Introduction

Geographic Information, Land Use Planning and Risks

Risks, a growing issue

As clearly asserted by the titles of two books written by the German sociologist, Ulrich Beck, we have entered into a *risk society* (1992), and more recently we could even say that we have entered into the *world risk society* (2000). Risk is omnipresent in our daily life. Now, the question is naturally raised whether we are living in a more "risky" society than ever before. This statement can be analyzed in two ways. On the political level, which we will not enter, risk acts as the social cement of a "society without enemies". On a more prosaic level, regarding our daily life, it is now commonly asserted that risk consists of the combination of a hazard (sometimes called danger, threat, etc.) and vulnerability. This analysis needs to be more comprehensive to paint a more accurate picture of reality, but it gives us something to work with.

This definition raises many difficulties, for it seems only to apply satisfactorily to the situations in which a phenomenon, totally independent from human activity, could assault people or damage their goods. In fact, this is true but only in borderline cases, such as, for instance, natural hazards related to crustal motions. Generally, we are both agent and victim, which means that not only do we not protect ourselves sufficiently from phenomena posing risks, but we create them. If this contrast appears artificial, yet we can more satisfactorily attest that risks can often be

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explained, whatever the real cause may be, such as poor use of land planning. This poor planning does not, in this case, stem from ill will, but from a lack of knowledge of spatial phenomena and issues. The territory, and the society that exists within it, is bounded by risk and every risk is written in the land.

As a result, the application of spatial analysis to any type of risk remains limited. The choice to give very concrete examples of spatial analyses led us to consider only certain types of risks with strong spatial logic. Therefore, we have focused on natural hazards, while some other risks, though important on the socio-political agenda, play less of a part. For example, food safety and health risks do not lend themselves to spatial analysis, although we do believe that the relatively small number of such analyses carried out on these phenomena is due to some other reasons.

The contribution of spatial analysis to risk analysis and prevention

According to our previous definition, threatening phenomena and human stakes are both clearly spatialized. For this reason, it is easy to see why spatial analysis is an indispensable tool for those in charge of risk management.

Risk management in large communities makes spatial analysis particularly relevant, since a high level of vulnerability is to be found there, and most large European cities have the necessary geomatic tools. Nevertheless, one of the major problems in large urban concentrations is that, although vulnerable concentrated elements are well known, hazards may originate from outside the urban territory – for example, water-related risks, whether they have to do with the quality (pollution) or the quantity (floods).

The chapters in this book have been chosen to illustrate various situations. Phenomena generating risks are quite diverse. Even though natural hazards make up the largest proportion of such applications, we have tried to compare other factors. This is the reason why some chapters focus on applications and others on theories.

Moreover, the examples given not only refer to prevention, but also to crisis management and feedbacks. Some chapters present urban applications with very highly spatially concentrated vulnerability, while some others present rural applications with more diffuse vulnerability and possibly more diffuse phenomena. It is certainly in the latter kind of case, which involves slow-dynamic phenomena, that spatial applications, which increasingly turn to temporal factors, are hugely beneficial to society, since they can detect both dangerous and irreversible slow changes on large territories. In this case, we can assert that spatial analysis is a tool serving sustainable development.

All the contributions in this book share a common point: they are all presented from a risk representation perspective, and not only from a potentially dangerous phenomena perspective. In all cases, human stakes are weighed against these phenomena and, even if, in most examples, we do not (yet) have an integrated risk management system, we do have an information and decision support tool. There is no doubt that the future, thanks to the expected continuing advances in software and equipment, will see the development of more and more sophisticated spatio-temporal interoperable systems. The field of risk management will probably welcome these systems more than any other field, since it requires the manipulation of numerous spatio-temporal objects, so as to support more and more complex decisions.

Presentation of chapters

In Chapter 1, the author gives a comprehensive summary of GISs used in crisis management. The spectacular evolution of problem management environments over the last 15 years is illustrated with the example of forest fire management performed by civil protection. The example of forest fire is particularly relevant to emphasize the obvious importance of spatial tools supporting risk management. Indeed, this natural hazard is very sensitive both in a temporal (the effect of a bucket of water after a minute of combustion is equivalent to the considerable means deployed an hour later) and spatial sense (not only for the management of preventive measures on vegetation and access, but also for pre-positioning of fire fighting and the conduct of fire-related operations). Two other examples are presented: one deals with the transportation of dangerous substances, while the other is about crisis management. In the first example, we discover a very concrete application, which takes special care to describe the notion of vulnerability. The second example introduces a very generic application that requires efficient telecommunications management. It enables the real-time acquisition of data on incidents and the issuing of the instructions necessary for implementing corrective actions.

Chapter 2 is dedicated to even more anthropogenic hazards, that is to say pollution risks generated by plant protection products. This type of pollution is widespread and related to agricultural practices that the so-called *reasoned* agriculture is willing to minimize. Yet, without further advances to improve water quality, it is necessary to implement and manage health information. To do so, the authors suggest the use of overall quality indexes to identify pollution levels in the logic of spatial representation. This index combines the determinants of pollutants leaching to ground water aquifers and waterways; these factors characterize the contaminants, the types of soil and rain. An original element of this contribution is the use of fuzzy numbers to list the results and reveal the inaccuracies related to spatial representation in general, especially when the purpose of the indicators is

more to reflect the variation of phenomena in a space, rather than to represent them with precise physical parameters at each point. An example is given to illustrate the method and to test management actions aimed at controlling water pollution from atrazine.

In Chapter 3 we remain in the field of risks related to farming practices, for which the implementation of a space observatory is proposed, so as to monitor water pollution, in all its forms (pesticides, fertilizes, solid objects), as well as soil erosion. The authors' approach rests on what they call process mapping, which corresponds to conceptual modeling. Their ambitious project led them to build a very comprehensive spatial database, consisting of elements related to topography, vegetation cover, structures (ditches, hedges, etc.) and to ground conditions. A risk/vulnerability analysis emphasizes the most exposed areas and proposes, as in the previous chapter, complementary management actions to improve the situation.

Chapter 4 was written in Italy, more precisely in the Piedmont region, and we would like to thank the authors who made the effort to write in French, for this book was first published in French. This chapter is an introduction to natural hazards and, in particular, to extremely severe events of nature. North-west Italy was hit very hard in October 2000, to such an extent that it led to the development of a spatial information and representation system. It lists a certain number of natural events characteristic of mountain zones near the Mediterranean Sea, and which are poorly defined by the French classifications. These phenomena correspond to flooding, landslides and torrential runoffs (formation of lavas). They are caused by heavy and long-lasting rain in geologically unstable areas, which generate several runoffs that sometimes stay away from thalwegs and carry huge amounts of solid objects, which can entail deposits exceeding several meters in thickness. Chapter 4 shows how these phenomena are inventoried through a specific survey, and then processed in a GIS, which in turn provides numerous information layers, among which the most prominent is related to the road network, assessing how vulnerable it is to these hydrological and geological phenomena through a list of accounted damage.

Chapter 5 also deals with mountain areas, albeit more peaceful mountain areas, with colder but less excessive climate conditions: the Northern Alps of France. In this area, the forest is a real protection structure that can be considered as ecological, because it is not natural, and results rather from an intensive gardening of the slopes, sometimes very steep, and dating back to very ancient times. The authors describe a very sophisticated multilayer spatial analysis system that makes it possible to emphasize the interactions between the forest and the various events disturbing it, and against which it provides protection: avalanches, rockfalls and landslides. This Geographic Information System highlights the weak areas in the forest ecosystem, where the slightest mistake, the slightest delay in terms of intervention could make whole areas at the foot of slopes unsuitable for building purposes. This type of

concern explains the reason why this chapter was written by a researcher and a practitioner, who developed a method that can be used and is operational to draw up risk prevention plans (plans de prévention des risques, PPR).

As in Chapter 1, Chapter 6 presents an application for forest fire management. It is also similar to Chapter 5, in the sense that it focuses on prevention via natural habitat management. Naturally-caused forest fires are often contested, because the majority of fires are caused by human activities, whether intentional or unintentional. The authors analyze the constraints related to this type of situation in terms of risk definition: the forest, but also humans are both risk creators and victims. Natural habitats are strongly affected by this phenomenon, which is not, ecologically speaking, completely negative. Moreover, forest fire being a physical phenomenon, its propagation suffers from greater uncertainties than rockfalls or avalanches influenced by slope inclination or even rivers running down their beds. All these circumstances make forest fire risk zone mapping very delicate. This explains why there are very few "forest fire" PPR. The authors propose to develop an interesting hazard mapping support system for the *Massif des Maures*, based on physical characteristics such as wind, slope or vegetation, to assess fire risks and fighting conditions. The application is presented in a very educational way, and comments and illustrations are provided for all the development phases of the spatial information system.

Chapter 7 also deals with forest fires and confirms the fact that this phenomenon is particularly relevant, due to its complexity and numerous feedbacks, to test the most sophisticated spatial analysis systems. The author thus proposes a very ambitious and very generic approach to spatial and temporal multi-agent risk management that integrates some decision support aspects in situations of uncertainty. He gives concrete examples of wind intensity changes, and especially of wind direction that can greatly endanger the resources deployed in the field. This type of management, which is highly decentralized in a multi-agent context, gives the author the opportunity to present distinctive theoretical results from a multi agent system. ISA are neither firemen nor a new kind of forest firefighters, but intelligent software agents exchanging information and coordinating their actions. The author gives a concrete example of crisis management to illustrate how such tools could foster theoretical developments that are not discussed in this volume, which is dedicated to the presentation of applications.

Chapters 8 and 9 describe applications used in the case of a specific phenomenon that no region of our country is immune from, even if it takes different forms according to geographic location (climate): floods. Brittany, Aude, Somme, Meuse and Var are among the most recently disaster-struck and/or susceptible regions, which does not mean that the next flood will necessarily occur in one of these specific locations of which, among others, the Loire and the Seine are not included.

As is clearly explained in Chapter 8, flood hazard management, and especially flood hazard warning largely depends on the size and slope of watersheds. Entering the geographic information field with great care, and staying away from debate among hydrologists, and even farther from political considerations regarding land planning, such analyses should enable us to define flood control measures that could be implemented to the entire French territory, and especially, to stay in the realm of GI, lead to the development of spatio-temporal information systems adaptable to local climatic and geomorphic conditions. The system presented by the authors in this chapter is used to manage the watersheds that drain into the Garonne, for though they are large, they are vulnerable to heavy rainfall. The authors also describe the meteo-hydrological forecasting chain, as well as the spatial tools supporting crisis managers. As in the previous chapter, we focus on short-range forecasting (*nowcasting*). Unfortunately, a disciplinary and administrative barrier between hydrologists and meteorologists has limited the advances necessary to reach the level of the application dedicated to forest fires presented in the previous chapter.

Chapter 9 is less ambitious, in the sense that it only targets the representation of historical floods. Yet, this inventory is very topical since we are in a field where spatial analysis uses both proven tools and large surfaces of buildable or already built zones. It concretely illustrates the risk issue, the assessment of which is based on a study of the phenomena that must be extremely accurate due to the economic stakes involved, as well as relevant when delivering results. To illustrate this, the author not only provides an inventory of the questions raised and the methods used in flood mapping, which is very valuable, but also an example relating to the Garonne river.

Chapter 10 is also dedicated to flooding, but its approach is very different from those used in the previous chapters. It describes a comprehensive project with ambitious plans to inventory and diagnose river dikes over the whole national territory. Above all this, this chapter is particularly fundamental in this volume because it provides an example of a major spatial system that integrates all the characteristics of a comprehensive public decision-support system. The average time for such projects is 10 years, and the proportion of resources necessary to carry it out is similar. The genesis of the application (the Camargue flooding and the concerns with the Loire embankments) is interesting, because it is based on the Government's willingness to find a long-term solution to this problem, and because it conducted a thorough analysis to identify the needs of a multi-scale spatial information system in nature, according to the variety of the objects involved. In the end, this system integrates the notions of hazard and vulnerability, from the most concrete and accurate geotechnical aspects related to dikes (e.g. rabbit burrows) to the most realistic scenarios of vulnerability, such as what if (e.g. what would happen if such a dike, which had received a diagnosis of weakness, finally breaks).

Chapter 11 concludes a volume essentially devoted to natural risks, or at least risks related to vast territories of low-density occupation, with an overview of spatial information systems dedicated to urban risks. This chapter is presented in a course format, which completes the volume by addressing spatial risk issues in a conceptually clear manner, by discussing alternatively application questions and examples, which will enable readers to shed new light on some developments already presented in the previous chapters. The author provides many different examples, including space risk management systems developed by the Urban Community of Lyon, which are, with those developed in Marseille, the most ambitious of their kind. He sets all the tools used in a public political context, which concludes the volume with an emphasis on the social and political nature of risk, as expressed at the beginning of our introduction.

Conclusion

Risk analysis involves a fundamental spatial component; there is no need to demonstrate this point again. The chapters of this volume illustrate the possible uses of spatial analysis tools. Without some of these tools, many delicate issues relating to land planning would be impossible to manage at the political level.

Some may be surprised from the above statements that our conclusion is actively pessimistic. Viewed more broadly, spatial risk analysis appears to be poorly developed in France. It is scarce in numerous fields, and a little more developed with respect to country-related risks, due to the agro-rural tradition of our society that some bodies, sometimes academic bodies, have acquired.

Nevertheless, we are still unable, for instance, to overlay natural hazard-related information layers, such as floods, with other information layers illustrating land use in urban and peri-urban environments. Moreover, information on flood damage is managed independently and its spatialization is not on the agenda, at least for now. Therefore, we are still unable to integrate the drainage system to a digital elevation model.

Many examples could be given to demonstrate how important it is for major managers of spatial databases, without whom applications would only remain academic monographs or systems of local interest, to provide quality and economic research products, such as topographic, land use, physical or economic databases. Some areas of study are still wide open, such as the creation of areal postal codes as in the UK, and the georeferencing of vulnerable components.

These issues can only be addressed with political support. They are a fundamental ingredient to the development of interoperated land use management systems, without which no risk integrated management is possible; only partial

management, often implemented in catastrophic events, which can lead to disappointing results, let alone negative results.