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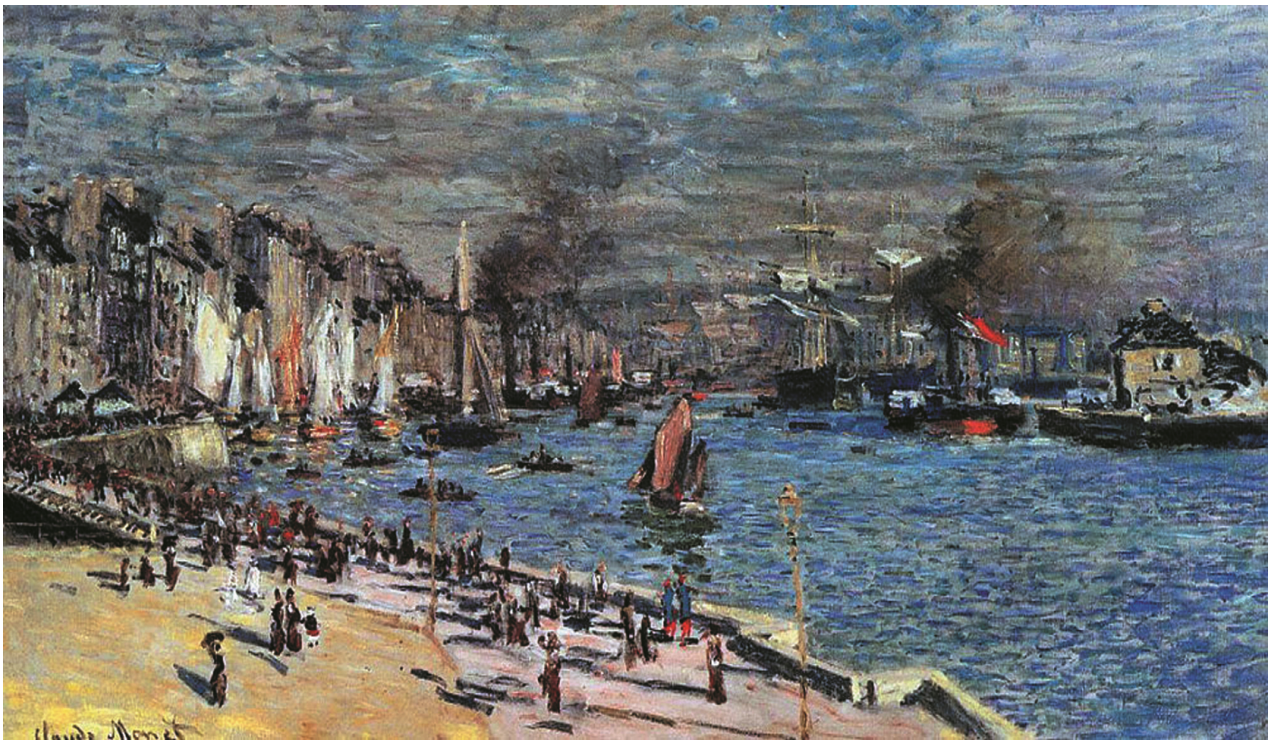
MASTER THESIS

FLOOD RISK MITIGATION

A Methodological Approach and a Case Study of Le Havre in France



Presented by Julián Gutiérrez Torres

Thesis Supervisor
Prof. Mathilde Gralepois
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FLOOD RISK MITIGATION: *A methodological approach and a Case study of Le Havre in France.*

Master Thesis in the Research Master in Planning and Sustainability: Urban & Regional Planning.

JULIAN GUTIÉRREZ TORRES

Polytech Tours,

Département Aménagement

University of Tours
Polytech Tours
37200, Tours – France
Contact: +33 (0)247 361 454

Contact: Julián GutiérrezTorres
E-mail: jgutierreztorres@gmail.com

Front page image: *"Port of Le Havre" 1874 by Claude Monet.*
CLAUDE MONET PAINTING GALLERY,
http//www.monetalia.com/paintings/monet-port-of-le-havre.aspx
Original painting is located in Philadelphia Museum of Art, USA.

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……..“Nature does not cause Natural Disasters”

(Anonymous)

Abstract

In the global context of flood risk, relevant progress in terms of how to deal with floods has been developing since a few decades ago. In this way, the idea of *living with the water* instead of *struggling against it* will address new challenges related to decreasing the consequences of flood events. In this context, risk mitigation is developed at different levels of spatial planning as well as in land use regulation policies; emerging concepts such as urban resilience which, through improvement of flood defense or flood preparation, will promote a systematic and coherent approach to flood mitigation.

In the context of the Seine River's estuary in France (Normandy), flood natural hazards - both sea-based and land-based flood risks - are especially observed in the city of Le Havre and surroundings. Since 1978, an increase in the activities of Le Havre has accelerated the construction work rate. Recent urban projects have been carried out in flood risk areas.

This paper will explore the different mitigation measures found in the literature review of stakeholders who are currently working on the adaptation of those measures on present scenarios. The aim is to show how these mitigation measures are influencing the urban morphology nowadays, based on case study of commune of *Le Havre*. It will be carried out through an interpretation exercise, analyzing and implementing some of the measures adapted.

Keywords: flood hazard, flood mitigation, urban morphology, urban resilience, urban planning, risk reduction, adaptation and implementation.

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List of Acronyms

SMBV *(Syndicat Mixte des Bassin Versants de la Pionte de Caux)* (Municipal Syndicate of Watershed)

CODAH *(La Communautè de l'agglomération Havraise)* (The commune of Havre agglomeration)

PPRi. *(Plan Prevention des Risques d'Inondation)* (Risk Plan Prevention of Flood)

PLU *(Plan Local d'Urbanisme)* (Urban Local Plan)

PPRNP *(Plans de Prévention des Risques Naturels Prévisibles).*

DRIRE.*(Directions Régionales de l'Industrie de la Recherche et de l'Environnement)*

POS *(Plan d'Occupation du Sol)*

DDE *(Direction Départementale de l'Equipement)*

PER *(Plan d'Exposition aux Risques Naturales Prévisibles)*

DDE *(Direction Départementale de l'Equipement)*

ORSEC *(Organisation de la Réponse de Securité Civile)*

SDAGE *(Schémas Directeurs d'Aménagement et de Gestion des Eaux*) (Master plans of Water Management)

SAGE *(Schémas d'Aménagement et de Gestion des Eaux)* (Documents of Planning and Management of Water)

DREAL *(Direction Régionale de l'Aménagement, de l'Environnement et du Logement (DIREN + DRE + DRIRE)*

DDRM (*Dossier Départementale des Risques Majeurs)* (Departmental Report of the Major Risks)

MDS (Spread of Modeling Methodology)

Contents

1. INTRODUCTION

1.1 Reasons for a research in flood risk

Nowadays we live in a non-stationary world. Climate change induces extreme weather events where the hydrological regimes are being affected in terms of intensity, frequency, severity and duration. As a result, changes in climatic drivers such as sea level rise, heavy rainfall or snowmelt are reflected by flood in coastal areas as well as land-based-floods in urban areas. In addition, human activities in many parts of the world are influencing runoff regimes (Kundzewicz 2012). In this scenario we should take into consideration the urgency of a critical view about it and furthermore to assume an attitude facing it (D. Mileti 1999).

In the framework of natural hazard floods[1], it is considered as one of the main responsible of high economic losses and several damages as well as a considerable human loss rate. It can be expected to rise especially in the developing world, where vulnerability is generally much higher than in the industrialized countries. Moreover, considerable investments are spent in flood defenses such as dikes, spillways, dams and reservoirs (Kundzewicz 2012).

Thus, the modern approach to dealing with the floods is based on using flood risk as a decision parameter. It allows providing new strategies about how to mitigate risk, as well as to be able to involve all stakeholders. For example flood defenses such as in a levee-protected built in coast zones were considered as a guarantee of safety for their inhabitants. It had as consequences that the resilience response was not adequate and the population was not prepared to deal with it (Kundzewicz 2012).

In order to adapt these new challenges flood mitigation has emerged based on adaptation[2] concept, it becomes an innovative way which is going to be adopted quickly in the urban public policies on the political agenda. Therefore it can be considered that until a few years ago the efforts by researchers in most countries were focused on elaborating strategies related to the defense and prevention (damages) (Start-flood 2012)[3].

This paper focuses on mitigation measures to reduce the vulnerability of flood in urban areas, through a methodological approach to the current picture of mitigation concept as well as a case study of *Le Havre*.

In a way this current research will give us tools to understand ongoing urban context in France about flood risk mitigation. Moreover, development and implementation of structural measures to reduce vulnerability can be carried out on the basis of a vulnerability analysis.

[1] In the World Economic Forum 2011, Climate change is number 1 and flooding number 9 in the top 10 of global risks.
[2] In the framework of Flood Reduction there are three basic adaption strategies for coping with floods: protect accommodate and retreat (Kundzewicz 2012).
[3] Star-flood is an ongoing research project of Flood Mitigation; it has been carried out in European context.

During the development of this paper I (the author) was enrolled in a research group in CITERES, working as an intern on Star-flood European Research Project.

1.2 Research question and purpose of the study.

At the beginning of the master programme, one of the discussions about the cities was focused on the role of the planners, who should develop the analytical skills to reveal when communicative processes which improves life conditions in cities and regions nowadays (P. Healey 2003). Arose, the question about the role of the architects in the cities; as consequences, there was visible a lack of suitable knowledge about that. In this way, considering the current situation and chaos - we are not out of the woods yet - a new sort of urbanism is necessary, and must be based on new ideas (M. Castells 2011).

Addressing to the flood events in cities currently, are arising issues such as *how do buildings in flooding areas work? ,* How can a resilient-to-floods environment be built? and furthermore *is there an urban form (morphological features) designed for flood risk reduction?* Therefore, it can be considered as a new way where we should explore new practices facing to flood events.

Taking previous into account we are going to suggest as main research question:

How can the links between architectural and urban fields supporting to the mitigation process in flood risk areas be created?

It will be carried out under goal of developing **design strategies for flood risk areas** focusing on urban and architectural features in order to provide tools to the regional authorities that would help them to improve their planning and land use regulations.

1.3 Methodology and Materials

1.3.1 Methods

Flood Mitigation Risk concerns a broad range of processes affecting it at very different scales; nowadays we can recognize theoretically this process pretending to create links which will integrate various sectors and actors. The study presented in this paper will include therefore several characteristics: flood mitigation in cities has been studied mainly on already built-up areas, but also we have taken others sectors into the city with increase of more and more urban regeneration processes as well as urban expansion projects.

Thus, we can consider differences among urban areas, which are areas consisting of the built-up area of its total extension, and on another hand urban agglomerations which are an extended urban areas of a certain place and any suburbs and rural areas that are linked to it[4].

Concerns our case study, we are going to find mainly agglomeration areas due to *Le Havre* has carried out an extended urban processes in the major part of the territory nowadays[5].

The methodological approach and the case studies are based on qualities data found in academics articles, books, and official reports. The data have been gathered through libraries, online databases and thorough personal interactions with different stakeholders of *Le Havre* involved into floods risk issue.

The strategy applied for this study was to use existing information, to gather it and to organize it in a way that *highlights the main strategies issues to be addressed when dealing with mitigation process*. The data used consist in primary data already gathered and interpreted by their authors and/or actors, which at the same time are working in their adoption and implementation from stakeholders as the *CODAH, SMBV, DRIRE Haute Normandie,* among others.

The interviews with different professionals helped to build the structure and arguments presented in this paper. During the research we used concepts and schemes to describe the different phenomena, situations and circumstances.

As the aim is to provide a better understanding of the flood risk mitigation in *Le Havre*, the taken strategy has been to develop an exploratory qualities study.

According to the flood mitigation discourse, which will be argued in the next chapters; we are going to identify and understanding some of the types of floods risk found in Le Havre, through a categorization of mitigation measures that are being adopted. To do that we will take one of the next cases studies and we are going to contrast all of the information to find related to mitigation adopted and how it works currently.

From this detailed contrast we could have a clear point of view about how is the mitigation process developing nowadays, and it allow us to provide what is going on with urban and architectural features. Therefore we are going to categorize mitigation measures given from the stakeholders and will provide some of them into the city, looking at their impacts over *Le Havre*.

[4] Urban agglomerations, urban areas and regions vulnerable to flooding will be more resilient, if multiple flood risk strategies are implemented simultaneously and are aligned (Start-flood 2012).
[5] Le Havre belong to *"Communes de L'agglomeration Havraise"* which are divided in 17 communes. See index 4.

1.3.2 Case Study

According to the different types of flood risk[6] found in *Le Havre*, we are going to identify three cases related to it.

The first case concerns the surrounding areas beside *Le Havre*, is *MONTIVILLIERS* which presents a traditional rural housing mixed with old buildings conserved both around historical urban areas. The second one, take place on the border (close to the airport) of the city, is *GRAND HAMEAU* which presents one of the most important expansion urban areas in *Le Havre* which is ongoing developing, based on the eco-neighborhood concept *"Eco-Quartier"*. The last one is *SAINT NICOLAS*, which is located into the harbor area which is based on urban regeneration areas.

We are going to consider the next classification:

	Montivilliers	Grand Hameau	Saint Nicolas
CCONTEXT	• Private and social housing. • Lush vegetation. • Old buildings, therefore old infrastructure. • Houses without protection against channel. • *Curande Stream*. • *Lézarde River* • Sewage system gets damaged. • Drain network.	• New buildings addressing social and private housings. • New infrastructure. • *Eco-quartier.* • Agricultural land • Basis raised from the ground (Aprox. 1meter) • Basin • Sewage system gets renovated. • Drain network gets renovated.	• New buildings addressing social and private flats. • Old houses get damaged. • Mixture of infrastructures (old and new ones). • Mixture residences and factories. • Urban gardens • Basis raised from the ground (aprox. 1meter) • Sewage system gets renovated. • Drain network gets renovated.
ISSUE	Overflows happen due to rainfall and flashfloods rising up the flow level of *The Curande Stream* and *The Lézarde River*. Most of the buildings that are beside the stream or river suffer damage and then, according to irregular topography on the area, water goes very fast over the streets.	Rainfall and flashfloods produce streaming around the area creating watershed and basin. This natural cycle has been transformed due to intensive agriculture during the last couple of decades and now urbanization is starting to increase in the zone.	The sea level rising up and strong wind have several submersions that, as consequences, go directly to the buildings around the basin.
FLOOD RISK	**Overflows**	**Runoffs and Mud Flows**	**Marine Submersion**

[6] See the types of flood risk according to the "*Risque Majeur en Haute Normandie" in* Index 1.

2. UNDERSTANDING FLOOD RISK AS A NATURAL HAZARD

Considering many discussions from several authors within the last decades, we are going to consider one definition which addresses us to focus in ongoing context of natural hazards. In this way, the term of natural hazard that has been defined by D. Alexander[7], will take into consideration four ways:

- *A naturally occurring or man-made geologic condition or phenomenon that presents at risk or is a potential danger to life or property.*

- *An interaction of people and nature governed by the co-existent state of adjustment of the human use system and state of nature in the natural events system.*

- *Those elements in the physical environment which are harmful to man and caused by force extraneous to him.*

- *The probability of occurrence within a specified period of time and within a given area of a potentially damaging phenomenon.*

Based on previous definition, the natural hazard concept will consider people as a main factor involved it, first of all as a victim. However, it is changing due to those last catastrophes as *Katrina* hurricane, *Fukushima* tsunami and recently *Sandy* hurricane, show us what thorough several factors the human being indirectly to become a driver of disasters. A clear example about it is global warming context[8]. In this way we should also be able to recognize the roots of the problem which is related to three main influences, first the earth's physical system are constantly changing, which will produce more dramatic meteorological events such as storms, flood, drought, and extreme temperatures. Second, recent and projected changes in the demographic composition and distribution the population in the world, has as consequences greater exposure to many hazards. Third, the built environment, related to public utilities, transportation systems, communications, and homes and office buildings, are growing in density, making the potential losses from natural forces larger (D. Mileti 1999).

Thus the aim should be to improve the conditions of this relation among human beings and nature. It will be framed into the contemporary context of our cities, achieving to identify features in each of them in order to develop growing process model but being taken natural hazards a role important part of it.

As main concept concerning natural hazard is risk. It is becoming misunderstanding due to several meanings given from wide range of disciplines and activities relating with economical, environmental and social issues. For this reason to be important to make a clear distinction between the words *"hazard"* and *"risk"* (*Floodsite* 2005).

[7] Natural Disaster, David Alexander. Department of Geology and Geography University of Massachusetts 1993.
[8] Global warming results from a build-up of carbon dioxide (CO2) and other greenhouse gases in the atmosphere; it has been identified by scientists as a major threat to the global environment. UN Decade of Education for Sustainable Development. UNESCO 2009.

Therefore:

> *Hazard[9] is described in different ways in relation with the topic/issue (earthquakes, landslides, debris flows, etc) deal with (D. de Wrachien, S. Mambretti, A. Sole 2008).*
>
> *Risk is the total damage caused by a specific event, and it is obtained as a function of hazard and vulnerability (D. de Wrachien, S. Mambretti, A. Sole 2008).*
>
> *R (Risk) = H (Hazard) x V (Vulnerability)*
>
> *Vulnerability represents the territorial system tendency to suffer damages during an extreme event (D. de Wrachien, S. Mambretti, A. Sole 2008).*

Alexander [10] distinguished between risk and vulnerability [11], noting that "vulnerability refers to the potential for causality, destruction, damage, disruption or other form of loss in particularly element: risk combines this with the probable level of loss to be expected from a predictable magnitude of hazard (which can be considered as the manifestation of the agent that produces the loss). That means the risk of disaster[12] is a compound function of the natural hazard and the number of people characterized by their varying degrees of vulnerability to that specific hazard, who occupy the space and time of exposure to the hazard event (B. Wisner, P. Blaikie 1994). Hence, the term of exposition is going to take an active role into the function expressed above:

> *R (Risk) = H (Hazard) x V (Vulnerability) x E (Exposition)*
>
> *Exposition can be defined as the "probability that certain element be exposed to the risk when an event of fixed magnitude, in a fixed time range and in a fixed area, occurs. Different authors define exposition as the "probability that element be affected by a fixed hazard" sometimes exposition is also defined as a "quantitative index to sum up the number of persons and goods potentially subject to the event" (D. de Wrachien, S. Mambretti, A. Sole 2008).*

To understand the link between hazard and risk we are going to consider a conceptual model which represents systems and processes that lead to a particular consequences (See Fig. 1). For a risk to arise there must be hazard that consists of a 'source' or initiator event[13] (i.e. high rainfall); a 'receptor' (e.g. flood plain properties); and a pathway between the source and the receptor (i.e. flood routes including defenses, overland flow or landslide) (*Floodsite* 2005).

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[9] In the UNESCO report of 1984 *Hazard* is defined as the probability of occurrence of a potentially dangerous event in a fixed time range and in a fixed area.

[10] Natural Disaster, David Alexander. Department of Geology and Geography. University of Massachusetts 1993.

[11] In the scope of risk the social production of vulnerability needs to be considered at the same degree of importance that is given to understanding and addressing natural hazards (B. Wisner, P. Blaikie 1994).

[12] According to the Swiss Civil Protection Agency, disaster is an event where damage exceeds the capacity of the affected society to recover by its own means. This definition is based on the economic capacity of the affected society which means that the same event as different impacts depending on where it happens.

[13] A hazard does not automatically lead to a harmful outcome, but identification of a hazard does mean that there is a possibility of harm occurring, with the actual harm depending upon the exposure to the hazard and the characteristics of the receptor.

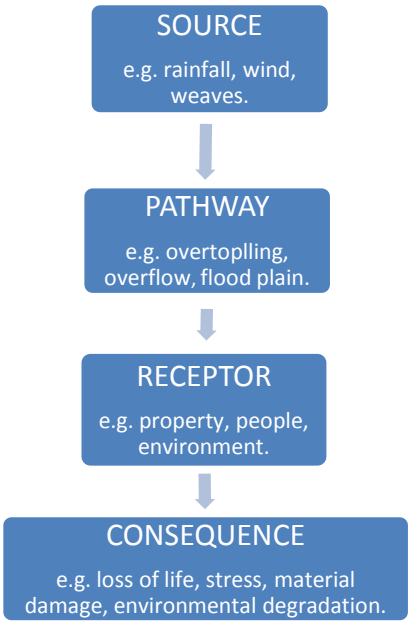


Fig. 1 Source, Pathway, Receptor, Consequence. (Source: *FloodSite*[14])

This conceptual model, which shows us how can be considered order of events. For example, in the event of heavy rainfall (the source) flood water may propagate across the flood plain (the pathway) and inundate housing (the receptor) that may suffer material damage (the harm or consequence).

In the scope of natural hazards since a couple decades ago floods are likely to become more frequent and serious hazards due to the effects of climate change and urbanization (See Fig. 2). Floods are among the most damaging natural hazards in urban areas around the world, in terms of monetary losses and human victims. Most of extensive, costly damage occurs during its development, affecting wealth, infrastructure and order as well (D. Alexander 1993).

Floods correspond to 40% of natural catastrophe in the world.[15] In Europe storms and floods are the most frequent and costly extreme weather events representing 69% of the overall natural catastrophic losses. For instance floods events occurred in 1993 and 1995 on the Rhine River and its tributaries, caused severe damage over 1.4 billion and 2.6 billion Euros respectively.[16]

Floods considered as natural hazard consist of the threat to life or property posed by rising or spilling water (D. Alexander 1993), according to that we are going to define floods as: overflowing or failing of the normal confines of a river, stream, lake, canal, sea or accumulation of water as a result of heavy precipitation where drains are lacking or their discharge capacity is exceeded (D. de Wrachien, S. Mambretti, A. Sole 2008).

[14] FLOOD site Report T32-04-01. See the concept model applied to flood event on Index 2.
[15] In United Estates floods were the most costly natural hazard in terms of deaths and dollar damage to propriety and crops between 1975 to 1994.
[16] Nat. Hazards Earth Syst. Sci., 11, 459–473, 2011 doi: 10.5194/nhess-11-459-2011 © Author(s) 2011. CC Attribution 3.0 License.

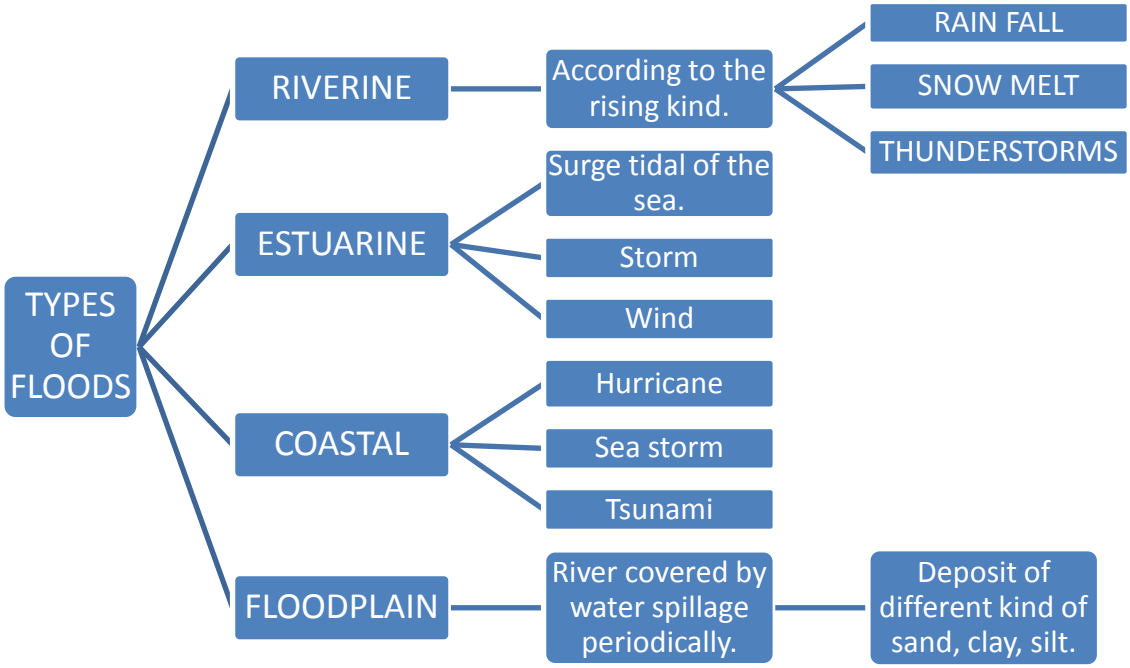


Fig. 2 Types of floods. Adapted *(Source: Natural Disaster, D. Alexander 1993)*

Considering atmospherics systems provides components of the terrestrial phase of hydrological cycle, there are strong links between various natural hazards caused by extremes of cold, heat, wind, precipitation and dryness. In the scenario of flood natural hazard, it is influenced by atmospheric factors related to the region as for example hot water on the coastal parts or extreme cold in high parts; those factors will have different consequences respect to the kind of hydrological events like storm, tornadoes, etc.

To cope with the hazards, it is imperative that human society adopts an effective flood hazard management approach. In this way the first characteristic to take into account about flood event is that flooding can never be eliminated entirely. However the consequences of flooding can be mitigated by appropriate behavior and actions due to unlike others natural hazards flood has a high level of predictability (D. de Wrachien, S. Mambretti, A. Sole 2008).

As mentioned above, the increase in natural hazards as well as climate change are being one of the main factors related to flood events during last decades at global level (T. Naumann, Nikilowski,S. Golz,R. Schinke 2011). Thus, nowadays improving risk reduction policies is of a particular interest on the political agenda in most of the European countries. As a result, concepts known as “risk management“ is becoming prevalent; it specially includes an analysis of vulnerability as well as the effectiveness and efficiency of protective and precautionary strategies for the potentially affected subjects and objects (T. Naumann, Nikilowski,S. Golz,R. Schinke 2011). Therefore, there are crucial factors that are part of adoption and implementation of flood mitigation; that we will discuss in the next chapter.

2.1 How flood mitigation have emerged at ongoing context

As mentioned on the introduction, few years ago the flood aims in most of the countries was focused to promote strategies in flood defense and risk prevention; in the European context for example, countries and regions were focused on flood defense (Start-flood 2012). As result, nowadays there are so many examples as well as research documents and information development about it, appearing accordingly the concept of risk management[17], which has as main objective to make risk an integral part of social and economic processes being is often increased by human interference with natural hydro-meteorological phenomena (D. de Wrachien, S. Mambretti, A. Sole 2008).

Take previous into account; risk management approach consists of systemic actions set up in a cycle of preparedness response and recovery that should form part of any integrated water resource management (D. de Wrachien, S. Mambretti, A. Sole 2008). It can therefore be considered as the basis of flood mitigation concept. To understand better that, first of all, we are going to define the framework under flood mitigation have been involved. Thus, from literature on flood risk management referred to a chain of responses to flood risks we identify five strategies (Start-flood 2012) (See Fig. 3):

Flood Risk Prevention: pro-active – spatial planning. Flood –related risks can be structurally prevented by planning as well as land use policies ("keeping people away from water"), e.g. by proactively locating housing or buildings areas at a safe distance or altitude.

Flood Defense: decreasing the probability of flooding. Flood risk can be prevented by infrastructural works, dikes, dams, embankments, sluice, etc. ("keeping water away from people"), mostly referred to as "flood defense" OR "structural measures"

Flood Mitigation: decreasing the consequences of flooding. Consequences of floods when they do occur can be mitigated through spatial or building orders, regulations such as conditions for building houses in flood prone areas or retention of water in the river basin (natural flood management).

Flood Preparation: develop flood warning systems and prepare disaster management plans. When mitigation is not feasible or appropriate, people should prepare for eventual flood problems (e.g. evacuation plans).

[17] According to the *Floodsite* Flood Risk Management is going to defined as: "Continuous and holistic societal analysis, assessment and mitigation of flood risk (Schanze et al (2005a,b)" and " According to context, either action taken to mitigate risk, or the complete process of risk assessment, option appraisal and risk mitigation. HR Wallingford (2002)". (*FloodSite* Report: T32-04-01 2005)

Flood Recovery: there is the last resort of recovery from flood damage, increasingly popular in the realm of (unpredictable) climate change effects. In this respect reconstruction or rebuilding plans as well as insurance systems are relevant.

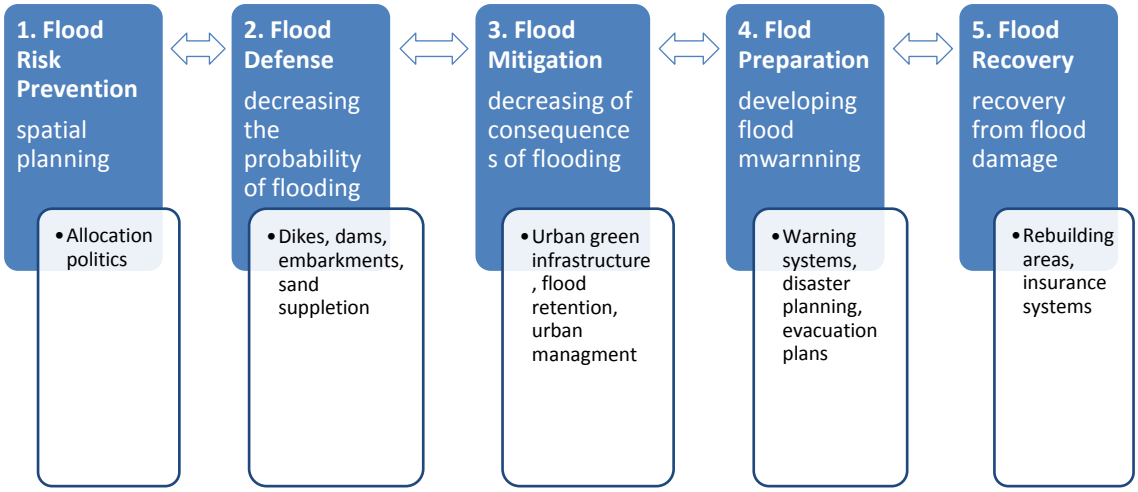


Fig. 3 Five Flood Strategies. Adapted *(Source: Star-Flood 2012).*

In this context, the concepts of "resilience" and "resistance" are becoming more important (T. Naumann, Nikilowski,S. Golz,R. Schinke 2011).

According to Holling (1973), the resilience concept is an approach to ecological research, aims at the dynamic development of ecosystems and the maintenance of their functions (A. Röhring, L. Gailing 2011). It will be interpreted analyzed by several authors within the years, having a holistic approach to this concept nowadays. It define resilience as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks" (Walker, Holling, Carpenter, and Kinzing 2004). In this way, we are going to define resilience and resistance as[18](See Fig. 4) :

Resilience: The ability of a system/community/society/defense to react to and recover from the damaging effect of realized hazards.

Resistance[19]: The ability of a system to remain unchanged by external events.

[18] *FloodSite* Report: T32-04-01 2005
[19] Due to our research aims, this concept will not be examined more closely.

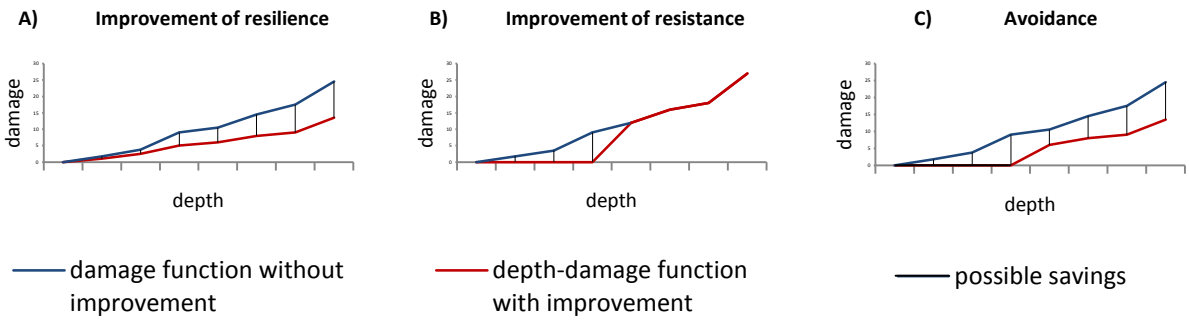


Fig. 4 The qualitative influence of mitigation measures on the depth-damage function. Adapted *(Source: German annual of Spatial Research and Policy 2010.)*

In fig. 4A, the effects of measures that enhance the resilience of buildings are characterized by the function's diminished slope. The course of the function in fig.4B shows a reduction of damages due to flooding up to defined depth by means of measures to enhance resistance. However when the defined depth of flooding (the so-called intake threshold) is exceeded, the effects of the measure are lost. Fig 4C illustrates how avoidance[20] works with the changed starting point of the damage function, resulting in lesser at the damages at the same depth.

Addressing the resilience concept towards the understanding of cities, we will consider that in terms of "urban resilience". It opens up promising perspectives for social science research about urban change. Moreover, conceptualizing "urban" as a complex multidimensional or hybrid system – system thinking is a key feature of resilience studies – leads us to look for the interaction of different dynamics and hybrid processes in their manifestation of vulnerability, crisis, and change (T. Lang 2011).

In the worldwide context, the resilience concept has a relevant importance since a few years ago. In this way, related to France, some examples has been carried out processes of conceptualization and adoption in terms of urban and resilience in the regions of *Loire*[21] as *Le Havre*; It based on the framework of PPRi. Nevertheless, the implementation in urban and regional resilience still needs further advancement, in particular when it comes to question of power (stakeholders), institutional constraint, and national regulation.

Take above into account, we can considered that the vulnerability depends on the capability of resilience or/and resistance. It will be influenced by the measures adopted facing flood events (See figure 5).

[20] Due to our research aims, this concept will not be examined more closely.
[21] See more information on the report *"Programme de Recherche sur la connaissance des vulnérabilités des activités humaines et des milieux du bassin de la Loire par rapport aux effets du changement climatique sur les régimes d'inondation et de sècheresse" CITERES 2011.*

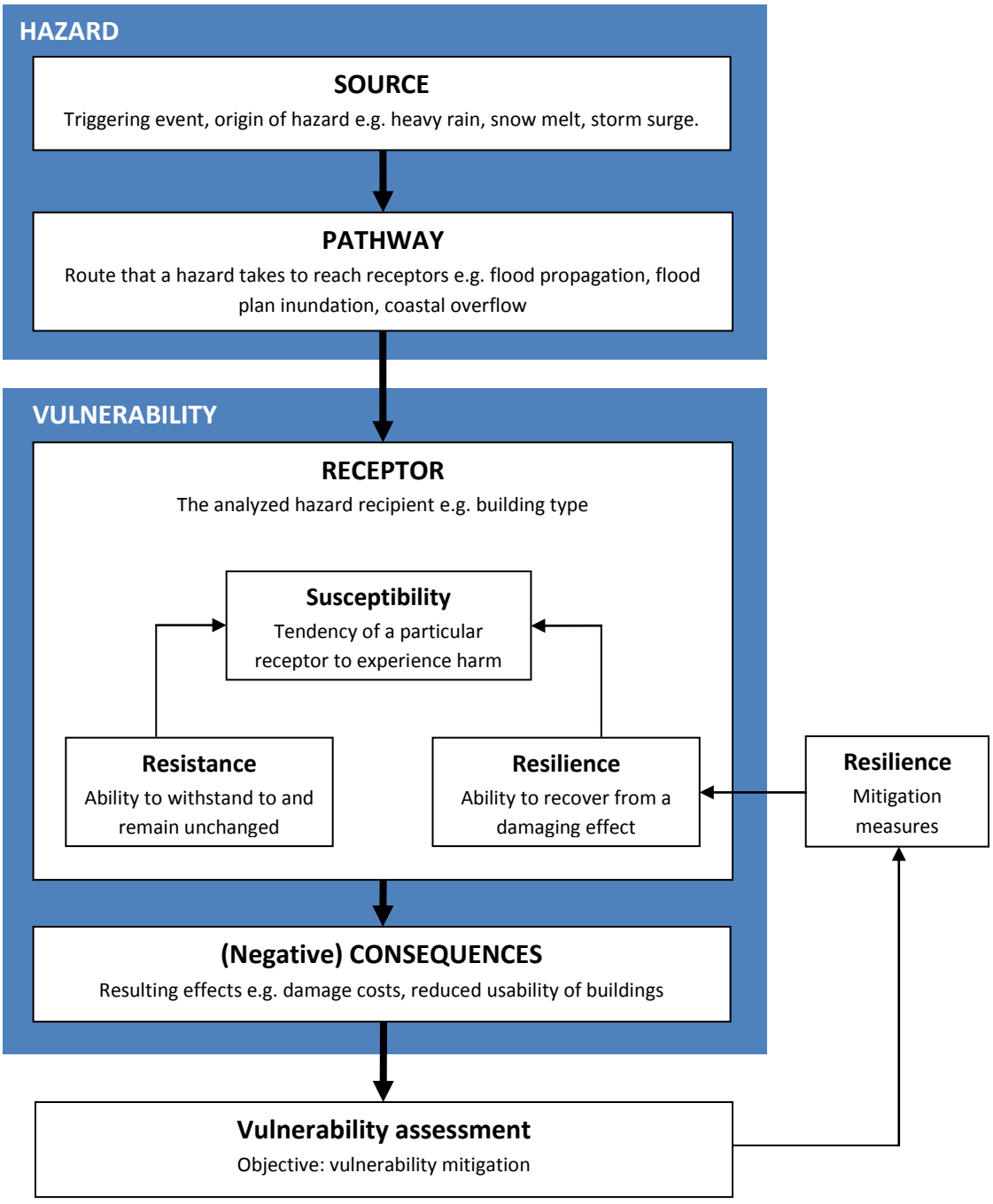


Fig. 5 The qualitative influence of mitigation measures on the dept-damage function. Adapted *(Source: German annual of Spatial Research and Policy 2010.)*

The vulnerability analysis described above can be used to select preventive measures, to analyze their impacts and to compare them with alternative measures. It is helpful in particular for deciding between measures to improve resilience.

2.1.1 Mitigation Measures

As a general model new buildings tend to suffer less from flooding than old ones. It due to the problems has been corrected after previous flood: flood control structures have been built and non-structural mitigation measures instigated slowly over time. On another hand damages in urban space tend to affects to publics services such as sewerage, public lighting, roads, runways and urban furniture. Most of them will spend short period of time (or long) to be corrected, it according to the city' resources (D. Mileti 1999).

In later years urban sprawl has often preceded the necessary environmental protection measures. Moreover, pressures on land and the rates of expansion are going to affect considerably into the cities and the growth itself (D. Mileti 1999).

Therefore, taking above into account, we are going to refer to the mitigation measures based on policies and activities that will reduce an area`s vulnerability to damage from disaster. These measures generally are in place before a disaster occurs and we can divide it in (D. Mileti 1999) (See Fig. 6):

> *Structural Mitigation: It tries to keep hazards away from people and building, aiming to control the rate and flow of floodwaters to prevent damage.*
>
> *Non-structural Mitigation[22]: It allows distributing the population and the constructed environment such that their exposure to disaster losses is limited.*

Discussion mentioned above can be based on systematic approach[23] . Thus, we considering:

Flood Risk Mitigation has emerged in recent years as one of the most significant challenges to innovate solutions facing natural hazards. The flood was an extraordinary moment to impulse sustainable decision making process[24] which would be carried out with citizens and stakeholders, cooperate them together (D. Mileti 1999)

In this way we should considering flood risk mitigation as a relevant issue into decision making on the worldwide political agenda as well as urban plans.

[22] Due to our research aims, this concept will not be examined more closely

[23] The objective of the systemic approach to flooding problems is to develop a set of measures suitable to reduce the damage to an acceptable level and to maximize the efficient use of flood-prone land (Wrachien, Mambrieti, Sole 2008).

[24] In Boulder - Colorado, EEUU. After floods events happened in 1976 from the city council have developed struggle public police related to mitigation measures to different levels having a faculty dedicated to study mitigation cases in EEUU for instance.

Hence, in the scope of UE countries[25], flood mitigation plans require thorough systematic approach [26] , addressing issues towards the adoption [27] and implementation of processes according to the ongoing development of cities[28].

It will be research aims to follow in current paper will be that the resilience of society to floods can be increased by diversifying and linking flood risk strategies, we consider resilience to be a criterion for the success of flood risk governance.

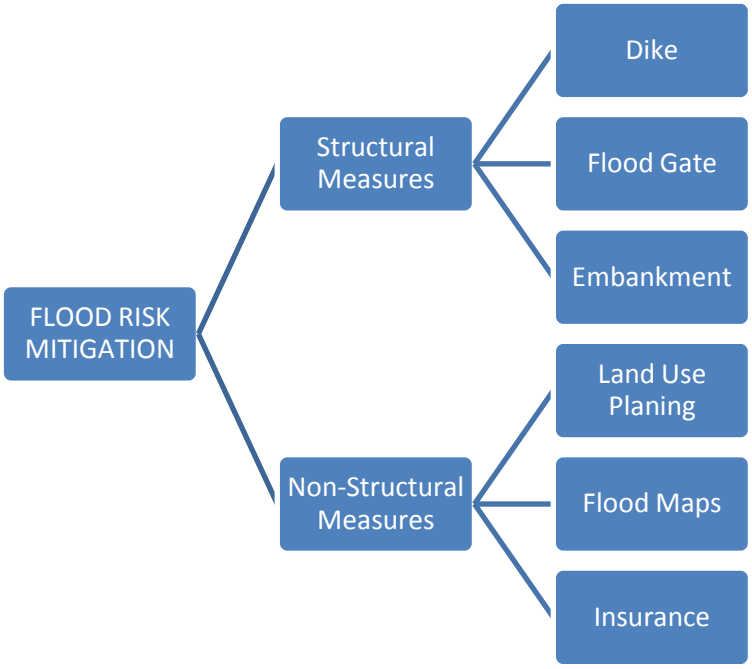


Fig. 6 Flood Risk Mitigation Measures[29]. Adapted *(Source: Disaster by design, D. Mileti 1999)*

[25] The general output from the FLOODsite Project discussion (Schanze et al, 2005) concluded that Flood management can be considered as a comprehensive activity involving, risk analysis and identification and implementation of risk mitigation measures. It was however, acknowledged that many consider management to be a separate process from the analysis process, focusing primarily on decisions and actions regarding mitigation options. Both these definitions are included in HR Wallingford (2002).

[26] The objective of the systemic approach to flooding problems is to develop a set of measures suitable to reduce the damage to an acceptable level and to maximize the efficient use of flood-prone land (Wrachien, Mambrieti, Sole 2008).

[27] Nowadays, the distinction made between 'mitigation' and 'adaptation' should be clear. The first deals with the impact that the built environment has upon climate change and the second (adaptation) with how we need to change our design practices to adapt to a warming world. (Brian Edwards, RIBA 2012)

[28] In the UE context is being carried out ongoing analysis through of the *Star-Flood* program research, where one of the assumptions is based on the resilience of society to floods can be increased by diversifying and linking flood risk strategies to becomes it a criteria for the success of flood risk governance (start-flood 2012).

[29] See examples in Index 3.

3. FLOOD RISK MANAGEMENT APPROACH IN FRANCE CONTEXT

Le Havre is located at the north of France on the Seine estuary (Normandy region). *Le Havre* metropolitan area is 293.851 inhabitants for 678 km². More than 60% of inhabitants live in *Le Havre* city (178.769 inhabitants in 47 square kilometer) (INSEE, 2010). And it is the second largest Harbor in France.

In France Flood Risk Management organization is a top-down and multilevel organization[30]:

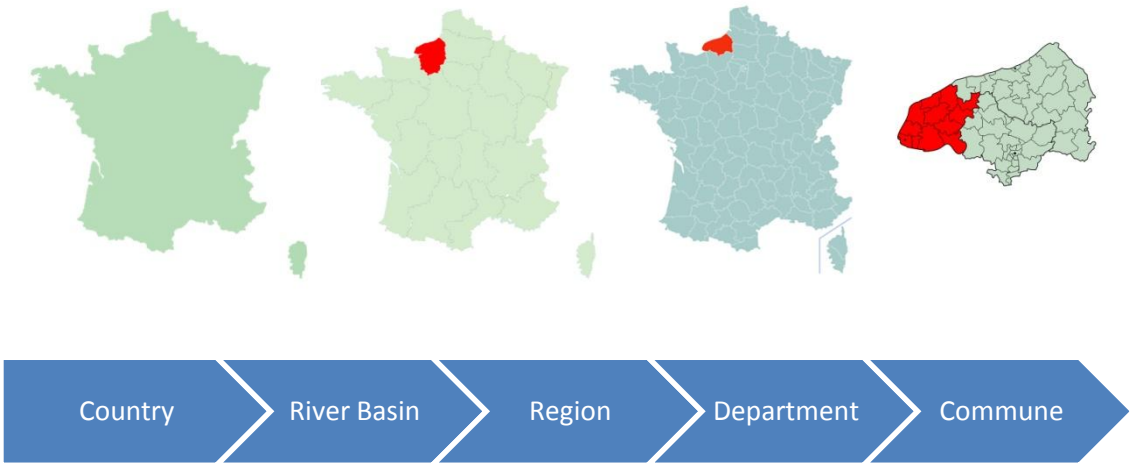


Fig. 7 Different levels of administration in France (*Source: FRM Actors,Kamal Serrini 2013)*

According to the administration level in France, Le Havre is located in the north of France, belong to the Normandy region "Haute Normandie", and taking part in "Communes de L'agglomeration Havraise" which is made up of a group of 17 communes[31].

In 1995 was created PPRi[32] *(Plan de Prévention des Risques d'Inondation)* based on the framework of PPRNP *(Plans de Prévention des Risques Naturels Prévisibles).* The state administration aim was to create a single planning document that would replace all the PSS, *Art. R111-3* perimeters and PER *(Plan d'Exposition aux Risques Naturales Prévisibles)* that existed. None of those procedures had really been successful and implemented locally. Hence, the PPRi aim is to be a simpler tool to identify flood prone areas and impose planning regulations on them (M. Amalric, S. Bernier, M. Fournier, J. Serrano, L.Verdell 2008).

The state administration is responsible and carries out the studies and mapping of the PPRi. Hence, it is a planning document (maps and rules) which constraints local planning documents). The prefect's administration (head of the

[30] See this organization in index 4.
[31] See the map on index 5.
[32] See index 6.

state administration at the departmental level) identifies the areas where a PPRi should be planned[33].
Then, the state administration through the DDE *(Direction Départementale de l'Equipement)* carries out the project. A negotiation phase is planned with the local authorities and a public inquiry before the PPRi is approved by the prefect[34] (M. Amalric, S. Bernier, M. Fournier, J. Serrano, L.Verdell 2008).

At the local level, concerns to the observation of the constraints imposed by the PPRi as well as the willing to develop the territory, there is a main instrument as the PLU *(Plan Local d'Urbanisme)*[35] which is a strategic document must follow what defined in the local PPRi that cancelled the former procedures (M. Amalric, S. Bernier, M. Fournier, J. Serrano, L.Verdell 2008).

3.1 Stakeholders of *Le Havre* in Flood Risk Mitigation.

CODAH. *(La Communautè de l'agglomération Havraise)*

CODAH is defined by 17 communes being *Le Havre* one of them. The aim is to help the population in several areas such as waste management, water management, transport, and information about major risks, hygiene and health, housing, economy, tourism, sports infrastructure. Related to the floods risk CODAH leads the development of guides about flood risk into the city addressed to the community.

SMBV *(Syndicat Mixte des Bassin Versants de la Pionte de Caux)*

It is a public entity which was created by the administrative body of Normandy region in 2000 focusing in mitigating flood risk concerning the Lezarde area. During the late 1990s as well as the 2000s, public policy for flood management has decided to renew and build several small retention basins (around 120 basins), but also to elaborate flood reduction strategies at inter-city level (inter-municipal institution) (Start-Flood 2012).

This entity is working with two more communes: *La Communauté de Communes de Saint-Romain-de-Colbosc, La Communauté de Communes de Criquetot-l'Esneva.*

TOWN HALL

The urban department in the town hall is addressing PLU *(Plan Local d'Urbanisme)* which is focused to identify flood risk areas into the city and provide it of rules such as: minimum height for ground floors, and forbidden areas to build underground parking.

[33] The PPRi has defined four different levels of risk: low, medium, high and very high risk. See Index 7.
[34] The PPRi was prescribed on 26 June 2003 and recently on 8th of Mai was approved as law.
[35] The PLU replace to the POS *(Plan d'Occupation du Sol)*

Likewise we found others mitigation measures which are being carried out from other stakeholders:

The *University of Le Havre* is developing different tests to verify or contrast water sea levels in order to better understand flood events that happened during 1982, 1983 and 1984 in *Saint François* neighborhood.

The ORSEC *(Organisation de la Réponse de Securité Civile)* has been developing, through hydrodynamic modeling, statistics to analyze the sea behavior during the last decade that; as main results they have proposed a chart according to sea tide: *Optimistic* when water from the sea overflows around 40 cm height, *Pessimistic* when water from the sea overflows around 60 cm height, and *Extreme* when water from the sea overflows around 1 meter height.

The MDS (Spread of Modeling Methodology) focusing on designing a communication process in terms of sea submersion, therefore they are promoting tools to spread information about sea overflow and their phenomena or different consequences.

3.1.1 Last Flood Events in *Le Havre*

Just as a historical date: *Le Havre* was established in 1517 and the first flood event happened in 1525. Therefore we can see that this area has lived with the water since its foundation, as well as with several other factors such as rainfall, the river, the sea, and the stream.

As past flood events we have:

- **01 June 1984** *Saint François* neighborhood was overflowed due to sea submersion; overflow height reached 1 meter.
- **04 July 2000** Downtown in *Le Havre* was overflowed due to rainfall; overflow height reached 1 meter.
- **01 June 2003** Overflow by marine submersion in *Saint François*, at that moment damages were almost catastrophic.
- **2009** Water came fast and went back fast to the sea having damage in housing and commercial buildings as results.
- **08 September 2010** *Montivilliers*; two hectares were overflowed due to rainfall.
- **03 August 2012** Overflows around *Le Havre* and basin.

Taking types of floods[36] into consideration nowadays we find as main flood events in *Le Havre*: overflows, runoffs and sea submersion; where pond, stream, filtration capacity of land are involved it. Moreover, the whole area close to the sea has been affected by flood since many years ago; *"each year in the last couple of decades we can see floods event happening due to level sea considerations not being taken in the majority of the buildings"(*CODAH 2013).

Although those flood events in this part of the city did not have damaging consequences, it has become frequent to have floods in the parking areas, overflows of some centimeters in the Public Square of the neighborhood, and closed roadways because of overflows. In this way, stakeholder as the CODAH intends to involve the community through informative programs.

4. STATE OF ART

4.1 Findings and Reflections

4.1.1 Findings

Taking argued above into account, firstly related to the flood mitigation approach and secondly our case study, we focus on the current scenario in *Le Havre* in terms of flood mitigation.

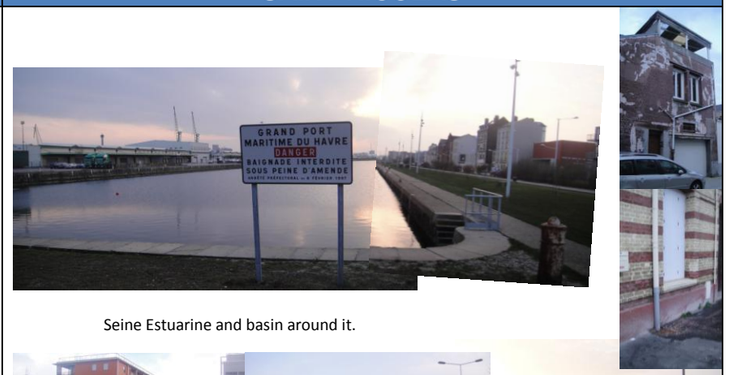
In this way, and after being analyzed the types of level of risk in *Le Havre*, we are going to find natural and human factors which are increasing flood risk. In addition, according to the localization of *Le Havre*, it is mainly affected by the sea and the river as well as a high rain level during the whole year. As result, there is a variety of scenarios around the city and surrounding where can be identified different issues related to the flood events in each of them.

We are going to choice three cases in order to identify those differences and to have a general point of view of the issue. Therefore, these scenarios will be analyzed in terms of morphology and architectural issues and, at the same time, their challenges concerning flood risk mitigation.

The cases are *Grand Hameau, Saint Nicolas*, which are neighborhoods in *Le Havre* city and *Montivilliers*[37] which is a municipality beside to the *Le Havre*.

Analysis will be showed in the next chart (figure 8):

[36] See in Index 1.
[37] See Index 5

	MONTIVILLIERS	GRAND HAMEAU	SAINT NICOLAS
SCENARIO	 *Curande* stream around it. *Lézarde* river around it.	 Water ways in the project. Built-up in surrounding areas.	 Seine Estuarine and basin around it.
ASPECTS RELATED TO MITIGATION MEASURES	– Basin built to save rainwater by SMBV and CODAH. – In 2011 around 116800 m3 of rainwater is saved by the basin everywhere in the region. – Since 2010 a program to limit the spread of household waste has been developed; it was carried out by Mairie in partner with SMBV *(Syndicat Mixte des Bassins Versants de la Pointe de Caux)* – After damage happened in 2003 a program from the municipality to study the vulnerability of the buildings and, if necessary, destroy them was launched. Then those areas are supposed to be hydraulics areas managed by CODAH. – Setting up a permanent service in site to supervise rise up water level. – Points of references have been put in flood risk areas around the village by SMBV, so that people can identify them easily.	– CODAH is promoting the awareness of risks with a pedagogic program called *The Risk Culture (La culture du Risque)* which is addressed to the community through schools, university, newspapers. – In 2007 CODAH invested an amount of 183.000.000 Euros to build basins around Le Havre region as well as to improve evacuation network from rainwater like ditch for instance. – PLU *(Plan Local d'Urbanisme)* identifies flood risk areas in the region and establishes rules according to the level of risk for each of them. For instance, minimum height to built ground floor, forbidden areas to build underground parking, and so on. – In 2007 the ongoing *"Le grand Hameau – L`eco-quartier du Havre"* urban project, from Le Havre town hall was launched. The project aims to innovate about water rain management, with different proposals such as: use of mineral material in public space, green roofs, waterways networks, basin and waterways which will be involved in the landscape design. We remarks mainly two issues of the project: 1. Waterways networks underground and on the ground which will address rainwater to basins. These waterways on the ground have 60 cm of maximum depth. 2. Main basin on the main point of area, due to topography at this point water is coming there by streaming. However, according to the expectations others small basin will be built in different part of the project to give support the main one.	– PLU (*Plan Local d'Urbanisme*) identifies flood risk areas related to submersion marine on the region and establishes rules according to the level of risk for each of them. – *Le Havre* town hall in 1986 built up a retaining wall next to the *Saint François* neighborhood in order to protect it against tide. – Le Havre town hall and CODAH launched a pedagogic program called *The Risk Culture (La culture du Risque)* which promotes information about main aspects related to the submersion marines such as wind, tide height; that people must take into account in order to recognize risk. – PLU (*Plan Local d'Urbanisme*) has established strong rules related to the minimum height to built ground floor, and forbidden areas to build underground parking. – Le Havre town hall through PLU *(Plan Local d'Urbanisme)* Is renewing part of sewage system since the last couple of years ago
	MONTIVILLIERS	**GRAND HAMEAU**	**SAINT NICOLAS**

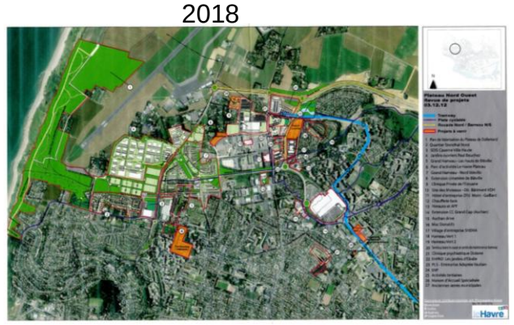
MORPHOLOGICAL AND ARCHITECTURAL ISSUES	Mainly from the destroying measures on risk areas, the urban form presents new empty space which is supposed to be used for hydraulics areas but in some of them it does not work, therefore those spaces are restricted to be built on but they do not have any use. According to the data gathered from CODAH and the municipality (look at website) we can conclude as next: 1. Since a couple years ago they have proposed considerations, recommendations, or strategies in terms of mitigation of flood risk based on several flood events happened before. 2. During the last ten years, many basins have been built taking place mainly on flood risk areas. <u>Urban Growth</u>  1968  2001	The major part of this area is considered as expansion area, which means that the whole urban project involving it will take up empty space of the city which is going to continue its growth. Nowadays we have an agricultural and expansion area which is being developed: the *Grand Hameau - Eco quartier* project[38]. In the project a basin as main design element in reference to large scale has been considered. Therefore there is a basin network proposed into the plan which is going to be underground and over the level ground saving rainwater. <u>Urban Growth</u> 2012  2018 	This area is considered as an urban renewal; therefore we can see old and new buildings around it which are producing two main issues: 1. Changing the height of buildings, turning places from one floor to social housing with fourth floors. 2. Needing to create empty spaces on the area such as urban parks, squares and so on, dedicated to the population. <u>Urban Growth</u>  2003  2012
CHALLENGE	Categorize all of the information gathered about mitigation measures from different stakes in each scale; in order to verify it if all of them can be applied nowadays.	Mitigation strategies at large and medium scale could get innovating changes that at the same time will involve the whole population who live in the neighborhoods including them into the general plan.	At the neighborhood there is only a restriction to use public space related to technological risk, none to the flood risk. In this way, it is necessary to take into account flood events happened from the sea in the past and as well as its fast growth ongoing. There is still acknowledging about the effects at structure, electric, and environmental level causing for the sea water in a flood event. How to improve that or how to approach to this knowledge?

Fig. 8 Analysis of 3 cases in *Le Havre.*

[38] See index 8. The urban plan and design is leaded by Town Hall through dealership given to *SHEMA*, which is half private and half public company.

4.1.2. Reflections

Is important to highlight that the fact of "flood risk" is involving the population both directly and indirectly at the same time, it depends on each case study. That means that when we see *Saint Nicolas* and *Montivilliers*, those are related to neighborhoods where people have lived since long time ago, meaning that they have a previous approaching to knowledge of risk, even experiences (it does not mean that it is enough or the whole of it), due to flood disaster that have already happened in both cases. On the another hand in *Grand Hamaeu* people started to come since a few years ago without becoming a consolidate neighborhood yet, it means that people are not totally involved in it or they do not have any experiences with flood risk as in other cases.

Taking previous reflection into account, the methodological approach about mitigation measures should be taken facing in different ways; for instance at the first case (*Montevilliers* and *Saint Nicolas*) we have a mixture between social buildings and private houses (That means a mixture of middle and high classes) which should be provided with technical measures to mitigate risk at building scale. In this way it is important to cover the whole population, to take actions with them at the same possibilities in terms of adoption and implementation[39]. One example is when there is high-level technical proposals into the houses such as green roof or saving water rain in buildings; it is going to represent high amount of money and most of the times it needs monitoring or following during some parts of the process. Therefore the state must be able to do it feasible to all inhabitants in risk (it does not mean it should be the same resources either design features, design rules, etc.) (D. Milleti 1999).

In the case of *Grand Hameau*, at the start of the project, was taken into account the flood risk issue, for which the project itself has been developed different strategies in terms of flood mitigation.

According to the previous discussion, we are focus in one case which provides us tools to understand the flood mitigation processes ongoing. In this way we have chosen to address the *Montivilliers'* case due to it presents a combination of factors in the cope of flood risk, among the flood urban areas and the mitigation strategies that are being developed within last decade. In a way it will give us valuable support to go deeper in the topic of flood mitigation in order to elaborate relevant results.

[39] At the framework of decision making processes "adoption" and "implementation" have a crucial position due to it will involve personal stakes, let say inhabitants; organizational stakes let say local communities, and national governmental stakes. Therefore, it should be taken as process where feedbacks among all of the actors mentioned before exist. (D. Mileti 1999)

4.2 How can mitigation strategies be interpreted ongoing? Special case in *Montivilliers*

On the scope of flood risk policies in France[40], during the last decade *Montivilliers'* municipality has developed an important plan about how to adopt and improve strategies in order to reduce the vulnerability facing flood events. This work has been carried out mainly by SMBV and CODAH at different scales on cities and supported, among others, by the Ministry of ecology, the sustainable development, transportation and housing.

In this context we have two main considerations: first, during the late 1990s and the 2000s, public policy for flood management has decided to renew and build several small retention basins (around 120 basins). The watershed valley "*La Lézarde"* it elaborates flood reduction strategies at the inter-city level (intermunicipal institution) (Start-Flood 2012). (See figure 1 and 2) Secondly, several documents have been launched in the same period from the stakes mentioned before, which are focusing to provide recommendations for households in order to mitigate flood risk at building scale in terms of minimizing the structural damages to reduce delay, become normal again and keep households safe[41] (Ministry of ecology 2011).

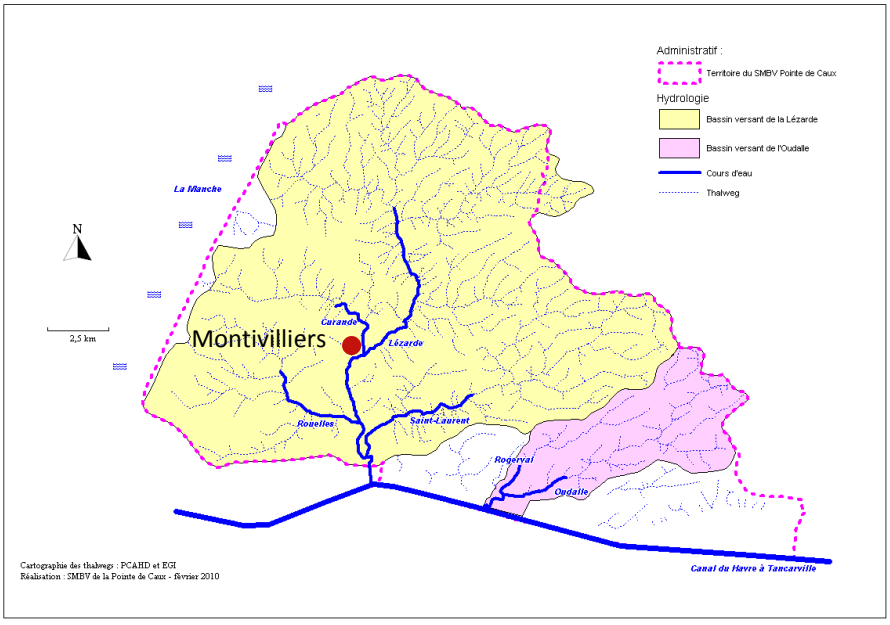


Fig. 9 Structuring axes runoff from watersheds of the community of Havre (source: SMBV, 2011)

The watershed area of the community of Le Havre is incised valleys plateau. The steady flows occupy only the terminal portion of these valleys. Upstream, the valleys are called "dry": the water flow is happening there in case of rainy weather. Valley bottoms or valleys are otherwise called troughs.

[40] According to the report about "French policy to reduce the risk from disasters" published by *Ministry of ecology, sustainable development, transport and housing in 2011,* reducing vulnerability is considered as one of the seven pillars of French prevention policy.

[41] According to the PPRi there is a classification which to allow considering the situation about building facing its vulnerability. See Index 9.

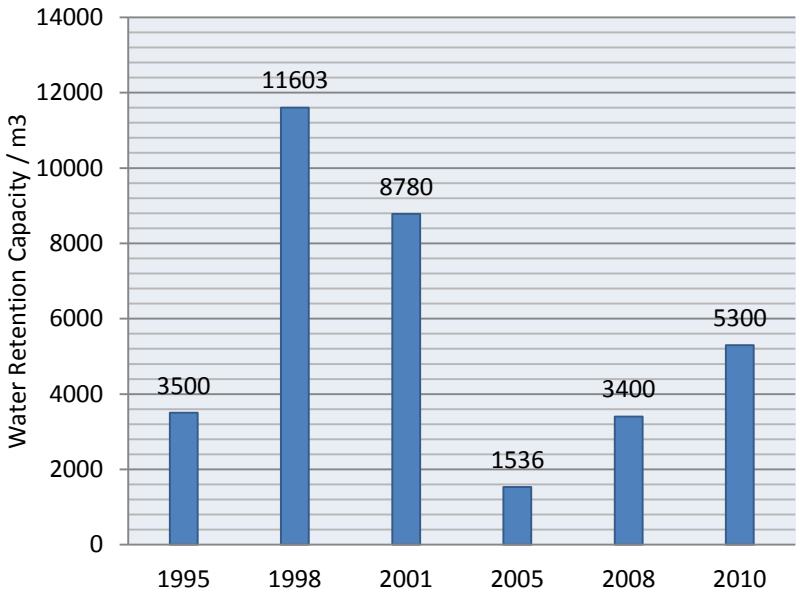


Fig. 10 Basins' water capability, it has built during last couple of decades in the of *Montivilliers'* municipality.

Since the beginning of eighties SMBV has been responsible for to build retention basins around Montivilliers' municipality, it is framed on the program called "rainwater structural works".

As a first step on this methodological approach, I have analyzed all of the data gathered according to the mitigation measures from different stakeholders involved in *Montivilliers*[42]. After that, and taking into account the major part of the references I read, I am going to clearly report three main scales which will allow an approach to flood risk that becomes more powerful in the France discourse about risk. As we can see, the PPRi report always identifies the building or lot scale as *"l'échelle du parcelle*", the neighborhood scale as "l'*échelle du quartier*" and the catchment scale as *"Agglomération"* (CODAH 2011). In a way from my viewpoint, it is a clear manner to face floods at different levels allowing us to get a broad scenario as at the same time we enter into further details. It is considered that at the beginning, as well as throughout the fieldwork, we have:

- *Catchment Scale*

  At the level of river basin, catchment scale focuses on providing measures to reduce flood risks through large infrastructure as dicks or barriers. Provision of temporary water storage capacity during flood events, to reduce peak flows can be adopted through the retarding basins as well as holding water in the upper parts of catchments which reduce downstream flooding (TCPA 2007).

[42] See all of the mitigation measures in Index 10.

- *Neighborhood Scale*

  At the level of river basin, neighborhood scale focuses on understanding and managing flood pathways and protecting areas at risk. In this way we should consider measures as permeable pavement, gravel or grass so that water can soak away and provide of green open space which could become a potential storage area, using for example infiltration ponds. Likewise green roofs reduce runoff and improve pressure on drainage systems during heavy rainfall (TCPA 2007).

- *Building Scale*

  At the level of river basin, building scale focuses on minimizing exposure to flooding whilst incorporating structural solutions to reduce vulnerability. Existing buildings can take advantage of new materials and products to manage flood risks. Some of the main resilient measures in the building are materials and removable household products. Nowadays, measures such as Green roofs are constantly increasing. This will help to reduce runoff and ease pressure on drainage systems as well as managing flood pathways and removing 'ditch', which during heavy rainfall can drain away (TCPA 2007).

Therefore, as main result we can see that most of the mitigation documents concerning *Montivilliers* are addressing mainly the building scale, producing so much information about it. In a way, this could be advantageous in terms of implementation approach [43] . Nevertheless, it is not because all of the recommendations that are not involved as feedback process where the owners can interact with persons who promote it, otherwise they should assume whole execution of measures, having as consequences that most of the owners do not carry out that.

According to what I have studied, an experimental survey[44] was carried out by the CODAH in 2012 on inhabitants, who were affected by flood events that happened in 2003. The target was damages caused at that time can propose them some infrastructure measures to minimize damages facing a future overflow. Currently, the results of this survey are still under review by the CODAH, but also the first perception was related to lack of application of these measures by the owners.

[43] At the framework of decision making processes "adoption" and "implementation" have a crucial position due to it will involve personal stakes, let say inhabitants; organizational stakes let say local communities, and national governmental stakes. Therefore, it should be taken as process where feedbacks among all of the actors mentioned before exist. (D. Mileti 1999)

[44] See whole survey in Index 11.

In this way, one consideration can be that those recommendations in the building scale do not have a clear link among the catchment and neighborhood scale measures, having as consequences the lack of suitable knowledge about how to implement that by the inhabitants.

Another consideration related to this scale has to do with the vulnerability measures that have started to obtain a certainly relevant policy plan after flood events happened in 2003 (See figure 11) mainly through PPRi. Nevertheless in the neighborhood as in the catchment scale they already began to be analyzed a few years before that.

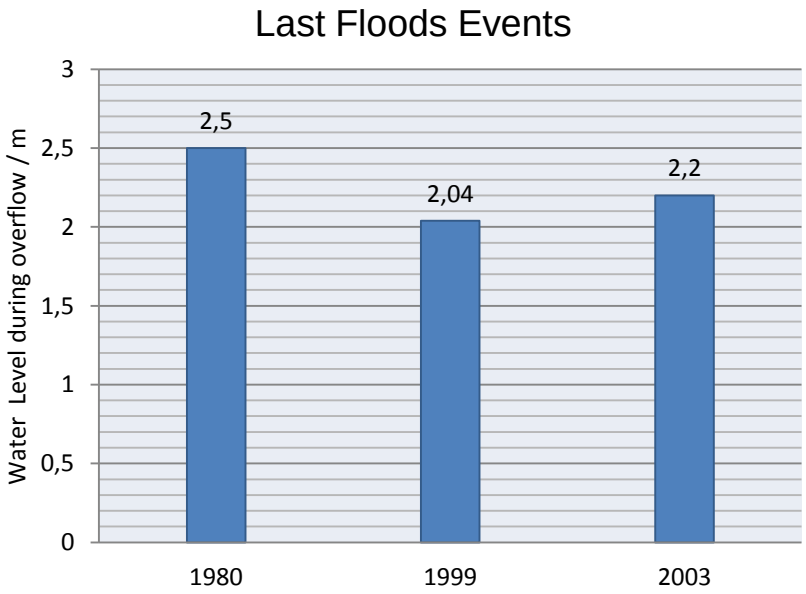


Fig. 11 Main last flood events happened in the *Montivilliers'* municipality.

In the framework of tendency *one overflow event per each 10 years; different actions facing floods is going to carried out during ninethies90, it will become recognize in the cope flood prevention policies through PPRi which was prescribed on 26 June 2003*[45]*. It involve watershed in the Lézarde river, coastal maritime and seine reverie.*

On the other hand at the catchment scale we are going to find that all of the mitigation measures are addressing the basins and expansion areas which have began to apply a few years ago. Despite the usefulness of these measures in terms of vulnerability reduction, they are hard to manage.
Some testimonies show that this fear takes an important consideration nowadays from stakes as CODAH:

"*It is a green space? Who will manage it? Which kind of construction could take place?"*

[45] The PPRi was prescribed on 26 June 2003 and recently on 8th of Mai was approved as law.

Taking previous questions into account as well as discourse argued above about “implementation”, an opposite scenario arises with the same consequences, meaning that most of the measures commented at this scale have been implemented but having a lack of integration with the inhabitants. In part it happens, in this case of basins for instance, they were created in the past on surrounding areas which have grown (see figure 12) so fast during the last decade through built-up areas that appear around them (see figure 13). Hence, this mixture that is found nowadays in built-up areas around basins helps us to keep that sense of living on water and should obtain an important position on political agenda, concerning not only flood risk areas, but also flood prone areas and further flood protected areas (V. Wattenberg, T. Brinkhof, J. Spits 2008).

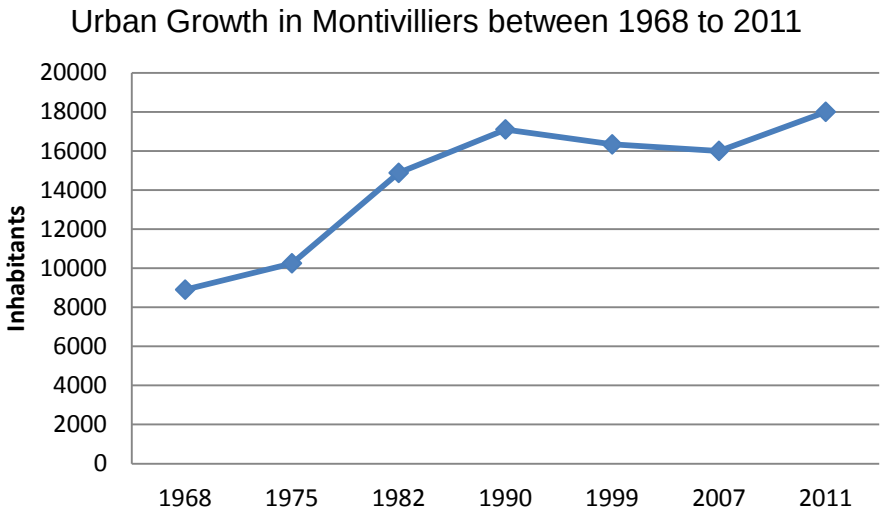


Fig. 12 Growth rate in *Montivilliers’* municipality. (Source: INSEE 2011)

In the framework of tendency *one overflow event per each 10 years; different actions facing floods is going to carried out during 90, it will become recognize in the cope flood prevention policies through PPRi which was prescribed on 26 June 2003. It involve watershed in the Lézarde river, coastal maritime and seine reverie.*

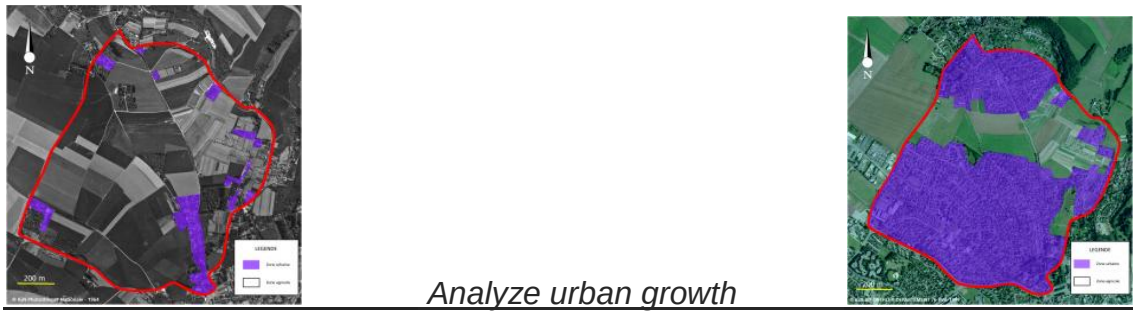


Fig. 13 Urban Growth between 1968 to 2001 in *Montivilliers’* municipality. (Source: SMVB 2011)

In *Montivilliers* since the last decade built-up (urbanizations over flood risk area without monitoring process) areas have increased.

In an international context it is well known that during the last couple of decades the attitude from struggling against water has been changed for an approach towards to live with it (living with water). At this point from known cases in countries as Netherlands or Germany we can perceive two positions about to build in floodplains areas which are going to help us to understand better this situation. On one hand it could be considered as viable once they strengthen the interrelation between safety, economy or sustainability, this belief is recognized under “water as companion” become a perspective where buildings can be considered to be solutions serving multiple purposes within complex problems (see figure 14). On another hand there is a belief that the river should keep the function of a river, and buildings are regarded as hydraulic obstructions and threatened objects. Buildings are then considered to be an unwise decision (V. Wattenberg, T. Brinkhof, J. Spits 2008). This contradiction in beliefs seems to be about disputes over water management versus spatial planning within the domains of risk management. In parallel, it shows the diversity of a broadly accepted philosophy such like “water as a companion” (V. Wattenberg, T. Brinkhof, J. Spits 2008).

Fig. 14 Residential area in *Trabrennbahn Farmsen* (Hamburg, Germany) 2000.

The storm water management train is clearly organized and well implemented. In the open water system the storm water is retained and on its way to the retention ponds, it is able to percolate into the soil. Therefore it contributes significantly to the redevelopment of a natural water cycle.

Finally, as far as the neighborhood scale is concerned, there are mitigation measures mainly based on filtration processes, carried out through easy techniques, highly related to the natural landscape, and moving towards sustainability, if applied successfully. Moreover, it is possible to be integrated into the storage water system due to some of these measures, which can storage temporarily water when at the same time its filtration capability improves. Specifically, the measures proposed at this scale also offer a talent on how to adapt it or extend it to another scale taking in consideration both, for instance in the case of water way is clearly that they can be connected to the retarding basins as well as take water from the dew pond which would carry out rural housings. In this way, we can see as the concept of water management, through the water conservation and drainage concept appears to take an important role in a flood mitigation strategies.

Therefore having a broad consideration about mitigation strategies ongoing in *Montivilliers*, and through careful examination procedure on literature review we have chosen all of the measures found mainly in SMVB, CODAH and Ministry of ecology. Then, according to the scales (Catchment, Neighborhood and Building scale) and its inter-relation with the water management process, we are going to categorize them.

As result, we approach through next chart to flood mitigation measures in *Montivilliers* (see figure 15):

MEASURE ADAPTATION	
A	Adapted Measure
NA	Non-adapted measure

ACHIEVE	
P	Primary
S	Secondary

		CATCHMENT SCALE	NEIGHBORHOOD SCALE	BUILDING SCALE	Sloping land >5%	Lower ground waterproof	Lower draining level	Reduced area parcel	To reduce damages	delay return to normal	Keep household Safe
					Land properties/characteristics				Expects		
WATER CONSERVATION		Flood Retarding Basins								P	
		Flood Barrier or Dams								P	
		Field Expansion Rise								S	P
			Dew Pond		NA	A	NA	NA		P	
DRAINAGE			Waterway		A	A	A	A*		P	
			Dew Pond		NA	A	NA	NA		P	
			Permeable pavement		A*	A	A	A		P	
				Ditch	A	A	A	A*		P	
				Draining trench	A	A	A	A		P	
INFRASTRUCTURE	Temporary methods to protect the housing. Height <1mt.			Cofferdams					P	P	P
				Sandbag					P	P	P
				Wrapping					P	P	P
				Shutter vents					P	P	P
				To protect the front porches located in the axis of the stream					P	P	P
				Refuge area into the housing							P
				Wastewater management					P	P	P
	Adaptation of the different kind of materials inside at home. Height >1mt			Walls					P	P	
				Dividing walls					P	P	
				Coatings wall					P	P	
				Floors					P	P	
				Woodwork					P	P	
				Weather-proofing					P	P	
				Protection of climate control equipment					P	P	
				Redistribution and / or modification of electrical circuits					P	P	P
				Protection of elevators					P	P	P
				Prevention of damage to networks					P	S	P
				Prevention of damage caused by oil tanks.					P		P
				Protection of persons in presence of swimming pools.							P
				Protection of crawl spaces.					P	P	

A* These measures are not adapted enough but can be implemented.

Fig. 15 Flood Mitigation Measures in *Montivilliers* (Designed by the author).

The measures have been collected through careful examination process on data of literature review mainly from the SMVB, CODAH, and Ministry of Ecology. On the chart only structural mitigation measures have been taken. We can see in detail on Index 10.

4.2.1 A holistic approach adopting measures

The flood events that happened in 2003 were a main factor to develop an important progress in terms of measures and strategies facing flood risk. As mentioned above, in this context one of the most important initiatives was carried out by the SMBV with the construction of basins around the community area. But at this point is important to remark that these basins started to built on countryside areas and with a high retention capability *o*f rainwater, while nowadays due to the urban growth the basins are decreasing in terms of retention capability (see figure 10). Moreover urban sprawl has as consequences that built-up areas are closer to the basins than before. Thus we have in term of urban scenarios, on one hand a scenario where the city should improves its resilience (adaptability) conditions against floods but on the other hand there is a second scenario which will be related to the question about how the basin is adapted to the new settlements that are being built (A. Röhring, L. Gailing 2011).

In our approach we will take into account the first from the two previous scenarios only one scenario, due to our focus to be taking the mitigation measures which are already done or proposed from stakeholder and to apply it. It will be more useful in order to enhance the mitigation strategies going on; otherwise the second scenario presents one more way of suggesting new uses about that space and furthermore it can be an empirical approach deal with spatial inter relation between measures and settles that gave the built up that comes to the measure. On the other hand in our research, the measure comes to the built up.

At the same time, large measures have been developed about how to mitigate flood risk at the building scale, producing numerous documents about that. All of them come from different stakeholders such as the national, the municipality level based on professional knowledge as well as experience getting in past flood events. It becomes a handbook guide of solutions which do not have strong or specific properties what allow them to get involved with the rest of scales. These measures can therefore be defined as from a theoretical perspective on the basis of conceptual and experience or based on statistical analysis, which will be adopted according to the risk of level of different areas into the city and implementing it directly by the owners.

The methodology presented by this section is a synthetic approach to the mitigation analysis of built environments[46] carried out around the city. The main

[46] Research on built environment deals with a complex and interdisciplinary subject; for example specific analyses and assessments will only be possible when the urban built environment is defined in categories like housing, office, and industrial building, and in a more detailed form such as housing periods and types. We would then be able to identify main features in order to get measures and carry them out (A. Blum, K. Gruhler 2011).

objective of the approach is to determinate how it can create resilience condition on the town applying the mitigation measures proposed by stakeholders through of empty space [47] based on urban morphology of *Montivilliers*.

Through an urban analyze we will identify different typological urban form produced into the city, and then this will allow us to identify different patterns of occupation of land focus on the "empty vs fill space" criteria.

The mitigation approach consists of three main components:

- The special identification of typologies based on urban features in municipality of *Montivilliers* and the choice of the most representative ones.
- The analysis of areas taking into account high and medium risk of level[48] which will represent a holistic approach to the flood risk going on.
- The hypothesis on how these cases could became if some of the mitigation measure would carry them out.

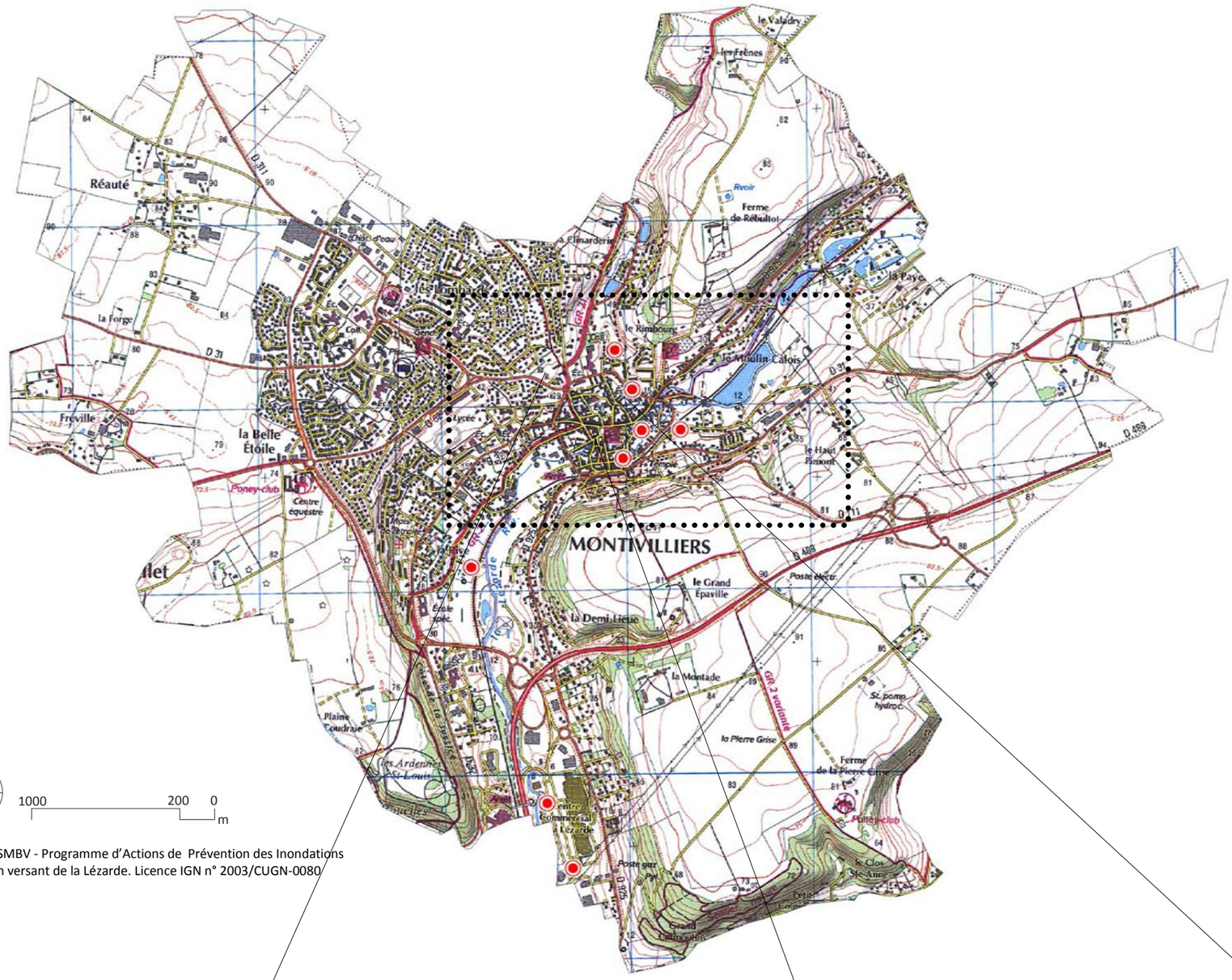
The first step based on urban morphology theory[49] is takes place in terms of "empty vs fill space", due to which understanding the cities with a broad view is possible. At the same time the urban form gives an idea about how it was structured, and how it works. In other words "the *skeleton system"* of the city (M. de Solà 1972). Considering it part of many discussions from several authors within the years, it can be considered that in the past there was holistic interest in to think the city but over the years it has undergone a metamorphosis to become quite contemporary concept known as "re-thinking the city". Specially in Europe, countries carry out urban develop process under this concept; arising new ways based on point of view as sustainable development, urban regeneration as well as hazards risk in urban areas. This latter subject it has been explained by Mark Pelling as *the co-evolution of urbanization and risk*, the nature of disaster risk is constantly being redefined as changes to urban landscapes and socio-economic characteristics are unfolded. Urbanization affects disasters just as profoundly as disaster can affect urbanization (M. Pelling 2003).

[47] Has been taken public and private space on whole analyze.
[48] It is based on the flood Risk map of Montivilliers by the PPRi.
[49] A.E.J Morris.

Second step, based on categorization of flood mitigation measures[50] (see figure 15), our next step will be to contrast the efficiency and dynamics of them. To do that, we are going to adopt some flood mitigation measures in the current area in *Montivilliers* through graphic exercise where we will able to identify the strengths or/and weakness of them.

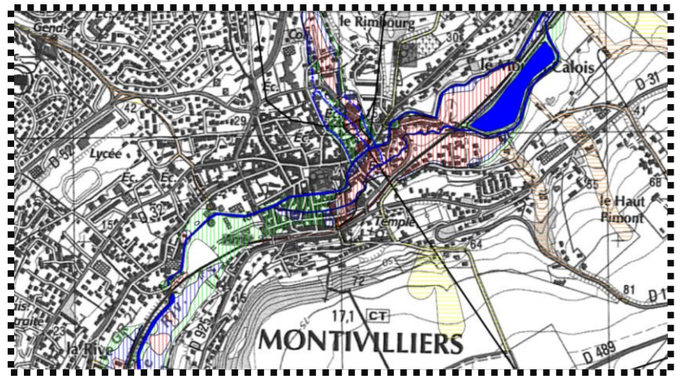
According to the previous consideration, we are going to explain how was carried the approach out, applying these measures in three different scenarios:

[50]Nowadays, several authors argue concerning flood mitigation: *it should extend to strategies in which actors are integral part of the system and either influences its resiliency to the places* (A. Röhring, L. Gailing 2011).



Source: SMBV - Programme d'Actions de Prévention des Inondations du bassin versant de la Lézarde. Licence IGN n° 2003/CUGN-0080

FLOOD MAPS ACCORDING TO PPRi



Source: DDTM Seine-Maritime | IGN Scan25®2005 | SAFEGE®2008
© DDTM de la Seine-Maritime - SRMT - BRN | conception : S. Perez - Mai 2011

EMPTY vs FILL SPACE

Empty Space

Fill Space

Streets

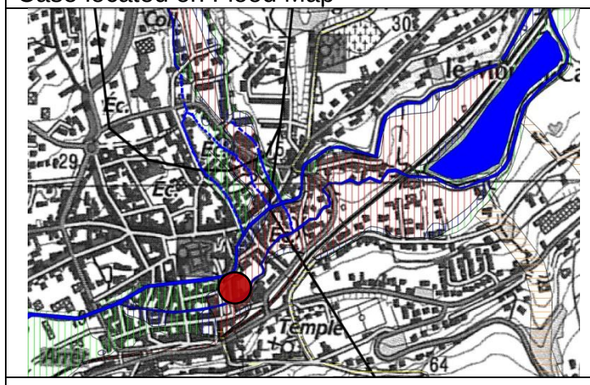
BLOCK TYPOLOGYS

Typology 1
Rural Housing
More than 50% empty space

Typology 2
Urban Buildings
More than 50% fill space

Typology 3
Mixture between Typology 1 and 2.

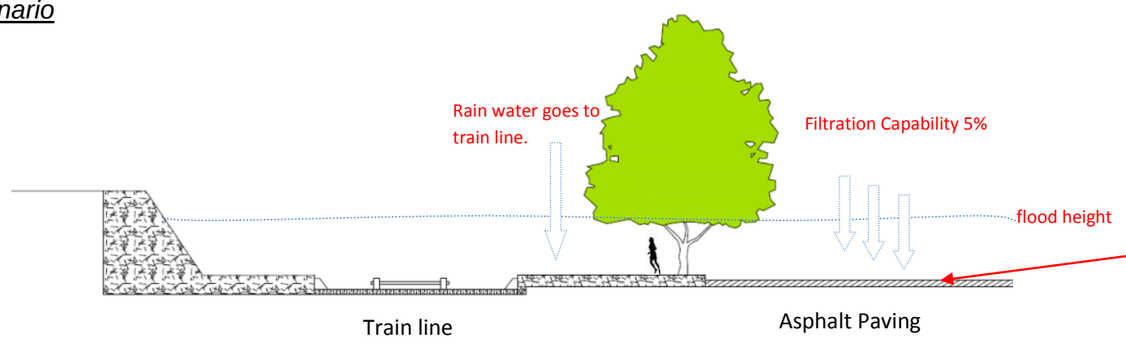
SCENARIO 1

Case located on Flood Map	Block Typology	Empty Space to Analyze	View
			
High Risk Medium Risk	Typology 2. Urban Buildings	Public space Private space	

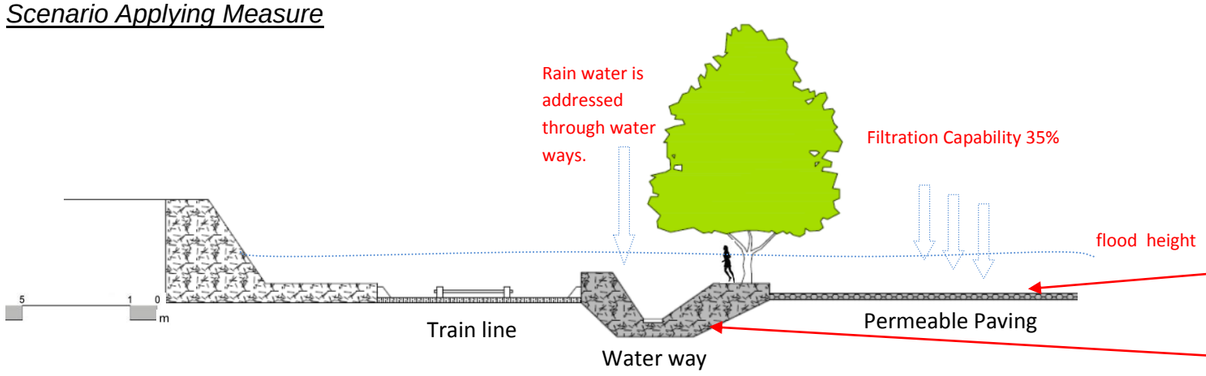
Empty Space to Analyze	
Empty Area	**Total Area 4108m2** Public: 3830m2 Private: 278m2
Use of the space	Parking Area
Material on the ground	Asphalt Paving
Green areas	Dense vegetation with tree around 8 – 10 height. Tree 4 m height on the parking.
Water level during last flood event	2,50 m
Construction around it.	Housing Residential Building
Use of the buildings	Commercial and housing
Max. Height of building	12m (4 levels)
Topography	Land flat
Water table	

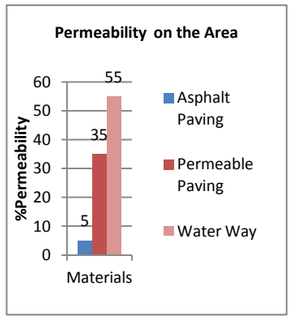
Measures adopted according to the chart (Fig. 15).	
Slope land <5%	**Permeable Paving Water way**
Low water table level	

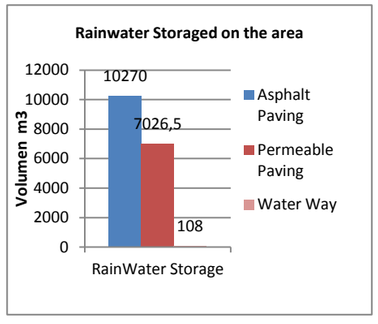
Scenario

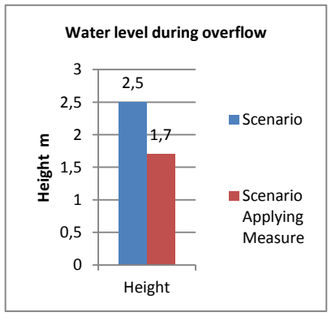


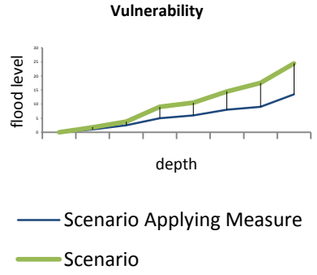
Scenario Applying Measure







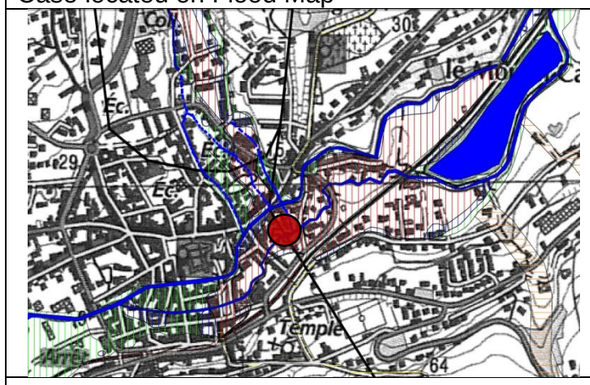
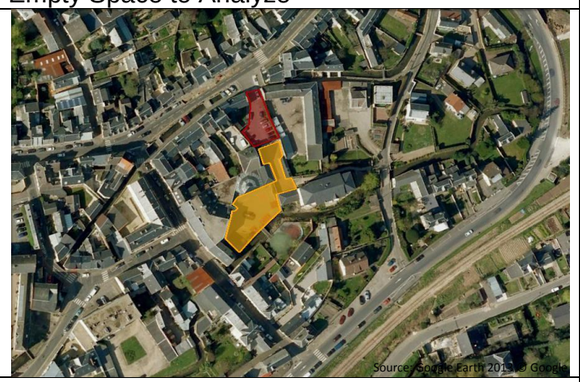




This analyzes shows as results: having applied the mitigation measures and using the same conditions happened during flood event in 2003, the flood risk have been reduced 32%.

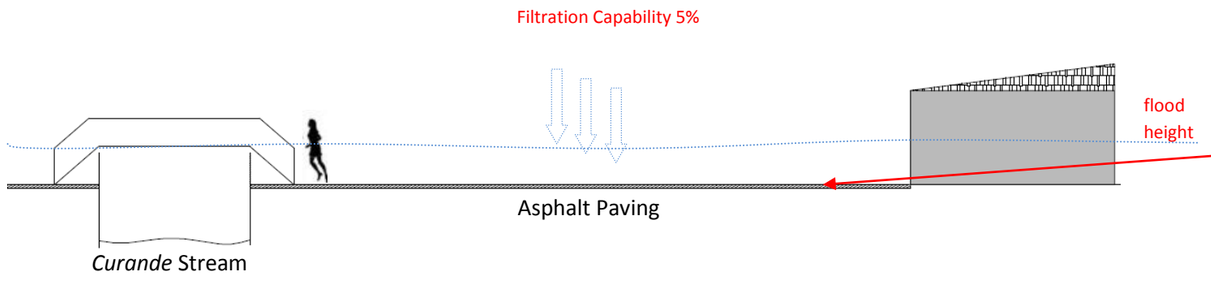
These quantities were calculated take into account list of standards material from France and UK, based on data and literature review about kind of permeable grounds and new kind of materials related to flood risk (See Index 12 – 13).

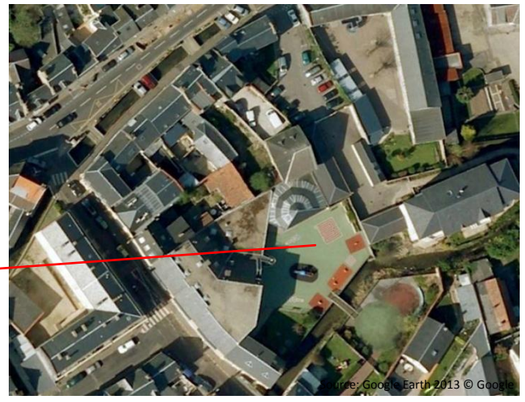
SCENARIO 2

Case located on Flood Map	Block Typology	Empty Space to Analyze	View
			
High Risk Medium Risk	Typology 2. Urban Buildings	Public space Private space	

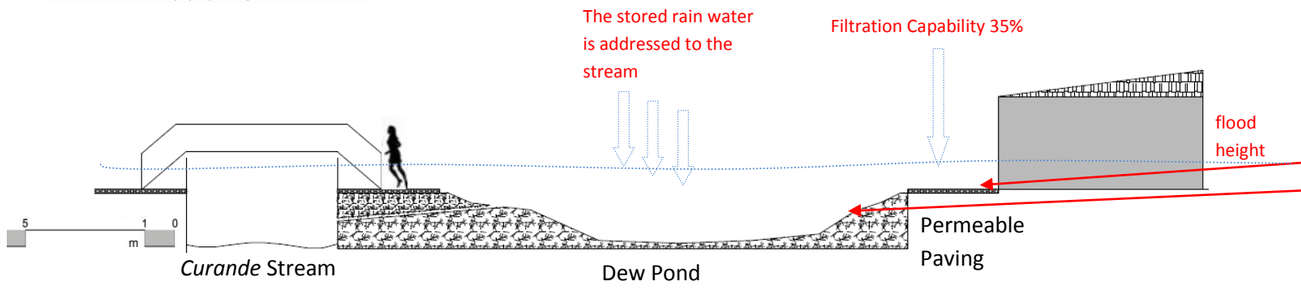
Empty Space to Analyze	
Empty Area	**Total Area 1163m2** Public: 363m2 Private: 800m2
Use of the space	Parking Area Leisure
Material on the ground	Paving Paving synthetic
Green areas	Lack of it
Water level during last flood event	1,15m
Construction around it.	Housing Residential Building
Use of the buildings	Housing
Max. Height of building	18m (5levels)
Topography	Land flat and slope
Water table	

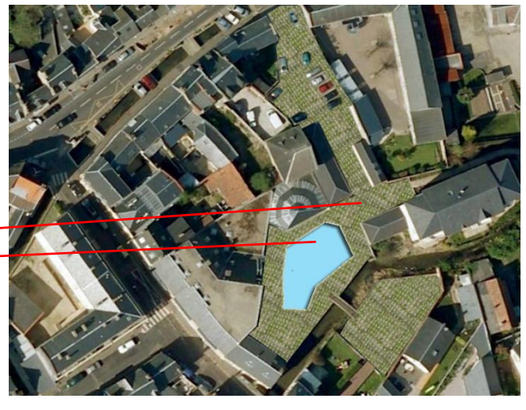
Scenario



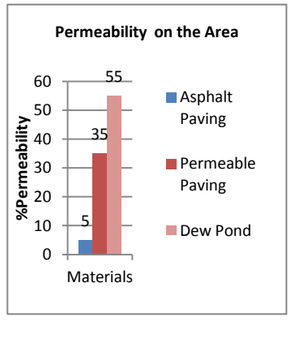


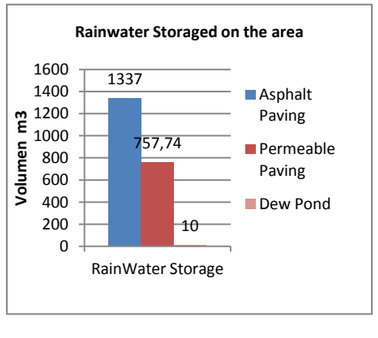
Scenario Applying Measure

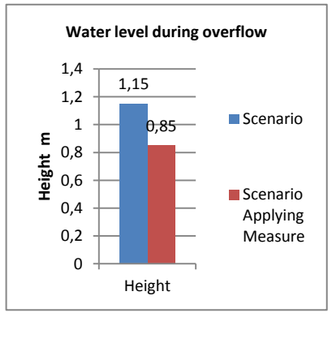


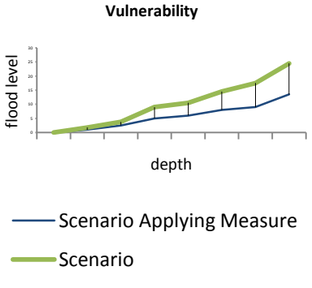


Measures adopted according to the chart (Fig. 15).	
Slope land <5%	**Permeable Paving Dew Pond**
Low water table level	





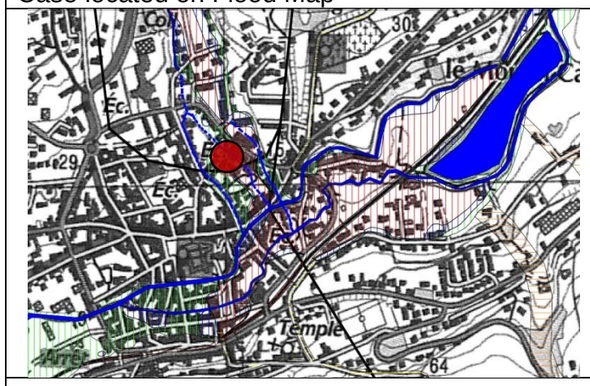




This analyzes shows as results: having applied the mitigation measures and using the same conditions happened during flood event in 2003, the flood risk has been reduced 26%.

These quantities were calculated take into account list of standards material from France and UK, based on data and literature review about kind of permeable grounds and new kind of materials related to flood risk (See Index 12 –

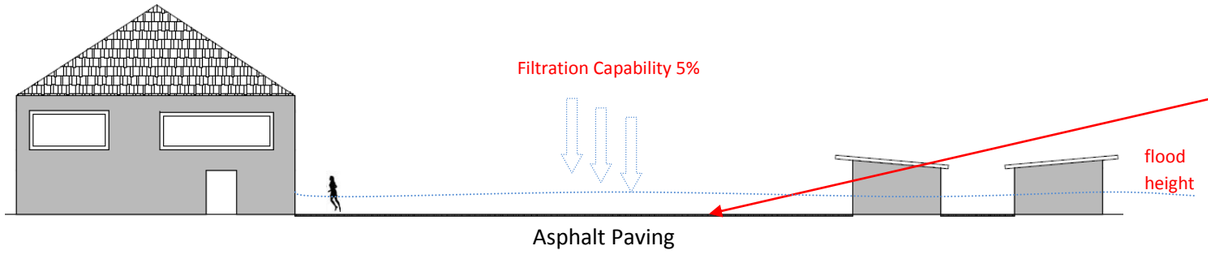
SCENARIO 3

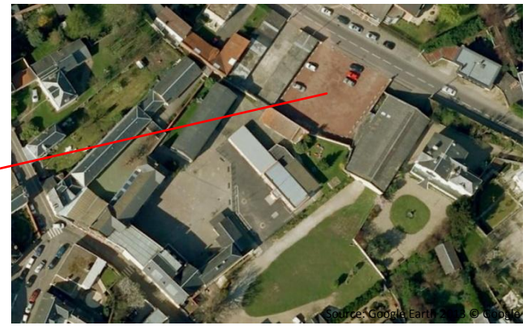
Case located on Flood Map	Block Typology	Empty Space to Analyze	View
			
High Risk / Medium Risk	Typology 3. Mixture of Buildings	Public space / Private space	

Empty Space to Analyze	
Empty Area	**Total Area 2254m2** Public: 792m2 Private: 1462m2
Use of the space	Parking Area
Material on the ground	Paving Paving without asphalt
Green areas	Lack of it
Water level during last flood event	0,71m
Construction around it.	Housing School
Use of the buildings	Housing
Max. Height of building	10m (3 levels)
Topography	Land flat
Water table	

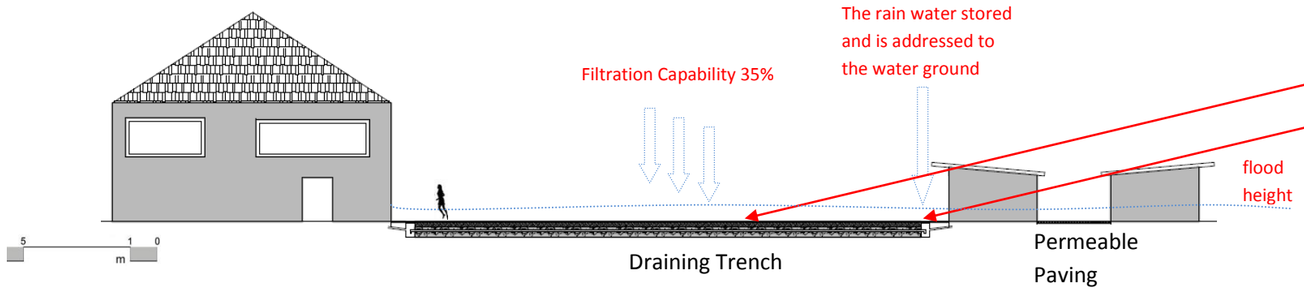
Measures adopted according to the chart (Fig. 15).	
Slope land <5%	**Permeable Paving Draining Trench**
Low water table level	

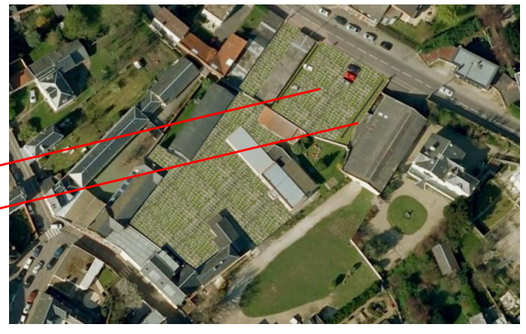
Scenario

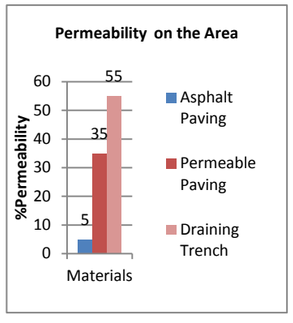


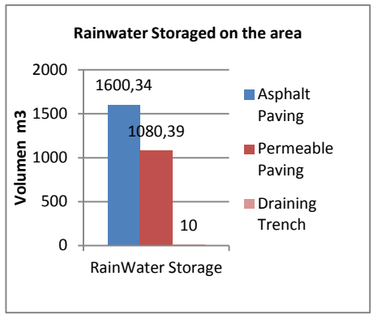


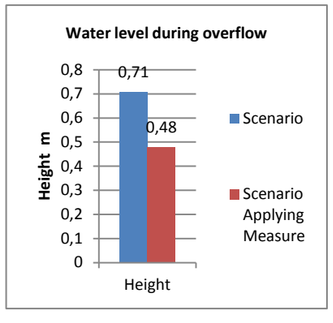
Scenario Applying Measure

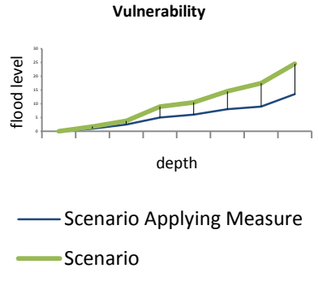












This analyzes shows as results: having applied the mitigation measures and using the same conditions happened during flood event in 2003, the flood risk has been reduced 33%.

These quantities were calculated take into account list of standards material from France and UK based on data and literature review about kind of permeable grounds and new kind of materials related to flood risk (See Index 12 –

Concerns previous exercise, we decided to apply mitigation measures at neighborhood scale taking into account two main considerations: first, mitigation measures found at this scale (waterways, dew pond permeable paving, ditch and draining trench) are not implemented in most of parts of the *Montivilliers*. Second, we found also around *Montiviliers* several empty areas, both public and private, such as parking, squares, and parks; which are producing different urban form into the city.

According to that arises the question about *how to involve these areas with the flood mitigation process?*

As main result, we can see as the vulnerability was reduced at average of 30% having applied the mitigation measures in all of the scenarios.

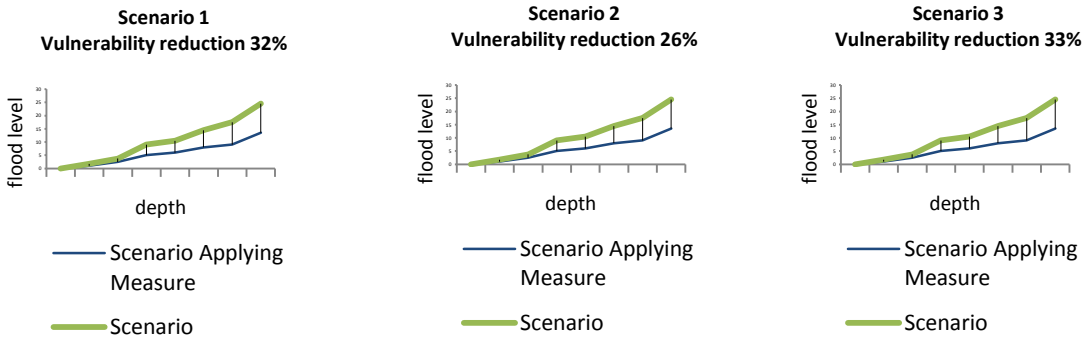


Fig. 16 Vulnerability reduction for each scenario.

We can consider that the neighborhood scale has a talent to involve stakeholders of both catchment and building scale due to it allows carry projects out that will serve as meeting point between professionals and inhabitants promoting to work together on flood mitigation.

As an example, the implementation of new material as permeable paving on the ground can take part at the municipality or regional level regarding the features of public and private space. But also it will involve directly to the community, due to in a way they could be able to make it, through participation process for instance (See figure 17).

Scenario

Scenario Applying Measure

Fig. 17 Holistic view on *scenario 1* having applied mitigation measure.

The flood mitigation measures have a talent to create participative process at different scales through of projects related to flood mitigation currently, as for example urban farming.

5. OUTCOMES

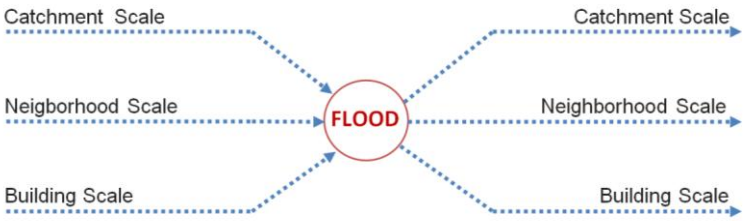
Considerations and Conclusions

- In the urban plan but it is not clearly integrated in the urban form features related to parks, squares, parking, etc; dealing with flood risk. Mainly, this is actually one of the weaknesses that we found in *Le Havre.*

- Nowadays we can see as projects at catchment scale which has been adopted and implemented (Flood retarding basins) mainly in surrounding areas, and at the same time, projects at neighborhood (Waterways, dew pond, etc) and building scale (Temporary methods to protect as well as adaptation of waterproof materials at home)[51] which has been adapted but are still not implemented entirely.

- Taking previous into consideration in a way is necessary to create links among those three scales that are related directly with flood mitigation (See figure 17)

18A). Lineal way



18B). Comprehensive way

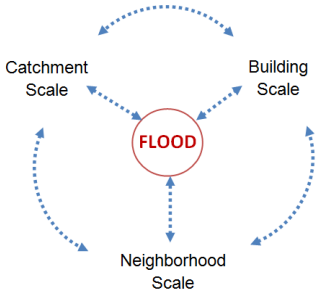


Fig. 18 Mitigation Measures Processes (Designed by the author).

Concerns flood mitigation measures there is not a clear links between different scales currently, It can be considered, due to each scale face flood risk in a lineal way (fig 17A); but what will happen if all of them facing flood risk in a comprehensive way?(fig 17B)

[51] See Figure 15

Hypothesis

Furthermore most of the authors included in the literature review have been focusing since few decades ago on the population growth issue which takes a relevant worldwide position on the political agenda. In this context, concepts such as renewal built-up and urban regeneration appear more and more in most of the studies/analyses about the cities. Referring to that, ongoing urban processes is going to suggest radical transformations including movement of people, changing habitudes, new views about the city, etc (B. Ginot 2010).

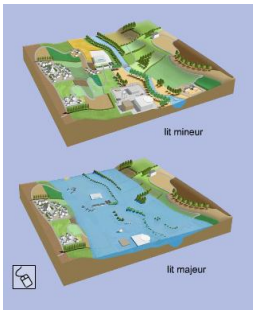
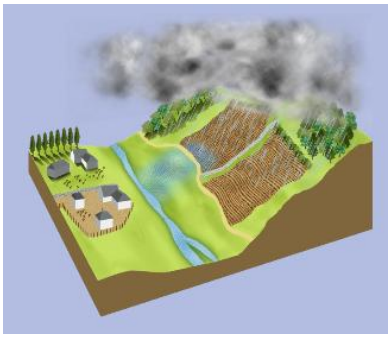
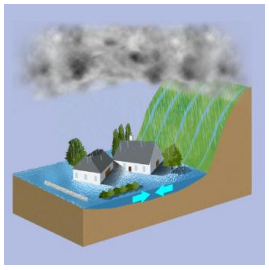
In this way our approach presents as hypothesis: if nowadays exits urban processes in terms of infrastructure of cities such as housing, buildings, runways, etc; where the aims are going to address mainly to adopt new construction material for instance. Concerns flood mitigation; it has a talent to producing considerable changes on the ongoing urban processes through the catchment, neighborhood and building scale working together on it.

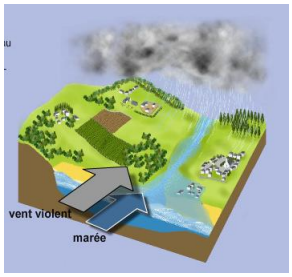
In this way, taking the previous argument into account, *Montivilliers* should be regarded as a city with a talent to produce innovative measures about regeneration of areas based on the resilience concept. This means that it can produce relevant changes in flood risk management related to the ongoing transformation of the city.

6. APPENDIX

Index 1

Types of Flood events in Le Havre, according to the *"Risque Majeur en Haute Normandie":*

TYPES OF FLOOD RISK IN *LE HAVRE*	
Overflows Stream overflows can understand as minor river beds (*lit mineur*) and it could increase until to occupy temporarily its major river beds (*lit majeur*). It progress is slow, and can be anticipated several hours even several days in advance.	
Runoffs and mud flows Rainfall can come along with runoff in slope areas. It become more often in the mountainous regions. Due to that, the plants which are acting as natural obstacles tend to disappear. In addition, the ground is often waterproofed in deforested surfaces due to the intensive agricultural practices which produce several amount of silt without allowing the infiltration of rainwater. Therefore, runoff tends to produce mud flows.	
Stagnation of water The stagnation is an accumulation of water in a low point. It due to non filtration capability, as well as slow evacuation of water, in a waterway during rainfall events.	
High water table levels In case of long rainfall events, the saturation of grounds can produce a flood due to rising in the water table levels. These ground-waters levels are affecting directly by the rainfalls event having as consequences differences of height. This type of flood can be several months while water table becomes low.	

Marine Submersion A strong tidal range and a steady wind coming from the sea, having as consequences an immersion which is going to opposite way to a natural evacuation of rainwater. The phenomenon disappears with the low tide.	

Source: CD-ROM sur la Prévention des Risques Majeurs en Haute - Normandie

Index 2

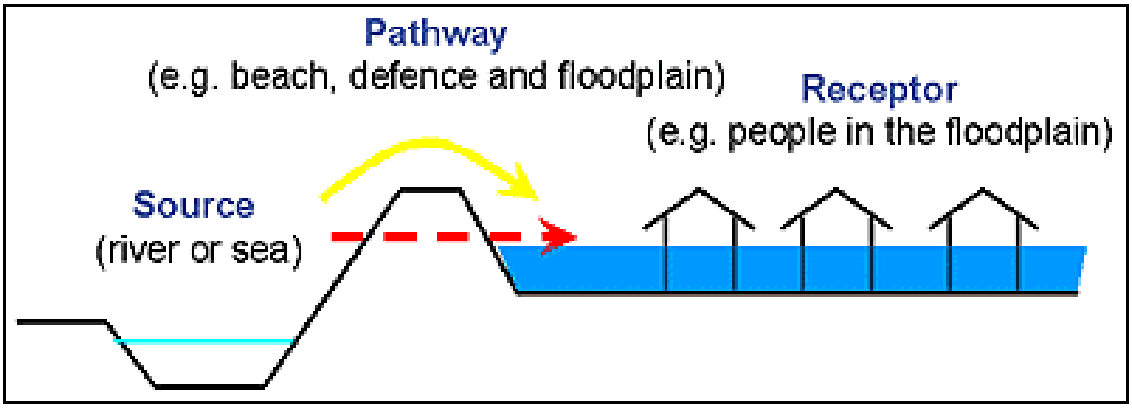
Definitions about flood events order:

Source - The origin of a hazard (for example, heavy rainfall, strong winds, surge etc).

Pathway - Route that a hazard takes to reach Receptors. A pathway must exist for a Hazard to be realized.

Receptor - Receptor refers to the entity that may be harmed (a person, property, habitat etc.). The vulnerability of a receptor can be modified by increasing its resilience to flooding.

Consequence - An impact such as economic, social or environmental damage/improvement that may result from a flood. May be expressed quantitatively (e.g. monetary value), by category (e.g. High, Medium, Low) or descriptively.

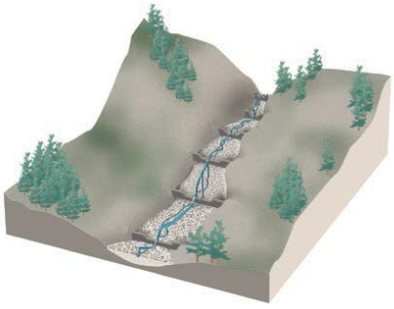


Source: *Floodsite* website.
Conceptual Model.

Index 3

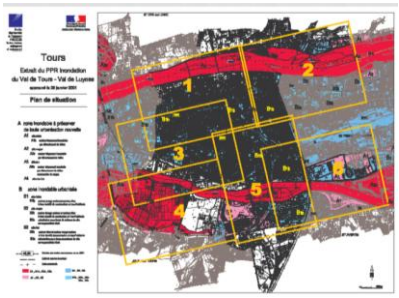
- *Structural Mitigation.*

Source: blog.cytrap.eu



Source: ministère de l'écologie et du développement durable

- *Non-structural Mitigation.*



Source :
http://www.prim.net/professionnel/documentation/guide_inond/page01.html

Index 4

Summary of the main actors / interventions:

Level / scale	Actor	Role	Intervention
Country (Government)	Ministry of Environment	Prevention	Documents of protection (Law), research
	Interior Ministry	Protection, management	Documents / Plans of management (Law)
Catchments basin	Basin council	Statutory	SDAGE, SAGE
	Public establishment	Information, research	Survey, scientific report
Regional	DREAL (DIREN)	Information, prevention	Survey, data bases, advices
Department	*Préfet*	Management	**PPRi**, DDRM
	DDT		
Commune	Mayor	Management	**PCS**
		Information	**DICRIM**
Others	Others: Associations, insurers, …	…	….

Source: FRM Actors M2RI 2013 Kamal Serrini.

ORSEC: “Organisation de la Réponse de Securité Civile”:

SDAGE: “Master plans of Water Management” (Schémas Directeurs d’Aménagement et de Gestion des Eaux)

SAGE: “Documents of Planning and Management of Water” (Schémas d’Aménagement et de Gestion des Eaux)

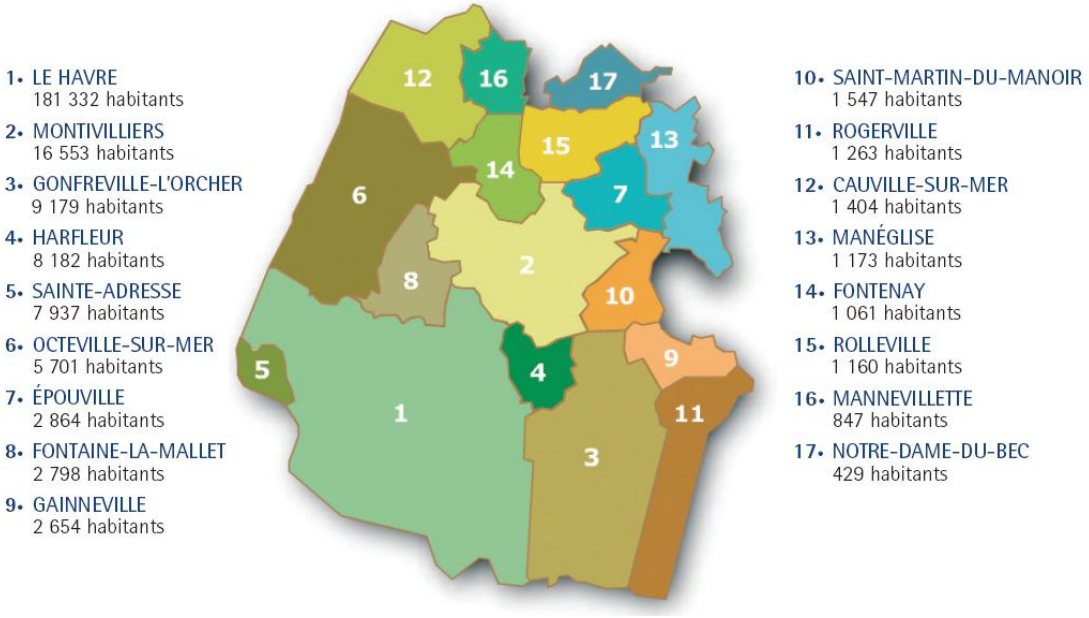
DREAL: Direction Régionale de l’Aménagement, de l’Environnement et du Logement (DIREN + DRE + DRIRE)

DDRM: “Departmental Report of the Major Risks” (*Dossier Départementale des Risques Majeurs)* Preventive Information & knowledge about all kinds of risk at the department level.

PPRi: “Plan of Flood Risk Prevention” (*Plan de Prévention du Risque Inondation)*

<u>Index 5</u>

Communes of the agglomeration of Havre:



Source: INSEE 2008

Index 6

The four majors steps in risk regulation in France- Inspired from N. POTTIER, 1998 in V. MORINIAUX, 2003.

In the field of flood prevention policies, different regulation systems succeeded since the beginning of the 20th century in France. One can consider 4 phases where both mapping tools and planning regulations were implemented. The following table summarizes those phases.

Phases	Flood events	Regulations	Mapping documents
1st phase (1930-1982): the first legal tools and maps dealing with flood are created 2 objectives: - to facilitate flows and preserve the open lands where floods can expand - to protect housing and the built environment against floods (R111-3)	**1930:** major floods of the rivers Tarn and Garonne ; about 400 people died	**1955:** the "Urban planning Code" and its article R111-2 and R111-3 restrict urban sprawl by Creating "*Périmètres de risque"*	**1935:** the "*Plans de Surfaces Submersibles"* are created
2nd phase (1981-1994): a new mapping tool to better take into account the issues at stake - new planning and mapping tool: the *PER* - objective to reduce damages by controlling urbanisation and Imposing prevention measures (on the existing and future issues) - information for citizens - objective of an integrated water management	**Winter 1981 - 82:**winter floods on the Saône, Rhône and Garonne Rivers **1983:** floods on the most river basins **Summer 1987:**flash flood in le Grand-Bornand (23 people died) **Autumn 1988:** flash flood in Nîmes (11 people died) **Summer 1992:**flash flood in Vaison-la- Romaine (34 people died) **Winter 1993-94:**massive floods in the North and Eastern parts of France	**1982:** new regulations concerning victims indemnification **1987:** law on the organisation of civil security, protection against forest fires and major risks prevention (the "Atlas des Zones Inondables" (Atlases of Flood-prone Areas) are created for public information) **1992:** Water Act (Loi sur l'eau)	**1984:** decree creating the "*Plan d'exposition aux risques naturels prévisibles"*, *PER*

3rd phase (1994-2003): **the PPRNP are created to clarify and reinforce the legal system** - The State clarifies the objectives of its prevention policy against natural hazards - The PPRNP are created and replace the former mapping documents (PSS, perimeters Art. R111-3, PER). They are the only legal document for prevention against natural hazards.	**Beginning of 1995:** floods in 43 districts (*départements*) and about 40 000 houses flooded in the northern part of France **Autumn 1999:** flash floods in Aude, Hérault, Pyrénéées-Orientales **Winter 2000-2001:** floods along the Somme river and in Brittany region	**1994:** circular on flood prevention and management of floodprone areas **1995:** Law on the reinforcement of environmental protection. **1995:** Decree on the possibility to expropriate owners when a natural hazard threaten human lives **1996:** Circular on specific dispositions for the built environment in flood-prone areas	**1995:** decree on the creation of the"*Plans de Prévention des Risques Naturels"* (PPRN)
4th phase (since 2003) The main objectives are: - the identification of areas where water retention could be done - a better information for the people - vulnerability reduction		**2003:** law on prevention against natural and technological risks and damages repair	

Source: AN INTERNATIONAL COMPARISON. M. Amalric, S. Bernier, M. Fournier, J. Serrano, L.Verdelli), 2008

Index 7

The four different levels of risk:

- LOW RISK: deepness of submersion <1m, no reference to speed
- MEDIUM RISK: deepness of submersion between 1 and 2m, with a speed from none to low or deepness of submersion <1m with a medium to high speed
- HIGH RISK: deepness of submersion >2m, with a speed from none to low or deepness of submersion <2m with a medium to high speed, completed by a particular danger zone of 300 m behind the dikes
- VERY HIGH RISK: deepness of submersion >2m with a medium to high speed, completed by a particular danger zone downhill spillways and others river works.

Index 8

Data related to *Grand Hameau "Eco-Quartier"* project.

Source: Town Hal of *Le Havre*,
Grands projets, Aménagement Urbain et prospective.

Gestion alternative des eaux pluviales

Toits végétaux, diminution de la minéralisation des espaces publics, stockage et utilisation des eaux pluviales : le dispositif de gestion des eaux de pluie mis en place au Grand Hameau répond aux techniques alternatives.

Il pleut ? On gère...

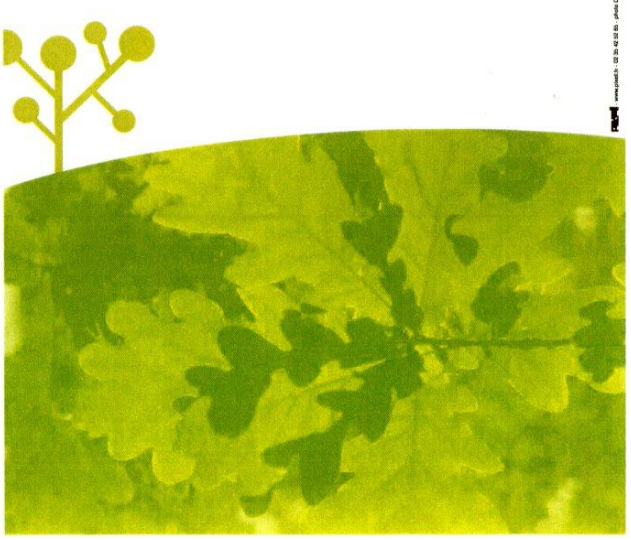
L'ensemble du réseau d'**évacuation des eaux pluviales est constitué de noues de stockage**, d'une profondeur maximum de 60 cm, et de **bassins tampon intégrés** au plan d'organisation générale du quartier et au plan paysager.

Ce système permet de **gérer le ruissellement des toitures et des différents aménagements** sur l'ensemble de la chaîne hydraulique, et sert également de mise en scène paysagère.

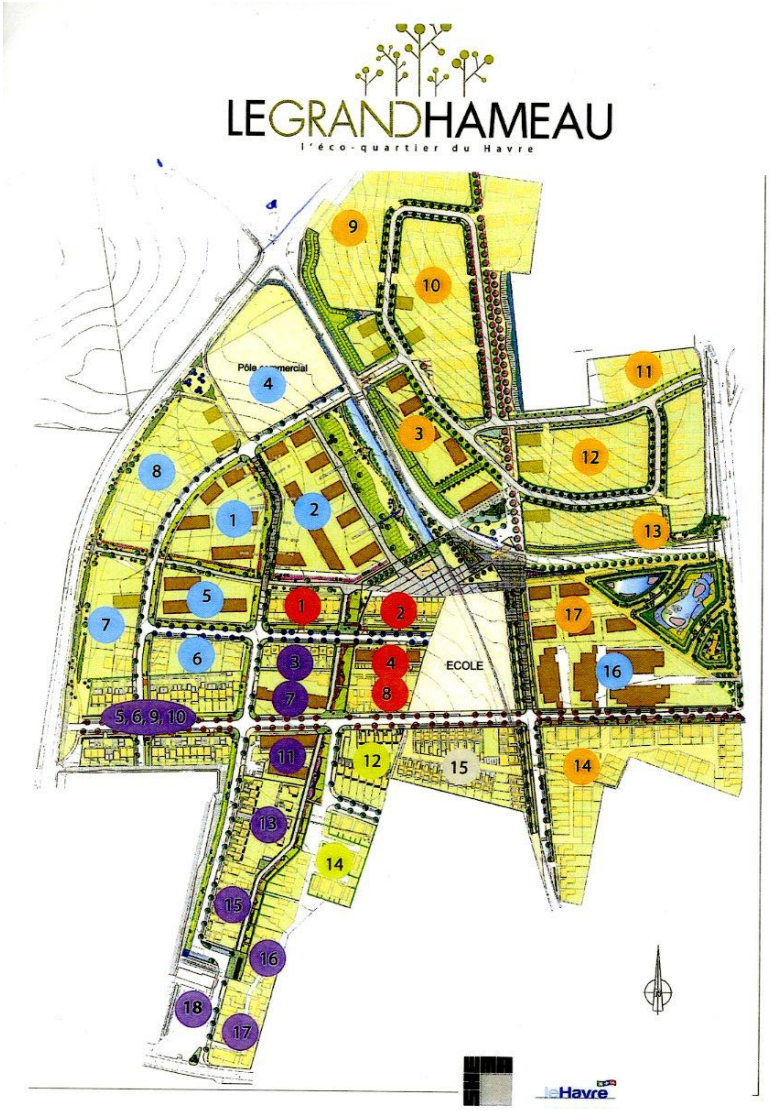
Le vert ? On aime...

L'impact écologique du Grand Hameau est également réduit par la diminution de la minéralisation des espaces publics.

Les toits végétaux sont préconisés, à la fois pour des raisons esthétiques et écologiques.



Source: Town Hal of *Le Havre*,
Grands projets, Aménagement Urbain et prospective.



OPERATIONS LIVREES

SECTEUR LOTISSEMENT HAUTS DE BLEVILLE

Lot 3 : Estuaire de la Seine
architecte : Bettinger/Desplanques
9 maisons de ville
livré fin juin 2011

Lot 7 : Estuaire de la Seine
architecte : CBA
43 logements collectifs
livré fin juin 2011

Lot 11 : Estuaire de la Seine
architecte : Bettinger/Desplanques
36 logements collectifs
livré fin juin 2011

Lot 15 : Estuaire de la Seine
architecte : Bettinger/Desplanques
10 maisons de ville
livré fin juin 2011

Lots 5, 6, 9, 10 : Maisons ELIKA
architecte : CBA
35 maisons
livré fin novembre 2011

Lot 13 : Estuaire de la Seine
architecte : CBA
13 maisons
livré mi-novembre 2012

Lots 16, 17 : PFN
architecte : ATAUB
20 maisons
livré mars 2013

OPERATIONS EN COURS

SECTEUR LOTISSEMENT HAUTS DE BLEVILLE

Lot 12 : Estuaire de la Seine
architecte : CBA
12 maisons
livraison prévisionnelle : mars 2013

Lot 14 : Pierres Normandes
architecte : MILLET – CHILOU et Associés
43 logements (36 collectifs, 7 individuels)
livraison prévisionnelle : mars / avril 2013

SECTEUR ZAC NORD BLEVILLE

Lot 15 : IBS
architecte : CBA
23 logements individuels / 12 logements collectifs
livraison prévisionnelle : mars 2013

OPERATIONS A VENIR

SECTEUR LOTISSEMENT HAUTS DE BLEVILLE

lot 1 : PFN
architecte : G2
30 logements collectifs
stade avancement : PC déposé

lot 2 : PFN
architecte : ATAUB
29 logements collectifs
stade avancement : PC déposé

lots 4/8 : PFN
architecte : ATAUB
8 logements intermédiaires / 13 logements individuels
stade avancement : PC déposé

lot 18 : PFN
architecte : ATAUB
7 maisons
stade avancement : en commercialisation

SECTEUR ZAC NORD BLEVILLE

Lot 1 : GOTHAM
architecte : agence Margerie & Pasquet
115 logements collectifs
stade avancement : en commercialisation

Lot 2 : OTI
architecte : agence Devillers / agence Paumier
191 logements collectifs / 7 logements individuels
stade avancement : en commercialisation

Lot 4 : projet NATUREO
architecte : SUD
supermarché bio + commerces de proximité + programme tertiaire
stade avancement : PC en cours d'instruction

Lots 5 / 6 / 7 : CAP HORN
architecte CBA
13 logements indivuduels / 14 logements intermédiaires /
57 logements collectifs
stade avancement : en commercialisation

Lot 16 : European Homes
architecte : BILLARD DURAND et Associés
74 logements
stade avancement : en commercialisation

PROGRAMMATION PREVISIONNELLE

SECTEUR ZAC NORD BLEVILLE

Lot 3 : 90 logements collectifs
Lot 8 : 10 logements individuels / 35 logements intermédiaires
Lot 9 : 25 logements individuels / 47 logements intermédiaires
Lot 10 : 30 logements individuels / 50 logements intermédiaires
Lot 11 : 8 logements individuels
Lot 12 : 25 logements individuels / 25 logements intermédiaires
Lot 13 : 22 logements individuels / 10 logements intermédiaires
lot 14 : 53 logements individuels
Lot 17 : 60 logements collectifs

Source: Town Hal of *Le Havre, Grands projets, Aménagement Urbain et prospective.*

Index 9

Potential damage by the water height:

Water Height	Damages during the construction	Damages on the networks and the finishing	Damages on personal goods
On the ground floor	Little damage on the structure. The water can enter from the basements, cellars and through the baseboard. Erosion is possible under the base.	Damage on the plugs and other networks in the cellars and basements. The carpets of these rooms must be removed.	All goods and objects placed in the cellar or basement are ruined.
Up to 50 cm above the ground floor	Damage in the finishing of the inside walls such as the wall covering and the sheetrock. They have to be subtracted to allow the wall to dry. The floors and the walls can be filled with water and so be in need of cleaning and drying. Humidity problems could follow that. Floor coverings must be replaced. External and internal doors as well as skirting boards are ruined.	Damage on the electric network and more particularly the meters and the circuit-breakers. Damages on the gas network, the heater and the land lines. Carpets and floor coverings mousy be replaced. Linoleums and kitchen cupboards can be strongly damaged. Washing machines, ovens, fridges and freezers will be damaged. Saturation of the sewage system.	Damage on the sofas, other furniture and TV / hi-fi. Damages on personal goods such as books, cassettes, videos, pictures. Food that is stored in the down kitchen cupboards can be infected.
More than 50 cm above the ground floor	Important damage of the walls. Possible damage of the structure of the house.	Damage of all networks.	Potential damage of all goods.

Source: SMVB 2011

Index 10

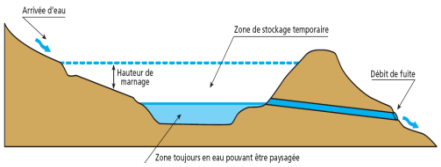
Measures mitigation in *Montivilliers*:

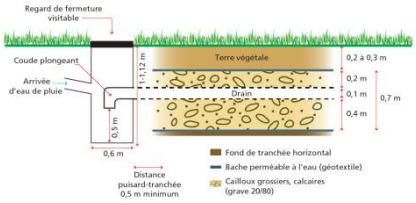
Catchment Scale.

The management of runoff is provided at different geographical scales and different communities in the territory of the watersheds of the Havre community. SMBV leadership and technical support to control runoff through storage water units. But the realization of the so-called "fight against floods" work was possible with the support and the responsibility of municipal structures as CODAH and SMVB.

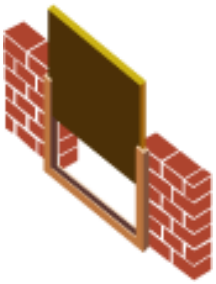
Flood Retarding Basins. Flood attenuation, or provision of temporary water storage capacity during flood events, to reduce peak flows.	
Flood Barrier or Dams. Those are made through an excavation of earth to create dams along in the valley. Grass located upstream of the dam is a flood meadow.	
Field Expansion Rise. These areas provided in the lower valley close to the river, allowing store several hundred cubic meters millers. A hundred hectares is being gotten for these facilities. Hence, the pressure over land as well as to deal with the owners always makes long processes to get it (expropriation and negotiation).	

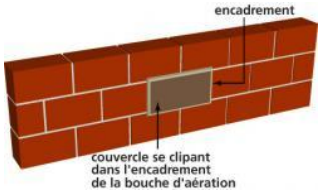
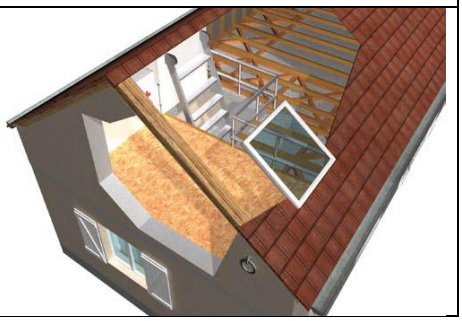
Neighborhood Scale.

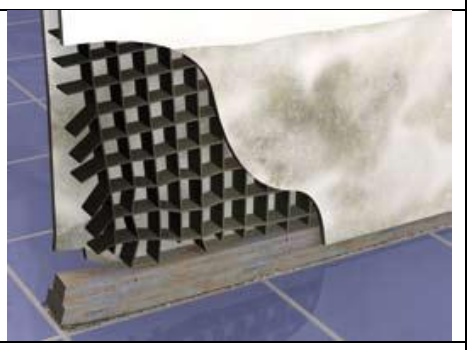
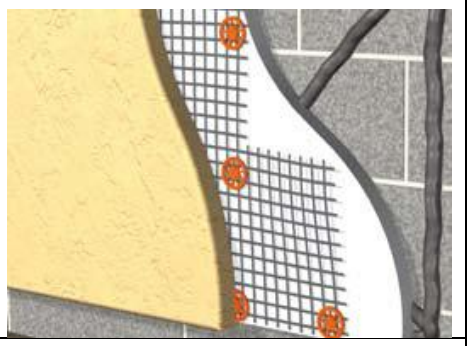
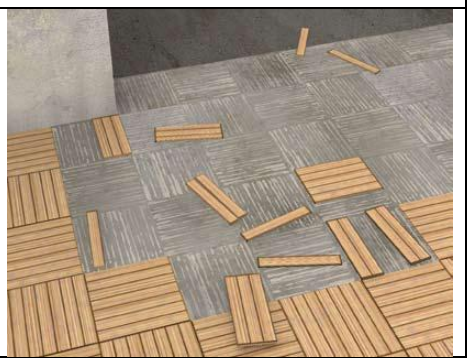
Dew Pond. At the beginning their aims were of watering animals but most of them have been removed the last decades. However, nowadays they come back focused on hydraulic function which is integrated into the landscaped.	

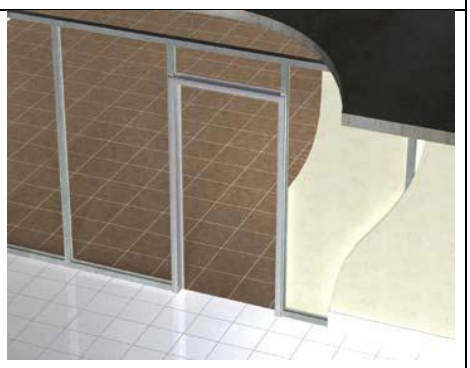
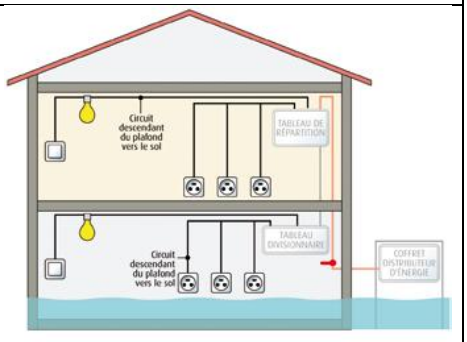
Draining Trench. It is a trench filled with granular material for the retention volume of water before discharge into the collective or network infiltration.	
Waterway. Ditch outdoor, shallow and wide profile that to become green area maintenance.	
Permeable pavement. Porous coatings improves water infiltration and are more and more used to replace conventional coatings which are the major providers of runoff and pollution.	

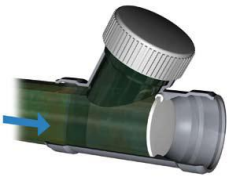
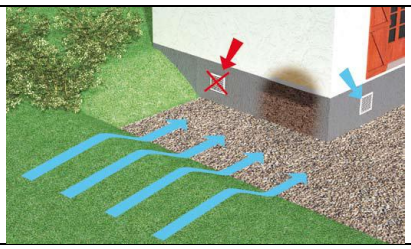
Building Scale.

Provide temporary protection strategies. The action is to promote the sealing of the house where the water pressure is bearable by the structure of the building. These kind of strategies will be applied on places where *water level not exceeding 1 meter level during the overflow*; because the pressure difference between the inside (no water) and outside (with rather than 1 meter of water level) would result irreparable damage to the building structure.	
Cofferdams. These are plates that fit into corners to prevent water from entering through openings (door, courtyard door, garage door, and window). Their efficacy and duration of protection depends on the care given to the seal.	

Sandbag. There may be a protective barrier from sandbags or absorbent polymers, positioned flat in the longitudinal direction of the flow in a staggered and superimposed. This barrier should not face the direction of flow but only contain its expansion. They are not tight.	
Wrapping. The penetration of water through the walls can be avoided as the moisture problems, holding a plastic film along the walls, complete with a drainage system. This is relatively long to implement.	
The temporary sealing vents. It will provide to block temporarily the vents located below the level of flooding. (Will use it only during the flood, otherwise it is forbidden to put it permanently).	
To protect the front porches located in the axis of the stream.	
Wastewater management. During the application of temporary protection measures are necessary as well as to ensure the evacuation of the wastewater by various methods adapted to each situation: mop, scoop. The full pumping will become efficiency and thereby helps to minimize the damage and time rehabilitation.	
Refuge area into the housing. The goal is to set security. The refuge area is a waiting area that can get away from the water until the eventual disposal or decline.	

Adaptation of building materials against flood. The action is to adapt the housing to the presence of water when *the water level exceeds 1 meter height*. To balance the pressure and prevent damage to the structure, the water must be able to enter the house by causing the least possible damage.	
Walls. Waterproof bricks, solid concrete, removable inner lining and waterproof, exterior foundation drains.	
Dividing walls. Solid brick masonry, plasterboard waterproof, partitions mounted metal frame, masonry walls coated.	
Weather-proofing. Rigid insulation polystyrene, polyurethane.	
Coatings wall. Wallpaper (drying facility by removing walls), earthenware	
Floors. • Work of armed concrete floors: The technical implementation of lower floors of existing buildings are varied but for individual houses, structures floor joists (steel, concrete) and slab (clay, concrete, synthetic material) and	

compression casting slabs in place are the most common. • Replacement flooring: concerns the choice of flooring that will be affected by water (at the material itself or its fixing method) and must take into consideration: *.Material behavior according to the contact with water.* *.Cost of material.* *.Ways to replace it.* *.It helps to reduce damage and delay return to normal.*	
<u>Woodwork.</u> PVC, aluminum, steel, treated wood protection product, it will apply indoor and outdoor as well.	
<u>Protection of climate control equipment.</u> Some examples, such as boilers, pumps heat, control devices, and so on; can become successful.	
<u>Redistribution and / or modification of electrical circuits.</u> The electrical distribution system is particularly vulnerable. They are however essential to achieve an effective drying (heating, ventilation) and cleaning thereby reducing the time back at house.	

Protection of elevators.	
Prevention of damage to networks. The wastewater systems are designed to discharge effluent from the building to the outside. During flooding, these effluents can follow the opposite path, pushed inwardly of the building by the pressure exerted by the water. Polluted water can cause significant damage to the building, despite the installation of protective devices openings.	 
Prevention of damage caused by oil tanks.	
Protection of persons in presence of swimming pools.	 
Protection of crawl spaces.	

Source: All of the images were taken from data analyzed in literature review, such as SMVB, Ministry of ecology, CODAH and by the author.

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Experimental survey did by the CODAH in *Montivilliers*, which is part of the mitigation measures adopted from the municipality.

(SURVEY)

In October 2012 a project from the CODAH / SMBV started. It was based on flood events occurred during 2003. It consists of making a guide to provide recommendations/measures/suggestions on how to rebuild their houses and making them less vulnerable against overflows. Then this guide will be given to them even including the specific cost for each house about materials, processes, and so on.
The first step has created a test to gather data about housing having as a result a diagnosis. It was done only among 40 houses.

Characteristics:

- Test was carried out as a survey manner.
- All persons engaged were volunteers.
- All of the persons had already been affected by floods events at home before.
- Test was done taken building scale into account, which means residential houses.
- Engineers, architects and sociologists worked on it.

Process:

- The sociologist team did interviews with owners to know different point of view or perceptions about flood risk according to each experience.
- It was developed mainly by SBVPC.
- As an outcome it expects to get a broad diagnosis over all cases, to follow it focusing in each of them through suggestions, structural recommendations, measures, and so on.
- After the diagnosis, meetings with the concerned population in order to contrast the results and addressing them towards the correct way will be carried out.

Outcomes:

- It will be showed mainly to the population concerning it, and then one way could be to get an official document. Nowadays it has been analyzed by the stakes on debate.
- How to continue this process? One of the doubts which have been discussed among people engages it.

Suggestions/comments:

- Which were the aims of the test?
- Which should be the logical process to follow? That means, according to the actors and related to scales.
- They propose them some measures to mitigate flood risk at home. It has a good instrument to carry out links among different scales, meaning large, medium and small. How to implement it?
- Could it be an example to implement it as non structural and structural mitigation measure?

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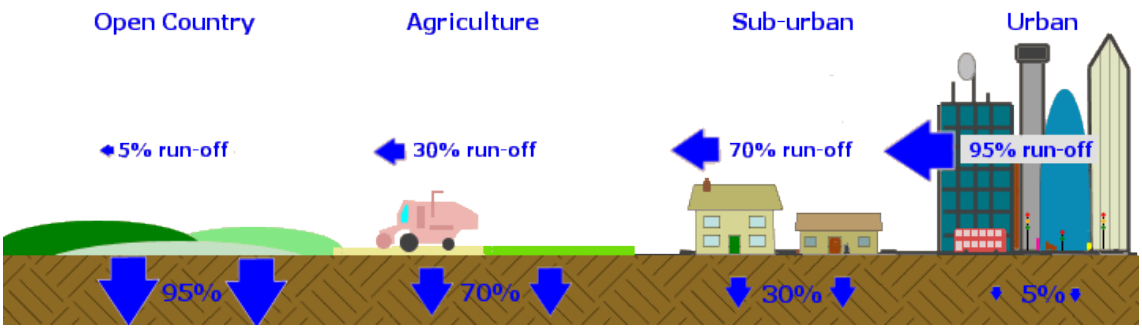
Permeability Processes between countryside and cities:



Source: www.pavingexperts.com.

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Different Permeable Pavements Specifications:

Material	Specification	Notes
Permeable Interlocking Concrete Pavers	Surface open area: 5% to 15%. Thickness: 3.125 inches for vehicles. Compressive strength: 55 Mpa. Open void fill media: aggregate	Must conform to ASTM C936 specifications. Reservoir layer required to support the structural load.
Concrete Grid Pavers	Open void content: 20% to 50%. Thickness: 3.5 inches. Compressive strength: 35 Mpa. Open void fill media: aggregate, topsoil and grass, coarse sand.	Must conform to ASTM C 1319 specifications. Reservoir layer required to support the structural load.
Plastic Reinforced Grid Pavers	Void content: depends on fill material. Compressive strength: varies, depending on fill material. Open void fill media: aggregate, topsoil and grass, coarse sand.	Reservoir layer required to support the structural load.
Pervious Concrete	Void content: 15% to 25 %. Thickness: typically 4 to 8 inches. Compressive strength: 2.8 to 28 Mpa. Open void fill media: None	May not require a reservoir layer to support the structural load, but a layer may be included to increase the storage or infiltration.
Porous Asphalt	Void content: 15% to 20 %. Thickness: typically 3 to 7 in. (depending on traffic load). Open void fill media: None.	Reservoir layer required to support the structural load.

Source: Virginia DCR Storm water Design Specification No. 7 *Permeable Pavement. Version 1.8* – March 1, 2011

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