

## **Regulatory flood maps in the US and the EU: Comparing different approaches**

Cartes réglementaires des inondations aux États-Unis et dans l'UE : comparaison de différentes approches

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### **RESUME**

Les cartes d'inondation réglementaires sont des outils essentiels pour gérer les inondations, car elles nous indiquent où nous pouvons construire (et comment) dans une plaine inondable et où nous ne pouvons pas le faire. Différents pays utilisent des approches différentes pour créer ces cartes, dans certains pays ces cartes sont liées à des actions de gestion des états d'urgence ou récupération (par exemple, liée à un système d'assurance comme aux États-Unis). La façon dont ces cartes sont réalisées peut avoir d'énormes implications sur le territoire, créant différents scénarios d'exposition et de vulnérabilité aux inondations. Dans cette étude, nous comparons les cartes d'inondations réglementaires aux États-Unis, en France et en Espagne afin d'évaluer la façon dont elles sont réalisées (aspects techniques), l'information qu'elles contiennent, les régulations qui leur sont liées, et leur efficacité en termes de communication. Les résultats préliminaires montrent que si les États-Unis étaient plus avancés dans la cartographie des plaines inondables et la gestion des inondations dans les années 1960-1970, l'UE est désormais en avance sur les États-Unis dans le cadre de l'implémentation du Water Framework Directive 2000.

### **ABSTRACT**

Regulatory flood maps are critical tools to manage floods because they tell us where we can build (and how) in a floodplain and where we cannot. Different countries use different approaches to create these maps, in some countries these maps are associated to emergency management actions or recovery aspects (e.g. linked to an insurance system like in the US). The way these maps are created can have tremendous implications in the territory, creating different scenarios of exposure and vulnerability to floods. In this study we compare regulatory flood maps in the US, France, and Spain to evaluate them in terms of how they are created (technical aspects), the information contained, the regulations linked to them, and how effectively the information is communicated. Preliminary results show that while while the US was more advanced in floodplain mapping and flood management in the 1960s-1970s, the EU is now ahead of the US as it implements the Floods Directive of 2007, within the context of the Water Framework Directive of 2000.

### **MOTS CLES**

Flood risk management, France, regulatory flood maps, Spain, US

## 1 INTRODUCTION

Maps are important tools to communicate risk. Of particular importance are regulatory flood maps through which experts directly or indirectly (intentionally or unintentionally) communicate risk to the public. Good maps can engage stakeholders and clearly communicate hazards and risk to end-users, while bad maps can create misperception or even a mistrust of the actual risk, as demonstrated by recent research on perception of risk from natural hazards (e.g., Slovic 2016, O'Neill et al. 2016), and advances in understanding how map design influences how well maps communicate risk (e.g., Fuchs et al. 2009, Chesneau 2011, Chesneau and Clement 2014, Augendre 2004). Furthermore, regulatory flood maps are critical tools to manage floods because they tell us where we can build (and how) in a floodplain and where we cannot. Different countries use different approaches to create these maps. This has tremendous implications in the territory, creating different scenarios of exposure and vulnerability. There is scientific literature describing different ways to evaluate and map flood hazard and risk but research on what are the implications of the regulatory flood maps in the territory. The goals of this paper is to fill this gap by comparing regulatory flood maps produced by two EU member states, France and Spain (in particular the region of Catalonia), with flood maps produced in the US, and evaluating these maps not only in terms of how they are created (technical aspects), and the information contained, but also the regulations linked to them, and how effectively the hazard and risk information is communicated.

## 2 METHODS

We analyzed three flood maps from the three study areas (US, France and Spain) along three key axes: (1) Technical aspects: What factors are considered in making the map? Only hazard (US standard) or true risk (accounting also for development/infrastructure at risk)? What criteria (e.g., hydrologic, hydraulic, ecological) and information (e.g., historical flood extents) are taken into account to define the regulatory flood prone area? How are hydraulic structures considered, and do the maps capture the residual risk to 'protected' lands from larger floods or failure of structures? And do the maps capture uncertainties such effects of future climate changes? (2) Regulatory aspects: What regulations are associated with these maps, and how to they affect land-use planning, emergency management, and post-flood recovery? (3) Design aspects: How effectively do the maps communicate (design, color choices, symbols used, etc.) information? We complemented our analysis of the maps with official reports and interviews with staff of the three government institutions responsible for creating the maps.

## 3 PRELIMINARY RESULTS

### 3.1 Regulatory flood maps in the US

Flood maps in the US are actually **Flood Insurance Rate Maps (FIRMs)**, not flood "risk" maps. They are produced by the Federal Emergency Management Agency (FEMA) under the National Flood Insurance Program (NFIP). These flood hazard maps (1:6000) determine which properties (with federally-backed mortgages) will require flood insurance and mitigation, but they are often also used by municipalities to zone developments. These maps show the Special Flood Hazard Area SFHA or Zone A (the part of the floodplain inundated by the 100-year "base" flood), the base flood elevation (BFE), the floodway (linear areas set aside to convey the 100-year discharge without increasing the base flood elevation by more than 1 foot), and Zone X (other areas considered moderate or low risk). Detail and accuracy of FIRMs vary across the country with modeling and data availability. The 100-year floodplain is mapped assuming that hydraulic infrastructures (levees, dams, etc) will perform well during a flood.

### 3.2 Regulatory flood maps in France

The **Plan de Prévention du Risque d'Inondation (PPR-i)**, created by the Préfectures, is the obligatory document regulating urban planning in the floodplains in France since 1995. The hazard map of the PPR-i (1:5000) is produced at a municipality level and combines hydraulic parameters, which vary by region in France. The flood frequency evaluated is a 100-year flood (considering hydraulic infrastructures invisibles) or a larger historic flood, which is called "crue de référence". In the north of France, a combination of duration and depth of flooding is used, while in the south, an area with a Mediterranean climate regime, maps combine velocity with flood depth. The hazard intensity is crossed with a vulnerability map (showing which areas are urban). Non-urban zones (areas not classified as urban and therefore not open to development) and urban zones with a high hazard level, are depicted as a red zone that prohibits all new buildings. Urban zones with medium hazard intensity appear as a blue zone, which authorizes new buildings with some restrictions.

### 3.3 Regulatory flood maps in Spain

The Planificació d'Espais Fluvials de Catalunya (PEFCAT) created by the Catalan Water Agency is the base study for the obligatory regulatory maps in floodplains of the Catalan River Basin District (Spain); it is also the tool to implement the European Floods and Water Framework Directives. Flood zones in urban areas are divided into 3 zones: the fluvial zone (10-year) and the hydric system (100-year), where no developments are allowed, and the flood prone area (500-year), where only some developments are allowed but with restrictions. The boundaries of the flood hazard area are created at a catchment scale (1:5000) and are based on ecological and geomorphological criteria as well as on hydrologic, hydraulic, photographic, cartographic, and historical information. This supports a diagnosis of the ecological status of the river and the delineation of flood prone areas. These maps are also complemented with the "potentially flooded area" for a 500-year flood, defined with geomorphologic criteria instead of hydraulic criteria. Although this area is only regulatory in areas where there is no hydraulic analysis, it is useful to understand the "residual risk" in the area in case of failure of the hydraulic infrastructures.

### 3.4 Comparing the Maps

Floodplain maps in the US are for the insurance program and show only flood hazard, i.e., percent probability of flooding. They do not consider what is vulnerable to flooding with an area, as shown on flood risk maps, an important innovation required across the EU since 2007. Floodplain maps in the US show areas 'protected' by a 100-year levee as *not* being in a floodplain, despite their residual risk from larger floods. In France, the PPR-i maps show the 100-year floodplain plus the historical flood if it is bigger, the *crue de référence*, which shows the extent of flooding if levees fail. The floodplain maps developed in Catalonia, Spain, show the extent of floods for 3 scenarios, a larger flood (500-y return period), a medium (100-y return period), and a small flood (10-y return period). Of the three map designs, the US maps provide the least information in black and white or limited colors: one is either 'in' the floodplain or out. The French and Spanish maps show more zones within the hazard area, acknowledging areas already built that are at risk, and the Spanish maps include river corridors that cannot be built for reasons of ecological protection (10-y return period). In the south of France regulatory maps also show the area subject to large floods in grey, and within the hazard zone, areas that are already built and are thus constructable, and unbuilt areas where construction is prohibited.

## 4 DISCUSSION AND CONCLUSIONS

While the US was more advanced in floodplain mapping and flood management in the 1960s-1970s, the EU is now ahead of the US as it implements the Floods Directive of 2007, within the context of the Water Framework Directive of 2000. Prior to 2007, EU member states had no consistent flood mapping policies, with practices often developed in response to specific historical flood disasters (e.g., Monstadt and Moss 2008, Serra-Llobet et al. 2013). Some countries, like France, had already developed a system to forbid building more developments in the floodplain, and to incorporate the notion of residual risk. Since 2007 all member states have been required to develop flood risk maps and management plans nation-wide, and as illustrated by the examples from southern France Catalonia, Spain, these maps provide far more information than the floodplain maps used in the US.

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