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Flood Risk Management

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Hazards, Vulnerability and Mitigation Measures

Edited by

Jochen Schanze,
Evzen Zeman and Jiri Marsalek

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Flood Risk Management: Hazards, Vulnerability and Mitigation Measures

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TABLE OF CONTENTS

Part 3. Flood forecasting

Part 4. Vulnerability and flood damages

Part 5. Mitigation measures

PREFACE

After a series of disastrous flood events during the recent years flood risks are in the forefront of public concerns. World-wide statistics indicate continuously increasing flood damages, and losses of human lives remain at unacceptably high levels. Many of these concerns have manifested themselves during recent extreme floods in Central Europe, like in the Vltava-Elbe river basin in August 2002 with catastrophic damages in the Czech Republic (2 billion EURO) and in Germany (9 billion EURO). In science and among professionals, there is a growing recognition that inundations by extreme floods cannot be totally avoided and maybe their occurrence will increase due to climate change. Accordingly, the previous paradigm of flood protection has to change to a societal flood risk management. This paradigm shift especially requires more comprehensive and continuous approaches considering all natural and societal factors of flood risks. Research and practice on flood risk management therefore depends on an enhanced collaboration of professionals in different fields, administrative sectors and regions or countries.

Against this background, the NATO Advanced Research Workshop (ARW) on 'Flood Risk Management – Hazard, Vulnerability and Mitigation Measures' aimed at discussing and advancing the understanding of an integrated and sustainable flood risk management. Therefore, it referred to the main risk factors and their theoretical and methodological investigations, like weather forecasting, climate change, flood propagation modelling, vulnerability assessment, design of risk reduction measures as well as the development of management strategies and instruments. In addition, it reflected practical experience from recent floods in Central Europe and elsewhere, considering both long-term as well as flood event measures, like flood warning, evacuation, etc. In this process, interdisciplinary and transboundary co-operation issues played an important role.

The workshop was held in Ostrov (near Decin), Czech Republic, close to the Czech-German border, from September 29th to October 3rd, 2004. Forty-three participants with backgrounds in natural sciences, social sciences, engineering and practical flood risk management represented 14 countries. The workshop covered sessions on 'flood hazard modelling', 'flood forecasting', 'modelling of vulnerability', 'flood risk mitigation' and 'historical floods and transboundary issues'. The proceedings provide the full texts of most of the formal oral presentations, and furthermore present the final conclusions of the ARW, which were announced during a reception by The Mayor of the City of Dresden.

Jochen Schanze, Dresden, Germany
Evzen Zeman, Prague, Czech Republic
Jiri Marsalek, Burlington, Canada

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The Advanced Research Workshop (ARW) on 'Flood Risk Management – Hazards, Vulnerability and Mitigation Measures' was directed by Jochen Schanze, Leibniz Institute of Ecological and Regional Development (IOER) as Member of the Dresden Flood Research Center (D-FRC), Dresden, Germany, and Evzen Zeman, DHI Hydroinform a.s., Prague, Czech Republic. Both were assisted by Jiri Marsalek, National Water Research Institute (NWRI), Environment Canada, Burlington, Canada, as member of the organising committee.

The ARW was sponsored by an award of NATO under the Programme Environmental and Earth Science & Technology. The co-directors and members of the organizing committee especially thank Dr. Alain H. Jubier and Dr. Deniz Beten for their personal assistance in preparing the workshop and the proceedings.

The institutes of the co-directors provided additional financial and staff resources. The local organisation of the workshop was predominantly provided by DHI Hydroinform a.s. headed by Evzen Zeman with extensive contributions from Pavlina Nesvadbova and other staff. The typescript of the proceedings was prepared by Jochen Schanze supported by Alfred Olfert, Katrin Vogel and Margitta Wahl at the Leibniz Institute of Ecological and Regional Development (IOER).

The co-directors thank all participants for their presentations at the workshop and their papers contributed to this book. The exchange of various scientific perspectives and experiences from different regions of the world made the workshop particularly fruitful in terms of the future improvement of flood prevention by the civil societies.

PART 1

FLOOD RISK MANAGEMENT

Chapter 1

FLOOD RISK MANAGEMENT – A BASIC FRAMEWORK

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Keywords: Flood risk management, risk analysis, risk assessment, risk reduction, flood risk system, vulnerability, management strategies, flood research, water policy.

1. INTRODUCTION

Floods are one of the most threatening natural hazards for human societies (e.g. WBGU 1999). This is evident from the increase in damages in the last 50 years due to a series of extreme floods (Munich Re Group 2003). Recently, the tsunami in South East Asia caused 220,000 deaths which makes it probably one of the most disastrous floods. During the International Decade of Natural Disaster Reduction (IDNDR) from 1990 to 1999 it was appreciated that the previous paradigm of "flood protection" was inappropriate (UNDRO 1991, Plate 1999). Absolute protection is both unachievable and unsustainable, because of high costs and inherent uncertainties. Instead, risk management has been recommended as being more suitable and this paradigm is now receiving growing attention within flood research (e.g. Plate 1999, Schanze 2002, Hall et al. 2003, Hooijer et al 2004). Also currently environmental and regional policies in many countries are starting to shift from flood protection to flood risk management (e.g. Budapest Initiative 2002, EU 2004).

Flood risk management deals with a wide array of issues and tasks ranging from the prediction of flood hazards, through their societal consequences to measures and instruments for risk reduction. Due to this variety of aspects, management of flood risks needs systematisation and integration. This chapter provides definitions of central terms, the systematisation of tasks and components and a basic framework for flood risk management. Based on this, there are challenges for research and practice which arise especially from an integrated risk based approach.

J. Schanze et al. (eds.), Flood Risk Management: Hazards, Vulnerability and Mitigation Measures, 1–20.

2. TERMS AND CONCEPTS

2.1. Flood risk

Floods can be defined as a temporary covering of land by water outside its normal confines (FLOODsite-Consortium 2005; cf. Munich Re 1997). They happen in small and large river basins, in estuaries, at coasts and locally. Beside these general conditions, floods can be systematised according to the cause of events, such as winter rainfall floods, summer convectional storm induced floods, snow-melt floods, sea surge and tidal floods, tsunamis, rising ground water floods, urban sewer floods, dam break or reservoir control floods. (cf. Penning-Rowsell and Peerbolte 1994, enhanced). A special type of flood is the highly dynamic flash floods. Each flood event can be characterised by features such as water depth, flow velocity, matter fluxes, and temporal and spatial dynamics. Flooding in most cases is a natural phenomenon which, for example, in natural floodplains cannot be classified as a threat. Nevertheless, floods in intensively used catchments are often influenced by man through land use, river training etc.

The probability of the occurrence of potentially damaging flood events is called *flood hazard* (cf. ITC 2004). Potentially damaging means that there are elements exposed to floods which could, but need not necessarily, be harmed (FLOODsite-Consortium 2005). The flood hazard encompasses events with various features. For instance, a building in a floodplain can be threatened by a 50-year flood, with a water level of 1 metre and by a 100-year flood, with a water level of 1.5 metres. Moreover, these events may be associated with different transport capabilities regarding debris, sediment and other (e.g. toxic) substances with varying impacts on man and the environment.

Damage by flood hazards depends on the *vulnerability* of exposed elements. The term vulnerability refers to inherent characteristics of these elements which determine their potential to be harmed (Sarewitz et al. 2003). It can be understood as a combination of susceptibility and societal value (FLOODsite-Consortium 2005) and expressed by direct and indirect effects which are tangible or intangible (Messner and Meyer, this issue). In contrast to the societal value, which is independent from the hazard, susceptibility indicates the process of damage generation (cf. Penning-Rowsell et al. 2003). It depends on both the type of flood event with its features and the constitution of the elements at risk. Three basic areas of flood vulnerability can be distinguished according to the principle of sustainability: social and cultural, economic and ecological vulnerability. *Social and cultural vulnerability* refers to loss of life, health impacts (injuries), loss of vitality, stress, social impacts, loss of personal articles, and loss of cultural heritage. *Economic vulnerability* alludes to direct and indirect financial losses by damage to property assets, basic material and goods, reduced productivity, and relief efforts. *Ecological vulnerability* comprises anthropogenic pollution of waters, soils and ecological systems with their biota (cf. Messner and Meyer, this issue).

Flood risk emerges from the convolution of flood hazard and flood vulnerability (WBGU 1999, ISDR 2004). It can be defined as the probability of negative consequences due to floods and depends on the exposure of elements at risk to a flood hazard (cf. ibid.). The general understanding of the term risk dates from the initial risk research (e.g. Knight 1921). In terms of floods it is interpreted as harm to flood-prone elements with a specific vulnerability ("elements at risk") due to probable flood events with their features. It should not be confused, therefore, with risk in terms of reliability, which plays a major role for quantifying the safety of structural works for flood protection (Plate 1999; see below).

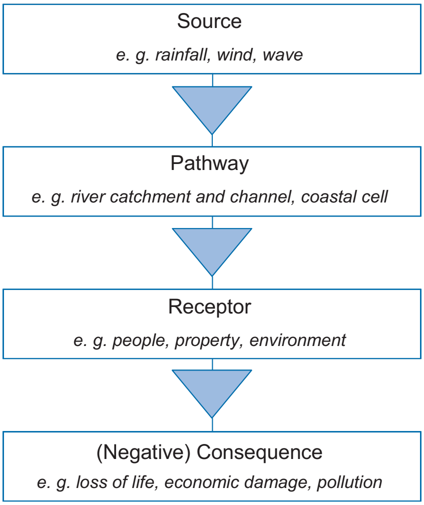

Figure 1. Source-Pathway-Receptor-Consequence-Model (ICE 2001, modified)

In order to describe flood risk the conceptual Source-Pathway-Receptor-Consequence-Model (SPRC-Model) has been proposed (ICE 2001; see Figure 1). It shows a simple causal chain ranging from the meteorological and hydrological events either in inland or at coasts (sources) through the discharge and inundation (pathways) and the physical impacts on elements at risk (receptors) to the assessment of effects (consequences). The chain links 'source', 'pathway' and 'receptor' refer to the physical process, whereas the assessment of the '(negative) consequence' is a matter of societal values.

In terms of flood risk, 'source' and 'pathway' represent the flood hazard. 'Source' is determined by the probability (p) of flood events with a certain magnitude and other features (m). Early warning (w) and the retention capacity of the source areas of inland floods (t) can be considered as two risk reduction factors. The 'pathway' can be described by the inland discharge or coastal overflow and inundation (i) with various attributes (a) and interventions for flood control (c). 'Receptor' and '(negative) consequence' state the vulnerability, whereas 'receptor' specifies the susceptibility (s) with interventions to strengthen resistance and resilience (r). ‘Consequence’ stands for the harm to values (v; damage) with interventions to decrease or to compensate them (d). Accordingly, flood risk can be expressed by the following function:

$$\text{Flood risk} = f\left((p,m,w,t)_{source}, (i, a, c)_{pathway}, (s, r)_{receptor}, (v, d)_{consequence}\right)$$

In reality the causal chain of the SPRC-Model occurs for each element at risk and each flood hazard. Moreover, complex interrelations exist between pathways, interventions for flood control and the exposure of vulnerable elements. In some cases the interrelations consist of multiple feedbacks. A system which is assumed to include all related elements and processes is called here a “flood risk system”. For inland floods it refers to river catchments, for coastal floods to coastal cells as areas which are hydraulically connected. The overall risk associated with a flood risk system can be described as the sum of risks of all individual elements.

2.2. Flood risk management

The term management is used in at least two different ways in the literature on floods, either excluding or including risk analysis. The first understanding is based on the hydrological reliability of existing flood defence structures. Management is interpreted, therefore, as decisions and actions undertaken to mitigate the remaining risk above flood protection design standards. In the past, the remaining risk has been assessed by scientific investigations. Dealing with flood risks in this case means carrying out flood risk analysis and then flood risk management (e.g. Marsalek 1999, Hooijer et al. 2004, Oumeraci 2004). The second understanding defines management as decisions and actions undertaken to analyse, assess and (to try to) reduce flood risks. In this case flood risk management covers the risk analysis, risk assessment and risk reduction (Plate 1999, Sayers et al. 2002, Hall et al. 2003). Both concepts are real alternatives and can hardly be combined.

Originally the term “management” comes from business economics. It is defined as all those activities which control the decisions and actions of an actor, an organisation, or a set of organisations (network) effectively and efficiently. Such activities include planning (data gathering, analysing, goal setting, evaluation of options, and so forth), organising, directing, staffing, monitoring, controlling and learning (Weihrich and Koontz 1992). In this sense “management” is already used in European Water Policy. One example is provided by the requirements of River Basin Management Plans (Art. 13) specified in Annex VII of the European Water Framework Directive (2000/60/EC). Beside others, they encompass (i) the *analysis* of pressures and impacts, (ii) the *assessment* of the water status and (iii) a programme of *measures.* Similar demands can be found in the “Guidelines for an integrated Management of Coastal Zones” (2002/413/EC).

Against this background, it is recommended that *flood risk management* should be defined as ‘holistic and continuous societal analysis, assessment and reduction of flood risk’. ‘Holistic’ refers to the flood risk system which should be considered as comprehensive as