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FLOOD aware

Prevention and forecast of floods

Floodaware Final report

August 1996 / July 1998

Floodaware
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Floodaware

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Abstract

The prospect of the Floodaware project is to build a European methodology for flood management and damage mitigation with accepted standards, especially on vulnerabilities and risk maps implementations (risk = vulnerability x hazard). The objectives are to implement into models and tools new synthetic approaches developed in water sciences and management. The flood management policy must be treated with carefulness toward the water resources and ecological aspects. This knowledge has deep implications in social and economic behaviour. So, a structured effort is made to present this new knowledge under a "negotiable" form : negotiations for water volumes, and/or for land uses, between the different communities and owners living all along a river.

The Inondabilité methodology deals with synthetic models in hydrology, hydraulic modeling, hazards parameters, vulnerabilities, crossed maps... All these concepts are devoted to a dynamic slowing down producing simultaneously hazard mitigation and resources improvement with socio-economic interfaces. First results have already been obtained for a quantification of the hazard and works are done for an estimate of the objectives of protection against floods.

A synthetic Heuristic approach is developed, for prevention and forecasting. This methodology will be confronted to Inondabilité, as an alternative procedure for data management, more adapted to tumbling rivers with unstable beds. Data are collected and treated for simulations and some first results will be available soon.
Research is done in the field of Regionalization in hydrology, in the field of rainfalls, extreme rainfalls and discharges evaluations, including reservoir management rules devoted to hazard mitigation, when water resources are critical. Theoretical results will be soon available and tested on data sets.

The aim of this project is to give effective answers to help decision-makers, engineers and researchers to develop solutions to their specific problems in flood risk prevention and forecasting.

Résumé

Depuis quelques années, et apparaissant comme une des principales priorités en environnement, de nouvelles approches synthétiques sont développées en sciences et en gestion de l'eau. Une des raisons d'une telle évolution est les liens étroits entre le climat, les régimes hydrologiques, et l'occupation du sol. Pour cela, les politiques environnementales doivent évoluer d'un état de connaissance actuel qualitatif ou trop compliqué vers des éléments objectifs et transférables.

Les inondations étant le processus le plus structurant des problèmes liés à l'eau, elles doivent être traitées en priorité par les concepts proposés ici. Pour utiliser ces concepts et ces outils, des cas tests sont nécessaires. La perspective est de construire, pour la gestion des inondations, et une diminution des dommages, une méthodologie européenne avec des standards reconnus, notamment pour l'établissement de cartes de risques et de vulnérabilité.

De plus, les politiques de gestion d'inondation doivent être prudentes face aux ressources en eau et plus généralement aux problèmes écologiques. Ces aspects doivent être pris au moins comme une contrainte, au plus comme un objectif supplémentaire. La gestion des inondations ayant un impact social important, et certaines réticences étant observées parmi les acteurs qui doivent prendre en compte ces réalités, des efforts doivent être fournis pour présenter de nouvelles méthodologies sous forme de négociations : négociations sur les volumes d'eau, et/ou sur l'occupation du sol, entre les différents acteurs concernés.

Ce projet est essentiellement consacré au développement de ces nouveaux concepts pour la gestion des inondations, tenant compte des connaissances déjà existantes.

SOMMAIRE

A Corinne.

Foreword

The prospect of the Floodaware project is to build a European methodology for flood management and damage mitigation with accepted standards, especially on vulnerabilities and risk maps implementations (risk = vulnerability x hazard). The objectives are to implement into models and tools new synthetic approaches developed in water sciences and management. The flood management policy must be treated with carefulness toward the water resources and ecological aspects. This knowledge has deep implications in social and economic behaviour. So, a structured effort is made to present this new knowledge under a " negotiable " form : negotiations for water volumes, and/or for land uses, between the different communities and owners living all along a river.

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NEEDS OF THE SOCIETY

The extreme climatic events of the last years in Europe have shown that flood management is a necessity and a priority to mitigate/avoid serious damages and disorders in social and economic terms.

When we analyse the operational needs of the Institutions and Services in charge of the flood and inundation management, we have to face the following items :

- A flood warning system ;
- The management of hydraulic structures ;
- The survey of hydraulic structures ;
- The forecast of the discharges for various needs ;
- The knowledge of the hydrological regime, and the short term meteorological events ;
- The knowledge of the vulnerability (social and economic stakes) of the major bed to design and operate, if necessary, some evacuation programs ;
- ... more ...

The scientists and the researchers who work in the fields of Hydrology and Hydraulics are able to make short or long term scientific proposals to improve the methodologies and the models used for flood management.

But it won't be sufficient to deal only with the improvement of the different items of a flood management system, without having previously defined and designed a global and general strategy, a conceptual framework, in which all the operational means, and the present, as the future, institutions will take place, and will be better developed. The scientists have, as a first task, to design and to propose a consistent methodology for flood and inundation management, then to derive from it, in a coordinated way, some tools, in particular modelling tools, for the Operational Services in charge.

OPERATIONAL METHODS AND TOOLS

The flood risk can be defined by disintegration between hazard and vulnerability components, which are more or less independent.

The flood hazard is measured from hydrological parameters transformed in hydraulic characteristics.

The vulnerability is strongly related to land use and economical stakes.

Usually, hazard doesn't change very much through the time (hydrological regimes are relatively stable at long term scale), except when structures' buildings change the hydraulic characteristics. On the contrary, vulnerability generally increases due to more and more major bed urban occupation.

Some concepts and methodologies such as the « Dynamic Slowing Down » or the « Inondabilité method » can take into account the consequences of the planned programs on the water resources generally speaking (in both terms of quality and quantity, and in terms of quantified elements of negotiation to exchange water volumes), and especially when low flows/severe low flows occur. They bring, at this

stage, some interesting element for the general analysis. These methods can be modelised in technical tools (softwares including multi-media).

A mapping of the flood risk (hydraulic hazard and vulnerability) has to be planned as a decision making tool, and also as an information tool for the concerned public. Such maps, allowing a clear and detailed diagnostic at any scale, allow negotiations and the adequate decisions to be taken, both on hazard (for hydraulic measures, crisis management included) and on vulnerability (progressive evolution in land use, and short term crisis measures included, like population evacuation).

Forecasting and crisis management are more efficient in a context where flood prediction and prevention are well developed.

Hydrological and hydraulic models allow to modernise flood warning system (the social request is easily expressed as the need of a flood plain forecast system, even when the actual need is more on land management), and to evaluate the consequences of future hydraulic works or the human influences.

RIVER MANAGEMENT

When we deal with rivers, we have to take into account many components of its functioning. As they are essentially used for their water resource, we have to study the impact of the water withdrawals especially during low flow period. Moreover rivers also overflow sometimes and people that have settled near have to be protected ; we have then to know about high and extreme flows. Finally, rivers are the place of life and we have to preserve their biological wealth.
Unfortunately, people that worked on rivers used to consider these components without relationships. That means that they usually solve problems without taking into account the other aspects. And the impacts generated by this way are sometimes very negative. For example, hydraulics engineers drilled the river beds to prevent from floods. These hydraulic works have huge effects on the availability of the water resources and on the ecosystem due to the lowering of the water level.
So, in order to provide river management, people try now :

- to propose an integrated river management that takes into account the global functioning of the river basin and the use of it
- to preserve future with action that take into account next generations : a sustainable management.

When people integrate all the components of the rivers for better solutions, it appears that it is very complex. Each discipline is usually well known but the

interactions between them are not as easy as we could firstly think. That is why we have to develop new concepts and tools to give better answers.

FLOOD MANAGEMENT

To mitigate the consequences of the floods, there are several methods : prevention, forecasting and promotion of risk culture. They have to be used all together.

It is not possible to suppress inundations. The hydro-meteorological processes will always generate floods, because the volumes of water are incompatible with the size of the minor river bed. We cannot avoid the flood water volumes to return to the sea.
In a short term management, we can try to forecast the propagation of the flood and to take all the measures to save people's life and goods. We are dealing with flood forecasting and crisis management.
In a long term management, we can try to move in space and time the flood volumes, with the natural constraints. We are then dealing with prevention.
At last, we need to inform and to sensibilise concerned people if we want them to accept and follow proposed measures. We are dealing with risk culture.

Flood management

Flood forecast or crisis management

The first known services of flood forecasting appeared in Egypt. In the 14th century, some systems existed in China. On the old continent, they appeared in the 18th century in Central Europe, on river Elbe. All these systems were based on a

transmission to downstream (by boat, rider or cannon fire) of a flood's arrival. It is only from the middle of the 19th century that start the first forecasting calculations from hydrometric and pluviometric data.
The stakes in flood forecasting were at the beginning essentially agricultural. They became later urban.

The missions of flood forecast have now changed : it is now "flooded areas" forecast. The demand is much complete. It is not enough to announce a flood arrival ; the information has to concern the arrival time of the discharge peak, the duration and the stretching of the inundation. The flood forecasting services have a increasingly complex work.
Moreover, flood forecast can quickly become crisis management. Over a certain threshold (of flow discharge, volume or duration), people need help or emergency assistance more than forecast.
We need in any case flood forecasting in already built areas that are vulnerable and potentially flooded..

Prevention

Prevention deals with long term management.
For ages, people have worked on rivers to mitigate floods, with often structural measures : chenalization, dike building... Taken at a very local scale (village), they had usually perverse effects downstream.
Flood risk prevention has to be understood as a management tool at catchment scale. It allows an integrated management taken into account other river functions as water resources, aquatic ecosystem...

Risk culture

Prevention and forecast cannot be efficient if we don't develop people's awareness and sensibilisation.
It remains little traces of an event because it has a high return period (by definition, a natural disaster happens very rarely). The geological and natural records are not always lisible. The time or the rebuilding often erase the material and historical archives.
We have to contribute to a living memory of the events. We have to develop this risk culture for a better understanding of prevention actions and crisis management. This sensibilisation has to begin in the early life at school and continue for all the life.

These three means to mitigate flood damages (prevention, prevision and promotion of risk culture) have different time scales and specific tools. Nevertheless, these measures are complementary and they should be applied all together.
Within the Floodaware project, we deal with flood prevention and prevision.

The Floodaware contract has been signed by the European Commission on July 1996. The formal start of the project is the 1st August 1996 and its duration is 2 years. Several work meetings have been organised within the Floodaware project :

- Lyon, 20 November 1995
- Torino, 12 March 1996
- Valencia, 16 July 1996
- Gembloux, 13-14 January 1997
- Dublin, 18-20 June 1997
- Madrid, 19-20 January 1998
- Barcelona, 29-30 June 1998

This book presents the results obtained within the project Floodaware.

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Scientific co-ordinator of the project Floodaware

The Inondabilité method

La méthode Inondabilité

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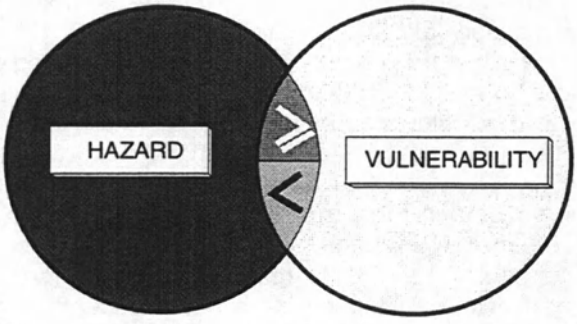
Abstract
To deal with flood risk management, it is now accepted to consider the risk as the comparison between vulnerability and hazard. The Inondabilité method uses this concept to provide tools for river management. The vulnerability, attached to the land use, determines the susceptibility to floods. We promote an expression of this component with hydrological variables: return period (T), duration (d) and water depth (p) of flood. The hazard is attached to hydro-meteorological phenomena and their consequences to the water flow; it is characterised by its discharge, its frequency and its duration, calculated by hydrological and hydraulic models. To compare the two notions of the vulnerability and the hazard, we use a discharge-duration-frequency (QdF) hydrological model, allowing the transformation of the two previous components in the same unit, a return period. The definition of the risk as a difference implies a search of an acceptable solution instead of an optimised solution, usually impossible to reach. These new concepts and methods should improve risk mitigation and lead to a better acceptable risk level in the potentially flooded area.

Résumé
Une partie de la réponse aux impacts économiques, sociaux et humains des inondations réside en une meilleure gestion de l'occupation des sols. La méthode Inondabilité permet d'apporter une réponse opérationnelle aux acteurs en charge de la gestion et l'aménagement des cours d'eau. Elle permet de mesurer dans la même unité et de comparer les deux facteurs indépendants que sont l'aléa et la vulnérabilité, pour aboutir à une quantification objective du risque. Sa mise en œuvre sur un bassin versant consiste en une modélisation de l'hydrologie grâce aux modèles Débit-durée-Fréquence, de l'hydraulique ainsi que de l'occupation du sol pour aboutir à une représentation cartographique du risque. L'originalité de la méthode Inondabilité tient à la quantification de l'aléa et de la vulnérabilité en une même unité, une période de retour qui permet une comparaison objective de deux grandeurs très différentes. De plus, la quantification du risque est estimée à l'aide d'une différence contrairement aux approches traditionnelles qui privilégient souvent un produit, permettant ainsi la définition d'un risque acceptable.

1 Introduction

Risk analysis may be approached by a first conceptual model made up of 2 components: hazard and vulnerability (sensitivity of the land use). It is particularly true for flood events: we practically never speak about flood risk neither in an alluvial forest or in a district situated at the top of a hill. Alluvial forests are regularly flooded (hazard), but with no prejudicial consequence; and at the top of a hill, whatever the stakes (vulnerability), any flood would never occur.
This first level of modelling (breaking the risk down into 2 parts, the hazard and the vulnerability) simplifies a complex reality, but grows away from the common citizen intuitive perception. So, we have to define very precisely the vocabulary used, to ensure a consistent dialogue between scientists, engineers, citizens and their elective representatives.

Conceptual model of the risk notion



The Inondabilité method aims at assessing quantitatively the risk, through a quantified modelling, parallel and independent of the two variables that are the hazard and the vulnerability. The comparison of these two dimensions allows defining an objective and rational measure of the risk, for each parcel. This summarised definition infers numerous hypotheses. Indeed, to achieve such a result, the hazard and the vulnerability must be quantified in the same unit of measure, that is to say with the same physical parameters (convertible into an equivalent measure). To apply that in a given place, we need a spatial modelling of these parameters. The method aims to be fitted to various geographic contexts, taking into account the local specificities without being dependent of them. So an objective quantification is necessary, and will also help to establish a real negotiation between the different involved people.

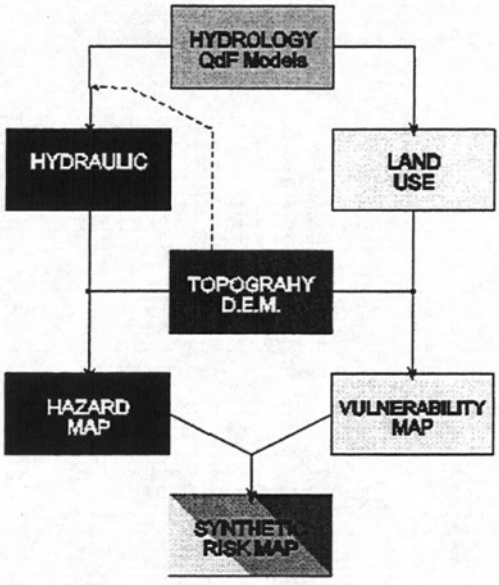
Thus, through a quantitative risk unit, the method defines the parcels over protected or under protected, following the sign of the risk:

1. positive sign = areas with a deficit of relative protection (high level of risk)
2. negative sign = areas with a credit of relative security (low level of risk).

Then, the two variables - the vulnerability and the hazard - and the results of their crossing - the risk -, will be mapped clearly, and will become a basis for the nego-

tiations (synthetic maps of the results are a readable way to make them understandable both by managers and inhabitants).

Chart of the Inondabilité method



So as to take into account the upstream and downstream interactions, and the hydraulic constraints of the river, it is necessary to work on an adapted geographic mesh, that is to say the whole linear of the considered river. Then the whole basin's inflows can be integrated, and the potential diversion of water from the upper part to the low part of a catchment might be tested.

The river linear has also to be significant in order to obtain a global view, at the basin scale, of the risk situation.

2 The concept of risk

The following detailed flowchart shows the different parts of the Inondabilité method, through 4 main subsets:

1. the hydrological "box"
2. the hydraulic "box"
3. the land use "box"
4. and the cartographic "box", including the topographic one's.

We can point out that these different sub-models are not sequentially ordered, since they will be put as well into the hazard analysis, as into the vulnerability one.

2.1 Analysis of the Hazard

The hazard represents here a specific natural constraint: the inundations, caused by the river floods. The Inondabilité method is only interested in the river flooding

Detailed chart of the method Inondabilité