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Flood Related Risk Management

Abstract – The crucial importance of the availability of effective environmental risk management systems has become more than clear – not only in Europe – during the recent flooding and drought events. Sustainable development of a region can only be achieved if the impacts caused by natural and man made disasters can be properly managed. Safety considerations must apply for large constructions as well as for environmentally susceptible areas such as flood plains.

Of particular concern are harmful effects caused by flooding or drought. Precaution, defence and remediation measures must be identified, elaborated and eventually applied, taking into account the very local situation as well as the situation in the entire hydrological basin. Of concern are not only short term effects caused by the destructive forces of the running water. Mobilisation, transport and deposition of soluble and particulate pollutants, including pathogenic organisms, are of importance as well. Historical, political, economical, educational and cultural diversity in large river basins as well as in costal areas makes it particularly challenging to develop and implement effective management systems, especially when rivers are shared by a large number of countries. In this context, the Rhine and the Danube river basin may serve as excellent development grounds for advanced risk management systems.

Introduction

Integration of European countries into the European Union requires not only harmonisation of political, administrative and economical structures. As important is the development of means to manage disastrous events such as drought and flooding, tornados and earthquakes.

In the year 2002, many parts of Europe were threatened by large scale flooding causing destruction of constructions like bridges and industrial plants, railroad

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tracks and highways. In 2003, we experienced drought situations in various parts of Europe causing forest fire and drop of the level of ground and surface waters. Subsequently, we were confronted with a tremendous loss of forest and agricultural products, real estate and property value, and even human life. Power plants had to be shut down, and river navigation came to a complete stop in some parts of Europe. The economy was harmed. Worse than that, the ecological function of forests and flood plains deteriorated. The effects will be noticeable over a long period of time. Long term effects, although not readily visible by the public, may have even greater impacts than the destructions and harms during the time catastrophic events occur.

What will happen next, nobody really knows. Will we run into another year of flooding or drought, or will we be hit by tornados and earthquakes? We know for sure only, that the economical and ecological consequences of natural disasters will add to the man made problems we already have to deal with.

Risks and risk management

The term "risk" describes the possibility or danger of suffering substantial harms and losses. In this context, risk conveys a negative message. However, one must understand that taking a risk is also the driving force in our every day life. It is the driving force of technological and societal advances and economical gains. For instance, the decision to drive a car, or the decision to buy stocks requires a basic readiness to take some sort of a risk. Not taking a risk means giving up on action, and subsequently on any further development necessary to cope with the ever changing environmental, economical or political conditions governing life on earth.

Risk management comprises the acts of balancing the potential harms and losses with any foreseeable chances and gains. To be provided are measures to minimise harms and losses, and means to avoid the development of catastrophic events, a subsequent crisis and the collapse of the economical and ecological system we depend on. Thus, risk management must be complemented with a proper crisis management. Once a disaster has occurred an effective crisis management must become effective to solve the problem as it came in existence (Wilderer *et al.*, 2002).

With respect to fresh water one has to distinguish between the quantitative and the qualitative aspects of risks and crisis management. In addition, the issue of scale must be taken into account. On the macro-scale, the entire catchment area of a river and its tributaries is under consideration. In contrast, the environmental situation at a single spot within a river basin or a costal zone requires observations and actions on the micro-scale.

As visualized in Figure 1, flooding related risk and crisis management is dependent on detailed real-time information about the current weather conditions and the predictable changes of weather, flow and water level in a river or a lake. With respect to long term impacts, for instance on the pristine ecology of flood plains (Bloesch, 2002), it is also important to monitor parameters which describe the state of pollution in rivers, lakes, costal zones and flood plains. Time series of satellite data and of data from ground based monitoring stations are to be collected and evaluated.

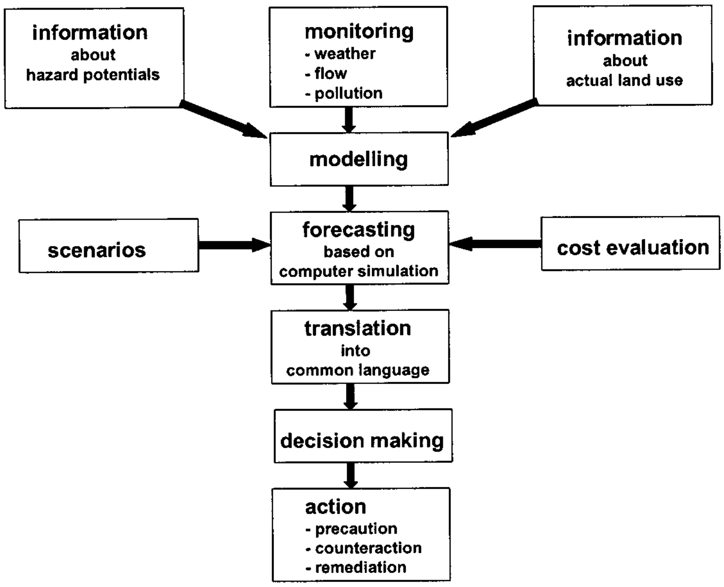

Fig. 1. The subsequent stages of a risk management scenario.

To be able to predict the development of catastrophic flooding events information is required about land cover with forests, meadows and ploughed land. Prediction of potential hazards requires information about the actual land use, the location of constructions, industrial sites, storage facilities of hazardous materials, wastewater treatment plants, landfills ect., structural details informing about susceptibility of a construction in the case of a physical impact. This type of information should be compiled in a computer based geographical information system (GIS).

On the basis of this information computer models have already been, but need to be further developed which allow accurate prediction of the evolution of peak flow condition in rivers, lakes and reservoirs, and the spread of the water across the flooding area. Mobilisation of river sediments, transport and subsequent sedimentation and accumulation, be it in the river bed or in the adjacent area are further processes to be implemented into the models.

Numerical simulation studies must be conducted to predict the consequences of enhanced flow, increasing water level and flooding of inhabited, agricultural and riverine areas. By means of simulation studies the potential hazards and the effects of prevention and counteraction measures can be evaluated. Various defence scenarios could be studied with the aim to estimate and cross-compare the potential losses in terms of property value, value of constructions, value of specifically important ecological function of a certain riverine area, and human life. Moreover, the costs of reconstruction, remediation and repair should be evaluated.

The results of the simulation studies are to be translated into a language which is comprehensible by persons who may not be trained to extract the essence of the specific data, figures and graphs provided by computer simulation studies, but are supposed to draw relevant decisions.

Finally, decisions have to be made, and actions have to be taken, be it precautionary, defence or remediation actions. The most difficult part is defence, when a flooding event is about to occur, and decisions have to be made under tremendous time constraints, even in panic. To take it in simple words: in case of the evolution of a catastrophic event, the captain of the local fire brigade must understand the signals raised by a monitoring station and a computer programme – even when located far in the distance and outside of his own domain – so that the "sand bags" are brought into the right position at the right time.

Risk management plans addressing the above mentioned aspects have been developed, during the past years, for many hydrographical regions of Europe. Most of them, however, are primarily focused on the very local geographical, economical and political conditions. Bilateral co-operation is common, but multilateral approaches are rather rare. The current situation in Europe is further complicated by the fact that the existing codes of the computer models differ greatly from each other making information transfer across national borders very difficult, especially in emergency cases.

Straightforward water related risk and crisis management requires the involvement of (1) scientists, (2) engineers, (3) the civil society and (4) political decision-makers. Of uppermost importance is a fast and smoothly working communication network between these four groups of players. Communication must function across the governmental, administrative, educational and language barriers as they are in existence in many parts of Europe, in particular in the Danube river basin (Water Europe: Water in Europe: The Danube river – Life Line of Greater Europe, Wilderer *et al.*, eds., 2002). Scientific and technical information must be explained so that people not educated in the scientific and technical field of concern can extract the message contained in the information base.

Prevention measures

To minimize the negative impacts of large scale droughts and flooding a number of very different methods are currently being discussed, and preventive constructions are being built. According to the opinion of the author, major emphasis is to be placed on the following measures:

– Deforestation needs urgently be reversed.
– On-site purification and infiltration of storm water runoff from roofs, roads and courtyards should be applied wherever possible (Figure 2).
– Flood plains should be revitalized as far as possible.
– Building developments within areas susceptible to getting flooded should be prohibited.
– Areas containing hazardous materials (including pathogenic organisms) require specific defence.
– Dikes should be elevated only, if no other prevention methods can be applied.

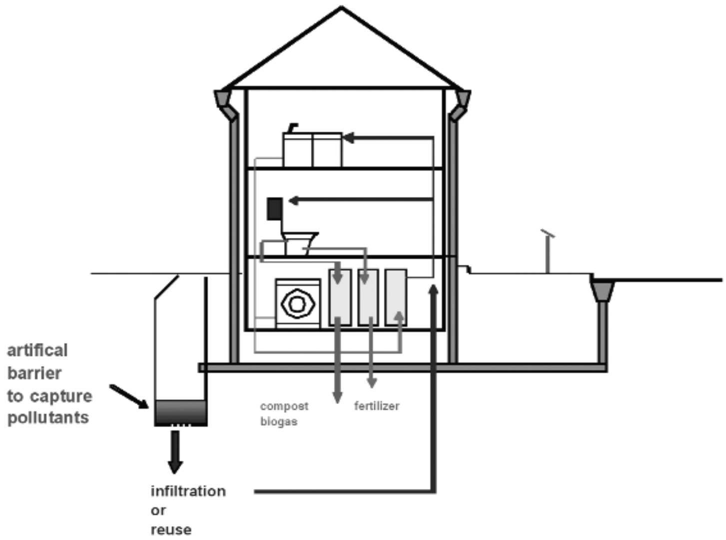

Fig. 2. Schematic representation of on site treatment, infiltration or use of roof and road runoff.

Translation of scientific results

As mentioned above, methods of transfer of the results of monitoring, computer modelling and numerical simulation studies into the conscious sphere of persons responsible for drawing actual decision are underdeveloped. During the flooding of the Elbe river basin in 2002 we had to learn that some loss of material and ecological values could have been avoided if decision makers would have better understood the signs and trusted the computer based results and predictions.

Transfer limitation of scientific knowledge to people appears to be a fundamental problem which increases in importance with further advances of science and technology. People react with fears and aggressions, and oppose technological advances despite the fact that we all depend heavily on technology. It is one of the most urgent tasks of the scientific community to develop means to translate the essence of scientific knowledge and results into a language people can readily understand irrespectively of their educational background.

Concluding remarks

It is irrational to assume that complete safety of large constructions, of technological means and of life on earth can be achieved. Man must live with risks. Taking risk is to be understood as a driving force of any societal and industrial development.

Risk management comprises the acts of keeping potential harms and losses in balance with any foreseeable chances and gains. Minimization of risks by applying technological or administrative measures is necessary only from a threshold level on marking the transition into a crisis or a catastrophe. Thus, risk management must be complemented with a crisis management.

With respect to water, a crisis and subsequently a catastrophe may happen in context with either heavy rain fall or a drought. Increase of flow and extensive raise of the water level in rivers and lakes my lead to massive deterioration of man made structures, agricultural land and life. Similarly, long lasting droughts may cause massive losses and harms.

Short term destructive effects like the ones mentioned above are often associated with long term deteriorations caused by mobilization of hazardous substances during flooding events, transport and deposition in particularly sensitive areas like flood plains.

Measures to minimize the effects of this type of a crisis include reforestation, on-site purification and infiltration of roof and road runoff, revitalization of flood plains, and specific protection of areas from which hazardous substances may be washed away. Elevation of dikes is to be taken only in concert with the above mentioned measures.

To be able to timely counteract catastrophic events an intensive monitoring programme must be executed on a permanent basis. Advanced computer models are needed, and numerical simulations have to be performed to get solid information about changes in flow, water level, spread of water, load of pollutants and their fate.

The information gained through science based methods must be converted into a language readily understandable by decision makers on the local, regional, national and supra-national level. Research is needed to develop appropriate communication means between the scientific community and the people.

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