Policy and Systems of Flood Risk Management:
A Comparative Study between Japan and Spain

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Abstract

This paper shows a comparison from the perspective of flood risk management, between two regions of different countries; Tokyo Metropolis (Japan) and Catalonia (Spain).The comparison is based on flood damage data for a thirty year period (1981-2010), legislation, disaster management plans, recovering measures and communication strategies. A total of 219 flood events and 110 deaths were recorded in Catalonia during 1981–2010, while there were 191 floods in Tokyo, during the same period, giving place to 27 deaths and missing people. In both countries, most of deaths occurred outdoors and the majority as a consequence of imprudent behavior. Nearly 10% of flood victims in Catalonia were foreign citizens. Regarding the institutions from the State and the communities involved in flood risk management, we have found a similar structure between the two countries In accordance with the European Floods Directive, all the Spanish regions susceptible of having floods have flood hazard maps for different return periods, including 500 years while in the case of Japan the return periods are usually shorter. Recently, flood risk maps have been built for Catalonia, but none is available in a foreign language. Although all the maps are available in internet, in Spain it is not mandatory to distribute maps to the public neither evacuation maps in flood prone areas. On the contrary, evacuation and hazard maps in Japan have some parts written in different languages. In both countries, flood hazard maps are not compulsorily linked to other countermeasures such as land-use regulation (the municipality has the last decision) or flood insurance. Thresholds of heavy rain warnings are similar in both countries, using rain amounts over both short and long periods. Although the Japanese method appears more sophisticated using humidity and runoff indexes, it is too complicated for people to understand it. In contrast, only Catalonia has forecast thresholds considering probability levels. On flood insurance, only Spain has governmental aid to the flood insurance system. The level of flood risk perception is low among the population in both countries, and social communication for flood risk is insufficient, mainly in Catalonia. Thus, it is very important that individuals recognize the flood risk in the area to reduce the number of victims.

Keywords:

Flood Risk Management; Flood warning; Japan; Spain; Catalonia; Tokyo; Barcelona

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1. Introduction

Floods and earthquakes are the most hazardous types of disaster worldwide (Llasat et al. 2009; Lara et al. 2010; Tapsell 2011). The United Nations Office for Disaster Risk Reduction (UNISDR) estimated that 2.437 billion people were affected by floods worldwide over two recent decades (Table 1), being the number affected greater for floods than for any other type of disaster (UNISDR 2012a).

In Western countries, approaches to flood management have recently changed. In the 1990s and 2000s, governments of the Netherlands, the United Kingdom and France adopted new flood policies that emphasize risk management (Pottier 2005; Hall and Penning-Rowsell 2011). In the case of flood risk management, future damage and its potential are estimated, and effective measures to mitigate it are proposed. Such management recognizes nowadays the importance of non-structural measures like land-use control or population evacuation, and the integration of different kind of measurements from an holistic approach (Hall 2003; Hall and Penning-Rowsell 2011; Faulkner et al. 2011). This is also called a "making space for water" policy (Defra 2005). The European Directive on Floods (Directive 2007/60/CE) is a symbol of change in flood risk management of European Union (EU) countries. The directive contains five consecutive phases: 1) preliminary evaluation of flood risk; 2) maps of flood hazard level and of flood risk; 3) flood risk management plans; 4) coordination with the Framework Directive on Water (Directive 2000/60/CE, European Parliament 2000), public information and consultation; and 5) execution measures and amendments. The directive obliged all member countries to have preliminary flood risk assessments for all river basins by late 2011, and to produce risk maps by late 2013. Flood risk management plans were to be in place by late 2015. The directive was created after severe floods and flash floods in central and southern Europe during summer and early autumn 2002 (Kundzewicz et al. 2005; Braud et al. 2010). Since then, there have been other catastrophic flood events in Europe (autumn 2011 and 2014, spring 2013, and winter 2015) (Grams et al. 2014; Hally et al. 2015-

Given this situation, studies of the social and human aspects of flood management are increasingly required. There are many studies in this field, especially on the sociology of disaster in the United States. These began in the 1950s (Drabek 2006; Lindel 2011) and included surveys of human behavior and administrative agencies in cases of natural disaster. Flood risk perception is essential to mitigate the flood risk. the United States (Kates 1962; Burton et al. 1993).In Europe, Steinfuhrer et al. (2007) reviewed surveys in Germany, Italy and the UK and stated that risk perception is high in areas prone to inundation by rivers, but low in areas prone to inundation by submersion. For the same countries, Kuhlicke et al. (2011) analysed the relationship between flood vulnerability (including risk perception) and social parameters and concluded that risk perception in Italy before flooding correlated with the past experience of floods, the risk to their residential area and trust in the authorities. In Spain there are studies of flood perception based on survey research (Lara et al. 2010; Olcina Cantos et al. 2010) that typically point to a low level of this perception, despite people living in flood prone areas. Further, generally few people see flood hazard maps and few understand the floodplain regulations (Faulkner 2011). In this sense, Luther et al. (2013) analysed flood maps and proposed some criteria to facilitate their comprehension. However, perception is not only related with risk or evacuation maps (that are more used for urban planning and emergency management). Usually, the media reflects dominant patterns and beliefs in a society and therefore has a strong influence on the collective risk perception (Delitala 2005; Fischer 1998). Given that the media focuses more on risk vulnerability and less on actual danger, it is necessary to assess all situational factors involved in the news item and any change in the socio-cultural paradigm (Llasat-Botija et al. 2007).

There have been many empirical studies of flood events in Europe and other countries, including Japan (Okabe et al. 1983; Hiroi et al. 2001, 2003, 2005).There have also been studies comparing the United States and Europe (Marincioni 2001) and various EU countries (Kuhlicke et al. 2011; Parker et al. 2009). However, there have been few studies comparing EU countries and Japan, except some internal reports made by the Japanese government (Yoshida et al. 2008; Policy Research Institute 2011). In this framework, the purpose of the present study is to explore differences and similarities of flood risk management (including prevention and warning systems) and flood risk perception between Spain and Japan, focusing on Catalonia (NE Spain) and Tokyo (E Japan), respectively. After constructing a conceptual approach in the first section, data and methodology area addressed in the second one. The following sections are devoted to the comparison between flood damage, flood management organization, flood maps, warning and flood risk perception and insurance systems in the two countries. Through this comparison, we address ideas to improve flood management in both countries.

2. Philosophy of risk-based flood management

Although the concept of risk differs among disciplines (Renn 2008), here it can be defined as "the combination of the probability of an event and its negative consequences" (UNISDR 2009). This definition is the same as in the social psychology of risk communication (National Research Council of USA 1989; Slovic 1987; ISO 2002). In natural science, it is common to define risk as functions of hazard and vulnerability (e.g. Tilling 1989) where hazard may include probability, and vulnerability refers to potential negative consequences and usually includes exposure and risk management (Llasat et al. 2009).

Generally, disaster management includes four functions according to disaster stage, which are mitigation, preparedness, response, and recovery (Drabek 2004). According to the terminology of UNISDR (2009), mitigation measures include engineering techniques, hazard-resistant construction, improved environmental policies, and public awareness (including risk perception). Preparedness consists of warning systems, contingency planning, equipment stockpiling, evacuation arrangements, associated training, and others (UNISDR 2009). Response and recovery functions follow mitigation and preparedness. Vulnerability, a characteristic of a community that increases hazard damage, is affected by mitigation, preparedness and response. Resilience, which is the ability of a community to resist and recover from hazard effects, is affected by the same three factors (Figure 1).

There are three dimensions of disaster management, philosophy, strategy, and tactics (Figure 2). The 2007 EU Floods Directive offers a philosophy of flood risk management. Strategy indicates objects or themes to complete each function, and tactics are concrete methods to execute each strategy. For example, enhancement of individual perceptions of risk is a mitigation strategy, which includes various tactics such as distributing flood risk maps, media campaigns, signboards, exhibitions, and school education.

According to Hall et al. (2011) and Faulkner et al. (2011), the philosophy of risk-based flood management has the following features: 1) Accepting the premise disasters are inevitable; 2) risk-based policy, including the concept of frequency and cost-benefit; 3) recognition of the importance of non-construction measures; 4) integrated portfolio-based policy; 5) sustainability in a society; 6) democratic policy in which many stakeholders can participate; and 7) consideration of uncertainty in risk analysis, risk management and evacuation of people. The 2007 EU Directive on Floods that provides flood maps from different return periods represents the acceptance of disaster and a risk-based policy including the concept of frequency.

In the United States, where flood insurance programs have been in effect since 1968, there is a philosophy similar to the above. In such programs, through insurance charges determined by flood risk, the use of floodplains is controlled by the government. An administrative report published after the Midwest flood of 1993 emphasizes the importance of integrated floodplain management and cooperation of stakeholders (Interagency Floodplain Management Review Committee 1994). There are similar concepts in Japan (Nakamura, 2016). Beginning in 1977, “comprehensive flood control measures” were introduced within Japanese flood control policy (Maki 2010). This stresses the importance of retaining rainwater in basin areas (by regulating bodies such as ponds and basin rainwater), control of floodplain use, and flood information to facilitate evacuation. Beginning in the mid-2000s, the word *Gensai* (disaster reduction), which focuses on non-construction measures, has been generally used (Kawada, 2012). Under the *Gensai* concept, numerical damage simulation and soft measures like evacuation and reconstruction following disaster became increasingly important.

We basically concur with the philosophy of risk-based flood management. Therefore, from the perspective of this philosophy, we compared strategy and tactics in Spain and Japan. We mostly compared at the country level but, for more precise comparison, we focused on the regions of Catalonia (Fig. 3) and the Tokyo Metropolis (Fig. 4) as a case study (Table 2). In some occasions we also referred to the Barcelona Metropolitan Area (AMB) (Catalonia).

3. Regions of study and data sources

Table 3 shows some comparative features of the selected regions. The interest of this comparison lays in the difference and similitudes between both countries and regions: a densely populated Asiatic region (near 6100 habitants /km^2 in Tokyo Metropolitan Area) that can be affected by major disasters, like tsunamis, typhoons or great storms, and a densely populated European region (near 5500 habitants /km^2 in Barcelona Metropolitan Area, but more than 15000 habitants /km^2 in Barcelona city) that is frequently affected by flash floods and severe weather.

. First, we investigate statistical data of floods and descriptions of victim situations in Japan, using data of *Statistics on Floods* (published by the Ministry of Land, Infrastructure, Transport and Tourism of Japan, MLIT), *Information on Disaster* (website data of the Fire and Disaster Management Agency of Japan, FDMA). In the case of Tokyo, the causes of death were also identified by searching a newspaper database “Yomidasu” of “Yomiuri Shinbun”. Information about floods and damages in Catalonia has been provided by the *INUNGAMA* database which contains information regarding all of the flood events that affected this region in the 1901–2010 period (Llasat et al. 2014), and the *PRESSGAMA* database containing all news items published in the daily newspaper *La Vanguardia* related to natural risks, climate change, and sustainable development, exceeding 15,000 news articles from 1981 to 2010 (Llasat et al. 2009).

Among many measures of risk-based flood management, we focus on the organization of flood management, hazard mapping, warnings and perception, and flood insurance system. Table 4 shows the main questions of study in this work and the kind of sources that could provide this information. We have analyzed the flood risk chain, from the national and regional legislation on civil protection and land uses to the organization of the flood risk management and emergency. The basic tool of risk-based flood management is the flood map. We investigate such maps (cartography, hazard or evacuation maps), which we found in disaster management plans or government websites. For effective evacuation, understandability and warning effectiveness are critical. We have compared criteria of flood warnings using documents of meteorological agencies: the Japan Meteorological Agency (JMA), The State Meteorological Agency of Spain (AEMET) and the Meteorological Service of Catalonia (SMC). Regarding resilience, we have explored the flood insurance system using laws and published documents.

4. Flood damage

Data on flood casualties are important basic data for risk-based flood management. According to the 2007 Floods Directive, “flooding” is defined as temporary submersion of land not normally covered by water. This includes floods caused by rivers, swollen mountain streams, intermittent water courses, and coastal floods caused by sea storms or high sea levels. This definition is also the same in Japan. In some occasions floods and flash floods are accompanied by other hazards like landslides, mudflows, tidal waves or wind storms and the available information does not allow distinguishing between the damages produced by each one of these hydrometeorological hazards. This is the case of the data of *Statistics on Floods* for Japan that includes not only flood victims but also those of landslides, mudflows and strong wind produced in the same event. Then, although data on casualties (dead and missing people) recorded between 1981 and 2010 in the two regions of study are shown in Table 5, precise comparison is possible only after 1999. Since this year we have estimated the number of drowning victims by flooding (including those who slipped into swollen rivers or streams) in basis to data from FDMA’s *Information of Disaster* reports (started in 1999), in which the number of casualties and the circumstances of the death are described.

4.1 Flood damage in Japan

Following Table 5 the number of fatalities as a consequence of flood events varied from 2 to 503 in Japan during the period 1981-2010.The most severe disaster during the period was the Nagasaki flood of 1982, in which heavy rain from a seasonal rain front affected all Japan, especially Nagasaki Prefecture, where a record of 187 mm/h and 366 mm/3h was observed. In Nagasaki City alone, 299 people died, 262 from landslide and mudflow and 37 from inundation (Cabinet Office, Government of Japan, 2005). In Tokyo, there were 191 flood events and 24 casualties during the above period. The cause of death in 13 cases was identified by searching the newspaper database “Yomidasu” of “Yomiuri Shinbun” newspaper; six were victims of landslide, one was carried away by a river during bird-watching and six drowned underground (in the basement of a house or in an underground sewerage system).

Considering only the period 1999-2010, there were 237 flood casualties over 12 years in Japan, an annual average of 19.8. In the 1999 flood event, 13 people drown in a riverside campsite, 12 drown in a tidal wave, and five died while driving cars or motorcycles.. In 2004 there was the Niigata-Fukushima flood, with 20 fatalities. Nineteen of these were identified by cause, three by landslide and 16 by inundation. Of those 16, five died in their homes and 11 outdoors (some trying to evacuate, some patrolling rice fields, and others fell into waterways) (Tanaka et al. 2005). In 2009 there were 20 flood casualties in Sayo Town of Hyogo prefecture. All casualties except one were on foot or in cars; nine of were trying to evacuate. In Tokyo, there were seven casualties during the above period Although in 1999, a man drowned in the basement of his house, in the other events victims were outdoors: in 2008, five workers drown in an underground sewerage system; in 2010, a man who was fishing drowned in the Tama River.

During 1999–2010, flood casualties in Japan did not concentrate in heavily populated zones. Large rivers near major cities like Tokyo or Osaka did not flooded, and no foreign victims were recorded. The typical case was slipping into rivers, which occurred often when people were monitoring agriculture, patrolling riverbanks, fishing or camping. According to Ushiyama (2015), who analyzed causes of casualties of heavy rainfall and typhoons in Japan during 2004–2014, a 18.4% of them were produced by inundations, 19.1% slipping into rivers, 48.9% by landslides, 2.7% by strong wind, and 1.9% by large waves. Following this author 67.2% of the casualties produced by floods occurred outdoors.

4.2 Flood damage in Catalonia

A total of 219 flood events were recorded in Catalonia during 1981–2010 (Table 5). Their geographic distribution reveals a concentration along the coast (71% of events), owing to torrential streams, higher frequency of intense and local convection , and greater vulnerability and exposure. The last characteristic is attributable to this area having the greatest concentration of population, industry, and services (Llasat et al. 2014). Forty-nine percent of municipalities in Catalonia have been affected by flooding, and there have been more than 10 events in all municipalities along the coast of population above 20,000 inhabitants. Barcelona is the most affected municipality, with 64 events in 10 years. However, damages in the city were generally not catastrophic, owing to its network of pluvial deposits and drainage (Barrera et al. 2006). It is important to note that Barcelona is the third most densely populated municipality in Catalonia, with 15.977 inhabitants/km^2 (IDESCAT 2010). Of the 219 flood events, 42 caused 110 fatalities; of these, 69% were from catastrophic floods (with three victims per event in average). The Metropolitan Area of Barcelona (AMB) recorded 13 victims. The event with the most victims on this period was 6–8 November 1982, which mainly affected the northern, mountainous part of Catalonia (14 deaths) and neighboring parts of Andorra and southern France. More than 600 mm of rainfall was recorded in 3 days, with a daily maximum of 408 mm. Other important events were 2–5 October 1987 (10 deaths), 11–13 November 1988 (9 deaths), and 9–10 October 1994 (10 deaths) that caused the greatest economic damage, because it affected the Port of Tarragona (south of Barcelona) and adjacent industrial areas. These three events mainly affected the coast and had precipitation amounts > 200 mm. The four events, including this one of November 1982 constituted 39% of total victims.

Causes of death in Catalonia are known for 80% of fatalities and the results are similar to those for Japan for the period 1999-2010, i.e., 70% died outdoors (89% for the period 1999-2010) some crossing a flooded street or stream on foot or in a vehicle). Of the 45% of cases in which a victim’s sex is known, 73% were male (80% for the period 1999-2010). Nearly 10% of flood victims were foreign citizens who were likely unaware of the violent nature of flash floods that tend to occur in Catalonia.

By comparing flood victims between the two countries, we have found the following. 1) From the data, flash flood risk is greater in Catalonia than in the Tokyo Metropolis. As stated above, a total of 219 flood events were recorded in Catalonia during 1981–2010. In Tokyo, there were 191 floods during the same period. There were 29 flood casualties in Catalonia and six in Tokyo over 1999–2010. 2) Most flood deaths occurred outdoors, the majority of which were a consequence of imprudent behavior. Of flooding casualties in Japan, 67.2% occurred outdoors, while more than 70% perished outdoors in Catalonia (some crossing a flooded street or stream on foot or in a vehicle). 3) Although nearly 10% of flood victims in Catalonia were foreign citizens who were likely unaware of the violent nature of flash floods that tend to occur there, there were no foreign victims recorded in Japan. 4) In both cases underground spaces in urbanized areas are dangerous during inundation.

5. Flood management organization

To determine which part of the governments were most responsible for risk-based flood management, we have compared flood management organizations and laws. Table 6 shows the comparison between the different levels of governments, administrative units and organizations related with flood management for Japan and Spain, and Tokyo and Catalonia, respectively.

5.1 Flood management in Japan

Japan has three levels of government: 1) national; 2) prefectures and the government of Tokyo); and 3) municipalities (city, town and village) (Table 3). The Tokyo Metropolitan Government is a type of prefectural government, encompassing 62 municipalities .Although each level of government has a responsibility for disaster management, municipalities have the primary responsibility because mayors have the authority to declare evacuation orders, establish restricted areas, and designate the use of land and facilities of the private sector for emergencies. These are provided for by the *Basic Act on Disaster Control Measures* (Act No. 223 of 1961) articles 5, 60, 62, 63 and 64. This is a basic law that describes the responsibility of governmental organizations, disaster-related non-governmental organizations, citizens, and basic strategy of disaster management.

National and prefectural governments assist municipalities by making laws, providing technical and financial help, and coordination between organizations. Within the national government, there are divisions concerned with disaster management (Table 6). The Cabinet Office, where the governmental headquarters for disaster control is established, has the role of coordination among all governmental organizations and of planning disaster policy. The Fire and Disaster Management Agency (FDMA) within the Ministry of Internal Affairs and Communications is another center of government disaster management that controls disaster prevention agencies and fire departments of both prefectures and municipalities.

In flood control, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has an important role. It directs river management and issues flood forecasts. The MLIT executes this function for major rivers and guides public works sections of prefectures, who control minor rivers. The flood prevention law that deals with hazard maps or flood warnings is the basic law for flood control. The Japan Meteorological Agency (JMA) issues forecasts and warnings of heavy rain and flooding. The JMA issues flood forecasts in cooperation with the MLIT and prefectural public works sections.

In land use regulation, the Building Standard Act (Act No. 201 of 1950, Article 39) and Urban Planning Act (Act No. 100 of 1968) restrict construction in areas at risk of flood. However, municipalities do not easily issue ordinances that strictly define such areas, because local interests often contradict them. Usually, area designations are not associated with the hazard map. As evident from the above, municipalities have a decisive role in flood management in Japan. Although this is useful for emergent measures, sufficient technical and political assistance from prefectures and government is needed for integrated risk-based flood management.

5.2 Flood management in Catalonia

Since 1978, Spain has had a system of territorial division and government, in which the most salient feature is recognition of the ability for self-government of regions grouped into so-called "autonomous communities," in which common laws and procedures coexist with those enacted by the community (Table 3). This fact drives to have, besides the National legislation and consequent structures and procedures, specific legislation in each one of the 19 autonomies (Table 3).

The Water Law (29/1985 of 2 August 1985) and Rules of the Hydraulic Public Domain (Royal Decree 849/1986 of 11 April 1986) set limits on land use in areas considered to belong to water, minor beds, area law enforcement, and floodplains. The Spanish government administration is responsible for delimitation of hydraulic public domain zones, and management must be done by basin agencies. In Catalonia, the internal basins (the river is within this autonomy) are the responsibility of the Catalan Water Agency but the inter community catchments (rivers traverse different autonomous communities) are managed by the inter community Hydrographic Confederations which depends on the administration of the State.

The Law of Civil Protection (2/1985 of 21 January 1985) and Royal Decree (407/1992 of24

April 1992) established the basic normative of Civil Protection and core competencies in risk management of the state and autonomous communities, as well as territorial and specific plans. The Directorate General of Civil Protection of the state is responsible for approval of flood plans elaborated by the autonomous communities, which for Catalonia is the INUNCAT (DGPC 2012). Under these laws, the Civil Protection of Catalonia is responsible of flood risk management (Table 6). Like in the case of Japan, local management is very important. At municipal level, the general framework is determined by the territorial plan of the autonomous community. Where there are municipal plans, the highest authority is the mayor. Plans must be approved first by city council plenary meetings, and then by the Regional Civil Protection Commission.

In Spain, there is no operational system of flood forecasting for all communities; this is usually substituted by heavy rainfall forecasts. The state meteorological agency of Spain (AEMET) is under the Ministry of Agriculture, Food and Environment of the Spanish government, and is responsible for forecasting and monitoring weather conditions in the country. It is responsible for heavy rainfall warnings to Spanish Civil Protection and communicates them at the regional (autonomous) level. In Catalonia, AEMET has coexisted since 2001 with the autonomous meteorological service (Meteorological Service of Catalonia SMC; Table 6), which operates an extensive meteorological network including four meteorological radars. SMC also warns of the meteorological risk situation , in our case heavy rainfall, and is responsible for alerting the Civil Protection of Catalonia and the Catalan Water Agency and monitoring the event.

From the comparison of organizations in the two countries, we have found the following. 1) For flood management, the level of local government is important in both countries. 2) Along major rivers, state administration is responsible in both countries. 3) The warning system for heavy rainfall is concentrated in a governmental meteorological agency in Japan, but two agencies coexist in Catalonia, one of the State (AEMET) the other of the autonomous community (SMC). 4) The meteorological agencies cooperate with the river management agencies in issuing flood forecasts in both countries, although in in Spain there are only heavy rainfall warnings rather than flood forecasts. 5) The state agency FDMA is responsible of the flood emergency in Japan, while in Catalonia the responsibility is from the autonomous civil protection and the civil protection from the State is only responsible for approval flood plans and can act in specific situations (i.e. floods affecting nuclear power plants).

6. Flood maps and flood risk perception

Flood mapping is essential to risk-based flood management. Knowledge of flooding in residential areas is very important for evacuation and other measures such as flood prevention for homes and insurance. If people perceive a flood risk in their residential area and know what to do in case of flood, damage will be reduced. To communicate flood risk and its countermeasures is one of the strategies of mitigation, for which there are many tactics. The EU Floods Directive expresses the need for hazard maps containing information on extent, water depth, velocity and probability of flood. Also stated is the need of risk maps with information on damages such as those of residents and the economy, as well as data on installations with the potential to cause accidental pollution (Directive 2007/60/EC, Article 6).

6.1 Flood maps in Japan

In Japan, flood hazard maps are constructed for the entire country. Article 14 of the Flood Control Act (Act No. 192 of 1949) states that the MLIT of the Central Government or prefectural governors should provide estimated inundation areas and depths in hazard maps of major rivers. There are 1,870 rivers and tributaries (among more than 30,000) designated as major, for which information of river level or flood forecasts must be issued. River management agencies (MLIT for major rivers, prefectures for small ones) simulate possible floods and produce basic cartography for municipalities. Usually the longest return periods of heavy rainfall for simulation are from 50 to 200 years. However, in remarkable cases like the Tone and Arakawa rivers, the longest return period assumed is 1000 years.

According to the Flood Control Act (Article 15), mayors with major rivers in their municipalities should distribute the maps in printed or other form to residents. Under this provision, 94% (1,265 of 1,342) of municipalities with major rivers have made public evacuation maps (in 2013), and 1,109 municipalities make them public via the Internet (MLIT 2013a; MLIT 2013b).

Based on the return periods, municipalities construct evacuation maps. Much information for residents is on the maps, such as evacuation shelters, knowledge of flood warnings, or tips in case of flood. In addition, some municipalities provided maps or instructions in foreign languages. Thus, all maps constructed by municipalities have the character of evacuation maps. The Tokyo Metropolis is one example, in the original language. Figures 5–8 show hazard map components for Hino City in Tokyo, which is traversed by a large river controlled by the MLIT. This map shows the flood-prone area for an estimated flood return period of 200 years (Fig. 5). Based on the data, Hino City made its evacuation map by adding required information (Fig. 6) and a legend, with an instruction leaflet for the map in foreign languages (Figs. 7 and 8).

In spite of these maps, much survey research on risk perception in Japan shows that perceptions of people are low everywhere, especially prior to a flood. For example, in Edogawa Ward of Tokyo where almost all areas have the potential for serious flood damage, only 27.8% of people believed there was a flood risk to their house. The elderly had less feeling of risk than younger people. In the Kanda River floodplain of Tokyo, where floods occurred in 1993 and 2005, a survey after the flood in 2005 showed only 31.0% of people believed there was a flood risk to their house before that flood (Hiroi et al. 2014).

6.2 Flood maps in Catalonia

The INUNCAT plan provides risk cartography at municipal scale (15-m spatial resolution) based on geomorphological and hydraulic calculations, and estimates river flood return periods of 50, 100, and 500 years. According to INUNCAT, more than 40% of municipalities in Catalonia have a high or very high flood risk (Fig. 9), with the majority along the coastal fringe, where most of the population is found (Llasat et al. 2014). The ACA has prepared its “River Area Planning” for the Internal Basins of Catalonia (e.g., Fig. 10), with more detailed material and environmental information for certain rivers (5-m resolution). All the cartography is available for the population trough internet. As a consequence of the European Floods Directive, the ACA, in collaboration with Civil Protection, executes flood risk management plans that have three phases. These are Preliminary Flood Risk Evaluation, Flood Risk Danger Maps and Flood Risk Management Plans. The same structure is followed by the other Spanish hydrological basins that can be affected by floods. However, these projects are more focused on modeling than on evacuation, recovery and analysis of historical information. Although there are not evacuation maps, Civil Protection does some seasonal campaigns and distribute some leaflets explaining what to do in case of heavy rainfalls or floods.

Between 2008 and 2010, the Civil Protection of Catalonia conducted surveys to ascertain the level of awareness of natural risk and of civil protection plans (Llasat et al., 2011). According to these surveys, only 15% of people thought that their region could have risks associated with natural phenomena such as floods, windstorms, snowfall or forest fires (in that order), although the majority of the population in Catalonia lives in areas frequently affected by heavy rains, floods or other hydrometeorological phenomena

(Llasat et al. 2014). The study showed that people living in small towns had a higher risk perception level, and that there are sectors of the population with low risk awareness, particularly the young, people with low education level, and immigrants. This result corroborates the finding that risks are constructed socially and experienced differently by different individuals or groups within a particular society. This leads to multiple individual perceptions of the same event (White 1986).

Comparing flood maps and flood risk perception between the two countries showed the following. 1) Both countries have flood maps. 2) The main purpose of flood maps in every Japanese municipality is evacuation, and they are obligated to be distributed to the public. In Spain, and particularly in Catalonia, flood maps are public in internet; they can be used for flood prevention but any evacuation map is provided. 3) In spite of flood risk awareness is major in Japan, flood risk perception is very low in the two analyzed regions. 4) In some Japanese municipalities, the flood maps are also in foreign languages; in Catalonia they are only in Catalan language. 5) The return period for simulation in Japan is shorter than in Spain, where all the maps are showed for different return periods until 500 years. On the contrary, there is no reference to probability of flood magnitude on Japanese flood maps.

7. Flood warnings

The warning contains information that forecasts and warns of severe damage from a disaster to encourage preventive measures such as evacuation. The warning consists of evacuation calls issued by local governments, formal warnings issued by meteorological agencies or hydrological services, and other critical weather information.

7.1 Flood warnings in Japan

Formal flood warnings consist of meteorological warnings issued by the JMA and hydrologic flood forecasts issued by river management agencies cooperating with the JMA. The meteorological warnings are 1) heavy rain warnings of sediment disaster and submersion flooding, and 2) warnings of riverine flooding. Heavy rain warnings have three grades, advisories, warnings and special warnings (Table 7). An advisory is issued when weather conditions are expected to produce damage, and a warning is for severe damage. The special warning is disseminated when serious damage from heavy rain of 50-year return period is expected.

Thresholds of heavy rain warnings are derived from estimated rain (within 1 or 3 hours) and the estimated soil water index (SWI)). The threshold of the heavy rain special warning is built from estimated rain (within 3 or 48 hours), the SWI, and expected extent of the heavy rain area. The threshold of flood warning is derived from estimated rain (within 1 or 3 hours) and estimated runoff index (RI, calculated based on runoff and flow processes and considering both antecedent rain and that expected in the next few hours). These thresholds are set in each municipal area. Tokyo is divided into 62 municipalities and each one has different criteria (Table 8 shows an example of three municipalities). For each municipality, the annual issuance frequency of heavy rain warnings may be between 1 and 10 (Nakamura 2011). Hydrologic flood forecasts are issued for major rivers. The threshold is determined by the river water level and expectation of water rise. These warning systems and thresholds are so complicated that they are difficult for the public to understand.

Short-range weather forecasts disseminated by JMA are for 1 and 6 hours. The TOMACS (Tokyo Metropolitan Area Convection Study for Extreme Weather Resilient Cities) project uses detailed (250-m grid) and rapid (1–5 minute interval) forecasts to prevent damages from short-duration extreme weather (NNIED 2012). It integrates data from radars concentrated in the Tokyo Metropolitan Area (seven X-band polarimetric radars, three X-band Doppler radars, one C-band polarimetric radar, and three C-band operational Doppler radars). The X-band polarimetric radar by which one can analyze raindrop shape is especially useful (MLIT had 35 such radars in operation all over Japan in 2013). These data permit estimates of precipitation in real time and the nowcasting of locally heavy rainfall for the next hour. Users of the data include fire departments that are involved in flood prevention and rescue, municipalities, management offices of riverside parks, railway companies that manage train service according to the rain, construction companies that schedule outdoor work, schools, and the public. For example, for the public, information on heavy rain at a given point is sent via mobile phone, and people can view current and detailed rain information.

7.2 Flood warnings in Catalonia

In Spain, thresholds used in weather warnings can change regionally and by meteorological service (Table 7). When a threshold is exceeded or anticipated to be exceeded, information is sent to Civil Protection and inserted in weather reports. Following European criteria for colors representing warning level (red–orange–

yellow–green), this information is also included on web pages of various meteorological services and mobile phone applications.

AEMET uses two thresholds, precipitation over 1 hour and cumulative rainfall over 12 hours. The first threshold deals with heavy rainfall and the second is related to persistent and generally extensive rainfall. SMC gives warnings of meteorological risk situation for rain, and distinguishes two severity levels and cumulative precipitation over 30 minutes and 24 hours, respectively, using probability levels. In Catalonia, rainfall data (1-h resolution) from SMC meteorological stations are used to characterize the precipitation field and its evolution, complemented by radar data (resolutions 10 min and 1 km × 1 km, C-band Doppler radars). This network is composed of 165 automatic weather stations. Radar data are obtained from composite images built from the four meteorological radars covering the region. This information can be complemented by SMC lightning data). River flow data are obtained from a network managed by the ACA, with 5-min resolution.

We have found similarities and differences in warning systems between Japan and Spain. Thresholds of heavy rain warnings are basically similar, using rain amounts over short and long periods. However, the calculations are more complicated in Japan, including the soil water index and the runoff index. However, because of this sophistication, it is too complicated for public understanding. The European warning criteria represented by four colors is easier to understand. Further, only Catalonia has forecast thresholds with probability levels.

8. Insurance systems

8.1 Flood insurance in Japan

Flood insurance is one of the non-structural measures that assume disaster is inevitable. There are two insurance systems in Japan, private accident and collective (e.g., JA or Japan Agricultural cooperatives). In both systems, flood insurance is included in home fire insurance. About half of householders buy fire insurance from companies, and about 80% of that insurance includes flood insurance. About 10% of homeowners buy insurance from JA, in which all fire insurance contains flood insurance (Policy Research Institute 2011). In both systems, the price of insurance does not vary with flood risk area indicated by hazard maps.

Underwriters of flood insurance and reinsurance are both private enterprises. For the moment, the balance of payment is profitable for these companies (by contrast, for earthquake insurance, the government gives financial aid to the reinsurance company). However, the price of home fire insurance is rising because floods are on the increase.

8.2 Flood insurance in Catalonia

In Spain the organization responsible for victim compensation and damage repair in case of flooding is a state agency, the Insurance Compensation Consortium (Consorcio de Compensación de Seguros or CCS), created in 1941. Royal Legislative Decree 7/2004 of 29 October 2004 approved the revised legal status of the Insurance Compensation Consortium text. All insurance must be provided with a supplement for the CCS, which covers damage classified by the government as "national disaster or calamity". For flooding, there is no specific threshold to declare that a region has been affected by natural disaster or should be reimbursed for flood damage by the CCS.

Among the two countries, only Spain has governmental aid to the flood insurance system. Because of the aforementioned flood increase and the potential for a major flood in Japan, a system of public underwriting is also necessary in that country.

9. Conclusions and discussion

We basically have used the method of comparative policy study between Tokyo and Japan, and Catalonia and Spain.. From the perspective of risk-based flood management, we have compared them for organization of flood management and flood damage, mapping, warning and insurance. We found many similarities and differences between the two countries, from which we gleaned some suggestions.

First we have explored flood damage. From the data, flood risk is major in Catalonia than in Tokyo Metropolitan Area. During 1981–2010, there was a total of 219 flood events recorded in Catalonia, and 191 in Tokyo. Over 1999–2010, we counted 29 flood casualties in Catalonia and seven in Tokyo. Given such serious flood damage in both countries, flood management plans should be based not only on flood modeling but on analysis on historical flood data.

In both countries, most flood deaths occurred outdoors, the majority of which were a consequence of imprudent behavior. Of total flood casualties, near the 70% occurred outdoors (some crossing a flooded street or stream on foot or in a vehicle). Although in Catalonia nearly 10% of flood victims were foreign citizens who were likely unaware of the violent nature of flash floods that tend to occur in this region, no foreign victims were recorded in Japan. On the other hand, underground spaces in urbanized areas are dangerous during inundation (as example, four old women died in their bedroom, placed in the basement of a residence in the last flood event that affected Catalonia on November 2014). To reduce flood damage, we should pay more attention to outdoor activities (including automobile operation), foreigners, and risk in underground spaces. Self-protection is a key factor to mitigate the flood impacts in human life.

We found similar structures of organization between the two countries. Although national administrations are responsible for laws and management along major rivers, local government have an important role in disaster management and prevention, Although it is necessary to study how these organizations function in a flood, we highlight the importance of cooperation between municipalities and state organizations. For example, for land use regulation on floodplains, municipalities require technical and political assistance from the government. Cooperation between river control organizations and meteorological agencies seems stronger in Tokyo than in Catalonia, although in both cases it could be still improved.

For flood mapping, we would suggest making maps for longer return periods in Japan. In Spain, we would recommend to municipalities or autonomous communities to distribute more information on flood risk and easy to understand maps to the public. Taking into account the importance of tourism in Spain, flood maps and recommendations should be in different languages in order to be understood by foreigners. In both countries, flood hazard maps are not compulsorily linked to other countermeasures, such as land-use regulation (the municipality can decide how to proceed in a flood-prone area) or flood insurance. Considering the philosophy of risk-based flood management, it is necessary to create such linkage.

For flood warnings, thresholds of heavy rain warnings are similar in the two countries, using rain amounts over short and long periods. However, calculations are more complicated in Japan, using the SWI or RI and it is too complicated for public understanding. The European warning criteria represented by four colors appears easier to understand. Although Catalonia has precipitation forecast thresholds considering probability levels, flood warnings mainly refer to precipitation. River data provided are complementary, but there is not any hydrological model that runs operatively.

Comparing flood insurance in the two countries, only Spain had governmental aid to the system of flood insurance. Because floods are currently increasing and major flooding is possible in Japan, a system of public underwriting appears necessary in that country.

There are some limitations of the present study to overcome. First, for flood damage, we could only analyze post-1999 data. It may be possible to add older data by referring to newspaper databases, for example. If we could analyze longer period, greater floods would be included and different tendencies could be also observed. Second, among measures of risk-based flood management, we did not address risk perception or risk communication enough. To address these with precise criteria, we could perform survey research using the same questionnaire in both countries.

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List of tables

Table 1. Impacts of disasters worldwide, 1992–2012 (UNISDR 2012)

	Flood	Drought	Storm	Earthquake	Extreme Temperature	Mass Movement	Wild Fire	Volcano
People Affected (millions)	2437	1141	627	112	96	5.6	5.6	2.5
People Killed	155799	2472	237268	759708	156770	17688	1549	821
Damage (USD billions)	480	71	720	636	49	5.5	42	0.3

Table 2. Regional targets of present research

Community of countries (EU)	Country (Spain, Japan)	State-Autonomous community (Catalonia, Tokyo Metropolis)	City (Barcelona, each wards or cities in Tokyo)

Table 3. Main features of the regions of study. Tokyo Met.: Tokyo Metropolitan Ara; Barcelona Met.: Barcelona Metropolitan Area

	Japan	Tokyo Met.	Spain	Catalonia	Barcelona Met.
Area (km^2)	377.944	2.188	504.645	32.114	636
Population (millions 2010)	127,5	13,2	47,0	7,5	3,2
Number prefectures/autonomies	47		19		
Municipalities	1.742	62	8.125	947	36

Table 4. Study objects and data sources. FDMA: Fire and Disaster Management Agency of Japan

Type of Data Source	**Data Extracted**	**Information Gathered**
Statistics on Floods, Information on Disaster of FDMA Database on Flood of Catalonia, INUNGAMA	Statistical data on flood and description on the situation of victims	Number and situation of victims of floods (Chap. 4)
Laws, Disaster management plans of governments, EU flood directives	Organization of flood management	Main authority of flood management, , Power to limit land use (Chap.5)
Disaster management plans	Flood cartography, Hazard map	Hazard assessed, Purpose of map (Chap.6)
Documents of Meteorological Agency	Criteria of Warning	Understandability and Effect of Warning (Chap. 7)
Laws and Published Documents	System of Insurance	System of Flood Insurance (Chap.8)

Table 5. Casualties and flood frequency in Japan and Catalonia (1981–2010)

	Japan		**Tokyo**		**Catalonia**		**AMB**	
Year	deaths & missing (1)	flooded river (2)	deaths & missing (1)	flooded river (3)	N of deaths	N of events	N of deaths (4)	N of events
1981	- (90)	5097		4		4		1
1982	- (503)	7819	- (3)	7	18	11	1	5
1983	- (270)	4827		5	3	5	3	2
1984	- (24)	1406		2	2	5		3
1985	- (103)	3959	- (1)	6	1	3	1	3
1986	- (47)	1259		7	1	5		2
1987	- (23)	1283		7	20	6	1	2
1988	- (58)	1215		5	10	7	3	3
1989	- (85)	1353	- (1)	6	2	6		2
1990	- (88)	2445		7	3	6		3
1991	- (114)	1806	- (6)	10	2	6		5
1992	- (5)	635		4		6		0
1993	- (185)	2134		6	1	9		8
1994	- (2)	958		7	12	8	1	4
1995	- (18)	1579	- (1)	4	1	5		4
1996	- (19)	730		2	3	9	1	4
1997	- (47)	1549	- (4)	9	1	12		4
1998	- (77)	2770		6	1	7		4
1999	49(107)	2237	1(1)	9	3	10		4
2000	7(14)	1005		9	11	6		3
2001	4(21)	925		7		7		2
2002	7(19)	911		9		9		5
2003	15(52)	681		8	1	11		5
2004	73(240)	2396	0(1)	5	3	7		1
2005	10(44)	913		8	8	13		6
2006	12(82)	785	0(1)	5	1	8	1	1
2007	10(20)	693		6	1	7		4
2008	11(23)	496	5(5)	7		8		3
2009	33(71)	554		5		5		2
2010	6(27)	813	1(3)	9	1	8	1	1
TOTAL	**237(2478)**	**55233**	**7(27)**	**191**	**110**	**219**	**13**	**96**

Source for Japan: *Information of Disasters*, on website of FDMA (Fire and Disaster Management Agency of Japan) (http://www.fdma.go.jp/bn/2015/)

Source for Tokyo: *Record of Floods*, Tokyo Metropolitan Government, (http://www.kensetsu.metro.tokyo.jp/suigai_kiroku/kako.htm)

Source for Catalonia: INUNGAMA (database of all floods in Catalonia since 1900), Llasat et al. (2014)

(1) Number of dead and missing were counted using data of the sources. From descriptions of the situation in each case, the authors determined the persons who were believed to be drown by inundating or non-inundating water (including those who fell into streams but excluding those drowned in sea disasters). Numbers in brackets indicated number of dead and missing people during heavy rain and typhoons, including floods, landslides, and strong wind.

(2) Number of floods is total number of rivers, tributaries and bays where houses, businesses and farm products suffered damage

(3) Number of cases of rain causing economic loss in the private sector, i.e., houses and stoppage of businesses or agricultural production; Tokyo Metropolitan Government, *Record of Flood* (each year)

(4) Number of flood events (including flash floods) affecting Catalonia and, specifically, metropolitan area of Barcelona, during 1981–2010. Number of deaths associated with the events is also shown.

Table 6. Organizations for flood management. FDMA: Fire and Disaster Management Agency; MLIT: Ministry of Land, Infrastructure, Transport and Tourism; JMA: Japan Meteorological Agency; AEMET: State Agency on Meteorology; SMC: Meteorological Service of Catalonia. Laws are written in cursive

Function	**Level of Region**	**Japan**	**Spain**
Disaster Management in General	State	Cabinet Office FDMA *Basic Act on Disaster Control Measures*	General Directorate of Civil Protection and Emergencies *Law of Civil Protection*
	Prefecture/ Autonomy	Disaster Prevention Division	General Directorate of Civil Protection of Catalonia
	Municipality	Disaster Prevention Division	City Council
Management of River	Major River	Ministry of Land, Infrastructure, Transport and Tourism (MLIT)	General Directorate of Hydrologic Works
	Minor River	Public Works Section of Prefecture	Catalan Water Agency
Land use legislation	State	*Building Standard Act* *Urban Planning Act*	*Water Law* *Rules of the Hydraulic Public Domain*
Warning of Flood	State	JMA, JMA with MLIT or Public Works Section of Pref. (for Flood Forecast)	AEMET
	Prefecture/ Autonomy		SMC

Table 7 Types and thresholds of flood warning

	Japan				Spain	
Organization	JMA			MLIT with JMA	AEMET	SMC
Type of Warning	Heavy Rain Warning		Flood Warning of River	Flood Forecast	Heavy Rain Warning	Heavy Rain Warning
	Sediment	Sub-mergence				
Used Data	Rain+ SWI*	Rain+ SWI	Rain+ RI**	Rain+ Water Level of River	Rain/1h(30mm) Rain/12h(80mm)	Rain/30min Rain/24min
Level	Advisories Warning Special warning		Advisories Warning	Level 1 Level 2 (watch) Level 3 (caution) Level 4 (dangerous) Level 5 (flooded)	Rain/1h(30mm) Rain/12h(80mm)	Level 1 20mm/30min 100mm/24h Level 2 50mm/30min 200mm/24h
Probability	-	-	-	-	-	10%≤p≤30% (low) 30%<p≤70% (medium) p>70% (high)

* SWI: Soil Water Index; ** RI: Runoff Index

Table 8. Example of warning thresholds in three municipalities of Tokyo

		Shibuya Ward	Nakano Ward	Okutama Village
Heavy Rain Warning	Estimated rain	50mm/1h	40mm/1h	70mm/1h
	Estimated SWI	167	174	147
Flood Warning of River	Estimated rain	50mm/1h	40mm/1h	70mm/1h
	Estimated RI	-	8 (Myoshoji River)	39 (Tma River)
	Complex criterion		30mm/1h and 9(Kanda river)	-
Hydrological Flood Warning	Water level of the river	Shibuya River Kanda River	Kanda River	-
Heavy Rain Special Warning	Estimated rain*	372mm/48h 163mm/3h	357mm/48h 167mm/3h	566mm/48h 137mm/3h
	Estimated SWI	167	174	147

*Although the threshold of the "heavy rain special warning" is based on estimated rain on a 5-km grid, the amount of rain in this table shows the average in each municipality.

List of Figures

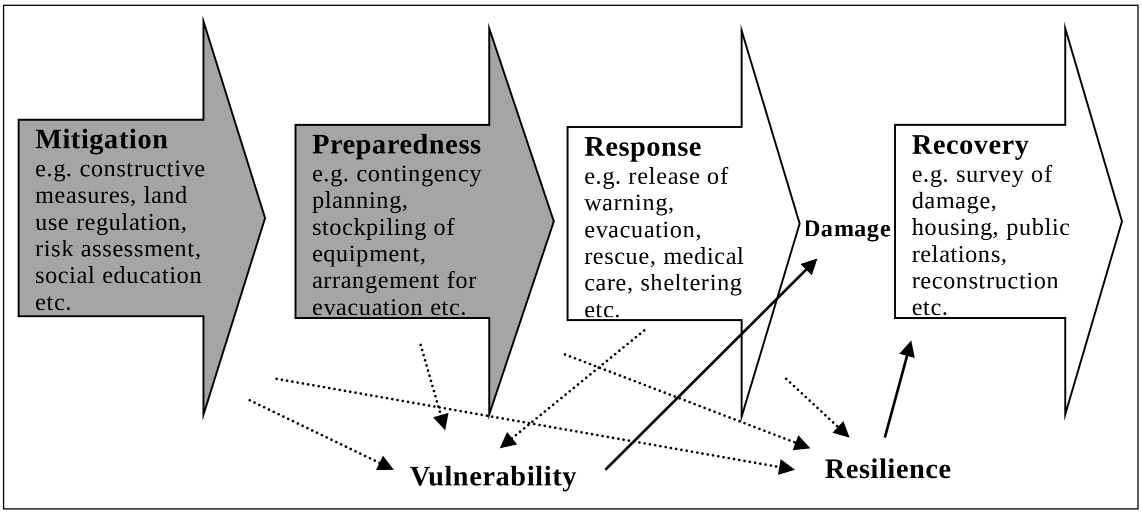


Fig. 1 Factors of disaster management according to disaster stage. This figure is our original, but with elaboration of the description of Drabek (2004)

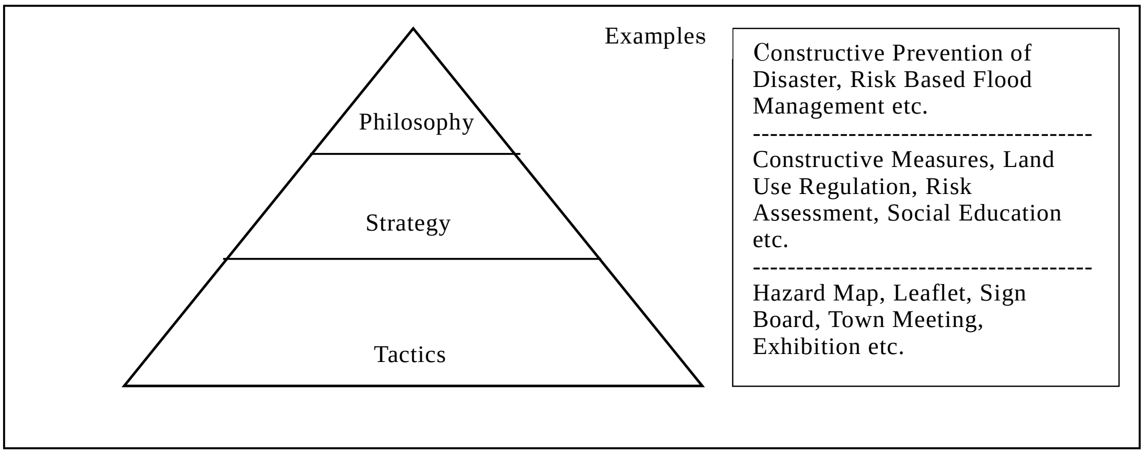
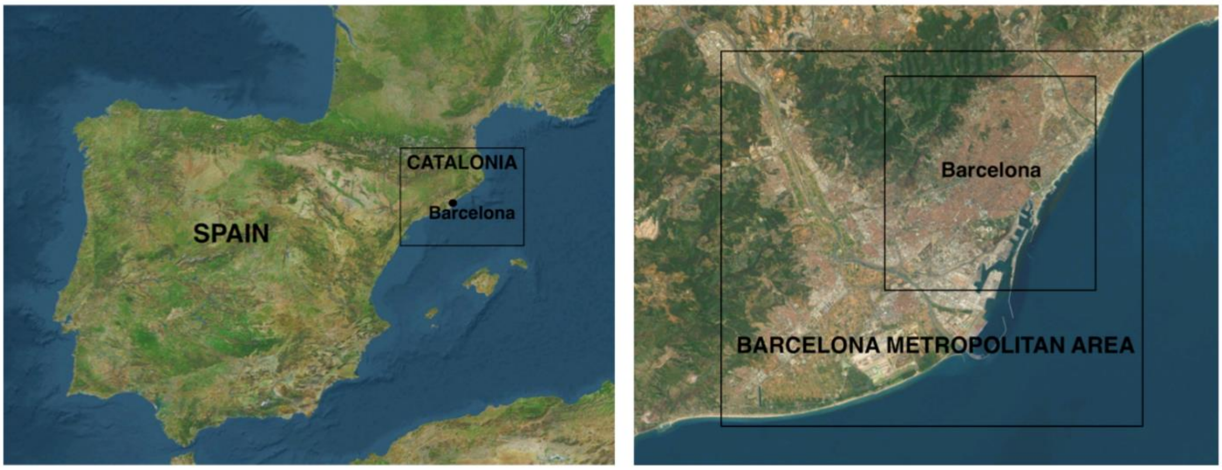


Fig. 2 Dimensions of flood management. The figure is our original, but with elaboration of the description of Drabek (2004)



a b

Fig. 3 Maps of a) Spain showingCatalonia; b) Barcelona Metropolitan Area. Source: Google Maps

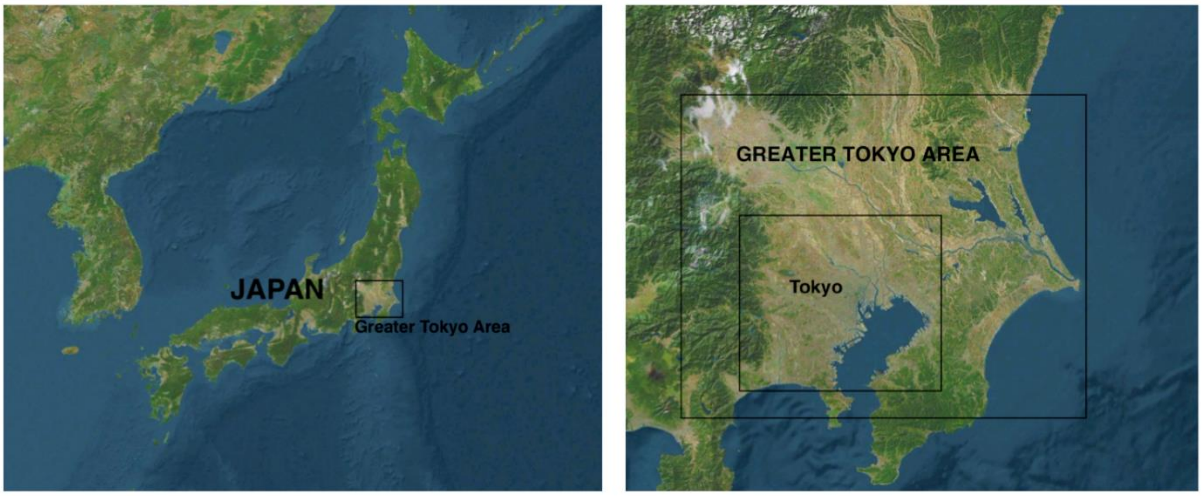


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Fig. 4 Maps of a) Japan and b) Tokyo Metropolis. Source: Google Maps

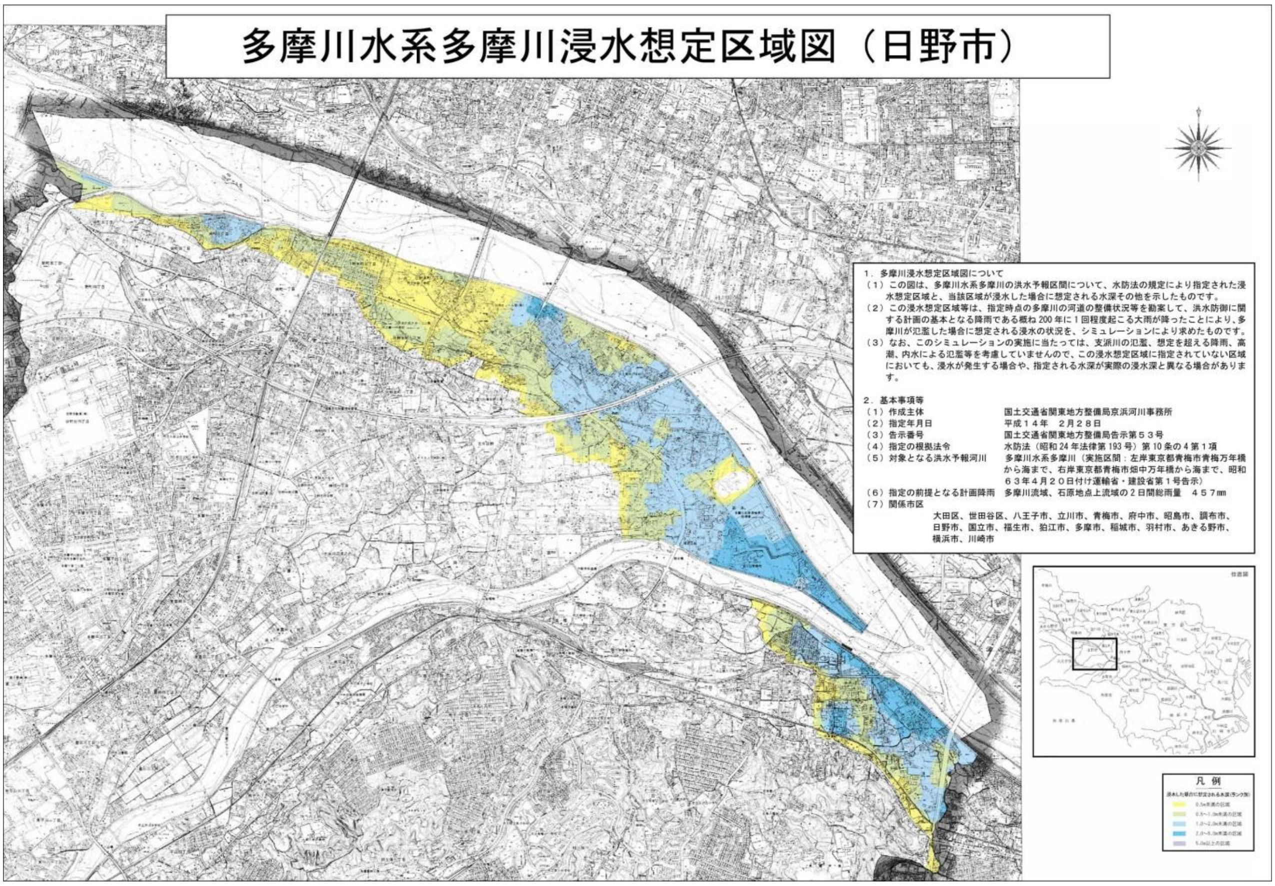

Fig. 5 Flood hazard map of Tama River made by MLIT as it is showed to the population. Source: Website of Office of Rivers of Keihin, MLIT.

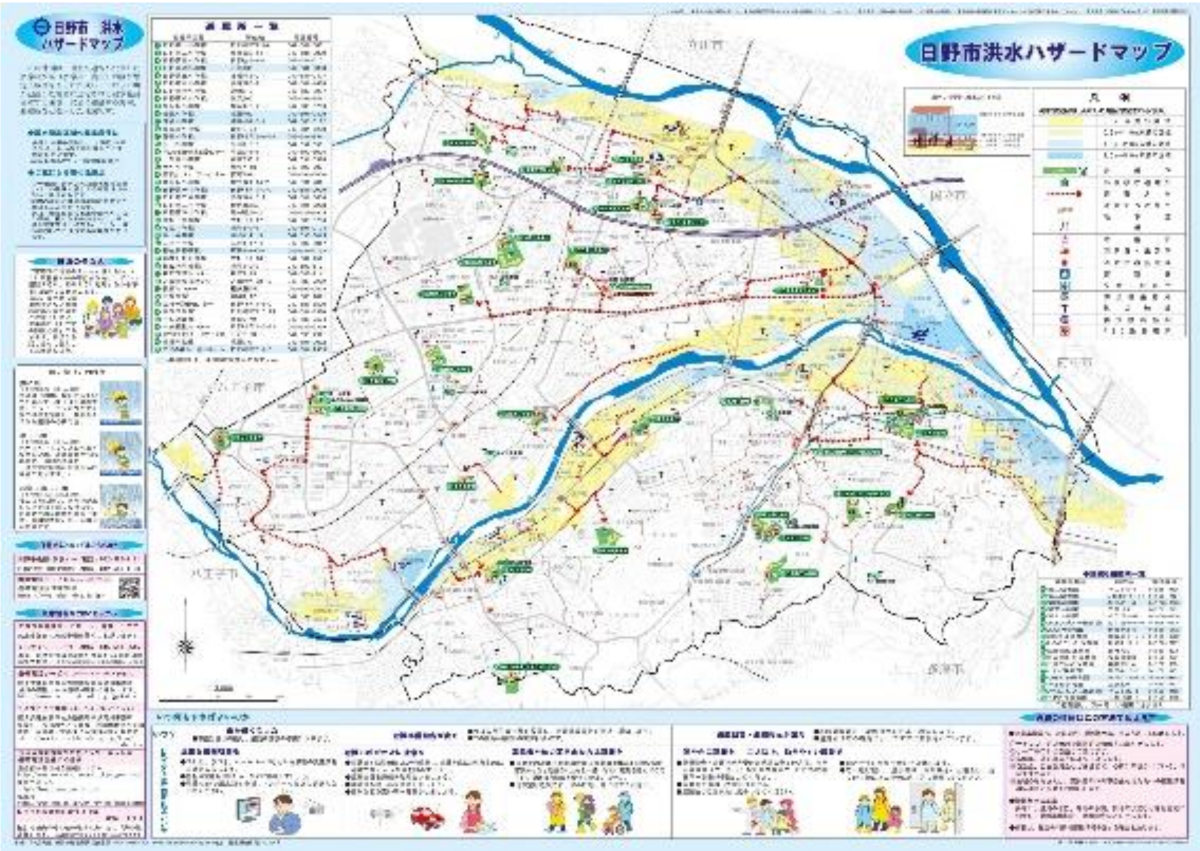

Fig. 6 Evacuation map of Hino, in the Tama River catchment, showing evacuation shelters and, on left side and bottom, evacuation instructions in Japanese. Source: Website of Hino City

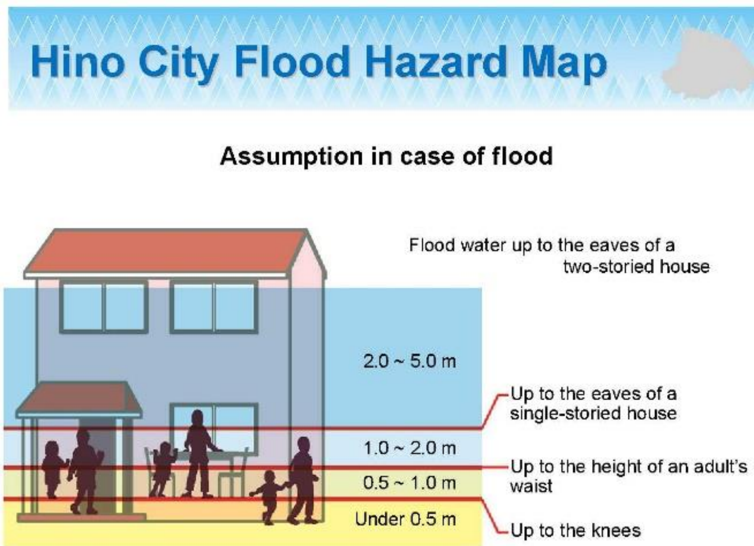

Fig. 7 Part of a flood hazard Map for the city of Hino translated to English for foreigners.

Source: Website of Hino City

Fig. 8 Legend of a prevention flood map translated to English for foreigners.
Source: Website of Hino City (Japan)

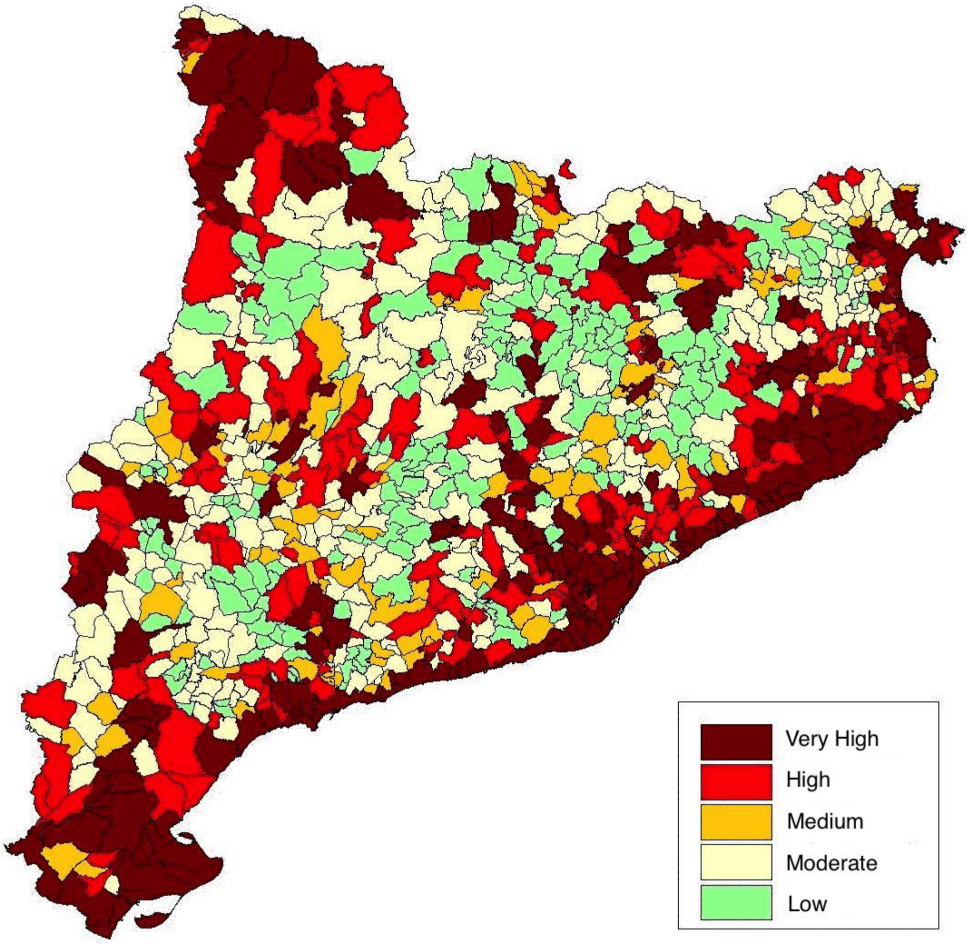

Fig. 9 Flood risk map of Catalonia in INUNCAT plan (DGCP 2012)

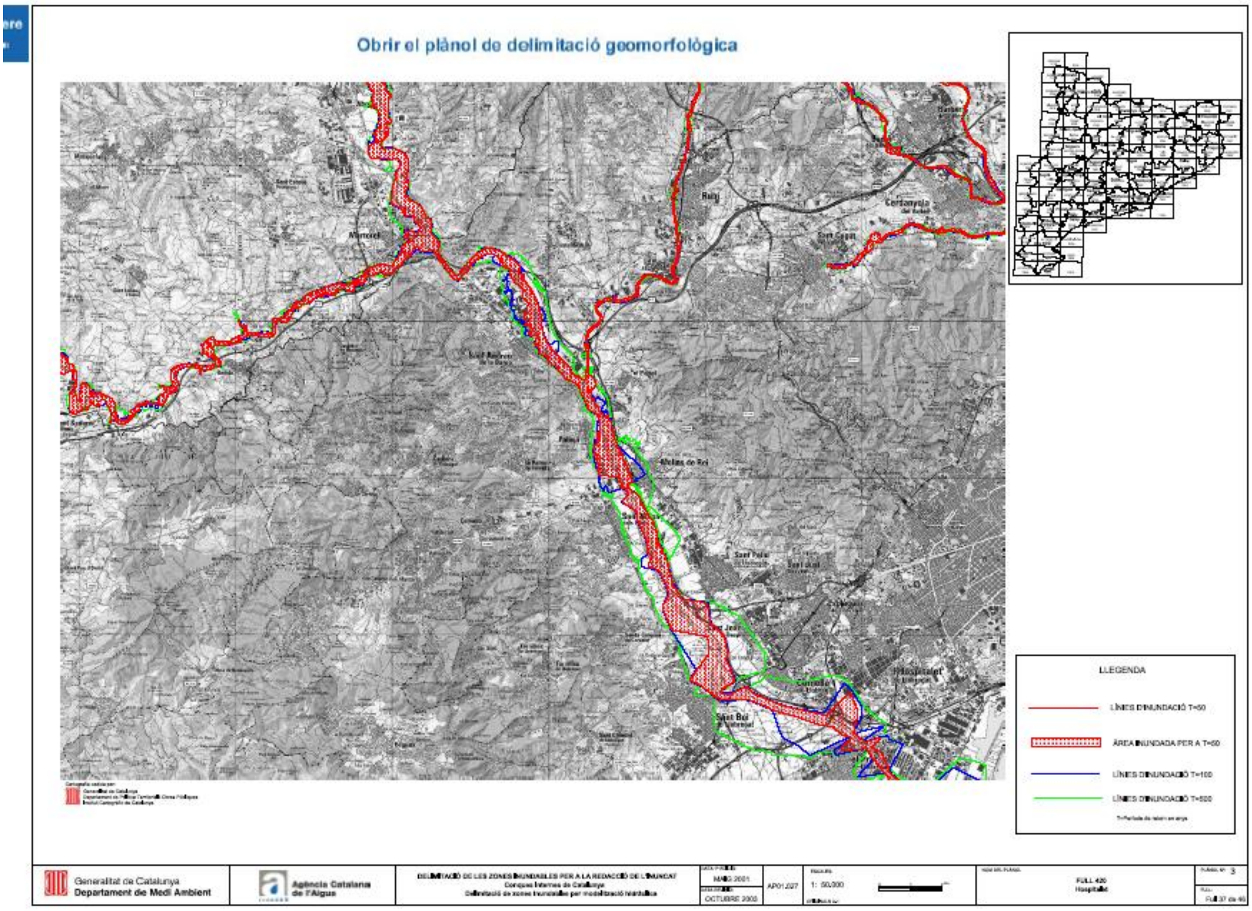

Fig. 10 Flood hazard map showing floodplain areas for return periods 50 years (red area), 100 years (blue line), and 500 years (green line). From "River Area Planning" (PEFCAT) of Llobregat River (this river is showed in Figure 3) (source: ACA)