstrate by means to evaluate the residual flood risk for different scenarios. The study is executed by identifying the sources, pathways, receptor of the floods and the consequences city's properties exposed to the floods. The flood risk map based on flood risk analysis will be developed to assess the government in rehabilitation and reconstruction programs.

INVESTIGATION ON THE RAINFALL INTENSITY EQUATIONS FOR THE DESIGN OF URBAN STORM WATER DRAINAGE SYSTEM

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The rainfall intensity and rainfall hyetograph are important design variables for urban storm drainage system planning. In Taiwan, three rainfall intensity equations developed by Talbot, Sherman, and Horner are commonly used, and the one with the highest rainfall intensity is chosen as the design rainfall after analyzing the precipitation data. The design hyetograph is then determined by applying the chosen intensity equation. However, rainfall intensity relates to the duration of the rainfall. Considering the temporal distribution of the hyetograph, it is questionable at what specific duration are the rainfall intensities determined by different equations supposed to be compared. This study investigates the temporal distributions of various design hyetographs for Yilan City in northern Taiwan. SWMM (Strom Water Management Model) developed by USEPA (United States Environmental Protection Agency) is utilized to simulate the rainfall-runoff process for the drainage sewer system of the city. The numbers of flooding manholes are compared to investigate the influence of intensity equations on the design of the drainage system.

SPATIAL AND TEMPORAL EVOLUTION OF RAINSTORM DISASTER IN THE RAPID URBANIZATION AREA—CASE STUDY OF THE YANGTZE RIVER DELTA REGION, CHINA

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The Yangtze River Delta Region, with the urbanization rate of 60%, is one of the fastest regions with rapid urbanization in China. Especially in the last 20 years, the urbanization pace of the region has obviously accelerated. Although the area is only 1% of that of China, it has 6% of the country's total population, and its GDP accounts for 20% of the total in China. While due to the rapid urbanization, the urban heat island effect and its influence on the local rainfall are obvious, which cause the formation of the rain island effect. With the increase of the conflict of resources and environment with population and with the growth of "hard bottom" and the backward facilities of Urban Drainage System, the region has become more and more risk to rainstorm. In this paper, according to weather stations' rainfall data and historical rainfall disaster data of the Yangtze River Delta region in 1956-2006, the spatial and temporal evolution of regional rainstorm disaster has been analyzed based on time series analysis and spatial correlation analysis. The results show that: the rainstorm disaster in Yangtze River delta region has an increased tendency, which is especially obvious in the last twenty years and in the Taihu Lake basin. Spatially, the region with high urbanization rate, which concentrates in the areas of Taihu Lake coast, Suzhou, Shanghai, Hangzhou, Huzhou, Jiaxing, Wuxi and Changzhou, is seriously affected by rainstorm disaster.

FLOOD ROUTING BASED ON A TVD-MACCORMACK SCHEME

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Conventional flood routing methods such as Muskingham-Cunge on the one hand and existing softwares such as HEC-RAS on the other hand are not capable of routing the flood in a river when shocks exist. Moreover, abrupt change in the inflow and outflow conditions at upstream and downstream ends of a river, that standard methods cannot handle, shows the futility of such schemes in flood routing procedure in such cases. In this paper, a simple and robust TVD-MacCormack scheme has been employed to accomplish the important task of flood routing in an open channel. The Saint-Venant equations are solved in a finite-difference framework. The model is both fast and shock-capturing and therefore can handle strong discontinuities as well. The model has been verified by solving some classic problems which show very good agreement with other standard methods and observed outflow hydrographs.

INVESTIGATING THE EFFECTS OF CHECKDAM CONSTRUCTION IN MITIGATION OF FLOOD HYDROGRAPH CHARACTERISTICS USING HYDROLOGICAL MODELING IN NORTH-WEST OF TEHRAN, IRAN

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Checkdams are small dams with very simple and relatively inexpensive structures and as they do not require any complicated technology or special materials for construction, they have many applications in flood and sediment control projects.

In the present study, the effects of applying checkdams in reducing peak discharges and increasing time to peak is investigated in Kan basin (approximately 250 km2 area). This basin is located in north-west of Tehran where there are many recreational centres and Holy Shrines in the area, therefore it has an important and sensitive position for decision makers. As this area has encountered with some devastating floods in the last decades, it is vital to implement appropriate flood control measures.

Using hydrological modeling, the effects of checkdam construction in mitigation of flood characteristics were evaluated in three scenarios. In the first scenario, the slope of upper sub-basins was considered to be reduced by half of the initial slope after checkdam construction. The slopes were reduced to a tenth and a hundredth of the initial slopes for the second and third scenarios, respectively. Results revealed that in the first scenario, checkdams have no effects in reducing peak discharges and increasing time to peak. But in the second scenario, it decreased the peak discharges between 0.5 and 3.5 percent and this reduction was between 3.9 to 10.6 percent in the third scenario. Also by using checkdams, the time to peak of hydrographs were postponed between 10 and 20 minutes and 10 to 50 minutes in the second and third scenarios, respectively. These values could be very effective in reducing flood damages for sub-basins in mountainous area with small time of concentration.

A CASE STUDY ON THE IMPACTS OF HYDROLOGIC DESIGN UNDER CLIMATE CHANGE ISSUE IN TAIWAN

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Recent years, climate change has been suspected as a contributor to the frequent occurrence of extreme weather events. The ongoing rainfall intensity both in short and long duration repeated breaks the historical record and threatens seriously to all water conservancy facilities. In this research, the influence of climate change to hydrologic design in Taiwan is discussed though analyzing the maximum annual 1, 2, 3, 6, 12, 24, 48, 72 hours rainfall from 20 stations in the Central Weather Bureau (CWB). The time period was from 1970 to 2009. In order to detect the spatial and temporal variations existed in the region, two different approaches is adopted. 1. Using 20 years as a fixed frame to perform a rainfall frequency analysis, from 1970 to 2009, the 1, 24 and 48 hours rainfall amount of 100 and 200 years return period will be calculated accordingly (i.e.1970-1989,1971-1990,…,1989-2008, 1990-2009). 2. Taking the 1970 as a beginning year and extend the time period year by year (i.e. 1970-1989, 1970-1990, 1970-1991,…, 1970-2008,1970-2009), to perform the rainfall frequency analysis as mentioned as in the description of the previous approach.

Throughout the analyzing of the maximum annual 1, 2, 3, 6, 12, 48, 72 hours rainfall with return period of 5 years, 100 years, and 200 years, the rainfall amount which manipulated as the criteria for city drainage system and river flood construction designing will be examined. The results will be useful to the planning of the flood management under climate change issue.

FLOOD CHARACTERISTICS/RATE IN KARSTIC AND NON-KARSTIC CATCHMENTS (CASE STUDY: MOJEN AND GORGDAREH CATCHMENTS IN IRAN)

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Control and management of flood peak flow is one of the most important purposes in national policy of each country, and a large amount of money is spent to reach this purpose every year. In the other hand, as hydrological analysis and estimation of flood discharges is an important factor to design and evaluate the efficiency of water related projects, and underestimation in this regard can cause considerable risks for the related investments. Karst topography is a landscape shaped by the dissolution of a layer or layers of soluble bedrock, usually carbonated rock such as limestone or dolomite. Potential of flood formation in catchments located in this landscape can be quite different from other landscapes due to specific drainage characteristics of the karst. Therefore recognition of the hydrological behavior of karstic catchments in comparison to the non-karstic catchments is necessary for flood management. The main objective of this research is to compare flood characteristics of two types of catchments including karstic and non-karstic catchments. Mojen catchment has a karstic topography that mostly covered by limestone, and Gorgdareh as a non-karstic topography in west side of Mojen catchment where both are located in central Alborz Mountain in Semnan province, with the similar climate, area, slop and annual rainfall. These two catchments are compared in view of maximum discharge, runoff coefficient, specific discharge and relationship between maximum instantaneous discharge and maximum daily mean discharge. Results indicate that runoff coefficient for Mojen's karstic catchment is 1.28 and for Gorgdareh that is Non- karstic catchment is 0.35. Specific discharge for Mojen on a concurrent period is 0.0174 $m^3/sec/km^2$ when for the Gorgdareh it is 0.051$m^3/sec/km^2$. Relationship between maximum instantaneous discharge and maximum daily mean discharge for Mojen is 1.145 and for Gorgdareh is 1.380. Finally this research showed that application of rational and empirical formulas for karstic catchment is unreliable. According to the obtained results, runoff coefficient for the Gorgdareh catchment is 0.345 and for Mojen catchment the runoff coefficient is 1.206, therefore the runoff coefficient of Mojen Karstic catchments is about 3.7 times greater than Gorgdareh non-Karastic catchment runoff coefficient. This is because of unusual runoff coefficient of the calcareous catchment. According to this run off coefficient, the runoff is about 1.206 times of rainfall in Mojen catchment. It is clear that for a catchment where is not any looses for rainfall, thus runoff coefficient can be equal to 1, so there should be another reason which considerably increase discharge value in this catchment, and it must be underground calcareous waterways which bring water to this catchment from neighboring catchments. Specific discharges obtained for Mojen and Gorgdareh catchments equal to 17.4 and 5.12 lit/s/km^2 respectively. Results of this research indicate that in Mojen calcareous catchment about 70% of outcome water value is provided through Karastic resources, therefore in Karastic catchments, there are two different sources of run off including rainfall and the Karastic water resources. In other word, oppose to non-Karastic regions where approximately whole run off is provided from rainfall, in Karastic catchment run off resulted from the catchment rainfall forms only part of the whole catchment run off. According to the results, discharge variations procedure is equal in both catchments, but Mojen discharges are considerably higher than those of Gorgdareh non- calcareous catchment. Finally it can be said that the potential of flood formation in karstic catchments can be considerably higher than the same catchments with non-karstic landscape, and this is a point that must be considered in flood estimation producers as well as flood management measures.

OVERVIEW OF A X-BAND MULTI-PARAMETER RADAR RAINFALL MONITORING PROJECT IN JAPAN

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In recent years, some unexpected torrential rainfall events caused inundation damage and death accidents in urban areas. In order to cope with these so-called "guerilla storms", MLIT is building a X-band multi-parameter (MP) radar system which covers major cities of Japan, aiming at full-scale service in 2013. This paper provides an overview of this project: design of the network system; monitoring accuracy estimation and calibration of individual radars; real-time data dissimilation system development; and other technical development necessary for full-scale service.

According to X-band MP radar observation research in the past, we set an area within 80km-radius circle as quantitative observation area by single X-band radar station. A radar network was designed to be able to cover every major urban area by two or more radar stations, considering massive radio wave attenuation by possible heavy rainfall and topographical shields. As a result, 26 radar stations were planned. As of June 2011, 11 radar stations were built and under test operation, and additional 15 radar stations are under construction.

The X-band MP radar network system was set to observe storm every one minute. For calibration, first, we performed quality tests of radar hardware by zenith observation of rain storms. Based on these tests, we had radar manufactures modulate the hardware. Next, we estimated radar parameters called Kdp and Z applying disdrometer and ground raingauge observation for each radar.

The accuracy of rainfall observation by X-band radar was evaluated by comparison with ground observation at 10 to 60 minutes intervals in contract with C-band radar observation accuracy assessed by the same method as X-band radar. Observation accuracy by X-band radar turned out to be equal to or higher than that of C-band radar at any time intervals. The X-band radar's accuracy was particularly significant for heavy storms.

Nest, we developed data processing and dissemination programs which enabled users to obtain composite images of current and cumulative rainfall by intensity with 250m square grid cells in one minute delay via the internet. Currently, we are receiving feedbacks from users on test dissemination of real-time radar rain information. So far, we have received no major faults or negative comments, but positive reactions showing benefit of this radar information from flood managers and public.

STORMWATER MODELING IN AN URBAN RUNOFF COLLECTION SYSTEM USING SWMM :(A CASE STUDY)

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A common concern for municipality authorities in big cities is the management of storm water in urbanized areas with considerable percentage of impervious areas which causes to increase flood flows. Modeling existing urban runoff collection systems is a best way to evaluate the performance of the existing systems and to present potential best management practices (BMPs). This paper presents the performance of an urban runoff collection system modeled by a conventional storm water simulation model known as SWMM. The model was applied to the Jamshidiyeh river watershed, including a 2950 ha urban catchment and a 350 ha mountainous catchment located in northern part of Tehran city in Iran. Estimates of CN values were obtained using digital soil and land use maps. The hydrologic model was calibrated for a storm event using 50-year return period precipitation data generated from three rain gauges within and outside the watershed. To achieve a proper result in the case study, a fully distributed hydrologic model was made to account for the complex hydrologic, topographic, and network flow processes involved, and to reflect the greater location flexibility. Therefore, the catchment was separated into 16 subcatchments and some main channels draining storm water into the catchment outlet. Moreover, digitized model of the catchment was provided by using Surfer Software. Input file for SWMM was provided by editing all point data in Autodesk map software. Some point data was also extracted from networking and interpolation by kiriging method. Finally, the main channels were modeled by SWMM model to assess the capability of the system in collecting and transferring the storm water into the watershed outlet. Possible BMPs including detention ponds and main channels restorations such as the change in their dimensions were offered for the volunteering points where overflows would occur within storm water event. Some rules were also generated for the operation of control devices within the main channels to alleviate the magnitude of the floods. The results show the capability of the SWMM and BMPs in the management of storm water in urban areas.

EXPERIMENTAL STUDY ON EROSION RESISTIBILITY FOR URBAN HOUSING

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An exceeding standard catastrophic flood occurred in northeastern China in July 2010. Persistent storm rainfall and flooding lead to some river channel inundation、a large number of house collapse. Taking the single-story residence in villages and small towns as the research object, erosion resistibility for three micro scale housing model, that is, normal mortar brick wall house、masonry basis mortar brick wall house、cement mortar brick wall house were studied based on the hydraulic engineering and hydraulics model test method. The results showed that the erosion resistibility for normal mortar brick wall house was the weakest, the foundation and its above part of wall were seriously damaged. Concrete surface reinforcement of foundation and wall obviously improved the erosion resistibility. Test conclusions offered decision basis for the reinforcement of existing housing, which possessed guiding significance for promoting flood control and disaster reduction capacity of floodplain housing.

ESTIMATING TYPHOON RAINFALL USING SATELLITE DATA

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Typhoons, which bring heavy rainstorms, usually cause casualties and economic losses, especially the typhoons with a large amount of rainfall. For example, Typhoon Nari, Toraji, and Morakot had resulted in large-scale floods and landslides. Early warnings, which are based on rainfall data, cannot be done when typhoons approach because all typhoons form on pelagic regions, and direction-observing data in pelagic regions is absent. Therefore, providing accurate rainfall data of typhoons is an important research topic.

In early days, rainfall estimation was done via physical methods and statistical methods. Physical methods are usually simplified, thus the methods cannot fit real-world atmospheric phenomena. Statistical methods work rapidly and are easy to use; however, the methods constructing the relation between temperatures and rainfall are limited to specific seasons and regions. Because of aforesaid reasons, applying artificial intelligence methods is the other alternative. Combining SSM/I (Special Sensor Microwave/Imager) meteorological satellite data from DMSP (Defense Meteorology Satellite Program) and BPN (back-propagation networks) to construct local ocean rainfall predicting model to help estimate rainfall during typhoons is the main target in this research.

IDENTIFICATION OF FAVORABLE AREAS FOR FLOOD SPREADING BY APPLYING SATELLITE IMAGES AND GIS IN IRAN

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It is announced and published that some projects of flood spreading have been operated successfully in quaternary deposits; therefore it aroused the development of such similar projects. The first step in development and operation of new projects in aquifer management is the identification of favorable areas.
It is evident that in the Quaternary deposits, alluvial fan with regard to having the upper basin and the presence of coarse alluvium in their areas has a suitable condition for flood spreading. Although the use of geological and topographic maps is necessary for identifying new areas, but the data of these maps, are not sufficient for decision making and prioritization of Quaternary deposits, particularly in alluvial fan deposits in terms of capacity for flood spreading. Multi-spectral satellite imagery, in addition to share spatial data and alluvial fan areas, they not only share spatial data and alluvial fan areas but also provide achieving to several of the descriptive information. This kind of information can be used for classifying in terms of alluvial fan priority for flood spreading. So with this attitude, alluvial fans were considered as the unit of studying for flood spreading and aquifer management. In order to choose the kind of false color images, various combinations of multi-spectral satellite images were created according to minimum correlation between bands, but finally, the band combination 1, 4, 7, or in other words RGB 741 was found suitable for interpretation, according to the objectives of this project. This combination of false color has some benefits. for instance the vegetation and water colors in the image appears to the same original color of themselves and soil and rock specifications would be more apparent because of existing the 7 band in the color combinations.
In the visual interpretation step of images, the interpreter is able to map easily the boundary of alluvial fans according to the pattern and shape of them. During the separation of units on the satellite images the Interpreter tries to consider the agricultural lands and urban areas. So in this way those quaternary sediments in which there are no agricultural activities in their areas and also have potentially water resources upstream of them are identified. In this research we have investigated 21parameters in order to identify the prone areas for flood spreading in the alluvial fans of Gonabad in north east of Iran. Consequently we have identified 53343 ha of studied area favorable for flood spreading.

IDENTIFY VULNERABLE PLACES BY SEA LEVEL RISE AND FLOODING IN SAN FRANCISCO BAY AREA (SOUTH) FOR PLANNERS

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The San Francisco Bay Area – South is home to millions of people. This unique area includes Silicon Valley, the heart of high tech innovation and development, accounting for one third of the venture capital in the United States.

The California State government has been forced to adapt to climate changes such as sea level rise and flash floods. Recently, more frequent extreme natural events other than the typical earthquake risk are being reported in this area. The vulnerable regions of high population or developed commercial industry need to be identified for the re-zoning places to reduce potential risks. For planners, understanding and selecting the priority re-zoning places are immediate strategies for climate change adaptation.

In this paper, using Geographic Information System, sea level rise inundation areas are displayed on maps in different inundation levels for next 50 years. Using hydrology analysis, intersecting sea level rise inundation areas and river basin watershed areas are selected. These areas are overlapped on urban growth prediction areas for 2020 and 2050. More than million population places are identified and overlapped. The identified areas are considered the most vulnerable to sea level rise and potential flood inundation for next 50 years. Geographic Information System (GIS) technology helps urban planners and policy decision makers to identify the most vulnerable areas to reduce social/economic loss in future.

ROBUSTNESS OF ECONOMICALLY EFFICIENT FLOOD PROTECTION STANDARDS: A COMBINATION OF MONTE CARLO AND COST-BENEFIT ANALYSIS

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The Netherlands is vulnerable to flooding from the sea and from the large rivers, such as the river Rhine. Dikes have been built throughout the ages to control the risk of flooding, often in response to a flood disaster. The current standards for flood protection were proposed by the Delta Committee following the major flood of 1953, which struck the south-western delta of The Netherlands. The standards were partly based on an economic optimization of investment costs and the benefits of damage reduction some 50 years ago. Since then, the potential damages have increased manifold. The flood standard and are therefore in urgent need of updating. Such an update is one of the objectives of the policy study 'Flood protection for the 21st Century'. The new flood protection standards will be decided by Parliament. The decision will be based on a cost-benefit analysis and an analysis of casualty risk.

The cost-benefit analysis uses a dynamic optimization model (*OptimaliseRing*) to determine an optimal investment strategy for dike reinforcement. This strategy minimizes the discounted investment cost and residual flood damages over a long time horizon. The impacts of economic growth and climate change on flood risk are taken into account. The cost-benefit analysis uses information on flood probabilities, flood consequences and the costs of investments in dike reinforcement. Consequences consist of direct flood damages, but also include an estimate of immaterial damages (based, among other, on the value of statistical life) and indirect damages. From the optimal investment strategy, economically efficient (optimal) flood protection standards for the coming decades (until 2050) are derived.

In 2008, the methodology and preliminary results from the CBA were presented at the ICFM3 conference held at Toronto, Canada. In 2011, the CBA was finalized, using better information on flood probabilities, consequences and costs and an improved optimization model.

The CBA's main conclusions are that, from an economic point of view, the current safety standards for the coastal areas (1/4000 tot 1/10000 per year) are sufficient high and that the safety standards for dikes along the major rivers (1/1250 to 1/2000) should be increased. To reach the optimal safety standards, an investment of several billions of euros is needed.

THE USE OF DIFFERENT FLOOD SCENARIO'S INCLUDING WORST CASES FOR EMERGENCY PLANNING AND FLOOD PREPAREDNESS

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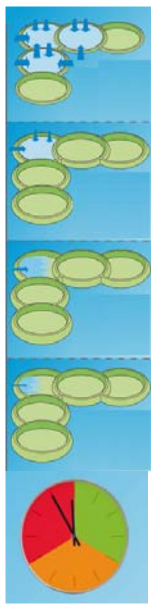
Flood preparedness is based on the frequency and possible impact of a flood and possible mitigating measures. This paper focuses on emergency preparation. Preparation is defined as: to maximize the use of available means and infrastructure in a possible event (threat or flood). The reduction of the impact of these measures depends on the impact of a flood and the available time to implement measures. When ambitions, as the required level of safety, are defined for emergency preparation the frequency of possible flood scenario's can be used in a risk based approach to define the required level of safety and effectiveness of emergency management (and so preparation of authorities, citizens and businesses). Therefore a representative set of scenarios is required.

Multiple flood scenarios can be defined varying from small events up to worst (credible) cases. History shows that in case of a flood event often multiple breaches and failures occur. Water levels can, by far, exceed the height and strength of the prevention system. Dikes and levees can also fail because of other circumstances as wrong design and bad maintenance. For the design of safety levels for flood prevention a (probabilistic) cost benefit approach can be used to define optimal safety levels; investments can be related with the reduction of the risk. For land use planning and emergency management within a protected area this only becomes effective when a flood occurs, so if the system of prevention fails. Multiple scenarios of flooding can occur and also defined in advance.

This research defines an approach to define a set of representative flood scenarios based on all known possibilities for emergency management and land use planning. This approach is applied for a case study in The Netherlands.

A scenario for flooding for emergency management contains an element of 'impact' and 'time', based on this combination also the probability can be defined. The impact related to the size of the flood zone, the number of inhabitants, damage and casualties. The time is related to the available time before a flood (lead time) and the progress of the flood over time. Combinations of impact and time can be used to define the effectiveness of mitigating strategies. When uncertainty is taken into account different classes can be defined over time and impact. Different classes for time are:1) red: unexpected flood (missed call) 2) green: enough time and 3) orange: a middle class of medium time. Different classes for the impact are: 1) expected flood in an area related to return period of safety level 2) small flood in an area: a probability of 10 times below the return period of the safety level 3) extreme flood in an area: a probability of 10 times more than the return period of the safety level and a combination of multiple breaches and 4) a worst case or worst credible flood (extreme flooding in multiple areas caused by the same event) that describes an upper limit that is considered to be realistic to take into account for planning.



GLOBAL 4 DIMENSIONS WATER CYCLE MANAGEMENT SYSTEM -PREDICTION, PROJECTION AND VISUALIZATION-

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1. Introduction

In the 21st century, the band of flood and drought will be larger due to global climate change, as the result the damage to social community caused by water disaster will seem to be getting worse. Also, as the energy resource will be definitely scarce, we need to shift the whole society to low-carbon system. The reexamination and reconstruction of water management system are inevitable for the construction of safe water society and the sustainable water management corresponding to this climate change and resource scarcity.

Besides, ground water is valuable national land resource and inseparable from surface water. However, the regulations for ground water as public property haven't enacted yet. The amount of ground water use is increasing rapidly, as the purification technology by membrane treatment progresses. It means that effectiveness of the water management system for surface water is decreasing. Especially, invisibility of ground water is one of the factors not to be treated as public property.

It is necessary for policy makers and decision makers regarding water policy to understand water cycle properly, and to develop the pioneering water management that can contribute to sustainable development.

2. What is four dimensions water cycle management?

Four dimensions water cycle management is the technology that can visualize intelligibly the flow conditions of surface water and subsurface water in past, present, and future to develop the policy related to water management system. This water cycle management makes it possible to reproduce natural water condition without artificial water transfer in the past, analyze water condition with artificial water use such as dam reservoir, water intake, water conveyance, and drainage in the present, and predict water condition affected by climate change and regional development in the future.

It is considered to utilize data obtained by satellite to understand wide range of geographical features, land use, and water use efficiently.

3. Application for policy related to national water management system

Significance of information provided by the four dimensions water cycle management can be the scientific base for policies related to all national water management system which includes national water resource management plan development such as water resource change according to climate change and social change, adequate water resource development and water resource restoration, besides national water resource management plan development such as long term ground water change and its recharge, furthermore national coastal restoration plan development such as prediction of ground water salinization and undersea spring water aquatic resources conservation. At the same time, significance of the above-stated information can be technology information for regional challenges such as environment assessment, environment and ecosystem conservation and restoration, flood analysis.

In this report, we would like to take up the summary, analysis cases and application examples of four dimensions water cycle management, and its future development.

ANNUAL MAXIMA FREQUENCY ANALYSIS OF LOWER BENGAWAN SOLO SUB-CATCHMENT USING L-MOMENTS

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Bengawan Solo River is flowing from Upper Bengawan Solo Sub-catchment located in Wonogiri-Central Java Province to Java Ocean through some regions in Central Java and East Java Provinces. The length of the river is about 600 km, and the total area of Bengawan Solo River Basin is about 19,778 km^2. On the end of December 2007, some regions in Central Java and East Java Provinces (Indonesia) located in Bengawan Solo River Basin were flooded due to high rainfall intensity which caused the overflow of River Bengawan Solo and released of excessive water from Wonogiri Dam in the upstream catchment. Some regions in the affected areas were inundated for several weeks. This flood phenomenon is the biggest flood in the river basin during the last 40 years. The flood not only damaged infrastructure and paddy fields in those regions, but also severely impacted many other sectors. In March 2008, some areas in Central Java and East Java located in Bengawan Solo River Basin were flooded again. Furthermore, the lower areas of the river basin get flooded annually recently, particularly in Lower Bengawan Solo sub-catchment areas.

This research aims to analyse the frequency of annual maxima in the Lower Bengawan Solo Sub-catchment using L-moments and relate this to flood frequency. Annual maximum stream flows data from appropriate river gauging stations will be used in this research. The data are available for several stream gauging stations in the sub-catchment from years 1975 to 2008. However, there are some data gaps in specific stream gauging station. Generalized Extreme Value (GEV), Generalized Logistic (GLO), and Pearson Type III distributions are used in the analysis of hydrologic extreme variables.