Chapter 3

Enhancing resilience in Île-de-France by preventing the risk of flooding

Enhancing resilience in Île-de-France against the risk of flooding of the Seine calls for a broad range of structural and non-structural prevention measures, which will be assessed in this chapter. The areas covered include risk awareness and risk culture, urbanisation and planning, critical network resilience, business continuity and hazard control through protection or storage infrastructure. This will enable synergies to be identified in order to reinforce resilience by harnessing innovation.

Introduction

The significant risk of flooding of the Seine in Île-de-France can be contained or reduced only by specific measures to increase the resilience of this strategic area. Revised governance will allow the vision, objectives and major principles of a flood management strategy to be defined, underpinned by implementation at local level in the catchment area, in exposed areas, in planning and development projects, in businesses, etc. While the La Bassée storage infrastructure project has been under study for over ten years, other risk prevention approaches must also be brought to the attention of decision makers.

Risk prevention policies in OECD countries focus on two principal types of action: hazard control and vulnerability reduction. Engineering or structural measures to limit exposure to flooding seek to harness variability or contain the river by means of storage or protection facilities (dams and dykes respectively). These hazard control approaches were preferred in the past but are now often limited by costs (financial, social and environmental) when new ones have to be built, or by their ageing and rising maintenance costs in the case of existing facilities (OECD, 2006). Softer and more environmentally friendly hazard control approaches have been developed more recently, based on dynamic flood damping or flood retention area conservation.

Reducing vulnerability also involves non-structural measures. The development of risk awareness and a risk culture is essential for laying the foundations for action at any level. Enhancing resilience may be based on appropriate urban planning and development which adequately incorporates the risk of flooding. This addresses the issue of critical networks and infrastructure whose vulnerability to flooding can increase the effects of a disaster, particularly in the case of the Île-de-France metropolitan area (Chapter 1). More broadly, the resilience of businesses and public services must also be developed by business continuity approaches, for example.

This chapter compares all these resilience enhancement approaches involving structural and non-structural flood risk prevention measures for the Seine in Île-de-France to identify priority areas. The essential monitoring measures, incentives and controls in this field are addressed, while their funding will be addressed in Chapter 4.

Knowledge and communication of the risk

Accurate and shared knowledge of the risk underpins any decision making concerning risk prevention, as does the awareness necessary to develop a risk culture. Government services and flood management stakeholders as a whole are aware at a technical level of the risk of the Seine flooding in Île-de-France, and this awareness continues to increase. The lack of a clear, shared and sufficiently widespread view of the level of risk and its precise consequences, however, limits the development of a risk culture and gives rise to differences in assessment and risk preparation levels. Many stakeholders have also spoken of confusion with respect to information and lack of access to it (Box 3.1).

Knowledge and assessment of the risk

Risk assessment allows the nature and characteristics of risks, particularly their magnitude, probability and consequences, to be determined methodically. A systematic approach based on the best scientific knowledge is required in order to ensure that risk management policies and the associated investment can be clearly targeted and can obtain the best return on investment. Poor risk assessment may give rise to uninformed or

arbitrary decision making and thus lead to costly and overly protective policies or, on the contrary, to dangerous negligence in protecting populations and assets.

Box 3.1. **Knowledge of the risk and risk culture**

To carry out this project, the OECD sent a questionnaire to some 150 participants. The response rate was around one-third. The analysis of responses from public stakeholders, businesses and network operators bears witness to varying effects, though several clear trends emerge in relation to knowledge of the risk and risk culture:

- 83% (19/23) of public stakeholders believe that citizens and socio-economic stakeholders "are not sufficiently aware" of the exposure of their activities to flooding
- 70% (16/23) of public stakeholders believe that citizens' and socio-economic stakeholders' awareness of the risk of major flooding is weak or poor; the remaining 30% (7/23) did not answer this question (in other words, all public stakeholders who answered this question answered unfavourably)
- 39% (9/23) of public stakeholders referred spontaneously to the lack of a culture or memory of risk, due in particular to the absence of recent flooding
- 50% (10/20) of private stakeholders and network operators referred more generally to the difficulty of obtaining a good level of information from network operators or government services as the principal difficulty in initiating measures to protect against and prevent flood-related damage
- 35% (7/20) of private stakeholders and network operators referred to the difficulty in obtaining information on the electricity weakness chart as the main difficulty in initiating measures to protect against and prevent flood-related damage.

Source: Questionnaire-based survey carried out by the OECD Secretariat. Public stakeholders who responded were representatives of local authorities as a whole and of the state. Private stakeholders and network operators represent major public or private network management enterprises (electricity, water, telecommunications, transport), other major enterprises in sectors such as banking, insurance or automobiles and several small and medium-sized enterprises (SMEs).

Rigorous risk assessment must consider the hydrological hazard, its consequences, the vulnerabilities of the region and the socio-economic impacts of flooding of the Seine. Cross-referencing the hazard and its consequences with the various assets exposed and their vulnerability allows a risk assessment to be obtained.

Flood mapping and modelling in Île-de-France

The Seine flood risk is precisely known and has been characterised by government departments through various mapping and modelling approaches. Past floods in the Seine basin are well documented, especially the 20th-century floods in 1910, 1924, 1955 and 1982. The chronological series of Seine flow rates and water depths at different measurement points can be obtained from government departments and the Seine Grands Lacs Local Public River Basin Authority (*Établissement Public Territorial de Bassin Seine Grands Lacs*). These data sources form the basis for a variety of flood mapping and modelling, and several maps showing the extent of flooding are outlined below.

The map showing the area with the highest known water levels (HKWL) obtained from a 1996 study by the Seine-Normandy Water Agency (*Agence de l'Eau Seine-Normandie*, AESN) on the whole basin is available and can be downloaded from

the website of the Regional and Inter-departmental Directorate for the Environment and Energy (*Direction Régionale et Interdépartementale de l'Environnement et de l'Énergie*, DRIEE) with a scale of 1:25 000 in the atlas of floodplains in Île-de-France. While the 1658 and 1740 floods reached very high levels (8.96 metres and 8.05 metres on the Austerlitz gauge, compared to 8.62 metres for the 1910 flood), this mapping was based mainly on data relating to the 1910 and 1955 floods of the Seine and the 1926 flood of the Oise.

Maps were also developed by the DRIEE in the 1990s to give a more accurate indication of the water height in flooded areas. Based on 1910 flood water heights measured on Seine bridges, topographic measurements showed the depth of the flood and allowed the "hazardous" and "very hazardous" areas where the water height exceeded 1 m and 2 m respectively to be identified. These 1:10 000 and 1:5 000 scale maps form the basis for the regulatory measurements of the risk prevention plans (*plans de prévention des risques*, PPRs). This zoning is also used by the Institute for Urban Planning and Development of the Île-de-France Region (*Institut d'Aménagement et d'Urbanisme d'Île-de-France*, IAU Île-de-France) to assess the assets exposed in its Visiau-Risque online tool.

In implementing EU Directive 2007/60/EC on the assessment and management of flood risks (the "Floods Directive"), a new envelope was chosen for the preliminary flood risk assessment (PFRA) underlying the procedure for identifying areas at significant risk of flooding. This is the approximated envelope for potential floods (*enveloppe approchée des inondations potentielles*, EAIP), a maximum envelope based on the HKWL map, drawn up in 1910 in the context of the Boreux Plan, the PPR maps and hydro-geomorphological approaches, in order to retain the broadest envelope each time.

In addition to this mapping based on historic data, other approaches based on hydraulic modelling have been developed to represent different flood scenarios and their extent. The ALPHEE model developed by the DRIEE and the EPTB Seine Grands Lacs in the 1990s (Chapter 1) represent the area of the floodplain, which is separated into compartments in which the water level reached and flood duration are calculated according to the different flood scenarios. Benchmark scenarios were established on the basis of the 1910 flood flow. This ranges from scenario R0.6, representing 60% of the flow of the Seine in 1910, to scenario R1.15, which, with 115% of the 1910 flow, does not reach higher than the level the flood reached in 1910 thanks to the work done since then on the bridges and on the bed of the river. These different scenarios were used for crisis preparation work under the ORSEC mechanism and for cost-benefit analyses of prevention measures. More recently, in the context of implementing the Floods Directive, the DRIEE used ALPHEE to establish a 1 000-year flood with a flow 40% greater than that in 1910. Another hydraulic model based on a determinist approach is used by the Central Reinsurance Fund (*Caisse Centrale de Réassurance*, CCR). The impact of climate change on the flood risk in the Seine basin was also assessed under the National Climate Change Adaptation Programme (Chapter 1). This did not enable a significant variation in the flood risk to be identified, neither in terms of intensity nor probability.

The use of different hazard modelling and mapping approaches is not problematic in itself, since neither corresponds to specific objectives or different uses. The existence of these different standards, however, may confuse certain stakeholders and call the coherence of the holistic approach to flood prevention into question. Thus, the fact that the PPR and HKWL zoning maps are different and are both available online could raise concerns. It seems meanwhile that agreement on the probability of different flood

scenarios and the approaches chosen to calculate them is not always apparent. The models used by the CCR and the DRIEE-EPTB Seine Grands Lacs produce a rather different floodplain surface area for the same scenarios. The CATNAT compensation scheme funding policies are thus based on flood probabilities that differ from those produced by the government departments responsible for risk prevention policy. Now that momentum has built up with respect to prevention, approaches must be harmonised so that a hazard and probability assessment can be established among all stakeholders.

Vulnerability analysis and mapping

Several complementary approaches have also been taken by government departments and local authorities to assess exposure and vulnerability to flooding in Île-de-France. Different sources of information are therefore available depending on the objective of the assessment: regulatory tools, project cost-benefit studies, crisis management preparation, strategic plan development, etc.

The implementation of the Floods Directive requires accurate risk maps, for which the DRIEE is responsible. This authority carried out a PFRA for the entire Seine-Normandy basin, specifying the various assets exposed according to the Directive's general principles. All the assets exposed in the broad envelope of the floodplain are surveyed, paying particular attention to human health, economic, environmental and cultural heritage issues. Although it is not intended to be a precise assessment, this PFRA has, above all, enabled high-risk areas (HRAs), including the Île-de-France conurbation, to be defined with specific criteria. The DRIEE has now begun to map the risks affecting this HRA more precisely, as required under the Floods Directive. Maps have thus been developed for different significant, average or low probability flood risks (1 000 year), which record both water heights and many assets. These highly detailed maps were proposed in consultation with the various stakeholders and local authorities in September 2013 and will form the basis for defining the local flood management strategy.

Crisis management preparation also requires information to be available on the different impacts and their vulnerability during a crisis. In the case of a modern metropolis such as the Île-de-France conurbation, critical network correlations are key elements to be considered in assessing knock-on effects. Police Headquarters and its General Secretariat of the Paris Defence and Security Zone (*Secrétariat général de la Zone de Défense et de Sécurité de Paris*, SGZDSP) used the DRIEE R0.6 to R1.15 scenarios to develop crisis preparation strategies under the ORSEC mechanism. Since 2010, thematic working groups have accordingly been organised with all network operators to assess and map their vulnerability and interlinkages. A geographic information system (GIS) has also been developed which allows the impacts on roads and public transport networks, drinking water production systems and the electricity network to be visualised in different scenarios. The SGZDSP also has information relating to the vulnerability of other sectors which are sensitive or essential to crisis management, such as banking, telecommunications and distribution. This information may be difficult to obtain and share, particularly when matters of security, confidentiality or competition are involved.

Its regional development responsibilities caused the Île-de-France region to develop performance tools, such as GIS, to fulfil its remit. The region's IAU thus created the Visiau-Risques GIS tool, available online in a general public version, with a more elaborate version for professionals. This tool contains a comprehensive range of detailed information on the variety of assets exposed as a whole, from public infrastructure to

businesses and habitat, and a layer of information on the at-risk area, based on the PPR zoning which specifies high- and low-hazard areas. This tool has, for example, allowed the IAU to make a precise estimate of the number of people, businesses and jobs affected by the risk of flooding, broken down in detail at local level.

Loss and damage assessment

To date, the economic impacts of flooding have been assessed by the EPTB Seine Grands Lacs in cost-benefit studies of its prevention projects, and by the CCR in developing its CATNAT financial management tools. The EPTB Seine Grands Lacs used the economic modelling component of the ALPHEE model to calculate the economic damage caused by various flood events. This component, developed in the late 1990s and updated in 2010, allows damage to habitat and businesses to be calculated by the statistical spatialisation of assets and damage functions which calculate the latter according to water height and flood duration. This approach, innovative in its day, could now be reappraised to improve its accuracy in light of tools now available, particularly asset geolocation. In addition to its hydraulic model, meanwhile, the CCR has a precise database of assets linked to geolocated insurance contracts and its own damage functions. These are successively adjusted and improved in line with the different floods in France, the respective insured damage being measured by the CCR on an event-by-event basis. These damage assessments are therefore different from those made by the EPTB Seine Grands Lacs.

Chapter 1 of this volume put forward a broader assessment of the loss and damage caused by different flood events. This assessment seeks to bring together and complete all the studies and data identified above in a coherent approach and has thus made it possible to consider the impacts of flooding on critical networks, the indirect impacts linked to interruptions in such networks, and the medium- and long-term macroeconomic effects of a major flood. This approach could be further improved by updating the ALPHEE economic modelling by means of geolocated databases.

Real progress confirmed by knowledge of the risk

The recent hazard and asset mapping developed by the DRIEE on the Île-de-France conurbation HRA in the context of implementing the European Floods Directive is very precise. In particular, it includes relevant information on water levels, which are crucial for assessing damage. The three hazard levels (high, average and low frequency) could be adopted as a benchmark for all initiatives in this area. In the long term, the understanding between the DRIEE and the SGZDSP with respect to the Île-de-France HRA will allow these new maps to include the damage on the networks of the crisis management working groups. To date, the variety of risk assessment approaches, tools and standards has been rather confusing and has prevented stakeholders from reaching agreement on similar results, with each of them tending to develop their own calculation methodology. The current sharing and harmonising of knowledge could be extended to other stakeholders, such as the insurance sector, the EPTBs and the IAU, in a coherent and comprehensive risk assessment approach, particularly at economic level. Questions of probability, loss-function improvement, the harnessing of floods for groundwater recharge through subsoils and the timescale of flooding are areas which merit further development and greater understanding. Initiatives at the national level could help to improve this situation, particularly the creation of the National Observatory for Natural Hazards (*Observatoire National des Risques Naturels*, ONRN) with the insurance sector (Box 3.2), and the Île-de-France Seine and Marne PAPI project (Chapter 2).

Development of a risk culture

Reinforcing risk culture at all levels is an essential aspect of prevention policy. Raising awareness of the risks facing the public, businesses and decision makers can motivate action to reduce vulnerability at each of these levels. Risk communication tools must therefore be developed which allow all parties to have a realistic understanding of the seriousness and frequency of floods and the effects they could have on their homes, businesses, local areas, lifestyles or welfare. Greater risk awareness may also promote and accompany dynamic public action in this field in response to high public demands.

Box 3.2. **The National Observatory for Natural Hazards**

The ONRN was set up jointly by the Directorate-General for Risk Prevention (*Direction Générale de la Prévention des Risques*, DGPR), a department of the Ministry of Ecology, Sustainable Development and Energy (MEDDE), the CCR and the private insurance companies represented by the insurance companies' Natural Risks Mission (*Mission Risques Naturels*, MRN) on 3 May 2012. The observatory was initiated by the National Policy Board for the Prevention of Major Natural Hazards (*Conseil d'Orientation pour la Prévention des Risques Naturels Majeurs*, COPRNM), in response to recommendations in a parliamentary report into the floods caused by cyclone Xynthia in Charente-Maritime.

A public-private tool for sharing and disseminating natural hazard data and indicators, the observatory seeks to connect suppliers and users of hazard data and information. The ONRN has five principal objectives: improve and capitalise on knowledge of hazards and challenges; drive a forward-looking assessment mechanism; contribute to risk prevention piloting and governance; contribute to the economic analysis of crisis prevention and management; contribute towards improving risk culture. The ONRN should thus organise, provide access to and enhance knowledge, and above all produce national and regional indicators.

Such an observatory or its local application could represent an ideal structure for harmonising approaches to assessing the risk of flooding of the Seine in Île-de-France and a unique benchmark for sharing and disseminating information on institutions, businesses and individuals.

Source: Observatoire national des risques naturels (2013), "L'Observatoire national des risques naturels (ONRN)", Ministry of Ecology, Sustainable Development and Energy, Paris-La Défense, www.onrn.fr/site/binaries/content/assets/documents/onrn/201303_brochureonrn_web.pdf.

The absence of significant flooding of the Seine for almost 60 years and the virtual disappearance of low-frequency 10- to 30-year events contained by reservoirs and dykes have dimmed the collective memory of the risk of flooding in Île-de-France. Moreover, while the CATNAT collective insurance coverage offers many advantages, it may involve a moral hazard (Chapter 4) by giving citizens, businesses and decision makers the false impression that they will be compensated for their losses come what may. This does not encourage them to address the risks or to focus on prevention measures. Stakeholders as a whole feel that the level of information and the degree of public awareness of the risk of significant flooding are not commensurate with the gravity of the threat. The development of a risk culture therefore requires a proactive approach in Île-de-France to raise awareness of the significant risk of flooding.

Risk communication tools and their implementation

There are various regulatory measures for providing the public with information on risks, though these have shown their limits in Île-de-France. City councils should make preventive information on risks available via the municipal information document on

major risks (*Document d'information communal sur les risques majeurs*, DICRIM). This procedure is mandatory in every municipality in Île-de-France identified by prefects as being threatened by the risk of flooding of the Seine. The purpose of the DICRIM is to inform the population of the risks to which the municipality is exposed and to identify protection measures. This document also includes the history of the flood risk; a survey of prevention, protection and safeguard measures; an inventory of existing flood markers; and a map of the highest known water levels.

The DICRIM should be displayed in city councils, they must be freely available for consultation at no charge and briefing meetings should be organised every two years to make the public aware of them. Although this document is meant for citizens, in practice it is not widely distributed for educational purposes, since city councils generally do not wish to draw attention to the risks particular to their municipality. In Île-de-France for example, 11 municipalities situated in floodplains which are amongst the 100 most heavily populated French municipalities do not post their DICRIM on their websites (Table 3.1).

Table 3.1. **Absence of DICRIM on websites of municipalities at risk of flooding in Île-de-France**

Municipality	Population	Flood risk prevention plan (PPRI)	Date of approval of PPRI
Boulogne-Billancourt	113 085	Hauts-de-Seine	2004
Argenteuil	102 844	Argenteuil, Bezons	2002
Créteil	89 359	Val-de-Marne	2007
Courbevoie	86 945	Hauts-de-Seine	2004
Colombes	84 572	Hauts-de-Seine	2004
Asnières-sur-Seine	81 603	Hauts-de-Seine	2004
Rueil-Malmaison	79 065	Hauts-de-Seine	2004
Saint-Maur-des-Fossés	75 251	Val-de-Marne	2007
Champigny-sur-Marne	75 090	Val-de-Marne	2007
Levallois-Perret	63 436	Hauts-de-Seine	2004
Noisy-le-Grand	63 405	Seine-Saint-Denis	2010
Neuilly-sur-Seine	60 501	Hauts-de-Seine	2004

Notes: Adapted from Moro (2012). The methodology is based on the INSEE survey of the 100 most heavily populated French cities in 2012, the *DICRIM national database* and the *Gaspar database*, and the official websites of the various municipalities examined. The principal limitation of this approach is that the author is under the impression that municipalities which have not posted their DICRIM online have not produced or communicated it and their communication is therefore poor, while in fact they are under no obligation to post them online.

Sources: *Gaspar database*, http://macommune.prim.net/gaspar (accessed in October 2013); *DICRIM national database*, www.bd-dicrim.fr (accessed in October 2013); Moro, C. (2012), "Ces grandes villes françaises qui cachent leurs risques majeurs" [French cities that hide their major risks], blog i-resilience.fr, www.i-resilience.fr/2012/07/ces-grandes-villes-francaises-qui-cachent-leurs-risques-majeurs (accessed in October 2013).

In addition to the DICRIM, city councils must also ensure that the risk of flooding is substantiated by listing, maintaining and affixing flood markers corresponding to the highest known water levels, which remind people of floods. Like the DICRIM, flood markers have not been widely developed by city councils in Île-de-France. The DRIEE surveys and maps these flood markers via a dedicated website. With the exception of Paris, which has many markers of the 1910 flood and which has doubled their number since 2011, flood markers are not very common along the Seine in upstream and downstream departments, which were not very heavily developed at the time of the 1910 flood.

The 2003 Law on Risk Prevention also introduced a risk communication tool for purchasers and tenants of buildings. Owners or lessors must inform purchasers or tenants of the risks existing in the municipality and of claims that have affected the properties concerned in the past. Municipalities must use this tool to inform citizens of the risks in response to their demands. Communication is effective in this respect, but the level of information communicated often remains basic and limited to a regulatory map.

French regulations make procedures mandatory: information procedures (affixing documents in city councils) or consultation with stakeholders (e.g. with associations or public enquiries) rather than the establishment of quantified risk awareness objectives among the population or with entrepreneurs. These procedures could be more effective in Île-de-France, either by wider dissemination or by presenting the information differently.

Innovative approaches to raising public awareness

Other approaches to raising public awareness of the risk of flooding which are more in step with citizens' expectations have been favourably received. The centenary of the 1910 flood, for example, was an opportunity to rekindle the memory of the risk: many exhibitions, colloquiums, films, information boards, etc. were organised. The Hauts-de-Seine General Council put on a travelling exhibition in several of its municipalities on the impacts of the 1910 flood, comparing it with what would happen today by means of period photographs. Information on this flood, however, does not seem to have been presented in the most effective way: highlighting a period in the past may give the impression that the flood reflected a phenomenon from another age and that progress in the 20th century guards against its effects. Representations of the risk based on modern communication tools, such as 3-D animated maps, may be more appropriate and could reach a broader public (Box 3.3).

The development of a river and water culture is also an opportunity to address the risks involved. The *Festival de l'Oh!* [*Festival de l'Eau*, or Water Festival] organised by the Val-de-Marne General Council under its annual "Blue Plan" was devoted to the flooding of the Seine in 2012. The AESN has proposed an option for raising awareness of water issues in schools which addresses floods and flooding. The many projects to develop river banks in the Île-de-France region over the past ten years (see below) have also allowed citizens to reappropriate the river and its irregular rhythm, the first signs of a risk culture.

A risk culture developing in businesses

Businesses have become increasingly aware of the major risk of flooding of the Seine in Île-de-France in recent years, but to very different extents according to their scale and sector. The creation of working groups focusing on critical sectors under the supervision of the area protection authority has helped to make these public and private stakeholders more aware of the interlinkages and knock-on effects of significant flooding. The leading businesses and operators in the energy, transport, water, banking, distribution and telecommunications sectors have gradually become aware of the risk and have made an effort to mitigate it or to increase their resilience.

Many other major businesses have been made aware of this risk by different means. Networks of the leading companies' risk and security directors can meet in the Business Security Directors' Club (*Club des Directeurs de la Sécurité des Entreprises*, CDSE), for example, which brings together most of the largest French groups. Regulations on key sectors of activity require many enterprises to develop business continuity plans.

Insurance and reinsurance companies have raised their clients' awareness of this risk when discussing their insurance coverage. The reinsurer Swiss Re classifies Île-de-France as one of the world's major at-risk metropolitan areas in its study on the impact of disasters on business activity (Swiss Re, 2013). The Paris Chamber of Commerce and Industry (CCI Paris) also published a special study in 2012 on the risk of flooding of the Seine in Paris (CCI Paris, 2012). Action taken locally at business district level (e.g. La Défense) may also help to raise awareness among the major groups. When they have been made aware, businesses make strong demands for access to precise information on the risk, both with respect to water levels and critical network interruptions (electricity, telecommunications, transport and water).

Box 3.3. **3-D maps: An awareness-raising tool**

The Institute for Urban Planning and Development of the Île-de-France Region (IAU) develops participatory tools for citizens to raise risk awareness. The risk prevention plans (PPR) maps or the map being developed under the Floods Directive are accurate and necessary from a legal and regulatory perspective. Although they are made available to the public, they are not very accessible to non-specialists because of their technicality. The use of simplified mapping tools or 3-D visualisation offers the public a new perception of the risk.

The IAU has produced a video representing the impact of the flooding of the Seine in Charenton-le-Pont and Ivry-sur-Seine. This three-dimensional video is available online and has been viewed around 3 000 times in a year.

Source: IAU (2013a), 3D video available at: www.youtube.com/watch?v=W_wJ8vYtMmU (accessed in November 2013).

The level of awareness of SMEs, on the other hand, remains very limited. There have been no information campaigns aimed specifically at businesses in Île-de-France, particularly SMEs. In partnership with the EPTB Seine Grands Lacs, the CCI Paris has conducted several vulnerability assessments in SMEs in Île-de-France which have highlighted their lack of awareness of the risk of flooding (CCI Paris, 2012). The CCI Paris could do more in this field. The development of flood risk assessment tools for businesses, such as those produced in the Loire basin, could motivate Île-de-France in this respect.

It is also crucial to strengthen the risk culture among certain professions that play a key role in terms of resilience. Action focusing on network and crisis management operators in the SGZDSP is particularly relevant in this regard and has proven its effectiveness. Mechanisms focusing on urban planners and developers, solicitors who provide information for purchasers and householders' associations responsible for maintenance have been used on a limited scale in Île-de-France by the Paris City Council and the EPTB Seine Grands Lacs, for example. This more long-term action may provide substantial leverage for the effective implementation of resilience measures.

Area, public service and business resilience

Increasing the Paris conurbation's resilience to major flooding of the Seine could be based on a range of measures and opportunities at area, business or public service level. Resilience relates to a system's capacity to absorb shocks and regain its ability to function. This multifaceted concept thus focuses on continuity with respect to a range of services, systems and societal functions and ensures links between the prevention action addressed in this study and preparatory and crisis management measures (Baubion, 2013). Appropriate urban planning and development which correctly factors in the risk of flooding may create the foundations for enhancing area resilience. This includes critical networks and infrastructure whose vulnerability to flooding can exacerbate the effects of a disaster. More broadly, business, public service and individual resilience must also be developed by means of business continuity approaches, for example. Many options for improving the resilience of the metropolitan area may thus be pursued through a culture of sharing risks. This requires stakeholders to commit to a common objective and, in particular, to long-term action in terms of urbanisation and infrastructure, both with respect to economic stakeholders and individuals.

Area resilience through urbanisation policies

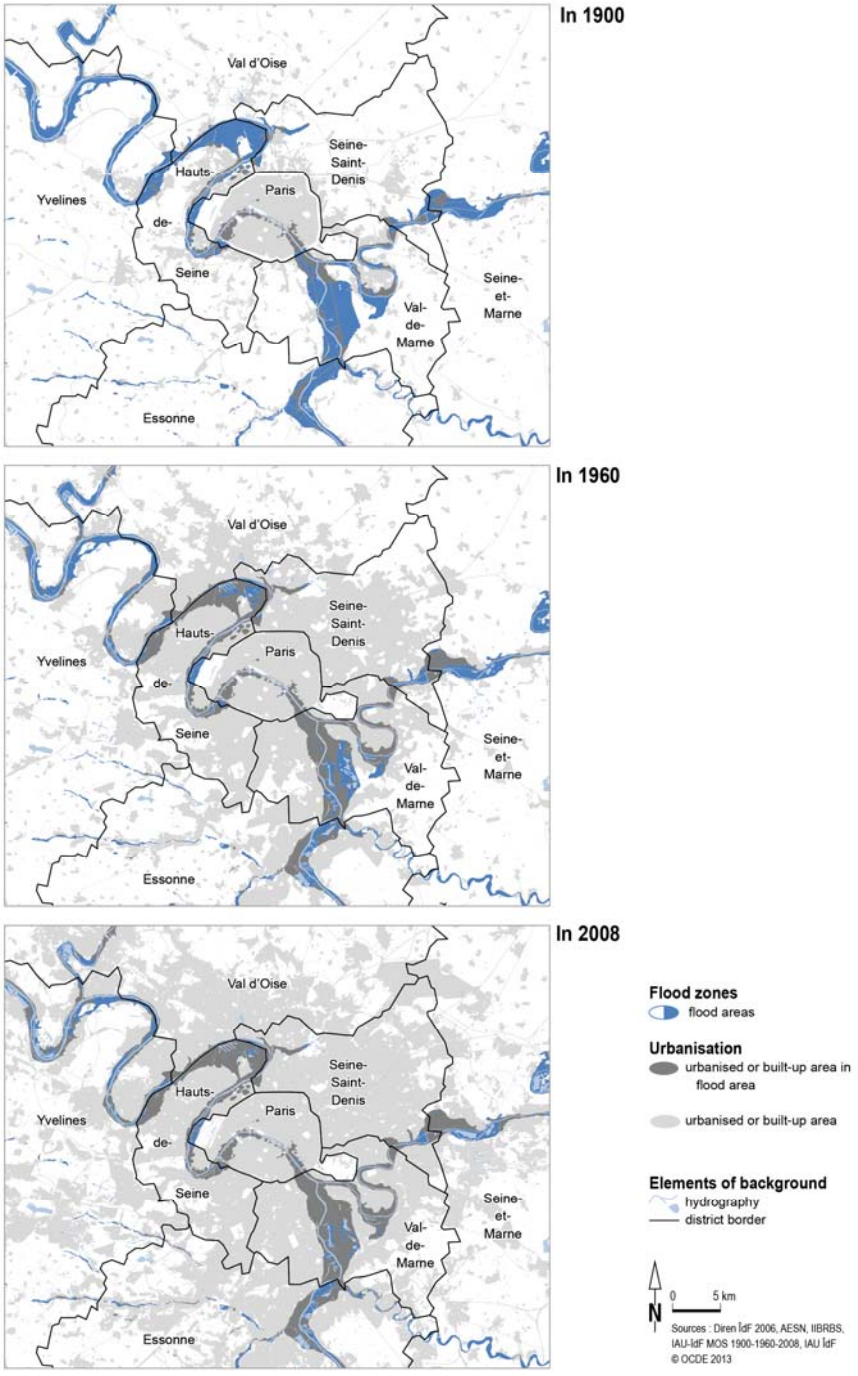
The resilience of areas primarily requires controlled urbanisation of floodplains and consideration of this risk in the strategic planning and design of urban development projects. Since the 1910 flood, the development of the Paris conurbation has given rise to heavy urbanisation on the alluvial plain and urban sprawl, which has been expanding for 40 years (Figure 3.1). The areas of natural expansion of the Seine upstream of Paris in the Val-de-Marne and downstream in the Hauts-de-Seine were heavily exploited initially to develop industry, and then for housing and services. While risk prevention policies based on controlled development or urban renewal did little significantly to mitigate the risk of flooding of the Seine in this largely built-up context, the unifying Greater Paris project offers hope that a flood-resilient metropolis may emerge around innovative urban projects developed along the course of the Seine.

The limits of the PPR regulatory tool

The limits of instruments to restrict building in floodplains have been reached both nationally and in Île-de-France. The management of urbanisation in floodplains in France is based on the PPR established since the 1995 Barnier Law. This state regulatory tool requires municipalities responsible for urban planning and development to ensure regulatory zoning according to the hazard defined on the basis of floodplain atlases, and applies building regulations ranging from a total ban on building to building under certain conditions. This is stipulated and approved by the prefect after a municipal consultation process and a public enquiry. The approval, which is attached to the local urban plan

(*plan local d'urbanisme*, PLU), creates public utility easements, making it effective against third parties with respect to any construction, works or development in the floodplains (OECD, 2010).

Figure 3.1. **Urban sprawl in Île-de-France**



Since its creation in 1995, this tool has become widely established in French municipalities identified as "at risk" by the public authorities: in 2011, over two-thirds of a target of 12 500 municipalities were covered by an approved PPR, and a PPR was prescribed

or in preparation in a further 3 800 municipalities (AScA, Ledoux Consultants, 2012). This tool has therefore been successful to some extent, even if the criteria chosen for whether to prescribe a PPR or not could be improved (Gerin et al., 2012). It seems to be broadly agreed, however, that it is ineffective in genuinely reducing risks.

The PPR is thus often the result of political negotiations between local authorities, the prefect and state technical departments (Grislain-Letrémy et al., 2012). It is therefore difficult for the state to impose a PPR that a local authority does not want (Conseil d'État, 2010). Following the dramatic flooding of the Var as well as that on the Atlantic coast (cyclone Xynthia) in 2010, the Court of Auditors highlighted the shortcomings of this system, concluding that: "Faced with a real thirst to build, generally fostered by local elected councillors, the state has not often shown sufficient determination at departmental level to prevent building in at-risk areas." The lack of procedures ensuring compliance with measures stipulated by PPRs is also underscored.

Flood risk prevention plans in Île-de-France

In the specific case of Île-de-France, notably the metropolitan area, the PPR mechanism is not very effective in reducing the vulnerability to flooding. The PPRs were prescribed for all municipalities at risk of flooding of the Seine, a very large majority of which were approved between 2000 and 2010. The Île-de-France PPRs are departmental in scope, which allows coherent planning at that level but offers no guarantees as to the risk basin as a whole. The PPRs for different departments therefore define areas differently according to the hazard and assets involved and use a very wide range of colour coding to characterise them. This does not provide a clear overview of the at-risk area for establishing a coherent regional approach (Table 3.2); building regulations in each area also vary widely.

Moreover, the different PPRs relating to flooding of the Seine – and the Marne – in Île-de-France are not very ambitious. Very few areas are classified as very high risk because of the slow kinetics of flooding. There are therefore virtually no areas where construction is prohibited in the departments in the inner suburbs. In addition, these documents have little impact on the existing building stock, which is largely in the majority in Île-de-France. Finally, the building regulations in the PPR areas are generally not very restrictive, often merely defining the height of the first floor and the total building area percentage, and they do not impose specific regulations on network operators either (except in Paris).

In its study on urbanisation in the floodplains, the IAU noted that the respective exposed population increased significantly from 1999 to 2006 (+5.9%), with a growth rate slightly above the regional average (+5.3%). Some 80% of this human development occurred in the inner suburbs where departments had established PPRs from 2000 onwards, mostly in high hazard areas (IAU, 2011). A substantial proportion of the population of many municipalities subject to a PPR is therefore located in the floodplains, and this proportion is increasing, despite the declared intention to limit urban density in such areas (Figure 3.2). In the past 20 years, 1 500 ha have thus been developed in the floodplains, and the last major hospital built in Paris, which opened in 2001, and the future headquarters of the French Army are situated in the heart of the Paris district most exposed to the risk of flooding.

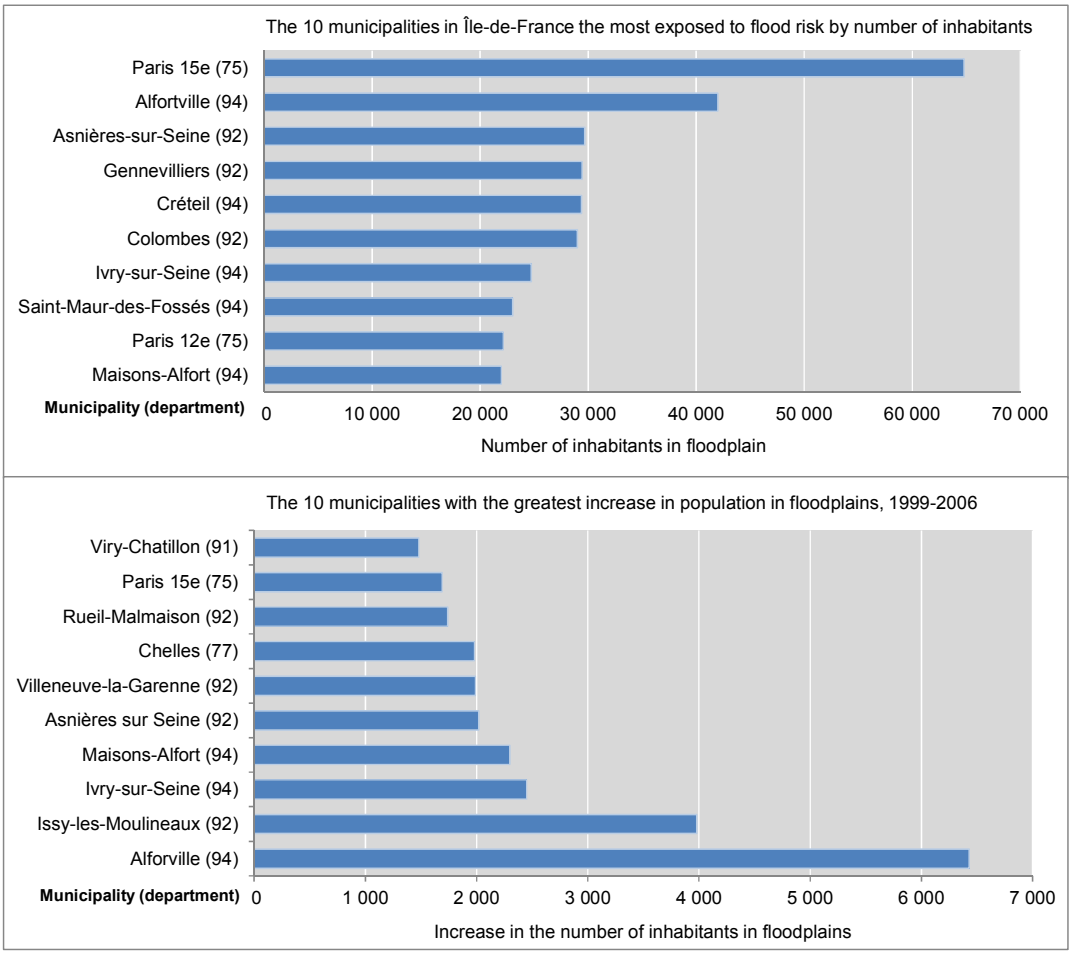
Table 3.2. **Risk prevention plans in departments in the inner suburbs of Île-de-France**

Department	Municipalities	Date prescribed	Dates approved/ revised	Description of areas defined by the regulation
75	1	1998	2003, revised in 2007	Green: flood retention areas Red: principal run-off area Dark blue: high hazard urban areas Light blue: urban areas in floodplain
92	18	1998	2004	Red: high hazard or high storage capacity areas Blue: urban centres Orange: dense urban areas Purple: areas of urban change
93	9	1999	2007 (Seine) 2010 (Marne)	Red: flood retention areas Orange: very high hazard urban area Yellow: high hazard urban area Green: urban centres
94	24	1998	2000, revised in 2007	Red: high run-off areas Green: flood retention areas Dark orange: other high to very high hazard urban areas Light orange: other moderate hazard urban areas Dark purple: high to very high hazard dense urban areas Light purple: areas situated in a moderate hazard area Blue: urban centres
77	8 (Marne) 21 (Seine)	1996/ 1999	2002 (Seine) 2007/09 (Marne)	Red: very high hazard areas Brown: natural or weakly urbanised areas Dark yellow: high storage capacity natural areas Light yellow: weakly urbanised areas Dark blue: densely urbanised areas Light blue: lower risk densely urbanised areas Green: "extremely important" urban centres for the conurbation Grey: sectors to which access is subject to high to very high hazards
78	57	1998	1998, revised in 2007	Brown: major run-off areas Green: non-/not very built-up areas – moderate to very high hazard Dark red: urban centres and urban areas – very high hazard Light red: built-up areas outside urban centres – high hazard Blue: urban centres – high hazard, other urban areas – moderate hazard, highly important areas – moderate to high hazard
91	18	1996	2003[1]	Red: non-built-up areas – high to very high hazard urban areas (urban centre or other) – very high hazard Orange: non-built-up areas – average hazard Blue: urban areas other than urban centres – high hazard Sky blue: urban areas other than urban centres – average hazard Green: urban areas in urban centres – average to high hazard
95	22	1998	1998 (Oise), revised in 2007 1999/2000/2002 (Seine)	Red: urban areas – high hazard Blue: urban areas – average hazard Yellow: sectors identified for facilities of general interest Green: flood retention areas Turquoise: sectors located above the reference flood

Notes: 1. Plan applied in advance in 13 municipalities, expiring in 2005; the moderate to high hazard corresponds to 0-1 metre submersion, high hazard at 1-2 metres submersion and very high hazard greater than 2 metres submersion.

Sources: Préfecture de la Seine-Saint-Denis (2007), *Plan de prévention du risque inondation de la Seine dans le département de la Seine-Saint-Denis: Règlement*; Préfecture de la Seine-Saint-Denis (2010), *Plan de prévention du risque inondation de la Marne dans le département de la Seine-Saint-Denis: Règlement*; Préfecture du Val-de-Marne (2007), *Plan de prévention du risque inondation de la Marne et de la Seine dans le département du Val-de-Marne: Règlement*; Préfecture de Paris (2007), *Plan de prévention des risques d'inondation du département de Paris révisé: Règlement*; Préfecture des Hauts-de-Seine (2004), *Plan de prévention des risques d'inondation de la Seine dans les Hauts-de-Seine: Règlement*; Val d'Oise, Yvelines, Seine-et-Marne and Essonne Prefectures.

Figure 3.2. **Population in floodplains and its growth, 1999-2006**



Source: IAU (2011), "Urbanisation et zones inondables: Les risques encourus", *Note rapide territoires*, No. 557, Institut d'Aménagement et d'Urbanisme, Paris, www.iau-idf.fr/fileadmin/Etudes/etude_839/NR_557_web.pdf.

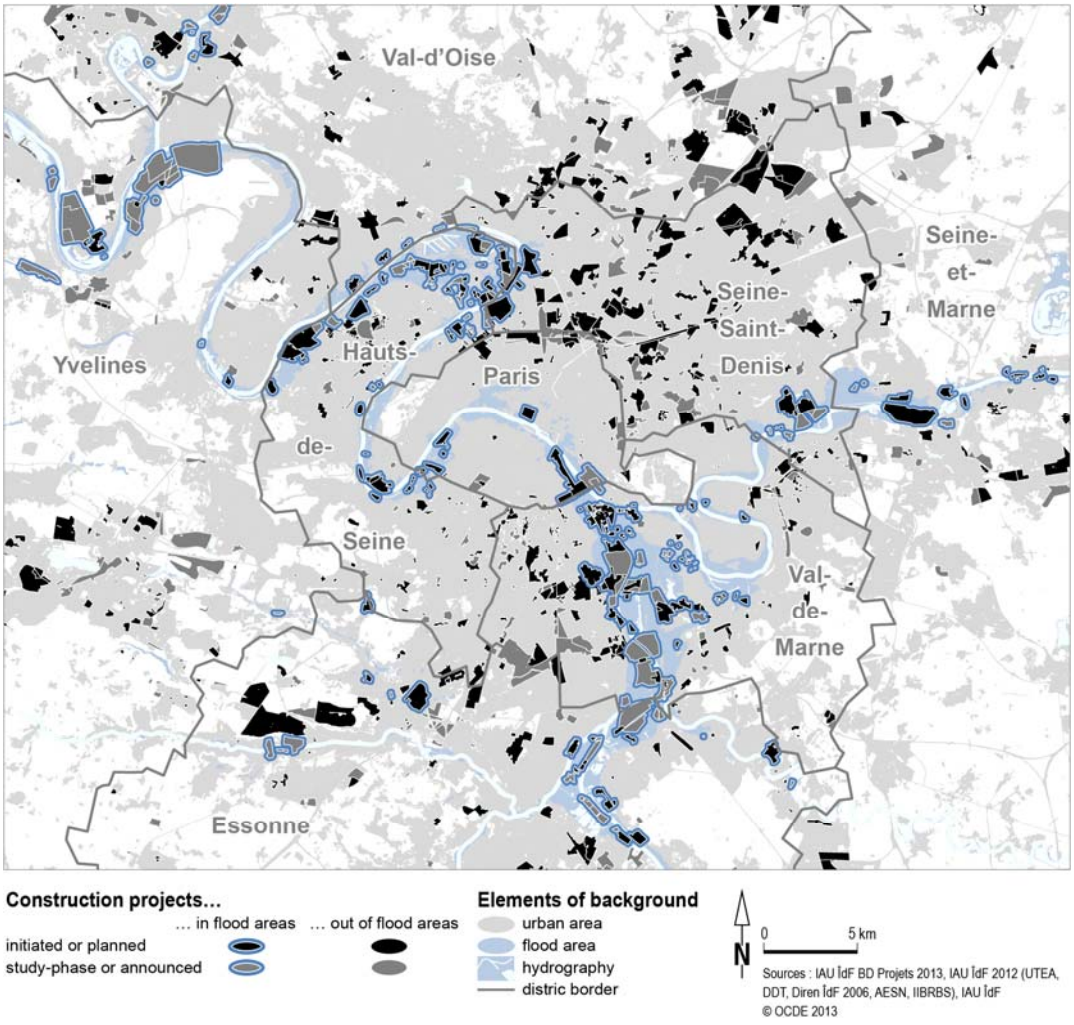
Rather than encouraging municipalities to limit building in floodplains, local development dynamics encourage them to develop these often attractive areas. In their eyes, taking a major flood risk into consideration is counter-productive because it is detrimental to economic development (and therefore local taxation), does not win votes like social infrastructure can, does not necessarily correspond to the demands of the electorate and requires technical capacities which most of the 141 relevant municipalities in Île-de-France do not have. This paradox means that the cost of land is dissociated from its exposure to the risk, with many municipalities with high property prices being situated in floodplains (Reghezza, 2006). Numerous planning projects in floodplains in Île-de-France are therefore in progress, scheduled or under study (Figure 3.3).

The opportunity for Greater Paris to become resilient

The Greater Paris project seeks to respond to the major development challenges facing the Île-de-France metropolitan area. Improving citizens' welfare, attracting business and combating climate change are the foundations for this innovative and green growth-based project (OECD, 2010). Specifically, the project aims to develop a major

public transport network around which high-density poles will form. The construction of 70 000 additional dwellings per year is accordingly envisaged, with an investment of around EUR 30 billion in public transport by 2030.

Figure 3.3. **Planning projects in floodplains**



The Greater Paris project represents an opportunity to take resilience into account in conurbation-wide urban renewal, development and infrastructure projects, since the local implementation of national risk prevention policy via the PPRs has not proven to be effective in Île-de-France. Many of the regional development poles being created are, in fact, situated in floodplains. The list of territorial development contracts – programming and planning tools that seek to achieve the objectives of the Greater Paris project in the regions – is illustrative in this respect. In October 2013, out of the 21 such contracts entered into or under study, 13 were affected by the risk of flooding of the Seine or Marne and are often situated in particularly exposed areas (e.g. Sénart in Seine-et-Marne, Les Grandes Ardoines in Val-de-Marne, La Boucle Nord des Hauts-de-Seine or the Seine-Oise confluence between the Yvelines and the Val d'Oise). Signed between the state and local authorities, these contractual instruments can act as powerful levers for incorporating urban resilience issues and the various environmental objectives: sustainable cities, "soft" densification and the battle against climate change.

To date, flooding of the Seine has not been a factor in the selection criteria for the Greater Paris project, neither in the choice of areas to be expanded nor the location of transport network stations. The expansion envisaged in floodplains should thus be accompanied by measures to reduce the vulnerability of these new districts so as to not increase the conurbation's already high risk level. A proactive approach must therefore be adopted which goes beyond the PPRs. In a context in which the urban fabric does not put vulnerability to flooding in the forefront of planning processes and does not establish objectives, public decision makers and developers ultimately plan solely on the basis of regulatory aspects such as the PPRs, which are often incorporated as a secondary constraint.

River-based innovation

Innovative approaches to urban and architectural design will ensure that resilience and flooding are no longer perceived solely as constraints. Contrary to developments in other OECD countries (Box 3.4), resilience has not yet become a source of innovation in France for design offices or urban development and architectural consultants, as other regulatory constraints on energy, air and water quality or noise have, for example (EPTB Seine Grands Lacs, 2010a). Little consideration has been given to this subject in France.

Box 3.4. **Development of a resilient district in Mayence, Germany**

The German *Land* of Rhineland-Palatinate has 4 million inhabitants, with many towns built in river valleys. The town of Mayence is situated on the banks of the Rhine, downstream of the confluence with the River Main, with Frankfurt further upstream. The redevelopment of two old port districts in this region, Zollhafen and Westhafen, demonstrate the potential for innovative construction in floodplains. In Mayence, Zollhafen is one of the largest container ports on the upper Rhine. In this district where spatially oriented approaches are evolving, the municipality planned the development of a new "town on the river", with 2 500 inhabitants and 4 000 jobs. The Rhine is the largest river in Western Europe, with a discharge that can reach 8 000 m^3/s and a recurrence interval of 200 years at Mayence. Because of its location on a floodplain and outside the defences of the town of Mayence, Zollhafen is flooded during 100-year Rhine floods. The redevelopment was therefore designed to resist floods by means of adapted buildings.

The master plan established binding density and spatial organisation conditions. Ground levels for new buildings must be built at 1.20 m and 1.50 m above the flood level of a 100-year flood. The infrastructure thus remains operational up to at least 200 years. Protection is ensured for existing buildings for a 100-year flood by temporary "retrofit" systems. Different scenarios have been developed: with a 100-year flood, the water is contained and no streets will be flooded; when the recurrence interval is 200 years, some streets will be flooded, but most of the main roads will be saved because their level has been designed to maintain access; for a 200-year flood and an additional 50 cm, corresponding to the extreme level of protection of the town of Mayence, Zollhafen's streets will be flooded, but the buildings will not be affected.

In Germany, building on floodplains was generally prohibited by a federal law in 2005. There are only a few exceptions to the rule, notably the conversion of port cities, when a special application for a building permit must be completed for the regional office of the Ministry of the Environment. The ministry is also currently co-operating with the municipality of Mayence to develop and promote Zollhafen as a model flood-adapted development project.

Source: Webler, H. (2010), "Redevelopment of the Zollhafen Mainz as flood resilient development", IAHR European Congress Edinburgh, 5 May 2010, http://web.sbe.hw.ac.uk/staffprofiles/bdgsa/IAHR_2010_European_Congress/Papers%20by%20session%20final/Flood%20Resilient%20Cities/FRCa.pdf.

At the beginning of the Greater Paris project, ten teams of architects were invited to propose a vision of Greater Paris in an international competition. While the Seine River was one of the subjects for consideration, only foreign teams provided ambitious proposals covering flooding, while only one French team out of the six in competition referred to the subject. These teams nevertheless often made reference to reclaiming the course of the Seine as a driver of development and planning, based particularly on the "blue network" concept. During and as a complement to the "green network", which links green spaces as a continuation of the city towards its rural periphery, the blue network seeks to reconnect the different water areas to incorporate them into an overall plan. Many river and bank enhancement projects have thus been initiated in Île-de-France by municipalities along the Seine, Marne or Oise (IAU, 2013b).

A strong political will and innovation support and dissemination mechanisms should accompany such moves, so that reinforcing a river culture is reflected in flood resilience projects. The dynamics of projects and the development of this culture among elected councillors, the public and developers create the conditions to foster such projects. Many urban renewal projects in floodplains will release spaces for developing resilient districts. The development of the Ardoines district beside the Seine in Val-de-Marne, under the Orly-Rungis Seine Amont Public Development Authority (*Établissement Public d'Aménagement d'Orly-Rungis Seine Amont*, EPAORSA), may serve as a guiding example and ambitious demonstrator, if it fulfils its aim to keep flooding issues at its heart (Box 3.5).

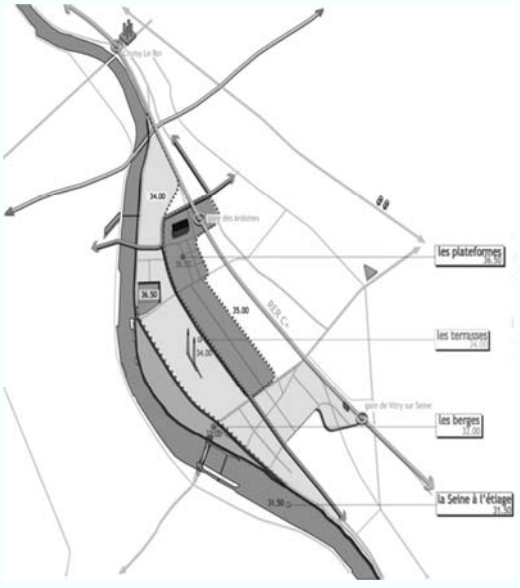
Box 3.5. **Model resilience in the Ardoines district**

Flood resilience is at the heart of the Ardoines urban renewal project in Vitry-sur-Seine, which is heavily exposed to this risk. This plan to build 13 000 dwellings and create 45 000 jobs in the area covered by the Orly-Rungis Seine Amont Public Development Authority (EPAORSA) is driven directly by the state as a measure of national interest. The EPAORSA wanted this urban project to incorporate flood resilience. Once it has been carried out, it will then serve as an ambitious demonstration of innovation in resilience measures.

A guideline plan was produced in 2009 which divided the planning district into three terraced areas:

- a 10-ha public park beside the Seine built by excavating the banks, which five-year floods would overflow
- an intermediate terrace which would accommodate low-density habitats and activities according to a flood-resilient design, with a 50-year protection level
- an upper platform where strategic activities and public infrastructure and facilities would be protected against the most severe flooding.

This ambitious approach has been undermined because of the cost of terracing and operational difficulties. The project is now geared more towards factoring in building resilience objectives and maintaining operations during flooding via an off-water communication network.



Source: Brun, A. and F. Adisson (2011), "Urban renewal and flood risk: The masterplan 'Seine Ardoines'", *Cybergeo: European Journal of Geography* [online], Regional and Urban Planning, Document 561, 29 October 2011, available at: http://cybergeo.revues.org/24751.

Resilience of metropolitan systems and functionalities: Critical networks, businesses, public services

A resilience approach must also include stakeholders who make the metropolitan system work: network operators, businesses and public services. Beyond the region and the building stock, the concept of resilience is based on the notion of the system: this is a matter not only of limiting the impact of a shock but also of rapidly restoring system functionalities. In this respect, urban resilience includes both vulnerability reduction and business continuity measures, in combination with crisis management. Approaches differ significantly according to the stakeholders, in line with the regulations and their own perception of the level of risk.

Critical network resilience and continuity

Urban networks and the critical operators who structure the metropolis and enable it to function (electricity, water, telecommunications, transport) are of particular concern. Their own flood resilience is crucial to that of the metropolitan area as a whole.

In Île-de-France, the resilience or continuity of the activity of critical network operators depends on a variety of regulatory instruments. The 2004 Law on the Modernisation of Civil Security requires stakeholders to ensure public service continuity. Most of these operators have also been identified as crucial to the implementation of the 2006 decree on vitally important activities. Risk analysis-based special protection plans must be put in place. Although the law initially focused on the risk of terrorism, the operators it designates must address all risks in their protection plans, including a major flood of the Seine. The Paris PPR also provides for bodies with a public service remit to draft flood protection plans (*plans de protection contre les inondations*, PPCI) for all establishments situated in floodplains. This also concerns many network operators such as the RATP (*Régie Autonome des Transports Parisiens*, the French state-owned public transport operator in Paris) or waste, district heating and water managers. Finally, specific contractual obligations can be included in delegated contracts. Despite the existing regulatory or contractual context, it seems that standards for a rapid resumption of activity are not sufficiently high in the event of major flooding of the Seine. Thus, while these various instruments exist, they lack a precise standard and overarching harmonisation that would define the required resilience and protection levels and measure them with predetermined indicators (Box 3.6).

Crisis management work carried out in connection with the Paris Defence and Security Zone has helped to raise the awareness of stakeholders and encourage them to assess their vulnerabilities and the knock-on effects they may have for other sectors of activity. Major flood risk assessment, preparation and resilience, however, continue to be highly diverse (Box 3.7). Some have a precise assessment of the impact of different flood scenarios, have developed business continuity plans and have sometimes even invested substantially to reduce their vulnerability (including by relocating). Others have meanwhile made less effort, or are reluctant to share the information they have so that each party involved can make preparations. In these circumstances, it is important to maintain momentum with respect to crisis management under the auspices of the Paris Defence and Security Zone so that it can continue to ensure that structural networks are more resilient. Public authority support could be ensured by establishing metropolitan-wide standards, regulatory measures and incentives.

Box 3.6. **Defining a network resilience indicator as a city resilience indicator**

In their work on network resilience, a team of researchers from the School of Engineering in Paris proposes to define an urban network resilience indicator as a basis for a city resilience indicator. In this analysis, the risk facing technical networks is threefold: material, functional and structural. A resilience indicator has been developed by aggregating three indicators for these three risks:

- the material resilience indicator includes damage incurred by the network, or a damage percentage for example
- the functional resilience indicator refers to the possibility that the network's degraded functions can be fully restored, e.g. by assessing available resources (financial, material and human) in relation to the possible damage
- the structural resilience indicator represents the network's capacity to function while damaged or to propose alternatives, such as a calculation of network redundancy.

A network resilience indicator may thus be defined at the level of the city's different districts and may be compared to the challenges with the help of a GIS, thus enabling a city resilience index to be defined by district and globally making it possible to assess the risk beyond the floodplain and to better target resilience enhancement measures.

Source: Lhomme, S. et al. (2010), "Les réseaux techniques face aux inondations ou comment définir des indicateurs de performance de ces réseaux pour évaluer la résilience urbaine", *Bulletin de l'Association des géographes français*, https://hal.archives-ouvertes.fr/hal-00580025.

Box 3.7. **Network operator resilience measures**

- Transport: the RATP has clearly identified the 446 possible water entry points in its metropolitan transport network and has produced an action and sealing plan within its flood protection plan. It also includes flood risk mitigation in its modernisation work. The SNCF has a protection scheme for its stations but is less well prepared in protecting its network.
- Water: in addition to an emergency plan to supply the metropolis with drinking water, water operators have invested in measures to protect their drinking water production facilities which are located in floodplains. Specific flood protection mechanisms have been introduced (removable protection, pumps). It should nevertheless be noted that resilience levels are not equal at metropolitan area level, with some operators having to interrupt services at a level lower than others.
- Electricity: electricity network vulnerabilities are clearly identified by the operator and efforts have been made to mitigate them. These appear to be too limited to meet the challenges, however, since the electricity network is particularly crucial to the overall resilience of the capital (Chapter 1). To the extent that the investment to be made to meet the risk is particularly significant, the operator favours a crisis management approach while including the "flood" criterion to ensure that investment develops to protect the network in the long term.
- Telecommunications: competition among different operators makes transparency with respect to resilience levels, available resources and investment in this sector more problematic. Orange, a French telecommunications operator, nevertheless seems to be well-prepared for the risk of flooding. It can function independently of the electricity network by using its own generators, thanks to which it can cover 98% of the region. Orange has furthermore relocated its data centres outside the floodplain. This operator's awareness-raising and preparation could serve as a model for other sectors.

Source: Interviews carried out by the OECD Secretariat during the peer review, 2013.

It is also useful to invest in network resilience from the design stage. Thus, while certain stations in the Greater Paris network have been established in floodplains, ensuring that this new critical network enjoys a high level of flood protection is an opportunity to contribute towards metropolitan area resilience through a network that functions in the event of flooding. Substantial investment in the other structural networks (water, electricity, telecommunications) linked to renewal or to the development of new technology (e.g. intelligent networks in the electricity sector) enables stress to be laid on this notion of flood risk resilience in the context of a global strategy. Such a strategy could also favour the development of multi-network passageways such as those in Prague in the Czech Republic (Sternadel, 2008). These passageways housing all the critical networks allow functions to be restored more quickly after flooding by avoiding work on the surface.

Public service resilience

Efforts to ensure public service resilience and continuity appear to be limited and highly variable according to the level of government. At state level, activity continuity plans must be developed in all ministries under the auspices of the General Secretariat for Defence and National Security (*Secrétariat Général à la Défense et à la Sécurité Nationale*, SGDSN), while via the SGZDSP, Police Headquarters organises crisis management under the ORSEC mechanism (Chapter 1). However, reducing the vulnerability of the numerous facilities and buildings in floodplains and the operations of the various public services that depend on them in the event of flooding is far from ensured.

Assessments have been carried out by risk-aware local authorities, such as the local councils in the inner suburbs and in the City of Paris. These represent the first phase in the development of business continuity plans (*plans de continuité d'activité*, PCAs), which are still under consideration. The Hauts-de-Seine General Council has examined the vulnerability of the public institutions for which it is responsible: vulnerability assessments have given rise to the development of vulnerability reduction plans for 41 of the department's sites, notably education institutions. Work to adapt or upgrade facilities has thus been decided in this context. Assessments in the Val-de-Marne have also enabled certain vulnerability reduction measures to be taken to ensure greater resilience. Provision is made in the City of Paris' PPR drawn up in 2007 for a special PPCI to be developed for the 900 public facilities situated in floodplains, including both prevention measures to reduce vulnerability and activity continuity measures. While this appears to be particularly ambitious, its implementation has not as yet been fully effective. The production of a guide by the Regional and Inter-departmental Directorate for Infrastructure and Development (*Direction Régionale et Interdépartementale de l'Équipement et de l'Aménagement*, DRIEA) in 2012 seeks to increase the pace of their development (DRIEA, 2012).

At municipal level, public service and infrastructure resilience measures are limited, as shown by the weak development of the local emergency response plans (*plan communal de sauvegarde*, PCS) prescribed under the PPRs since the 2004 Law to Modernise Civil Security. In 2013, for example, less than 40% of districts in Île-de-France exposed to the risk of flooding had implemented a PCS. Reflecting the low awareness and low flood risk culture at municipal level, flood risk resilience and public service continuity are limited here. The draft PAPI ensured by the EPTB Seine Grands Lacs provides for a broad range of activities in this domain.

Box 3.8. **Heritage and flooding: Transfer of museum reserve stocks**

Public buildings in floodplains include a considerable number of museums of heritage or cultural value which are intangible assets whose loss or damage is inestimable (Chapter 1). The awareness of the public authorities towards the risk of flooding of the Seine for the Louvre's reserve stocks thus led the Ministry of Culture to decide, in September 2013, to transfer them to Louvre-Lens in northern France. Tests on the Louvre's contingency plan in fact showed that the 72-hour time limit provided for in the plan was not sufficient to transfer the reserves located in floodplains.

By contrast, the more recently built National Library of France and the Quai Branly Museum, whose reserve stocks are stored in basements along the Seine, were designed with tanked basements. A 5-metre thick concrete wall protects the reserve stocks of the National Library of France from flooding of the Seine. The reserves are therefore protected by a supplementary cost to be charged to flood risk prevention. However, this type of solution may also help to increase the risk of flooding in neighbouring buildings and structures in the event of rising water levels.

Source: Blue Shield, interview carried out by the OECD.

Business continuity

The commitment of private-sector businesses to improving their own resilience appears to be linked to their scale or sector. The private sector, particularly large enterprises, is increasingly driven by the markets to take account of its risk exposure, the possible impact on its business plan and measures likely to mitigate risks. Risk awareness in the banking and insurance sectors is rather well established. In 2010, the Bank of France organised a market test within the financial community in Paris to test the flood resilience of institutions' critical processes, while Crédit Agricole has developed clear emergency measures which enable the bank to function with a reduced staff in a flood-protected building. AXA also has a business continuity plan and is reconsidering the location of certain strategic activities. In the hotel sector, the ACCOR group, with 55 hotels in floodplains, is also well informed as to the risk of flooding. The group has invested in developing a business continuity strategy and in broad insurance coverage. These approaches could set an example for other businesses.

While some major businesses have now developed or are currently developing their own flood risk prevention and management strategies in line with the regulations and the regulatory authorities (banks, telecommunications), SMEs as a whole remain highly vulnerable and ill-prepared. As for the building stock in Île-de-France, there is no specific public policy instrument to encourage or regulate SME resilience to the risk of flooding of the Seine. The CCI Paris and the respective professional associations can play a key role here by assessing business vulnerability beyond the pilot experiments already carried out, based on the example of the Loire basin (Box 3.9). Experience in business districts or future Greater Paris development areas, for example, may also draw on initiatives to enhance resilience applied in the La Défense business district, which is itself heavily exposed. The concerns of large businesses in La Défense regarding the reality of the economic impacts of major flooding of the Seine and the existence of a structure bringing them together to take issues of common interest forward (Defacto) have enabled this initiative to be launched.

Box 3.9. Assessment of business vulnerability in the Loire basin

In the Loire basin, a flood risk prevention programme for businesses undertaken by the Loire River Basin Authority (*Établissement Public Loire*, EP Loire) recently helped to provide information to over 15 000 businesses, despite the difficult economic and financial circumstances. Based mainly on a free vulnerability assessment of businesses located in floodplains, the objective of this "industrial-scale" measure was to reduce the vulnerability of economic activities in the Loire basin and its tributaries to the risk of significant flooding by preserving the vital interests of businesses against a major flood in the Loire catchment area.

This assessment is a useful aid to business decision making in view of that objective: over 15 000 businesses were made aware of the risk of flooding and 2 000 vulnerability assessments were requested by businesses, 1 812 of which had already been carried out or were in progress in 2012. The assessment involves an on-site analysis and the delivery of a report identifying vulnerabilities and establishing a hierarchy according to their gravity and an estimate of potential losses. Businesses that have shown an interest in a vulnerability assessment are then given support in assessing their interest in implementing a range of effective measures to reduce vulnerability, together with an estimate of the cost. In certain cases, the measures recommended may even be co-funded. Some 280 businesses were monitored in this way in 2011, 21 of which received financial support.

Source: Établissement Public Loire (2012), *Rapport d'activité 2012*, Établissement Public Loire, Orléans, France.

Addressing the flood hazard to reduce the risk

Structural and technical measures to control the flood hazard and its variability are usually among the options available for reducing the risk of flooding. Many countries rely on civil engineering work to modify river flows by means of dams and channel them by means of dykes and walls to protect potentially exposed assets. Dynamic flood slowing and flood retention area conservation are new environmental engineering approaches which enable the hazard to be reduced while preserving the environment. Following the 1910 flood, the Picard Commission, set up to assess the crisis and make recommendations for improvements, proposed a number of protection measures that were developed during the 20th century: the bed of the Seine was deepened, bridges in Paris were heightened, dykes and walls were built along the river and four reservoirs were created upstream. The continued growth of the assets exposed to flooding of the Seine in Île-de-France has now raised questions as to the advisable level of protection for this region and the means to achieve it.

Local protection

Flood protection levels are not consistent throughout the Paris conurbation and do not ensure equal protection of the public. The flood protection levels reflect historic strata that no longer corresponds to contemporary urban and industrial density. Thus, while local flood defences (dykes and walls) have been built along the Seine and Marne, they do not cover all of the current built-up areas, particularly in the north and south of the Val-de-Marne and the north and west of the Hauts-de-Seine (Figure 3.4). What is more, these facilities are not scaled at the same level: the City of Paris is protected against a 1910-type flood, while the neighbouring departments of the Hauts-de-Seine and the Val-de-Marne are only protected against a 1924-type flood, which is almost 1.5 metres lower (Table 3.3). These areas were not heavily developed in 1936 when the state began

to build these defences. In terms of current urbanisation, this difference in protection levels raises concerns regarding the economic assets now exposed.

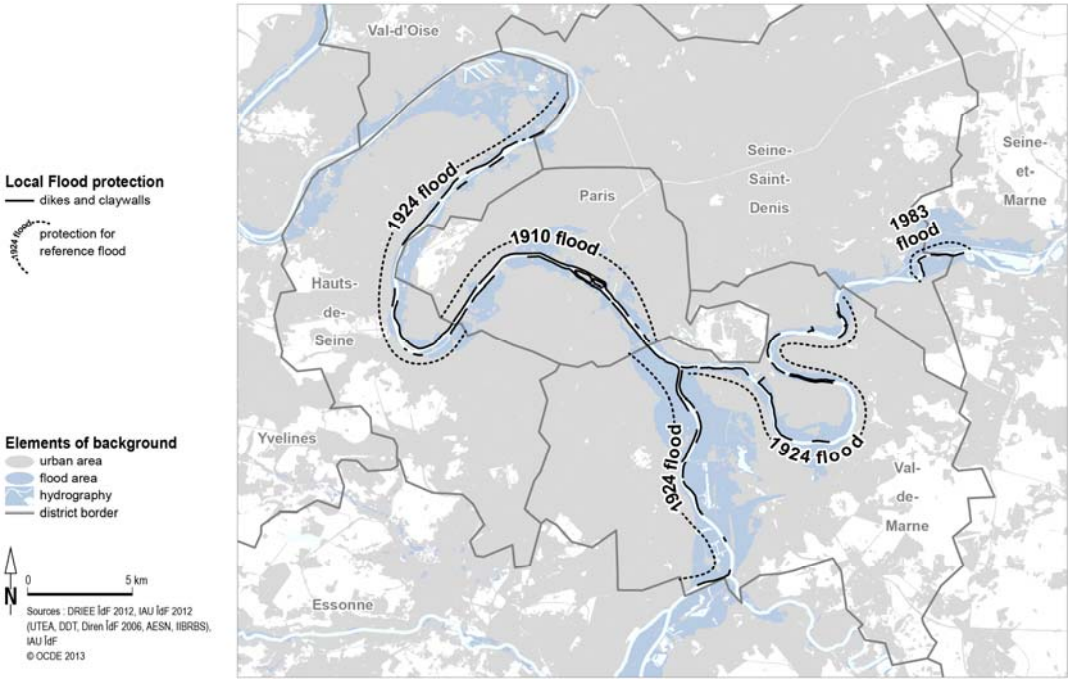
Table 3.3. **Local flood defences in Île-de-France**

River valley concerned	Theoretical protection level	
	Historic flood level	Flood recurrence interval
Seine in departments 77, 78, 91	1955[1]	30 years
Seine in departments 92, 93, 94 ; Marne in department 94	1924	30 years
Seine in Paris	1910	100 years
Marne in departments 77 and 93	1970	8 years
Oise	1926	40 years

Note: 1. In the departments 77, 78 and 91, the defences do not continue along the watercourses and their level of protection is different and therefore not global.

Sources: DRIEE (2013), "Cartographie des zones inondables et des risques d'inondation du TRI Métropole Francilienne, projet de rapport explicative", Direction Régionale et Interdépartementale de l'Environnement et de l'Énergie d'Île-de-France, Paris, www.driee.ile-de-france.developpement-durable.gouv.fr/IMG/pdf/Rapport_accompagnement_IDF_VF_cle03163c.pdf (accessed in November 2013); Roche, P.-A. (2004), "The Seine river flooding in the Île-de-France region: What account is taken of climate change in the decision-making process?", OECD Global Forum on Sustainable Development, Paris, 11-12 November 2004, www.oecd.org/env/cc/33995401.pdf.

Figure 3.4. **Location of dykes and walls in Île-de-France**



The upkeep and maintenance of this protection infrastructure was rather neglected in the past. In the absence of major flooding for almost 60 years, dykes and walls have gradually been perceived more as obstacles to the development of river-based activities, and local residents have created openings in them. What is more, the effectiveness of cofferdam-type structures in closing these gaps in the event of flooding is uneven and

does not guarantee that these defences can play their full role in response to a crisis. By way of illustration, 450 gaps have been counted in the walls in the Val-de-Marne.

The state has reinforced flood defence regulations following recent disasters that have sometimes highlighted design or maintenance defects in these structures. Flood protection mechanisms became a national issue after a succession of breaches of dykes and deadly coastal flooding: flooding in the Camargue in 1993 and 1994, the Gard floods in 2002 and, more recently, cyclone Xynthia in 2010 underscored the inadequacy of existing defences (AScA, Ledoux Consultants, 2012). In response to these shortcomings, Decree 2007-1735 issued by the Ministry of Ecology on 11 December 2007 established state surveying and classification of dykes according to their height and the number of persons protected. The decree defines studies, checks and assessments for each class and sets frequencies for them, as well as potential improvement and restoration work to be carried out by the responsible authorities. Hazard studies, which describe the risks to which defences are exposed and identify means of prevention and protection to mitigate them, must also be carried out on class A, B and C dykes. A national dyke restoration programme was also introduced in 2010 following the Xynthia and Var floods: the rapid flooding plan (*plan submersions rapides*, PSR) provides for works managers to assess projects and establishes an associated funding programme (Chapter 2).

A drive to assess and rehabilitate flood defences was initiated in the departments in the inner suburbs from 2007, albeit unevenly because of differing priorities and resources among the local councils responsible for them. The DRIEE is responsible for controlling this process and for ensuring that resources are correctly allocated via the studies and the work carried out. The department of the Val-de-Marne, which manages 30 kilometres of protection walls along the Seine and Marne, is currently carrying out a hazard study. In Paris, quay walls are currently being surveyed and classified. In order to complete these fixed structures, which have already been significantly heightened, Paris has invested in a system of removable devices, mainly in the form of cofferdams. These are checked regularly by means of annual exercises. Safety assessments and hazard studies for certain facilities will soon be carried out. In the Hauts-de-Seine, the survey and classification process has been completed and the hazard study will soon be undertaken. A multi-annual programme to rehabilitate floodwalls, including the replacement of old cofferdams by new easier-to-handle aluminium equipment has been introduced. The department of Seine-Saint-Denis is planning to take measures to reduce the vulnerability of defences under the PAPI project currently in progress. The measures referred to above to reappropriate the river banks in order to develop a resilient metropolis along the course of the Seine provide synergies when they are designed to take flood protection into account. This applies, for example, in the Hauts-de-Seine with its planning and sustainable management scheme for the banks of the Seine.

While these local defences can play a key role in protecting assets exposed to flooding, the lack of harmonisation and the governance deficit linked to the vast range of project management structures involved is not conducive to a coherent approach. It is therefore difficult to obtain a clear view of the actual level of protection, both in terms of real coverage, the condition of the infrastructure and the solidity of the banks supporting it. Similarly, the lack of a common risk basin or nationwide protection standard does not allow the level of investment required to be defined, as it is in other OECD countries (Box 3.10). The completion of hazard studies scheduled for late 2014 will provide a precise overview of the position. A technical, financial and legal feasibility assessment to standardise these defences in Île-de-France as a whole was proposed in the PAPI project undertaken by the EPTB Seine Grands Lacs.

Box 3.10. **Level of protection in the Netherlands and Norway**

Following the major sea surge in the Netherlands in 1953, many flood risk analyses were carried out to reinforce the protection of the country's coastal and catchment areas. The level of acceptable risk was determined with reference to a 100 000-year flood. This level of acceptable risk was then converted into a reference hazard, calculated with a recurrence interval of 10 000 years for some provinces in mid-Holland, northern Holland and Utrecht, since these areas were below sea level, in some cases by up to 6 metres. Based on this risk assessment method, legally established enhanced protection levels were defined for all coastal areas. For low population density areas along the coast, the recurrence interval considered for an event is 4 000 years. Along rivers, the reference hazard corresponds to a recurrence interval of 1 250 years, while for areas exposed to a combined river and sea risk, the recurrence period is defined at 2 000 years. The dykes intended to ensure protection for inhabitants along the Meuse will be scaled in 2015 for a 250-year event. The urban and industrial districts in the unprotected area are generally higher in relation to the level of the dykes or are required to adopt adapted construction principles.

Flood protection standards in Norway

Types of assets	Protection level recurrence interval	
	Risk of loss of human life	Risk of material damage
Sheds, outbuildings	100 years	50 years
Habitat, motorways with alternative routes	1 000 years	100 years
Schools, hospitals, industry, critical infrastructure	>1 000 years	> 200 years

Following major flooding in south-east Norway in 1995, a government commission made several recommendations to reduce future flood losses. Floodplain mapping begun in 1998 enabled flood protection to be improved by defining differentiated protection standards. The level of acceptable risk as defined by the Norwegian Water Resources and Energy Directorate differs according to the type of risk and the type of assets to be protected. Habitat, for example, is protected against a 1 000-year flood if there is a risk of loss of human life, and a 100-year flood if the risk is material. Industry and critical infrastructure are thus protected against floods with a recurrence interval greater than 1 000 years if there is a risk to human life and greater than 200 years if the risk is material.

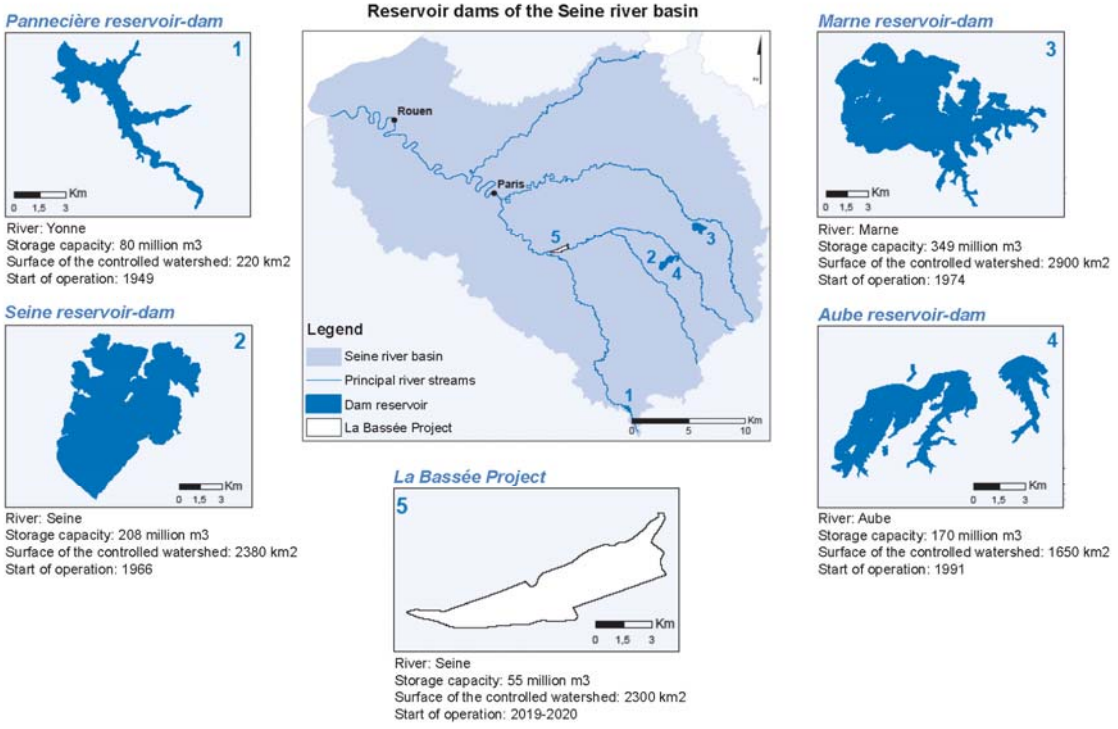
Sources: Dutch Ministry of Infrastructure and Environment (2012), "Le cadre législatif et organisationnel de la gestion du risque d'inondation aux Pays-Bas", audition au Senat du 29 mai 2012; NVE (2009), "Flood inundation maps", Norwegian Water Resources and Energy Directorate, Oslo, www.nve.no/en/Floods-and-landslides/Flood-inundation-maps.

The Grands Lacs de Seine reservoirs

Hazard management is also ensured by reservoirs created upstream of the basin. These facilities, built by diverting the Aube, Marne, Seine and Yonne, control some 17% of the basin as far as Paris (Figure 3.5). They were built gradually between 1949 and 1991, according to a plan defined in 1926 in response to the 1910 and 1924 floods and the droughts in the 1920s. This infrastructure has the capacity to store 805 million m^3 of water – compared to a total volume for the 1910 flood estimated at 3-6 billion m^3 (Roche, 2004) – and would, as a whole, help to lower the water line by 70 cm in the event of major flooding of the Seine with a flow identical to that reached in January 1910. This equates to reducing direct losses from flooding in Île-de-France by half, but is

nevertheless not sufficient to prevent water from submerging local defences in the Hauts-de-Seine and Val-de-Marne.

Figure 3.5. **Storage facilities in the Seine basin**



Source: Central Reinsurance Fund (CCR).

The multi-purpose use of the reservoirs (combating floods/low-water management/leisure) means that the respective rules must be optimised while still ensuring their optimum effectiveness in the event of flooding. Every winter, these facilities dampen low- and medium-level floods and gradually fill up from 1 November to 30 June to be able to ensure low-water management in summer, which forms part of their tasks from 15 June to 15 December. Recurring droughts also contributed to the decision to initiate their construction in 1926. The final two were co-financed by the Seine-Normandy Water Agency on the basis of the latter function. Other uses have also been developed over the years, particularly leisure and tourism around the lakes. This also allows upstream regions to take advantage of this infrastructure and thus contribute to the development of much-needed upstream-downstream water and flood management solidarity. The water regulations for these facilities are defined on the basis of their different uses. They can be adapted according to hydrological conditions on decision of the prefects of the departments in which the dams are located, and in co-ordination with the Prefect of Paris in his capacity as basin co-ordinator, after consulting a technical co-ordination committee. The flood control effect of these facilities may be reduced in two situations: *i)* in the event of successive flooding, since the reservoirs will be full and potentially saturated from the first rains; *ii)* in the event of major flooding at the end of winter, since the reservoirs are generally almost entirely full at the beginning of April. The use of these facilities could be optimised by increasing their storage capacity or improving their emptying capacity.

Box 3.11. **Operational effectiveness of defences during a crisis in Australia**

Floods in Queensland, particularly Brisbane, have demonstrated the importance of ensuring the operational effectiveness of flood risk defences and of regularly reviewing their conditions of use. Hydrologists tasked with investigating the damage caused by flooding in Brisbane, Ipswich, Toowoomba and the Lockyer Valley found that the diversion of water from the saturated Wivenhoe Dam was a crucial factor in floods upstream on 11 and 12 January 2011. According to these specialists, the dam's operational ineffectiveness largely contributed to the scale of flooding in and around Brisbane, which caused considerable damage. Despite the warnings issued by the Australian Bureau of Meteorology concerning the potential power of the La Niña phenomenon, the staff responsible for operating the Wivenhoe Dam did not take any special action to empty the reservoir because its operating conditions did not cover such an eventuality. Ensuring the operational effectiveness of flood defences includes regular reviews of their operating conditions.

Source: Queensland Flood Commission Inquiry (2012), "Final report", Queensland Flood Commission of Inquiry, Brisbane, Australia.

The remit of the EPTB Seine Grands Lacs, which holds and manages these four reservoirs, has gradually expanded to that of a basin-wide organisation. It is responsible for their operational functioning and maintenance and has an annual budget of EUR 10-11 million and 120 staff. Investment costs can vary significantly from year to year, from EUR 6 million in 2010 to EUR 12 million in 2011 and EUR 22 million in 2012, according to the maintenance work required, which will probably increase over the years because of the ageing of the infrastructure (OECD, 2007). The EPTB's budget comes essentially from Paris (50%) and the three inner suburb departments (17% each), as founding members of the institution. Subsidies may come from the state, the Seine-Normandy Water Agency for maintaining the flow during low-water levels, or from EU funds such as the European Regional Development Fund. In 2012, the EPTB Seine Grands Lacs was authorised to charge a new fee for services provided in connection with its low-water management function. This is charged to the main water users, who must pay EUR 0.017 per cubic metre withdrawn in a low-water period. From 2013, the EPTB estimates that it will collect EUR 7.5 million per year via this fee, which will be charged by the Seine-Normandy Water Agency. In addition to this increase in revenue, the remit of the EPTB Seine Grands Lacs is also expanding: it became an EPTB in 2011, which now means that it is a river basin institution for the entire region upstream of Paris, rather than only for the four Île-de-France departments that run facilities in the distant upstream regions solely for the benefit of the Île-de-France conurbation. It also focuses on reducing flood vulnerability, an issue it brings into its area of operations through the PAPI Île-de-France Seine and Marne project which it ensures.

The development of the EPTB Seine Grands Lacs, with its status of a river basin institution whose geographic remit extends upstream and with its new revenue linked to low-water management functions, confirms this body's capacity to operate and maintain its reservoirs. This also raises questions as to the operating rules of the facilities for which it is responsible. Over time, notably in the post-World War II period, it proved possible to construct the Seine reservoirs largely in accordance with recommendations made in the various post-1910 flood reports. In the absence of major flooding since then, the importance of these facilities has been based essentially on their other uses (low-water management, leisure). The remit of the EPTB in relation to low-water management is moreover confirmed by its new right to charge a fee for services provided to major users.

Optimising the management of existing facilities in line with different uses is thus a challenge that must be met on a regular basis, particularly in the light of climate change: prospects for more severe low-water levels could lead to the need to adapt the management rules at the expense of combating floods.

Towards new flood defences?

The EPTB Seine Grands Lacs has proposed a new facility to limit flooding of the Seine in Île-de-France, based on new temporary excess storage measures. Reducing the risk further now requires new approaches to be considered that lay greater stress on environmental preservation. This means reconciling the objectives of achieving a good environmental status for water by 2015 envisaged by the European Water Framework Directive, and preventing flooding by restoring the functioning of water systems. The work carried out following the 1982 floods and up to the beginning of the year 2000 proposed different planning options to reduce the flood peak of the Yonne, which in combination with the peak of the Seine causes the most serious flooding. The EPTB Seine Grands Lacs is thus promoting the La Bassée project (Box 3.12). This has the dual objective of limiting flooding of the Seine and restoring the La Bassée wetlands, the most important in Île-de-France. These wetlands can no longer serve as a buffer zone as they did in 1910 because of the channelling of the river in the 1980s to improve navigability.

Box 3.12. **The La Bassée planning project**

The aim of the La Bassée planning project is to slow flood wave progress by using the last large usable flood retention area to create excess storage basins. Situated upstream of the confluence of the Seine and Yonne, by storing water from the Seine, this area would make it possible to ensure that the flood peaks of these two watercourses do not coincide to create the conditions for major flooding.

The La Bassée area extends over 16 000 hectares and is the most important flood retention area upstream of Paris. This natural function was lost in the 1970s when the Seine was channelled. The aim of the project is to build 19 storage basins for a total volume of 55 million m^3 of water pumped from the Seine. This would make it possible to reduce the level of a 100-year flood in the Paris conurbation by a further 20-30 cm, and to reduce damage in the suburbs of Paris in particular. The project also includes a strong wetlands restoration environmental component.

With an estimated budget of around EUR 600 million, a cost-benefit study estimates that it could have a benefit of around EUR 70 million on average per year (though with high sensitivity to its operating mode in the event of flooding, this result being obtained on the basis of optimum functioning from all perspectives in a crisis). A multi-criteria analysis considering technical, economic and environmental functioning and the impact on habitat and landscape has also been carried out on this project, in comparison with two other hazard mitigation options (multiple damping facilities and a flood control dam on the Yonne).

Source: EPTB Seine Grands Lacs (2011b), "Projet d'aménagement de La Bassée", dossier du maître d'ouvrage, EPTBSeine Grands Lacs, Paris, www.debatpublic-crueseinebassee.org/docs/DMO/Intro/DMOA_la-bassee_1-9.pdf.

The implementation of this innovative project is a promising example in many respects, though it is difficult to persuade decision makers of its merits, particularly at the financial level. The combining of multiple uses (wetland restoration, ecotourism, economic activity), the use of economic assessments via cost-benefit analyses and

comparisons with other options to ensure a multi-criteria analysis and the involvement of local populations upstream through transparent public debate are all part of good practices in OECD countries. Public discussion of the project in 2011-12 fostered by the National Commission for Public Debate (*Commission Nationale du Débat Public*, CNDP) involved the holding of 15 public meetings in the various districts concerned. Some 1 200 people contributed to the debate, and the respective website received 39 300 hits in just over a year. The project did not receive strong support from public decision makers, however, particularly at the financial level. The discussions showed that the risk of flooding is not a priority for certain water and development stakeholders compared to the risk of water shortages. The climate change argument invoked to bring low-water levels into focus amounts to a denial of the fact that, irrespective of such change, the risk of flooding is currently very real.

The EPTB Seine Grands Lacs decided to continue to promote this project and is now proposing to construct a first pilot basin to demonstrate the viability of this technical option. This is because in addition to the financial aspects (see Chapter 4), this project must still demonstrate its operational usefulness and respond to the concerns raised on the governance of such a facility during a crisis. The emerging solution of rolling out this project in phases seems to have potential inasmuch as that each phase financed can prove its usefulness and effectiveness in reducing water levels in the event of major flooding. It will also be necessary to ensure that a project of this kind will not stop the work required on other risk prevention pillars, particularly regional resilience. In addition to this potential large-scale project, other hazard reduction options can be examined. The renovation of the Joinville-Le-Pont sector gate could protect many inhabitants in the loop of the Marne and upstream at little cost. Reflection on the optimising of existing defences or the ecological restoration of headwaters should also be closely considered as part of an overall strategy. As with dykes, because of the different project management structures involved, a cost-benefit comparison of these projects as a whole has not been carried out, at the expense of an overall and genuinely efficient approach.

Conclusion and recommendations

A broad range of measures contributes to preventing the risk of flooding of the Seine in Île-de-France, even if a certain diversity predominates. Whether these measures are regulatory or voluntary or are ensured by the state, local authorities, the public or businesses, this overview highlights the many opportunities for improving risk awareness and culture, resilience, public services and businesses, and hazard mitigation options by means of protective measures. Positive synergies leading to greater resilience have been identified and could be further exploited. This includes the incorporation of resilience into development policies in Greater Paris, the link between the culture of the river and the culture of risk, moves to develop river banks and to strengthen protection infrastructure, the combining of risk prevention policy and crisis management, the increasing awareness of businesses and network operators and the reappropriation of the functionalities of water systems to combat flooding from an environmental protection perspective. The local flood management strategy currently under development is an opportunity to organise prevention measures as a whole and prioritise them in a coherent approach towards an ambitious resilience for the metropolitan area.

Knowledge of the risk is improving, and approaches are being harmonised so that all risk prevention stakeholders will, in due course, have information that allows them to act coherently. To date, the many risk assessment approaches, tools and standards have

combined to sow confusion, preventing stakeholders from agreeing on similar results, since they tend to develop their own calculation methodology. The current drive to share and harmonise knowledge, especially under the guidance of the DRIEE and the SGZDSP, and the development of a precise risk map in implementing the Floods Directive suggest that the tools necessary to design and closely assess these prevention measures as a whole might be available.

Risk perception on the part of the public and decision makers is poor because the memory of historic events is fading although the vulnerability remains. In view of the many initiatives identified in this area, the development of a risk culture in relation to flooding in Île-de-France nevertheless seems to be an area of concern for many stakeholders. These initiatives often complement regulatory measures, the effectiveness and implementation of which vary from one local authority to another. They may draw on innovative risk communication tools which are more effective in raising risk awareness. However, it is difficult to obtain an overall view and to understand their impact and effectiveness in the absence of a precise assessment. Furthermore, the use of different and not always harmonious risk reference materials and benchmarks gives rise to differences in the level of awareness and engagement of stakeholders (large businesses, infrastructure operators, SMEs, the public, local authorities). This hinders the development of a genuinely shared safety culture. It is also clear that the lack of determination of public decision makers to engage with and communicate on this subject is a major constraint on the development of a risk culture and is illustrative of their own weak awareness of this risk, which continues to be perceived as not very likely.

With respect to the region's resilience, risk prevention policies based on urban development management have contributed little, if any, significant reduction in the level of the risk of flooding of the Seine. Regulatory instruments such as PPRs have proven to be limited, particularly because they have no impact on the existing building stock. In this context of a dense urban area, the unifying Greater Paris project offers opportunities: a flood-resilient metropolis based on innovative urban projects along the course of the Seine could emerge. Examples from other OECD countries show that resilience can be a source of innovation and thereby contribute to green growth. Infrastructure investment over the next 30 years could also improve the resilience of networks, which is crucial for the resilience of the metropolitan area as a whole. Great disparities remain, meanwhile, between different network operators in terms of major flood risk assessment and preparation. At business and public service level, the development of business continuity plans and investment in prevention is in its infancy. While some large businesses have developed or are currently developing flood prevention and risk management strategies in accordance with the regulatory framework and regulatory authorities (banks, telecommunications), SMEs as a whole remain highly vulnerable and ill-prepared. Similarly, city councils have also invested little in this regard.

Hazard protection and control infrastructure could be built largely in line with recommendations in the various post-1910 flood reports. Such infrastructure nevertheless has its limits in terms of protection and raises fundamental issues of equity and governance. The difference between the levels of protection sought by dykes and walls, their maintenance and investment between the centre and the periphery of the conurbation do not allow equivalent protection to be ensured among the public in Île-de-France. This is problematic in terms of current urban development, in which the periphery has become much more densely populated. Recent state-promoted efforts to diagnose vulnerability and local reinforcement work should be noted in an approach which is nevertheless fragmented because of different project management structures. Contrary to other OECD

countries, the lack of a predefined standard protection level reinforces the negative effects of the lack of an overall approach to managing these defences. Existing hazard control facilities come under the control of another organisation, the EPTB Seine Grands Lacs, whose remit is gradually expanding to other aspects of water and flood management. Now that the new La Bassée hazard mitigation project is coming to the fore, questions are being raised as to funding, the prioritisation of hazard control action and governance. The establishment of a local flood management strategy and the PAPI project run by the EPTB Seine Grands Lacs jointly represent an opportunity to make an informed choice between the different options and to uphold that choice in total transparency with stakeholders as a whole.

The recommendations set out below should reinforce prevention and resilience efforts at all levels in order to achieve greater flood risk resilience in Île-de-France.

- Continue to improve and harmonise risk awareness and ensure that information on risks is available. The meeting of minds between the Prefecture of Police and the DRIEE could be pursued with other stakeholders, such as the insurance sector, in a global and coherent approach to risk assessment, particularly at economic level. All information on risks could be centralised while respecting confidentiality, security and competition. This could work in parallel with the provision of modelling tools and the respective data according to needs, drawing inspiration from the observatory established at national level.
- Reinforce a risk culture among the public, decision makers and businesses. New communication topics stressing the positive benefits of greater resilience must ensure greater risk awareness at all levels. Regular information based on the best knowledge available at the service of a common strategy could accompany the local flood risk management strategy. This communication strategy should use new technologies (3-D visualisation, virtual animation, social networks), target specific audiences (businesses, the public, decision makers, developers and architects) and be assessed according to results by regular risk perception surveys.
- Improve the resilience of areas by taking advantage of the opportunities offered by the Greater Paris project. The definition of a resilience level for Greater Paris, particularly through regional development contracts, could give rise to model resilient districts such as the Ardoines. Harmonising and reinforcing PPRs at regional level will allow resilience to be raised towards this predefined level in the long term. These plans must be based on the latest risk assessments and their control should be improved. Incentives to reduce the vulnerability of existing buildings could also be envisaged by renewing electricity meters, for example.
- Gradually reinforce critical network resilience and ensure business and public service continuity. A predefined resilience level should also be applied gradually to network operators to raise the requirements. New infrastructure, particularly transport, must ensure maximum flood resilience. The establishment and control of requirement levels could be ensured by the sector regulator. A mechanism to accompany enterprises, particularly SMEs, in their business continuity measures could also be developed, such as a risk assessment service, risk labelling or the drafting of awareness-raising guides.
- Place flood protection infrastructure under the responsibility of a single project management structure with responsibility for establishing a predefined safety standard for all infrastructure, with a common cost-benefit approach framed in an

appropriate institutional structure. The steering and organisation of maintenance, renovation and the need to carry out work could be assessed according to the same criteria in the light of the possible need for new infrastructure. This would involve assessing the feasibility of harmonising protection levels for the conurbation as a whole, with work being done in phases and priority being given to the most beneficial works.

- Favour experimentation in relation to the La Bassée storage project. Stage-by-stage roll-out of the project should make it possible to adapt the approach through practice-based learning and demonstrate its operational usefulness beyond theoretical cost-benefit studies. The governance of such a facility is a matter that should also be determined beforehand, with a view, in particular, to decision making during crises in order to ensure effectiveness.

Bibliography

ASCA, Ledoux Consultants (2012), "L'Agence de l'Eau Seine-Normandie et la gestion du risque inondation: Quelle stratégie de positionnement? Synthèse stratégique", Agence de l'Eau Seine Normandie, Nanterre, France.

Base Gaspar, http://macommune.prim.net/gaspar (accessed in October 2013).

Base Nationale sur les DICRIM, www.bd-dicrim.fr (accessed in October 2013).

Baubion, C. (2013), "OECD risk management: Strategic crisis management", *OECD Working Papers on Public Governance*, No. 23, OECD Publishing, Paris, http://dx.doi.org/10.1787/5k41rbd1lzr7-en.

Brun, A. and F. Adisson (2011), "Urban renewal and flood risk: The masterplan 'Seine Ardoines'", *Cybergeo: European Journal of Geography* [online], Regional and Urban Planning, Document 561, 29 October, available at: http://cybergeo.revues.org/24751.

CEPRI (2010), *Les digues de protection contre les inondations*, Collection Les Guides du CEPRI, CEPRI, Orléans, France, www.cepri.net/tl_files/pdf/CEPRI-guide-reglementation-digues-2010.pdf.

CCI Paris (2012), *Les entreprises face au risque inondation, pour un développement durable du Grand Paris*, Chambre de commerce et d'industrie de Paris, Paris.

Conseil d'État (2010), *L'eau et son droit*, Études et documents du Conseil d'État.

Conseil général des Hauts-de-Seine (2010), exposition "La science se livre", Conseil général des Hauts-de-Seine, Nanterre, France.

Conseil général des Hauts-de-Seine (2007), "Diagnostics de vulnérabilité, assistance à l'élaboration de plans de crise et d'actions de réduction de vulnérabilité", Conseil général des Hauts-de-Seine, Nanterre, France.

DRIEE (2013), "Cartographie des zones inondables et des risques d'inondation du TRI métropole francilienne, projet de rapport explicative", Direction Régionale et Interdépartementale de l'Environnement et de l'Énergie d'Île-de-France, Paris, www.driee.ile-de-france.developpement-durable.gouv.fr/IMG/pdf/Rapport_accompagnement_IDF_VF_cle03163c.pdf (accessed in November 2013).

DRIEA (2012), "Guide d'élaboration d'un plan de protection contre les inondations à Paris", Direction Régionale et Interdépartementale de l'Equipement et de lm'Amménagement d'Île-de-France, Paris.

DRIEE (2010), "Directive inondation n° 2007/60/CE cartographie des zones inondables et des risques d'inondation du TRI métropole francilienne, projet de rapport explicative", Direction Régionale et Interdépartementale de l'Environnement et de l'Énergie d'Île-de-France, Paris, www.driee.ile-de-france.developpement-durable.gouv.fr/consultation-des-parties-prenantes-a1580.html.

Dutch Ministry of Infrastructure and Environment (2012), "Le cadre législatif et organisationnel de la gestion du risque d'inondation aux Pays-Bas", audition au Senat du 29 mai 2012.

Établissement public d'aménagement Orly-Rungis Seine Amont, "Les Ardoines à Vitry-sur-Seine", presentation.

Établissement Public Loire (2012), *Rapport d'activité 2012*, Établissement Public Loire, Orléans, France.

EPTB Seine Grands Lacs (2013), "Programme d'actions de prévention des inondations de la Seine et de la Marne franciliennes", rapport de présentation, EPTB Seine Grands Lacs, Paris.

EPTB Seine Grands Lacs (2012), *Rapport d'activité 2012*, EPTB Seine Grands Lacs, Paris, www.seinegrandslacs.fr/rapport-activite/SeineGrandLacs_web.pdf.

EPTB Seine Grands Lacs (2011a), *Rapport d'activité 2011*, EPTB Seine Grands Lacs, Paris, www.seinegrandslacs.fr/docs/EPTB%20Seine%20Grands%20Lacs/Rapport%20d%20Activit%C3%A9/2011-Rapport-activit%C3%A9-EPTB-Seine-Grands-Lacs.pdf.

EPTB Seine Grands Lacs (2011b), "Projet d'aménagement de La Bassée", dossier du maître d'ouvrage, EPTB Seine Grands Lacs, Paris, www.debatpublic-crueseinebassee.org/docs/DMO/Intro/DMOA_la-bassee_1-9.pdf.

EPTB Seine Grands Lacs (2010a), *L'aménagement des zones inondables en Île-de-France, regards croisés de praticiens*, EPTB Seine Grands Lacs, Paris.

EPTB Seine Grands Lacs (2010b), *Rapport d'activité 2010*, EPTB Seine Grands Lacs, Paris, http://pascalpopelin.fr/docs/grands-lacs-de-seine/rapport_activite_2010.

Essonne, *Les différents plans de prévention du risque inondation du département de l'Essonne.*

Gerin, S., R. Laganier and R. Nussbaum (2012), "Le PPRN: D'un objectif de moyens à un objectif de résultats", *RISEO La Revue en Ligne*, No. 2, Risques Études et Observations, Colmar, www.riseo.fr/-Revue-2012-2-#page109.

Grislain-Letrémy, C., R. Lahidji and P. Mongin (2012), *Les risques majeurs et l'action publique*, rapport du Conseil d'analyse économique, La Documentation française, Paris.

IAU (2013a), video 3D available at: www.youtube.com/watch?v=W_wJ8vYtMmU (accessed in November 2013).

IAU (2013b) "Le 'fleuve', berges et rives, territoires de projets communaux", *Note rapide territoires*, No. 629, Institut d'Aménagement et d'Urbanisme, Paris, www.iau-idf.fr/fileadmin/Etudes/etude_1010/NR629_web.pdf.

IAU (2011), "Urbanisation et zones inondables: Les risques encourus", *Note rapide territoires*, No. 557, Institut d'Aménagement et d'Urbanisme, Paris, www.iau-idf.fr/fileadmin/Etudes/etude_839/NR_557_web.pdf.

Lhomme, S. et al. (2010), "Les réseaux techniques face aux inondations ou comment définir des indicateurs de performance de ces réseaux pour évaluer la résilience urbaine", *Bulletin de l'Association des géographes français*.

Ministry of Culture and Communication (2008), " Le grand pari de l'agglomération parisienne, fleuves et cours d'eau", consultation de 2008 à l'Atelier international du Grand Paris, www.ateliergrandparis.fr/aigp/conseil/GP_Fleuves.pdf.

Ministry of Ecology, Sustainable Development and Energy (2011), "Sécurité des ouvrages hydrauliques et de protection", *Portail Prévention du Risque*, www.developpement-durable.gouv.fr/Securite-des-ouvrages-hydrauliques.html (accessed in October 2013).

Moro, C. (2012), "Ces grandes villes françaises qui cachent leurs risques majeurs" [French cities that hide their major risks], blog i-resilience.fr, www.i-resilience.fr/2012/07/ces-grandes-villes-francaises-qui-cachent-leurs-risques-majeurs (accessed in October 2013).

NVE (2009), "Flood inundation maps", Norwegian Water Resources and Energy Directorate, Oslo, www.nve.no/en/Floods-and-landslides/Flood-inundation-maps.

OECD (2013), *OECD Reviews of Risk Management Policies: Mexico 2013: Review of the Mexican National Civil Protection System* OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264192294-en.

OECD (2010), *Étude de l'OCDE sur la gestion des risques d'inondation: Bassin de la Loire, France 2010*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264056817-en.

OECD (2006), *Infrastructures to 2030, Telecom, land, transport, water and electricity*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264023994-en

Observatoire national des risques naturels (2013), "L'Observatoire national des risques naturels (ONRN)", Ministry of Ecology, Sustainable Development and Energy, Paris-La Défense, www.onrn.fr/site/binaries/content/assets/documents/onrn/201303_brochureonrn_web.pdf.

Préfecture des Hauts-de-Seine (2004), *Plan de prévention des risques d'inondation de la Seine dans les Hauts-de-Seine: Règlement*.

Préfecture de Paris (2007), *Plan de prévention des risques d'inondation du département de Paris révisé: Règlement*.

Préfecture de la Seine-Saint-Denis (2010), *Plan de prévention du risque inondation de la Marne dans le département de la Seine-Saint-Denis: Règlement*.

Préfecture de la Seine-Saint-Denis (2007), *Plan de prévention du risque inondation de la Seine dans le département de la Seine-Saint-Denis: Règlement*.

Préfecture du Val-de-Marne (2007), *Plan de prévention du risque inondation de la Marne et de la Seine dans le département du Val-de-Marne: Règlement*.

Préfet de Paris (2011), arrêté préfectoral N° DEP-2011-150-1 du 30 mai 2011 portant complément à l'autorisation reconnue au titre de l'article L. 214-6 du Code de l'Environnement concernant les digues fluviales (murs anti-crue) situées en rive droite de la Seine et aux pourtours des Îles de la Cité et Saint-Louis à Paris et dont la ville de Paris assure la maîtrise d'ouvrage.

Queensland Flood Commission Inquiry (2012), "Final report", Queensland Flood Commission of Inquiry, Brisbane, Australia.

Reghezza, M. (2006), *Réflexions autour de la vulnérabilité métropolitaine: La métropole parisienne face au risque de crue centennale*, thesis, University of Paris X.

Roche, P.-A. (2004), "The Seine river flooding in the Île-de-France region: What account is taken of climate change in the decision-making process?", OECD Global Forum on Sustainable Development, Paris, 11-12 November 2004, www.oecd.org/env/cc/33995401.pdf.

Secrétariat général de la Défense et de la Sécurité nationale (2013), *Guide pour réaliser un plan de continuité d'activité*, Secrétariat général de la Défense et de la Sécurité nationale, Paris.

Seine-et-Marne, Les différents plans de prévention du risque inondation du département de la Seine-et-Marne.

Sternadel, J. (2008), "Galeries multiréseaux, l'expérience de Prague", *Travaux*, No. 857, www.cledesol.org/IMG/pdf/Sternadel-L.pdf.

Schieb, P. (2008), "Infrastructure to 2030: Main findings and policy recommendations", in OECD, *Infrastructure to 2030 (Vol.2): Mapping Policy for Electricity, Water and Transport*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264031326-3-en.

Swiss Re (2013), *Mind the Risk – A Global ranking of cities under threat from natural disasters*, Swiss Re, Zurich, http://media.swissre.com/documents/Swiss_Re_Mind_the_risk.pdf.

Toubin, M. et al. (2012), "La résilience urbaine: Un nouveau concept opérationnel vecteur de durabilité urbaine?", *Développement durable et territoires*, Vol. 3, No. 1, http://developpementdurable.revues.org/9208 (accessed 15 November 2013).

Toubin, M. et al. (2013), "Améliorer la résilience urbaine par une gestion intégrée des services urbains", international colloquium « Futurs urbains », University of Paris-Est, Champs-sur-Marne, France.

Val-d'Oise, Les différents plans de prévention du risque inondation du département du Val-d'Oise.

Veyret, Y. and R. Lagnier (2013), *Atlas des risques en France, prévenir les catastrophes naturelles et technologiques*, Autrement, Paris.

Webler, H. (2010), "Redevelopment of the Zollhafen Mainz as flood resilient development", IAHR European Congress Edinburgh, 5 May, http://web.sbe.hw.ac.uk/staffprofiles/bdgsa/IAHR_2010_European_Congress/Papers%20by%20session%20final/Flood%20Resilient%20Cities/FRCa.pdf.

Wikhydro (2013), "Étape 1: Préparation à une crue majeure en region parisienne, analyse territorial", http://wikhydro.developpement-durable.gouv.fr/index.php/AIRT_:_Etape_1_:_pr%C3%A9paration_%C3%A0_une_crue_majeure_en_r%C3%A9gion_parisienne_-_analyse_territoriale (accessed 15 November 2013).

Yvelines, Les différents plans de prévention du risque inondation du département des Yvelines.