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Flood Hazard Assessment and Management: Interface with the Public

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Abstract. The understanding of how people evaluate and respond to natural hazards in an urban area, and how this knowledge can be integrated in the planning and management process, are becoming very important elements of a comprehensive and participatory approach to flood hazard management. Such an approach demands a clear comprehension of the processes of the risks perception, causal attribution, possible solutions for the problem and patterns of behaviour developed during hazard situations. The willingness of the public to participate in flood management, and the attitudes to previous initiatives also need to be addressed. The provision of structural flood defences can have a major impact on the environment and there has been an expression of concern by many members of the public for the degradation of river corridors. In this context, it is becoming a commonly accepted practice by central or local governments to submit flood management plans to public discussion. Appropriate techniques for interfacing with the public are necessary to support this upsurge of public involvement. This paper presents results from research on public perception of floods, flood management and participatory initiatives in Setúbal, Portugal. An extensive interview programme was undertaken with residents and shopkeepers – with and without flood experience, professionals responsible for dealing with flood control problems and local authorities responsible for decision-making on flood management. The paper concludes with a number of recommendations for flood hazard management policy making and processes.

Key words: flood management, flood risk, public involvement, public perception.

1. Introduction

Flood hazard management epitomises the multi-dimensional nature of much environmental management. It is a problem incorporating aspects of the natural sciences (hydrology, ecology, etc.), the social sciences (economics, politics, psychology, culture, etc.) and engineering. It is important for the efficiency and efficacy of the decision-making process to recognise this complexity.

The provision of structural flood defences can have a major impact on the environment and there has been an expression of concern by many members of the public over the degradation of river corridors through river and floodplain

management in recent years. River and flood defence managers can be regarded as developers in the countryside and public reactions to proposed river and floodplain works can be similar to any other development. Flood hazard management is no exception to this even though its primary purpose may appear, to those involved, to be an unequivocal public good (Fordham, 1993).

However, there are now examples of a more proactive approach towards environmentally sensitive river engineering and also towards river rehabilitation and restoration which attempt to manage rivers and floodplains without destroying their ecological and aesthetic qualities (Gardiner, 1988). A key issue of these new initiatives is the inclusion of public consultation and participation.

The research reported in this paper was conducted in the framework of EUROflood 1 and 2, projects partially funded by the EU, under the Climatology and Natural Hazards area of the Environment Research Programme. JNICT, the Portuguese Board for Science and Technology, also supported Portuguese participation in these projects. Other collaborators of EUROflood are referred to in the acknowledgements. A more detailed description of these projects can be found in Penning-Rowsell and Fordham (1994) and Penning-Rowsell (1996).

2. Flood Hazard Perception and Management Options

The flood hazard literature demonstrates the primary importance of experience in the development of flood hazard perception in floodplain occupants (Smith and Tobin, 1979). In communities with a 'flood culture' -essentially those that experience floods relatively frequently -pre-event adaptations and adequate 'in-event' responses can lead to reductions in both tangible and intangible damage. In urban communities in particular, where there is a shifting population, the build-up of flood experience is often lacking. This is further exacerbated in areas subject to only infrequent flooding. Thus the urban floodplain resident must often make decisions in relative ignorance and extreme uncertainty (Fordham, 1992).

The technical expert, often from outside the community, cannot expect an optimum response to his/her hazard management decision from floodplain residents who may have no knowledge and experience of (flood) hazard or, if they do have experience, may have their own, conflicting, preferences for action and management. There can be no single, 'right', technical decision in such a situation. For the decision to be workable it must be often negotiated with a range of individuals and agencies having regard to both technical and socio-political imperatives, and it must be based on adequate information. The theoretical range of options available to manage flood hazards is large. It can include structural (dams, reservoirs, relief channels, embankments) and non-structural (land use planning, flood warning systems, evacuation, insurance) options at the individual, institutional and government level. In reality, however, this range is limited by technical, political, economic, social and environmental constraints.

It is common for a mix of response options – both structural and non-structural – to be appraised. This involves complex institutional and decision-making frameworks to arrive at the compatibility of these options. Public involvement is also more complex, due to the extension of roles, and requires a comprehensive approach, with clear processes of information dissemination. Land use planning in areas prone to flooding involves the establishment of specific regulatory constraints to avoid or limit development, and reduce flood damages. This process can have multiple aims. For example, by the linking of regulatory measures with insurance programmes, as in the United States National Flood Insurance Program; by the promotion of 'hazard-compatible' uses; or by the environmental protection and enhancement of river corridors. In all cases, public involvement and participation is required for effective implementation.

Burby and French (1981) discuss the performance of land use management programmes in the protection of floodplains from urban encroachment and increasing flood damages. They argue for the need to take into account the specific local context in the designing of options. Optimal effectiveness of land use management tools depends upon their implementation before the floodplain is intensively encroached. When major urban development has already occurred, the sole use of these tools is less effective and a mix of structural and non-structural options is usually required.

Wood *et al.* (1985) stress the importance of public consultation and public perception in the selection of options for a flood management plan. Their study involved close interaction with community residents and officials through the use of questionnaires, interviews and contacts with the local community advisory committee.

In the case of structural options, it is insufficient to opt for the most efficient from a technical/engineering standpoint: other factors may intrude into the decision-making process when the technically preferred option is made public. Thus it is important to appraise options within the widest possible disciplinary and professional framework (Fordham *et al.*, 1991).

On an historic continuum, the relationship of humans and nature has been represented by phases such as an early, fearful phase incorporating sacred and magical elements; a controlling phase incorporating the exercise of power over nature; and a phase of harmony in which human beings adapt to and cope with the environment (Correia *et al.*, 1990, Saraiva, 1995). A similar, earlier representation (White, 1973) characterises the same three phases as folk, industrial and post-industrial.

The value of a multi-dimensional approach to flood hazard management (corresponding to a post-industrial, harmonic phase) has been increasingly recognised as the most appropriate. However, these opportunities can be limited in practice because of a range of institutional/agency constraints. This is a problem which can be difficult to solve (even when individual agency personnel are supportive) because of the problems involved in breaking down barriers in budgetary manage-

ment. The will to work together may be there but the flexibility of funding (between departments and institutions) often is not.

This paper addresses possibilities for a post-industrial, harmonic phase of human-environmental interactions which, it is argued, represents the favoured present and future option for sustainable environmental management. This, it is argued, is likely to incorporate a mix of responses – both structural and non-structural – and to attempt to gain general consensus (absolute consensus being unrealistic) through the canvassing of a wide range of opinions and decision-making inputs.

3. Public Participation

Public participation and an understanding of public perception are important components at all stages in the implementation of water resources projects. They have a particularly important and specific role of flood control measures. Appropriate behaviour during the occurrence of flood events (or indeed other natural hazards) is an important element in the minimisation of losses. Arguably, flood hazards tend to be better understood by local populations than other natural hazards: the frequency of the event and the proximity of the river acts as constant reminders of the risks to which they are exposed. Thus, willingness to participate in the process of public involvement is, in principle, more likely to happen (Bernardo *et al.*, 1993).

Whether responses to flood hazard take a structural, non-structural or mixed form, there remains a need for mechanisms for public involvement in decision-making. A structural approach – river channel improvements or the construction of floodwalls and banks, for example – can be effective but can have negative environmental impacts and be difficult, therefore, to obtain public acceptance or a consensus of agreement. If non-structural measures – such as flood warning systems, for example – are adopted, their efficiency is likely to be impaired if the needs and response capabilities of the public have not been incorporated into the system design. Thus, the inclusion of opportunities for public input should lead ultimately to more efficient management of flood hazards.

It is increasingly necessary to involve the public in the decision-making process in order to attempt to achieve consensus on what can be controversial issues. The European Union Directives 85/337/EEC and 97/11/EC make public participation a legal requirement in European Member States. There is, however, some discretion in its interpretation and implementation in most Member States.

In the UK, this directive was implemented in 1988 through Statutory Instrument 1217 (in respect of proposals for land drainage improvement works) which requires an environmental statement to be produced for projects likely to have a significant effect on the environment. However, the public involvement in this process tends to be at the end stage – consultation after production of statement or assessment – and not necessarily in a pro-active way at the early stages of decision-making.

The EU Directive was implemented in Portugal in June 1990 through Decree-Law No. 186/90. Public consultation is required as part of the Environmental

Impact Assessment procedures for all types of projects, public and private. Nevertheless, the public becomes involved only at the end of the process when the EIA is complete. Public involvement and participation in these processes have little background and tradition but an awareness of the need to participate is now beginning to emerge.

There is less of a culture of public participation in Portugal, with few interest/action/community groups compared to the UK, for example. The Setúbal study, discussed in detail below, is an innovative example of what could be achieved with a pro-active response to land use planning incorporating the examination of options for public involvement in flood hazard management decision-making.

4. Methodology

The main objective of the research presented in this paper is to increase understanding of how people evaluate and respond to natural hazards in an urban area and how this knowledge can be integrated in the planning and management process. Such an approach demands a clear comprehension of the processes of the risks perception, causal attribution, possible solutions for the problem and patterns of behaviour developed during hazard situations. The willingness of the public to participate in flood management, and the attitudes towards previous initiatives are also addressed.

The Livramento river catchment and the population of the Portuguese town of Setúbal living in this catchment area were selected as a case study. The research has stressed three main inter-related issues. Firstly, perception of flood risk by different groups, including residents, shopkeepers, professionals and local authorities and decision makers, focusing on flash floods in urban and suburban areas.

Secondly, hydrological and hydraulic modelling of the physical system and the catchment-wide study of biophysical and socio-economic variables that affect the hydrologic cycle and land use decisions.

Thirdly, the use of a Geographic Information System (GIS) as a tool to integrate the information and to simulate and compare scenarios of development and options of flood alleviation. Their potential for data management and display make Geographic Information Systems (and the other computer graphic devices that were used in this study) powerful tools for decision-making support and for communication with the public.

Figure 1 shows the integration of research modules through GIS for the effective assessment of flood management policies. Figure 2 displays the general approach to flood management decision-making. The model that is being developed, based on GIS, will be capable of handling the following four phases of the decision process: data collection, characterisation (analysis and synthesis), formulation of alternatives and decision-making.

In the first phase, a digital data base for the catchment was implemented, storing biophysical, socio-economic and perception data. Then, the river basin and the flood-prone area were characterised. Hydrological and hydraulic models are used

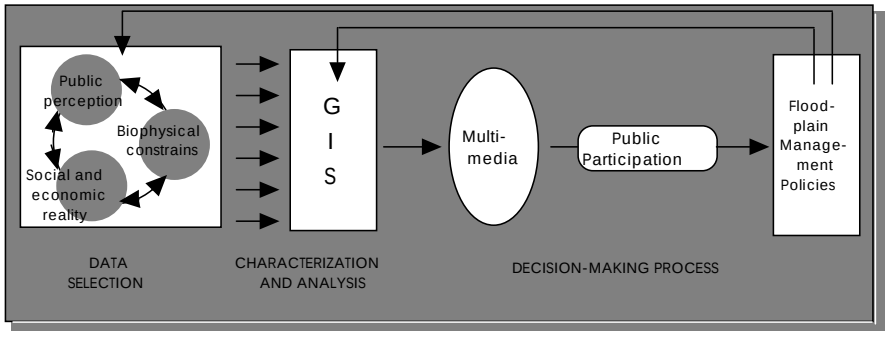

Figure 1. GIS as a tool for an integrated approach.

to evaluate flood risk, socio-economic data is assessed for damage estimation and regulatory constraints on urban development or environmental protection are taken into consideration.

The scenario formulation will be based jointly on urban growth development, and on different options for flood alleviation measures. Four options can be considered in general terms: the 'do-nothing' scenario (which assumes that urban development will grow with few constraints, and no structural or non-structural measures will be implemented); The second option considers structural measures for flood control, (such as building a dam in the headwaters and retention basins in floodplain inside the town); The third choice is the application of non-structural measures, (such as floodplain regulation and zoning and regulatory constraints within the catchment, through the application of environmental protection regulations); A fourth option would be the use of a mix of structural and non-structural measures. For each of these scenarios, an assessment process can be generated using GIS capabilities.

The model can be an useful tool to support decision-making at the local level, and facilitate the assessment and monitoring of the process within its comprehensive context. The graphical display capabilities of the GIS and its interactivity are an important tool for the efficient information and communication with the public, especially because this information is, generally, highly technical.

Arguably, this methodology can contribute to better human-environment relationships in terms of catchment and floodplain management. In this paper, only those aspects relating to the perception of flood hazards will be described: a more complete description of the results can be found in Correia *et al.* (1994) and Correia *et al.* (1995).

5. General Description of the Study Area: Setúbal

In recent years (i.e. 1967 and 1983), very severe flash floods affected the Lisbon area. Widespread and unmanaged urban sprawl was identified as a significant cause of the serious damages. One of the most affected areas during the severe 1967 and

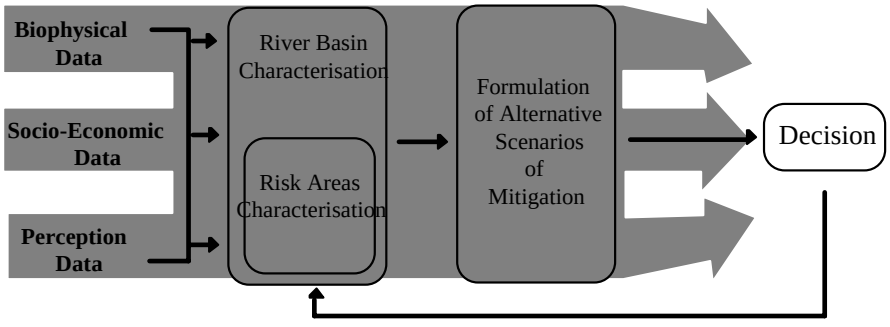

Figure 2. Conceptual model for flood analysis and management.

1983 flood events in the metropolitan area of Lisbon was Setúbal (Figure 3). This is a town with 90,000 inhabitants, located 35 km south of Lisbon, on the estuary of the River Sado. It is a town whose development is based on industry, fishing, its harbour, and also to its proximity of Lisbon.

The most severe floods in Setúbal are mainly due to the overflow of a small creek named Ribeira do Livramento with a catchment area of 24 km^2. This creek may be completely dry during summer and reach a discharge of 123 m^3/sec for a 100 year return period. The final reach has been culverted in the beginning of this century, and runoff conditions can be made more difficult due to tide variations.

After the major flood of 1983, the local authority initiated a series of studies which characterised the flood regime through the estimation of different variables, such as hydrographs corresponding to several return periods and probable maximum flood, hydraulic conditions of the flows, sediment transports, estimation of flood volumes and inundation areas were estimated and mapped.

Several neighbourhoods (both modern and old) are affected by flood events. In the older areas, it is common to see individual floodproofing measures protecting the thresholds of shops and houses. This type of measure has also been incorporated into some new buildings to protect basements and parking spaces.

Apart from the extreme events of 1967 and 1983 when the river came out of bank, some flooding, due to deficiencies in the urban drainage system and affecting areas in the lowest part of the town, occurs almost annually. Some residents and shopkeepers, therefore, are familiar with this type of hazard to some degree.

Setúbal has been growing along a main valley and floodplain: high grade agricultural soils have been built upon which has increased the imperviousness of the catchment and is considered a significant reason for the increased flood risk. Powerful interest groups at the local level often benefit from fast, and largely unplanned, urban growth. However, local environmental groups have promoted campaigns against floodplain development and encroachment and alternative plans have been suggested, incorporating development control and the preservation of the floodplain as a natural park area. This area and the problems it faces are representative of many southern European urban regions, vulnerable to flood hazards. Other

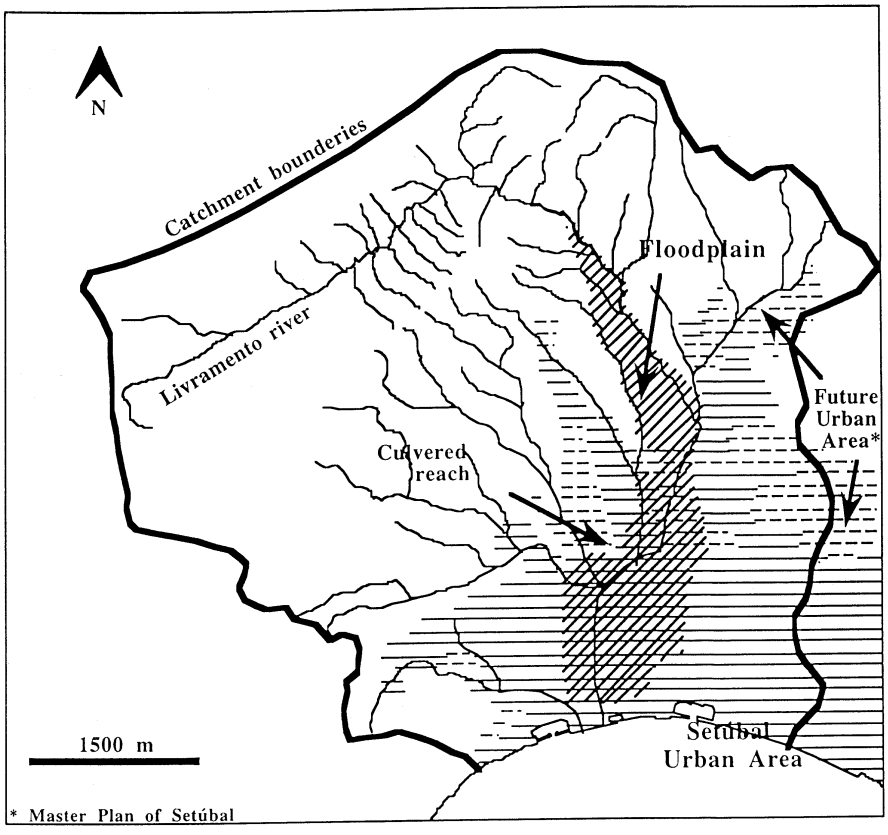

Figure 3. Location of study area.

related studies carried out in the area, based on GIS use for floodplain management are presented elsewhere (Correia *et al*. 1997a, 1997b, 1997c).

6. Survey Methodology and Results

6.1. OBJECTIVES AND FORMAT OF THE SURVEY

The aim of this study is to understand the perception of flood hazard, the action patterns developed in the situation, the causal attribution and the possible public participation in Setúbal urban area. The understanding of the impact of flood hazard in the different groups involved in the problem is crucial so that the most adequate flood control measures can be developed.

The following five factors were hypothesised to contribute to the perception of flood hazards and were examined in the Setúbal study. Firstly, the importance of previous flood experience. In order to examine this, residents and shopkeepers were divided into two groups: one with flood experience and the other without it. Secondly, the influence of the educational level. Two groups of residents were

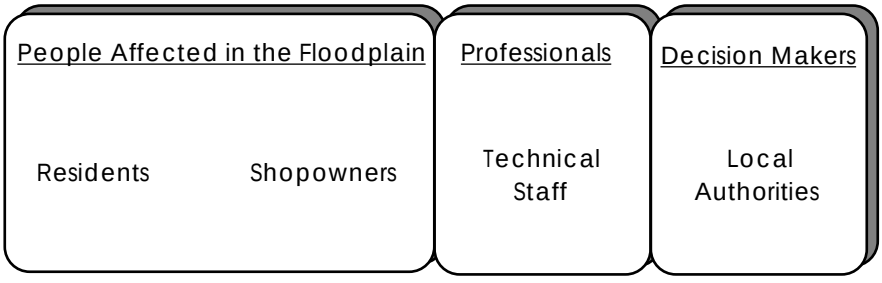

Figure 4. Population under Study.

considered: one with medium/high and the other with low educational levels. However, it proved impossible to select a sample of residents with this medium/high educational level because none lived on the ground floor and thus none had ever been directly affected by floods (as defined in this study).

Thirdly, the difference between the perception of two flood-affected groups was explored: residents and shopkeepers. In addition, the perception of other groups involved in the problem was explored: people directly affected in flood plain, technical staff in the Municipality; and the decision makers (local politicians and local authority members). Finally, the identification of cultural adaptations to the flooding and their importance in the perception of flood hazard were targeted.

These issues were examined in Setúbal using a social survey, incorporating structured interviews. All the additional information that was provided by respondents during the lengthy interviews was tape recorded and transcribed.

6.2. SAMPLE AND QUESTIONNAIRE DESIGN

The sample comprised sixty residents and sixty shopkeepers, sixteen professionals and all seven members of the Executive Board, the local authorities, including the President of the Municipality. The sub-groups examined in the survey are shown in Figure 4.

The interviews were structured according to the following topics. Firstly, socio-demographic data (age, marital status, educational level, occupational status, residential history, residential ownership). Secondly, according to attitudes towards the neighbourhood and perception of the 'local problems' to be solved: respondents were asked to talk about their neighbourhood, their level of attachment to it and the reasons for this attachment. Afterwards, they were asked to identify the major local problems to be solved as well as the obstacles preventing the solution of those problems. In addition, they were asked about their personal involvement in any kind of action for finding or implementing possible solutions to the existing problems.

Thirdly, flood hazard experience was quantified. The residents were asked about: their personal knowledge of flood hazards in the area and if they had any personal

Table I. Sample Distribution

		With Experience	Without Experience	Total
People affected in the Floodplain	Residents	22	17	39
	Shopkeepers	22	20	42
Technical Staff				13
Decision-Makers				7

experience of having their house flooded; the major flood in 1983 and the possibility that such an event could happen again; their perception of the damage caused by floods and their personal behaviour during the floods, including any kind of action undertaken in the building in order to mitigate the effects of the hazards. The respondents were also asked to express what they consider to be an appropriate attitude to floods.

A further category of information sought was on causal attribution and environmental participation. The respondents were asked about the causes of floods in Setúbal; only after being allowed to describe the causes of flood events as they perceived them, the real cause, i.e. the Livramento river, was mentioned and possible solutions to the problem and potential difficulties investigated. They were then asked about their personal participation in previous initiatives aimed at the solution of the flood problems and the reasons for this specific behaviour. Additionally, they were asked as to how the local population might contribute to the solution of flood hazards.

An introductory letter was sent one or two weeks in advance to all the potential respondents asking for collaboration on the project. The interviews were designed to last from 30 to 60 minutes but, since most of the questions were open-ended, no time limit was imposed on the respondents. The interviews were recorded on audio tape, so that a content analysis of the verbal responses could be carried out. While the interview was conducted with this structured questionnaire, it had some 'open' questions that provided opportunities for respondents to comment in their own words. Furthermore, interviewers were encouraged to note down any additional comments that were made during the lengthy interviews.

The response to the survey was good in that most of the respondents became very interested and involved in the issues under discussion. The interviews were carried out during 1991 and early 1993, and the duration was between thirty minutes and two hours. A total of 81 interviews were carried out for the groups of residents and shopkeepers. The distribution among different groups is presented in Table 1.

The data was analysed using the SPSS computer software package and the transcriptions of the verbal responses were content analysed.

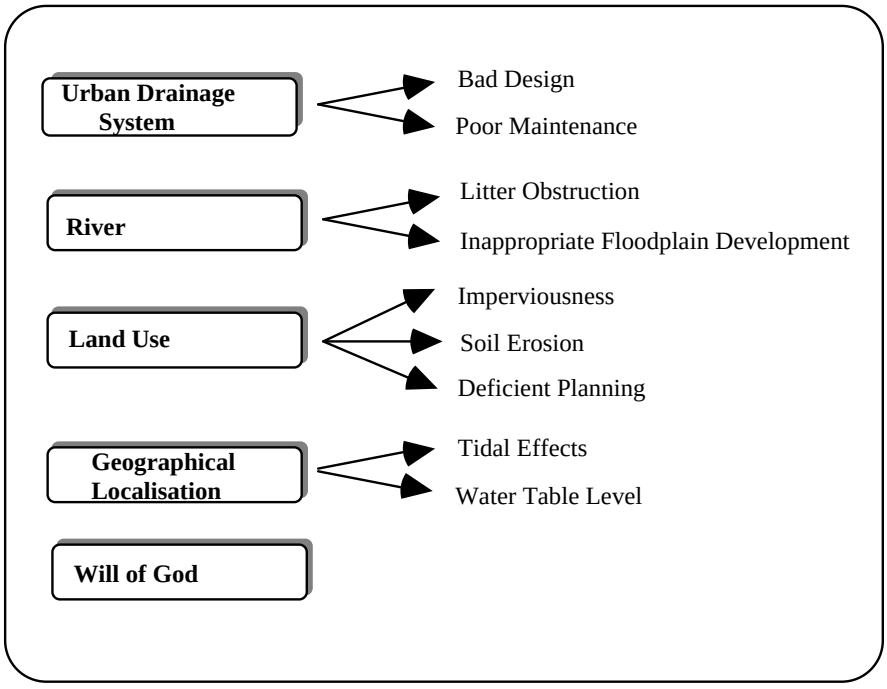

Figure 5. Flood causes identified by respondents.

6.3. SURVEY CONCLUSIONS

6.3.1. *Public Perception of Flood Hazard*

There appears to be a widespread perception of the flood situation in Setúbal. In fact, all the population seems capable of correctly describing, locating and identifying the causes of flood events. The Setúbal flood problem is as old as human settlement in this area. The flooding which occurred during the eighteenth century was of such importance that it was described in local literature (Ramos, 1992). Spontaneously the subjects remember histories related to flood occurrences.

All the respondents made a multicausal attribution for the flood problem in Setúbal. It is the union of different causes which can cause flooding. Content analysis of the answers led to the classification presented in Figure 5.

All groups seem to understand the flood hazard as a problem to some extent natural or uncontrollable and partially 'man-made' or controllable, in other words a 'quasi-natural' hazard (Fordham, 1992). Several solutions that can be implemented in order to minimise the problem were mentioned. But they also realised that even if these solutions were implemented the flood problem would still persist.

Some public statements emphasised the human influence on the flood problem: 'There is a maxim that goes like this: Things are going as straightforward as a creek'. The river is the meeting point of nature. It makes its own way, that may

have a lot of turns, but it is still the straightest' (Shopkeeper with flood experience, a man of 47 years old).

The flood hazard literature reveals the importance of experience in the development of flood hazard perception (Penning-Rowsell, 1976, Lave and Lave, 1991). In this research, the concept of 'flood experience' was defined as having ever had their houses or shops flooded. However, most of the respondents without flood experience have, at least once, been witnesses of a flood situation. Perhaps this fact explains why the group without flood experience recognises, describes and identifies the flood causes approximately in the same way as the respondents with flood experience.

Nevertheless, the respondents without flood experience had some difficulties in answering about flood frequency (35% of the residents without flood experience and 50% of the shopkeepers without flood experience answered 'I don't know') and had a more optimistic opinion about the likelihood of future flooding. In this research, apparently, the experience of floods at home or shops influenced the perception of the risk more than the perception of the causes and damages of the flood occurrence.

River environments are often described in terms of their aesthetic and recreational importance and landscape heritage values (Litton *et al.*, 1974; Fordham, 1992, Saraiva, 1995). This can make it difficult for authorities to implement structural flood protection measures that threaten these values. This is not the case for the Livramento Creek which is a neglected river in an area without access roads. Generally speaking, the inhabitants of Setúbal do not visit the area and associate the river with flooding.

Under these circumstances, structural mitigation measures are not generally seen as causing damage to the landscape. However, environmental groups are leading a movement against the destruction of the floodplain and attempting to protect the river and promote environmental enhancement of the area.

6.3.2. *The Perception of Different Groups*

In the study of natural hazard perception, different segments of the public involved in the process must be considered: namely the general public affected, the professionals involved in the design of flood alleviation schemes and the decision makers (Correia *et al.*, 1990; Green *et al.*, 1991; Fordham, 1992).

However, each group has a different perspective on the problem of appropriate and likely behaviour. These expectations may be not only different but may also result in conflict when considering solutions to flood problems. Therefore, in order to better conceptualise flood defence options, it is useful to understand and take into consideration the specific views and perceptions of those parties involved.

In Setúbal the different groups describe the flood events, damages, responsibilities and actions undertaken during hazard events in the same way. Surprisingly, however, the population is not aware of the civil protection services as an entity with responsibilities to help during hazard situations.

In this research the residents and shopkeepers seem to have a more optimistic opinion about the low likelihood of a future big flood and about the frequency of the flood occurrence than the technicians and local authorities. The people affected in flood plain seems to have a cognitive adjustment in order to reduce the perception of risk (Lima and Faisca, 1992). This kind of strategies have individual advantages since it reduces the cognitive dissonance of living in a risk area. Thus, the environment is perceived as more secure than it in reality is.

In terms of severity, the politicians do not consider floods in Setúbal to be a very serious problem. However, the technicians considered the flood occurrence in Setúbal as an important problem that could cause serious damages. The politicians seem to have a biased perception that reduces the risk and thus reduces the need for a more rapid intervention.

In terms of cause identification, some differences can be observed among the groups. The cumulative effects of an inadequate urban drainage system and tide effects were easily identified by residents and shopkeepers and refered to as the most common cause of floods. In order to explain the situation, one shopkeeper without flood experience, said: 'if you had a tap turned on at your bathroom and the water didn't get drained, you'd get a flood – naturally'. The technicians have a broader flood events view of the situation and mention not only the deficiencies in the urban drainage and the tidal effects, but also the land use problems and the water table levels. This is a more 'scientific' point of view which is more difficult for the population to grasp (Lima, 1993). However, a few residents and shopkeepers also mentioned the land use problem. A shopkeeper with flood experience explained 'before the terrain was open and functioned as a 'blotting paper', an absorption took place. With all this concrete and asphalt the water is not absorbed and there it comes'.

The local authority members present a combination of causes that we can consider as being somewhere between the public's perception and that of the technicians. They mention the joint effect of inappropriate urban drainage, the tidal effects and the imperviousness of some areas of the watershed area.

It is interesting to note that the political preferences may have some influence on the opinions on flood risk among the authorities. The members of the Executive Board belonging to the political party with a majority in local government have a more optimistic view as to the likelihood of a big flood. This group refers to the geographic location as a very important aspect. This is a man-made cause but the origin is very remote and no responsibility can be associated with them. The political opposition emphasises the increasing imperviousness of the watershed. As to the reasons why the problem has not been solved yet, the politicians of the majority party refer to external factors like the lack of funds or to the complexities of the problem. The opposition refers to more local and tangible reasons like lack of political willingness.

With respect to possible solutions of the problem, the most frequent answers refer to the drainage system. However, other solutions are mentioned among the res-

Figure 6. Individual flood protection.

idents and the shopkeepers, like the rehabilitation of the river system, silt dragging the river and correct land use. The technicians and the authorities refer frequently to the correct land use and structural measures like retention basins.

6.3.3. *Cultural Adaptation to Flood Occurrence*

In this study we recognise communities with a traditional flood culture, characterised by adjustments to mitigate flood effects. In this neighbourhood coexist simultaneously other people like new residents lacking flood experience, without protections against the flood effects. This problem was recognised in the inquiries: 'The building around the corner is brand new and yet last year in the underground parking, the cars were dancing and bumping on the ceiling' (Shopkeeper with flood experience, woman, 38 years old). In the new buildings located in flood plain, after a big flood, some adjustments were implemented to protect from a new flood problem. Usually they installed floodboards at the door or at the garage door, or systems to pump water from the basement.

For the group of residents, perhaps because of the frequency and the long history of flooding, it is possible to find collective action patterns and cognitive patterns which have been adjusted to the hazard situation. Many have installed floodboards at the door entrance to protect their homes from the floodwaters, as shown in Figure 6.

Another kind of adjustment is the knowledge of the tidal influence. This is a form of cognitive adjustment through the elimination of doubt, thus making the situation predictable. It is common to refer to 'disaster subcultures' as a cultural

characteristic of communities that are frequently exposed to a given type of threat (Moore 1964; Wenger, 1978, Laska, 1990). This is apparent in populations that have been living for long periods in flood plains. Emergency situations are faced with less panic and many spontaneous measures are adopted in order to mitigate the consequences of flood hazards.

In the group of shopkeepers with flood experience it is possible to identify two different patterns of behaviour: among shopkeepers with frequent flood experience there exists a group that shows the same flood mitigation characteristics as the resident group (i.e. the use of floodboards and checking the tide levels). Those shopkeepers at risk from infrequent floods (such as occurred in 1983) adopt measures – such as insurance – that reduce but do not prevent damage or do not adopt any form of protection; in the case of rare but severe flood events they may experience serious problems.

6.3.4. *Public Participation*

Most respondents had done nothing to help solve the problem. However, it is interesting to note that a significant number of people believe that something or even a lot could be achieved if the population took a more active role. Technicians and politicians give a very important role to the technical solution to the problem. People see flood control as a municipal responsibility. The role of the public is only to put pressure on the municipality through their civic pride. Some research has shown that the controllability of the hazard increases public participation (Rochford and Blocker, 1991), although in this case it is not really evident.

The European Union Directives 85/337/EEC and 97/11/EC make public participation a legal requirement in European Member States for some specific situations. However, in Portugal there is little evidence of a culture of public participation in flood hazard management, except for the response during and immediately after severe flood events. This case study emphasises the need to understand public perception of floods and flood hazard management in order to increase the efficiency of the possible solutions to the flood problem. It will be necessary, however, to raise public awareness through the implementation of a risk communication programme (Slovic, 1986; Keeney and Winterfeldt, 1986). One possible tool in this process is the use of GIS.

7. Concluding Comments

Traditionally, discussions about environmental risks and their assessment have been punctuated by debates between members of various sub-cultures in our society, namely between the sub-culture of science, policy and the public. The use of GIS to model and estimate risks allows the integration of different sub-cultures and the possibility of navigating in and between theses cultures. Rejeski (1993) presents a model to represent this conception (see Figure 7).

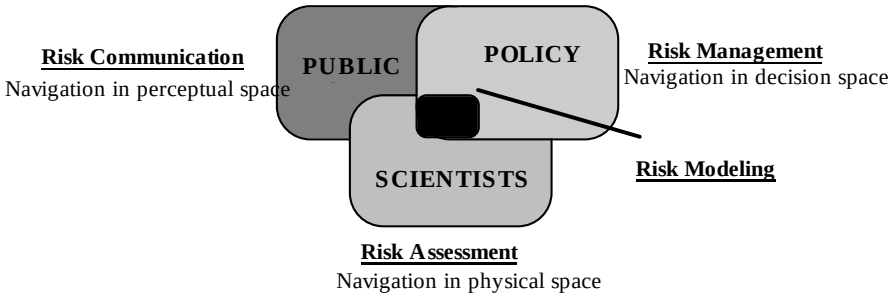

Figure 7. The three sub-cultures of risk.

GIS can be an important tool for involving the public in the different stages of the planning process of risk alleviation. It allows a representation of reality and the simulation of different scenarios such as different flood levels. In this way the public has the opportunity of seeing and understanding some of the technical aspects of the flood problem. In addition, the simulation of different flood management options can create the possibility of active participation in the decision-process which can be carried out in a user-friendly environment, using innovative methods such as multi-media devices.

An extension of the uses discussed above could be the incorporation into a GIS of the oral narratives of flood affected people. According to Kouzmin (1992), oral narratives, while naturally idiosyncratic, can provide a rich data source which can be recorded as both text and graphics in a GIS. Flood locations, house/landmark water heights and other distinguishing characteristics of the days of flood-level build-up can be usefully recorded. Thus, a large database can be constructed incorporating anecdotal, qualitative material, as well as the more usual quantitative 'scientific' data.

If handled properly, public participation in planning, decision-making and environmental management has a critical role to play in helping to integrate economic, social and environmental objectives. It is a mechanism to increase public awareness of the delicate balance between economic and environmental trade-offs, and it can increase public confidence in the decision making-process.

Based on the authors' experience in coping with flood hazard situations and on the detailed analysis of the Setúbal case study, there are several conclusions and policy recommendations that can be presented:

- Floodplain management programmes cannot be dissociated from catchment land use management. An integrated approach should prevail;
- Planning for flood alleviation require a mix of technical, social, economic and environmental concerns and solutions. There is a need to take into account multidimensional problems, multidisciplinary solutions, a wide range of tools and a complex and multi-directional (vertical and horizontal) institutional framework;

- A wise combination of structural and non-structural approaches for floodplain management should be based upon and reflect the local context and its physical and social conditions;
- Interface with the public plays an important role in floodplain management. Search for public perception and attitudes with respect to flood hazard is an essential means to understand how the public copes with those events, and for planning relief, emergency and recovery measures;
- Environmental concerns should be combined with floodplain management at different stages. Comprehensive land use planning and resource management in the catchment area, the protection of natural and cultural values of floodplains and rivers, and consideration of the environmental impact of structural and non-structural measures are important aspects requiring appropriate consideration;
- Flood frequency analysis and hydraulic modelling are essential tools for the definition of areas subject to inundation and for the assessment of flood risk;
- Local level responses and their context are key factors for a proactive management process;
- GIS are useful and powerful tools not only for floodplain management, but also for facilitating the dialogue with decision-makers, interest groups and the public in general.

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