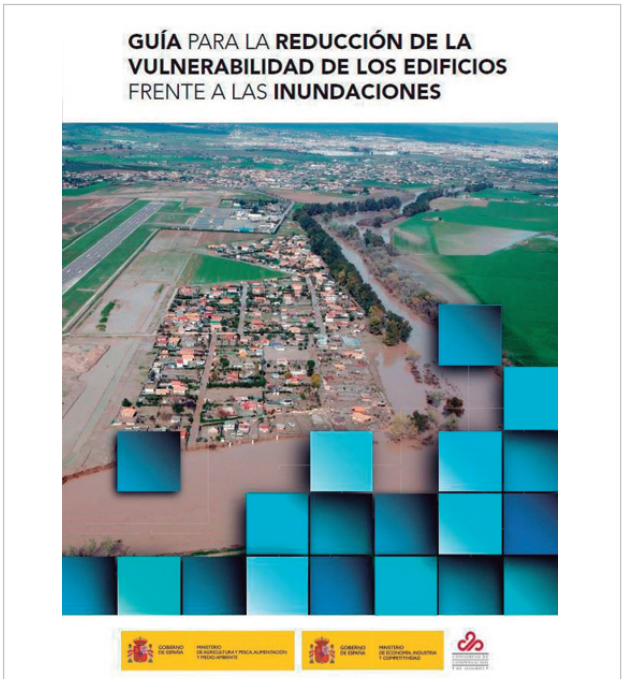
Guide to reducing building vulnerability to flooding

Silvia Cordero, Sonsoles González and Elena Martínez
Department of Hydrology and Hydraulics
INCLAM Group

Floods in Spain represent a natural risk with major consequences. On average, every year some 10 serious flooding events occur. According to the Consorcio de Compensación de Seguros (CCS) and the Directorate General for Civil Protection and Emergencies, floods have caused the death of 312 people in the past 20 years and property damage worth 800 million euros a year. Consistent with maps produced by the Ministry of Agriculture and Fisheries, Food and Environment (MAPAMA), it is estimated that around three million Spaniards live in zones where there is a high risk of flooding that were identified during efforts to implement European Commission Directive 2007/60/EC on the assessment and management of flood risks.



Cover of the Guide to reducing building vulnerability to flooding.

This directive was transposed into Spanish legislation via Royal Decree 903/2010 on the assessment and management of flood risks and obliges Member States to draw up, approve and implement flood risk management plans (FRMPs).

One of the aims of this regulation is to procure coordinated action by all of the arms of government and society to minimise the adverse consequences of flooding on the health and safety of people and property, as well as on the environment, the cultural heritage, economic activity and infrastructure. Coordinated action of this kind is reflected in the Programme of Measures in FRMPs.

Within this setting, on 1 June 2016 the partnership agreement between the CCS and the Directorate General for Water, belonging to the Ministry of Agriculture and Fisheries, Food and Environment was signed with a view to developing the preventive and risk-mitigation measures that were included in the flood risk management plans. One of the activities pursued under this agreement consisted of preparing a guide to reducing building vulnerability to flooding.

The overall aim of this guide is to increase understanding about flood behaviour and their consequences, to foster a commitment to self-protection within society (and therefore to alleviating risk) by reducing the vulnerability of both people and property, as well as enhancing the resilience of buildings in zones at risk from flooding. The guide is a tool for materialising risk reduction by recommending guidelines and solutions that can be deployed to minimise the loss occasioned by flooding. It does not claim to be the answer to the entire range of situations that might arise, although it does offer a catalogue of potential solutions by giving references to other sources of information.

These are stated as partial goals:

- Identifying and reminding about the responsibilities of owners, users and/or property managers of a building, premises, home or facility.

- Raising awareness about the fact that we have to co-exist with floods and about the inevitable challenge that faces all of us to work together to mitigate the effects of flooding.
- Recognising the flood risk faced and diagnosing the present situation.
- Identifying action to protect oneself from flooding and deciding on the most appropriate way to do this.
- Pinpointing possible action to take to recover from a flood and the importance of having an insurance policy.
- Familiarising oneself about compensation systems, financial assistance, subsidies and other means to pull through.

The guide particularly targets owners, users or property managers of buildings (homes, shops, facilities, schools, hospitals, etc.).

In drafting it, other guides of a similar nature have been consulted. Within the European orbit, guides written in France, the UK and the Netherlands have been studied, all of them countries with long experience of producing this kind of written material. Notable among these countries and with respect to the question of flood prevention and management are the efforts by organisations such as the European Centre for Flood Risk Prevention (CEPRI) or the Environment Agency (EA) of the Department for Environment, Food and Rural Affairs (DEFRA) in the UK. Other significant sources of information and on which almost all of the documents reviewed are based are the guides produced by the Federal Emergency Management Agency (FEMA) in the United States, which is a country that has been a pioneer in flood risk mitigation.

The effects of flooding and the quest for solutions have evolved in keeping with the level of development of countries and the value which their citizenry attaches to safety. This gradual change with respect to the level of risk taken on, and managing and mitigating it, is mirrored in legislation, both Europe-wide, and within the state and regional spheres, which is why we have examined the key laws and regulatory texts on waters and coastlines, insurance cover for flood risk, civil protection and land planning and urban development within the confines of the various levels of coverage that apply in Spain.

In the practical vein which ought to characterise any sort of tool, a thorough analysis of the problem at hand is conducted bearing in mind the three aspects of building vulnerability (CEPRI, 2010): the safety of people and their property, including the time taken to get back to normal; the safety of the building, in terms of both its structure (the shell and equipment and services) and its contents, and the knock-on effects which might be brought about for the immediate surroundings. This analysis is rounded off with a both practical and theoretical example which sets out the problems and solutions for four hypothetical homes.

In line with this approach the guide is split into five very distinct thematic sections:

- The FIRST SECTION offers the reader an overview of the guide and key concepts.
- The SECOND SECTION provides tools for finding out if a building can be affected by a flood to promote awareness of the risk involved. Two applied examples for identifying flood risk are included in this section using the viewer from the National Cartographic System for Zones at Risk of Flooding (SNCZI) of the MAPAMA, as well as the viewer from the National Catalogue of Historical Floods (CNIH) of the Directorate General for Civil Protection and Emergencies.
- The THIRD SECTION deals with the diagnosis of the problem. It says how to identify the weak points in a building when it suffers flooding, what the damage might be and how to assess it by evaluating the level of risk according to estimated loss. This section develops part of the practical example applied to a home exposed to four separate situations.

Figure 1. Data on water depths in the area surrounding a typical building.

- The FOURTH SECTION provides possible solutions and measures to mitigate potential damage, looks at what the most appropriate ways are to do this, and finally examines how to plan a strategy to be prepared, adapted, and capable of responding and recovering in the event of an incident. Linked to this section may be found catalogues of measures and construction materials, as well as the exposition and evaluation of alternative solutions, and calculation of the residual risk for the home in the example for the four cases studied.
- Finally, the FIFTH SECTION covers the emergency phase. On the one hand it sets out the basic rules for action over the three emergency phases: before, during and after the flood, and, secondly, users are given orientation as regards the steps to take in recovering from damage suffered, including how to apply for compensation from the CCS. Various examples of what a self-protection plan might contain for either a home or a business are appended to this section.

In summary, the guide goes over all of the concepts required to understand the problem of flooding and advises about (i) all the competencies which the public authorities have and the actions they take with respect to water, civil protection, land planning and insurance, (ii) where to find information on zones at risk from flooding, (iii) how to diagnose the degree to which a building is affected, find out what type of measures and actions can be taken to mitigate risk levels, choose the best solution and draw up a self-protection plan, (iv) what you should do during an emergency and (v) how to get back to normal as swiftly as possible and access indemnities from the CCS or either financial assistance or subsidies from the national government, as well as the terms and conditions under which these might be forthcoming.

The methodology followed to assess the problem and the solution for it as regards a building is the same as that used in any planning exercise. Figure 2 shows this diagrammatically.

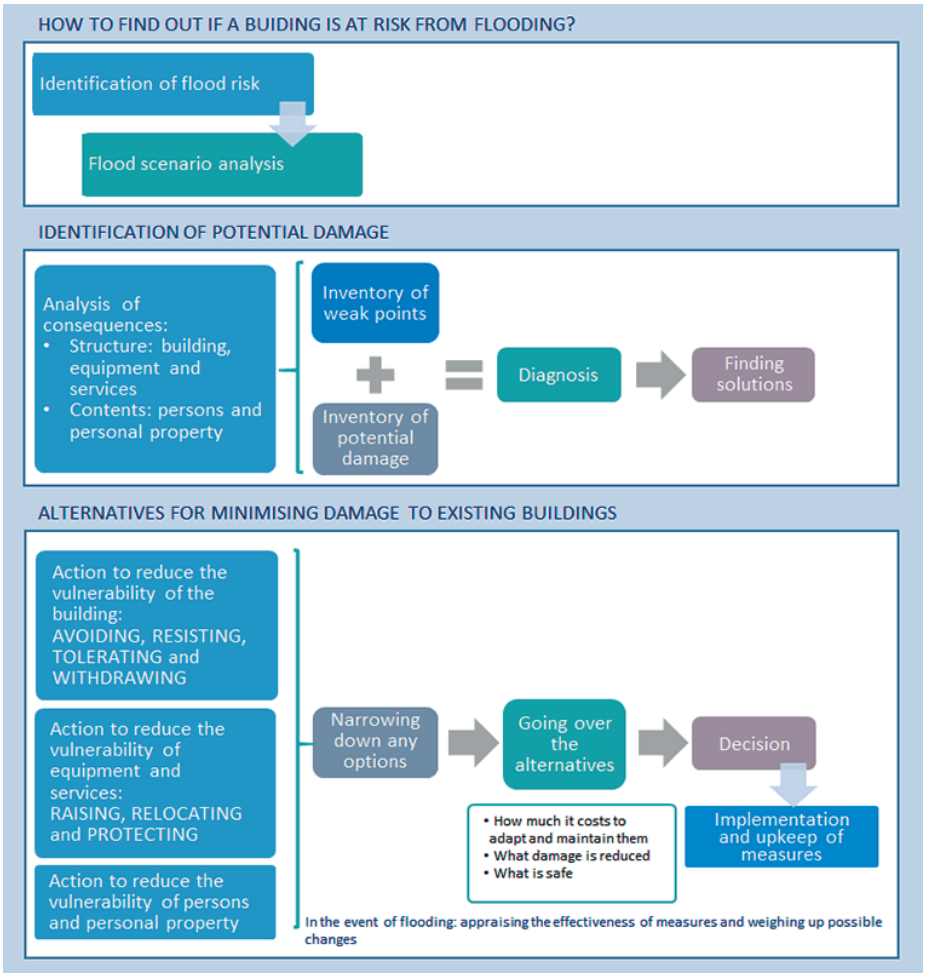


Figure 2. Plan of action flow diagram.

For the theoretical and practical case mentioned four hypotheses for calculation have been considered which combine two types of building with two locations with exposures to different hazard levels:

- Hypothesis 1, featuring a home located on the ground floor of a block of flats with serious flooding.
- Hypothesis 2, featuring the same flat but this time affected by minor flooding.
- Hypothesis 3, featuring a single-family housing unit affected by serious flooding.
- Hypothesis 4, featuring the single family housing unit when located in a zone with minor flooding.

When applying the diagram for the plan of action to the four hypotheses, the following tasks have to be carried out:

- Determining the depth the water can reach in the vicinity of the theoretical home for floods recurring with different frequencies obtained on the basis of the information from the National Cartographic System for Zones at Risk of Flooding.
- Identifying the points of entry of water into the home.
- Writing up a list of all the valuable items in the homes, both with respect to the structure and the contents. This list has been valued in a pecuniary sense.
- Plotting the curves that relate depth to damage.
- Having ascertained the probability level of a hydrological event and the damage that would be caused should such an event take place (Chow et al., 1994), estimating the expected annual cost of flood damage.
- Calculating expected damage over a useful life of 30 years. In simplified terms, the assumption has been to multiply the average annual cost by 30.
- Diagnosing the problem, including the risk level that may feasibly be assumed. In this case the objective is held to be to try to minimise the risk level relative to the cost of the measures to employ.
- Making an exposition and assessment of the alternatives, including structural and non-structural, permanent and temporary measures.
- Analysing residual risk after applying the measures.
- Making a financial cost-benefit analysis.
- Taking other factors into consideration to arrive at a choice via a multi-criteria process.

To start with as regards the theoretical and practical case, a reasoned estimate has been made of a total notional value of the housing unit according to the plan below (structure and contents, without taking into account the land value).

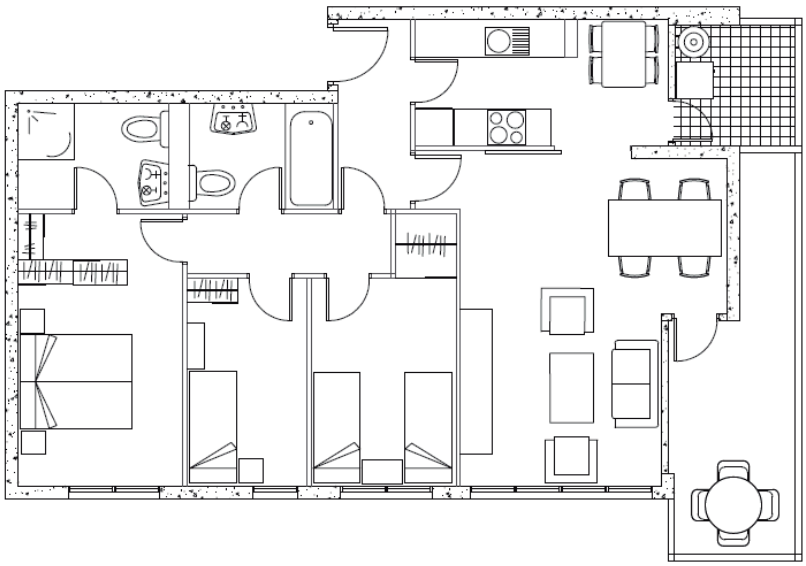


Figure 3. Floor plan of the typical housing unit considered and its contents. Approximate area of 100 m2.

A valuation been made of the worth of each element of the home based on the average market price and the experience from CCS. In this case the housing unit is valued at 150,000 euros.

Using this justified valuation, the notional cost of the water damage has been calculated on the basis of the water reaching different depths. These results are also obtained on the basis of the CCS' claims experience. Figure 4 shows the water-depth/damage curve:

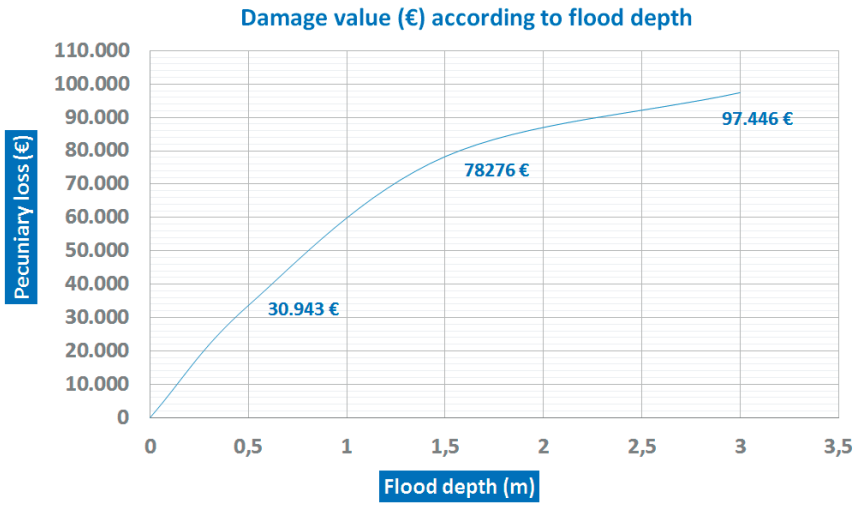


Figure 4. Value of potential damage according to water depth.

Finally the pecuniary value of the losses that flooding would produce over thirty years has been calculated for each analysis. By way of an example Figure 5 shows the results for both serious and minor flooding of a home on the ground floor of a block of flats.

	Serious flooding			Minor flooding		
Housing unit in block of flats	Flooding frequency: T=10 years	Flooding frequency: T= 100 years	Flooding frequency: T=500 years	Flooding frequency: T=10 years	Flooding frequency:T= 100 years	Flooding frequency: T=500 years
Water depth	0.4 m	1.8 m	2.7 m	-	-	0.3 m
Annual probability	0.1	0.01	0.002	0,1	0.01	0.002
Damage	€26,000	€84,000	€94,000	€0	€0	€20,000
Average annual damage	€6,962			€80		
Cumulative damage over 30 years	€208,860			€2,400		

Figure 5. Example of potential damage that a home could suffer.

From the point of view of the dangerousness of the flooding, damage will essentially depend on the level of the water reached during the flood and the frequency of the event. It is important to calculate the losses within a given period of time, such as the years spent living in a home, years in business activity etc., and to consider both frequent damages for the period in question as well as those with a very low probability yet which entails having to face major prejudicial consequences when it arises. Including frequency means adding an important factor to the diagnosis which is the risk level that can be assumed.

Having run a diagnosis of the damage, there are several kinds of structural measures that can be implemented in order to reduce the impact of flooding on a building. The principal ones have been included in a catalogue. These measures may be sorted into two categories: those which keep the water outside the building (often known as insulation measures) and those which enhance the building's ability to withstand the effects of flooding after the water has entered it. Based on these categories four types of actions have been established which diminish an already constructed building's vulnerability (FEMA, 2014).

• AVOIDING flooding by preventing the water from reaching the building.

Figure 6: Example of measures to adapt buildings to combat flooding.
Source: Tandem and Aggéres.

• RESISTING by preventing water from entering the building after it has reached the outside of it.

Figure 7. Building containing housing units that is adapted to flooding, where the doorways and windows through which water can seep in have been raised. Guadalmar (Malaga).
Source: Google Street View.
Temporary flood barrier in doorway of main entrance.
Source: Aggéres.

• TOLERATING by allowing water into the building (as it is impossible not to), though taking the necessary adaptive measures to limit damage and reduce the time taken to get back to normal.
• WITHDRAWING, consisting of leaving and/or demolishing the building in those cases where the risk is too high.

By the same token there are three kinds of actions for adapting the services for the building (electricity, gas, water, air-conditioning, waste, etc.) which must be implemented in a manner consistent with the above structural actions:

- RAISING, by lifting equipment above the protection level.
- RELOCATING, by altering the siting of equipment, normally to a higher floor.
- PROTECTING, by keeping equipment where it is but taking the necessary measures to limit damage and reduce the time taken to get back to normal.

The figure below shows some of the measures which can be implemented to adapt a generic home:

Figure 8. Left: Heat/cooling pump compressor installed on a plinth. Source: Homeowner's Guide to Retrofitting, Six Ways to Protect Your Home From Flooding, FEMA P-312, 3rd Edition / June 2014. Right: Electricity switches raised to 1.7 m, Hungarian household. Source: Manuel Cayuela.

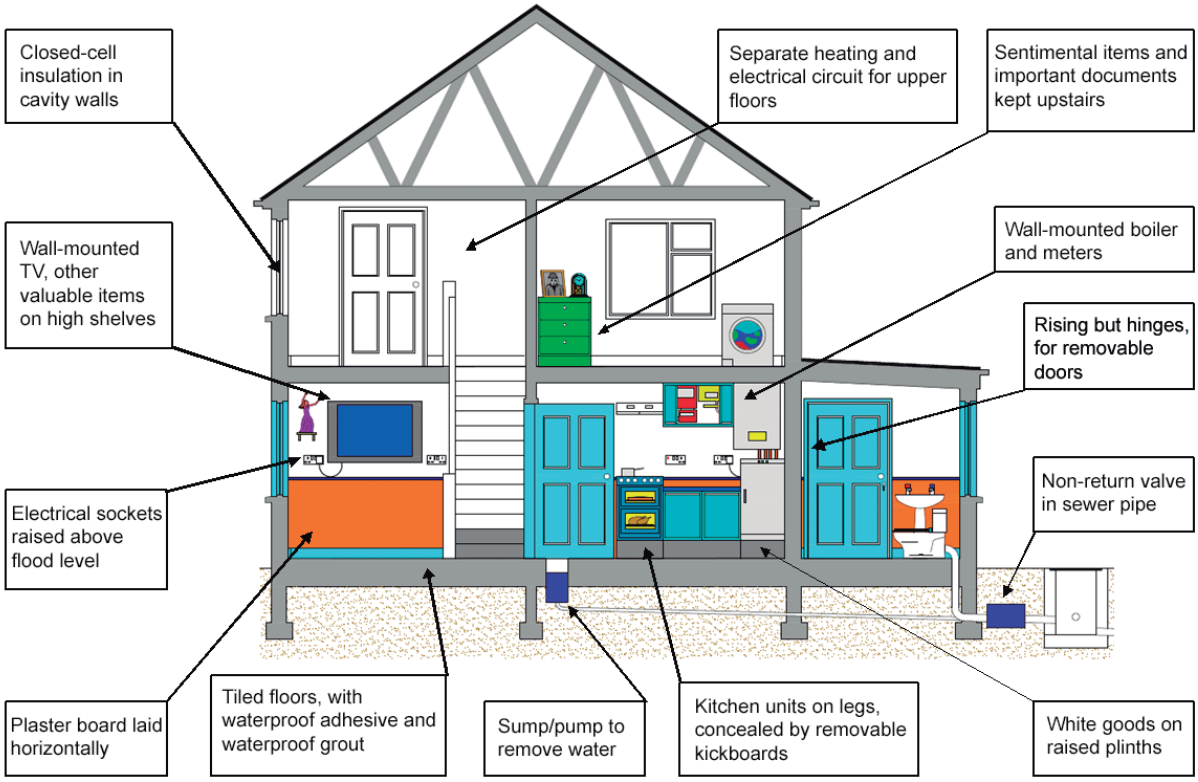


Figure 9. Example of a typical home adapted for flooding.
Source: UK Department for Environment, Food and Rural Affairs (Defra).

To analyse what the feasible actions are to reduce vulnerability and rule out those which are not suitable for any given case, three basic questions are proposed:

- Is the damage acceptable?
- Are potential measures effective for reducing vulnerability?
- Are the potential measures viable from a technical and financial point of view?

The array of different cases that crop up in real life is so wide-ranging that it makes it possible to offer solutions for every situation, although the kinds of actions to take can be sorted into groups because most measures can normally be applied depending on how high the water reaches. These types of actions are given in Figure 10.

Expected depth of floodwater (m)	Approach	Measure
0-0.5	Avoiding	Permanent or temporary protection
	Resisting	Protection: barriers or sandbags
		Raising doorways and window openings
		Waterproof materials outside
	Tolerating	Waterproof materials
		Adapted building
		Adapted services and equipment
		Building drainage
0.5-1	Avoiding	Permanent or temporary protection
	Resisting	Special protective barriers
		Waterproof materials outside
	Tolerating	Waterproof materials
		Adapted services and equipment
		Emergency exit
		Dry accesses
		Building drainage
>1	Avoiding	Permanent or temporary protection. Design up to 1.5 - 2m.
	Resisting	Special protective barriers
		Waterproof materials outside
	Tolerating	Waterproof materials
		Adapted services and equipment
		Emergency exit
		Building drainage

Figure 10. Suggested effective and feasible measures that can be taken depending on the depth of the floodwater.

Having identified the types of measures that can be implemented, weighing up the following factors is established as the criterion for comparing the alternatives and choosing the optimal solution: pecuniary damage, bodily injury, investment in measures, technical factors that have a bearing on measures, social factors that influence measures, reducing vulnerability. In other words, it is necessary to consider a broad range of aspects.

Returning to the theoretical example mentioned above, having made a diagnosis of damage a set of alternative solutions are proposed to reduce risk exposure. In weighing up and assessing alternatives, only those technically viable are considered so as to narrow down the number of different options. By way of example, figure 11 shows the results for hypothesis 2, namely the ground floor flat that suffers minor flooding.

	Period of recurrence		
HYPOTHESIS 2	**T=10 yrs.**	**T=100 yrs.**	**T=500 yrs.**
Water level	-	-	0.3 m
Annual probability	0.1	0.01	0.002
Damage	€0	€0	€20,000
Incremental damage	€0	€0	€80
Average annual damage		€80	
Cumulative damage over 30 years		€2,400	
COST OF MEASURES FOR ALTERNATIVE 1: - Family emergency plan - Ensuring the property - TEMPORARY RESISTING ACTIONS: - Installing barriers for doors or buying containing sandbags: €600 - Temporary waterproofing of the lower air grille: €50 - Installing non-return valves: €500		€1,150	
Residual damage with Alternative 1		€0	
Risk reduction with Alternative 1		100%	
COST OF MEASURES FOR ALTERNATIVE 2: - Family emergency plan - Ensuring the property - TOLERATING ACTIONS: - Replacing floorboards with ceramic paving: €4,000 - Installing non-return valves: €500 - Measures considered to have zero cost: raising carpets, removing curtains, raising furnishings, PCs, TV, microwave, valuable items, etc., standard and table lamps, chairs, etc.		€4,500	
Residual damage with Alternative 2		€0	
Incremental residual damage with Alternative 2	€0	€0	€12,500
Cumulative residual damage over 30 years with Alternative 2	€0	€1,500	€50
Risk reduction with Alternative 2		38%	

Figure 11. Example of damage and costs of measures according to the various different alternatives put forward in hypothesis 1: flat, flooding with mild hazard level.

Besides the kind of flooding and its consequences, the type of building is another major factor to bear in mind when considering one or other kind of measure. For example the measures of the AVOIDING kind are a sound choice when it comes to single-family housing, but they cannot be implemented individually to flats except where they have common zones or associated areas. Another important point is the substantial reduction in expected damage over 30 years that can be achieved just by means of measures to adapt the contents of the home and involving action in the initial pre-emergency phase, even though the latter is very short in cases of flash floods given the small amount of response time available.

Finally the most appropriate alternative would have to be chosen. As mentioned earlier, this decision is based on simplified consideration of a broad range of aspects. In the decision-making process with respect to the best solution as well as the financial side and the level of risk reduction achieved it would remain to factor in the specific aspects which influence each particular case, such as restrictions on using the land, urban by-law specifications, the owner's maximum budget allowance for investing, access restrictions, etc. or the level of security at which people accept to live. This last factor has been implicitly taken into account in the practical case given that the theoretical risk reduction target is 100%.

In none of the four hypotheses has it transpired that the best alternative in terms of the benefit-cost ratio achieves a reduction of less than 100%. When this happens the optimal solution might not be the most cost efficient and it is necessary to act in conjunction with investment capacity as regards the level of risk that the owner or property manager would be able to assume.

All measures directed at reducing vulnerability linked to people's safety and security are also considered to be essential, such as drawing up a family emergency or self-protection plan, protecting the most vulnerable items of property, taking out an insurance policy and stowing away personal and/or legal documents in a safe place. For this reason these are included in all of the alternatives.

With respect to this point, a set of considerations have been included regarding taking out an insurance policy. Obviously insurance is not a tool for avoiding flooding or minimising flood damage, although its effectiveness has been demonstrated when it comes to swiftly recovering from the financial blow that floods cause in relation to homes, offices, industries, infrastructure, motor vehicles as well as life and accidents. It is important to make a proper calculation of the values to be insured and, in the case of buildings housing economic activities, to also insure (either in the same policy or under a separate one) for business interruption, given that in this case compensation will also be paid out for business interruption throughout the time during which these activities in the property insured are affected as a result of the flooding. The policy also covers certain related costs, such as cleaning up or clearing rubble away.

During the process of writing the guide, its aims and content have been presented in a series of workshops organised by CCS, the MAPAMA and several basin authorities (hydrographic confederations of the Guadalquivir, Ebro, Segura and Júcar, and Aguas de Galicia). These workshops were expressly aimed to improving coordination among local economic and social agents and the various different government bodies involved in managing flood risk under the Flood Risk Management Plans approved via Royal Decree 18/2016 of 15 January. At them it was evident that the Guide had been well received. In fact several municipal technical experts offered to apply it within the sphere of their remits on their own initiative.

The objective of proposing an approach that encompasses the problem of flooding in a building and a comprehensive solution to this means that it can be used by municipal town planning and civil protection services, autonomic government bodies, and the owners or property managers of buildings and properties, etc.

While the guide was being written and at the workshops, some confusion became apparent with respect to understanding specific issues, whereupon efforts were made to clarify this both in the document and in presentation rooms. This underlines how important it is to disseminate this information. The areas of confusion were:

- Linkage between pay-outs from CCS, and financial assistance and subsidies from General Government, on the one hand, and a building, vehicle or life insurance policy and the value of the contract premium pursuant to RD 300/2004 of 20 February endorsing the Extraordinary Risk Insurance Regulations, Law 17/2015 of 9 July on the National Civil Protection System and RD 307/2005 of 18 March regulating subsidies that address certain needs that arise from emergency or natural disaster situations and establishing the procedure for granting and modifying these in accordance with RD 477/2007 of 13 April.
- The duty of self-protection which every member of the public has and the obligation to draft Municipal Action and Self-Protection Plans pursuant to RD 407/1992 of 24 April endorsing the Basic Civil Protection Regulation and RD 393/2007 of 23 March endorsing the Basic Self-Protection Regulation for centres, establishments and annexes that are used for activities that may give rise to emergency situations and subsequent amendment thereof (RD 1468/2008 of 5 September).
- A lack of understanding in interpreting the demarcation of zones at risk of flooding and information associated with them, including with respect to the viewer from the National Cartographic System for Zones at Risk of Flooding (SNCZI), as well as where to find other information or how to assess the seriousness of floods when no accurate data is available such as that offered within the National Cartographic System for Zones at Risk of Flooding.
- The need to obtain a comprehensive idea of the solution to the problem from the smallest scale (owner, property manager, building, equipment or service) upward and to be familiar with the competencies of the other bodies involved in managing water (at autonomic and state level) pursuant to the aims of Royal Decree 903/2010 of 9 July and all of the flood risk management plans written by the hydrographic demarcations.

We reiterate that the guide is aimed at adapting existing buildings, although many of the measures are valid for newly built ones. These and, most particularly new urban developments, must comply with the directions given in RD 638/2016 of 9 December amending the Regulations for Water in the Public Domain, as well as the rules and limitations in regional and local legislation on territorial planning, which is essentially the most important measure when it comes to not increasing future risk.

Finally the theoretical and practical exercise comes into its own on account of its relevance to the area of insurance in Europe, given that no similar example has been published in any other guide and also because it utilises CCS' data drawn from real life losses and adjusting work in both assessing damage and using the data to hit upon the right strategies to adopt.

The guide is available at no cost at the following link:
http://www.consorseguros.es/web/documents/10184/48069/guia_inundaciones_completa_22jun.pdf/480edc31-446b-40a5-af5b-2c37daf20a35

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