Adaptation to flood risk and evacuation procedure changes in the Shonai river basin, comparison of the Tokai flood (2000) and the 2011 flood

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ABSTRACT

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Flood risk in Japan is a serious and complex problem. Due to the location of cities and megacities in deltaic plains, the probability of hazards' intensity increase, the convergence on one area of several type of floods (urban floods, river floods, and floods caused by typhoon sea level rise or tsunami), the consequences flood can have on an urban environment (transportation, electric and information system failure…) and the potential loss of flood risk culture are making megacities highly vulnerable.

Studies on vulnerability and resilience and studies on disaster in occident as elsewhere are depending on sciences evolution, the disaster events, and the general society uses and understanding of these concepts. They change as societies change. Therefore, the purpose of this research was to point out this evolution, and the problematic situation of the current situation, where there are many concepts with many definitions and there is a need to choose more or less the best definition for the studied area. The purpose of the theoretical study in this research was to find definitions if not methodologies that could fit for both social sciences and applied sciences. The focus was put on the adaptation concept for several reasons. The first reason is that the "adaptation" concept has been considered similar in meaning to Japanese concepts. The second is that the adaptation concept has not yet reached the scientific and mediatized popularity of resilience and vulnerability, and therefore, the definition of adaptation are less politically oriented than the definitions of resilience and vulnerability. The last and maybe more important reason is that the adaptation concept helps researchers to focus not on the disaster itself but on the times between events. It allows the learning from events that did not become disasters, and it helps understand the evolution in time of society resilience and vulnerability.

In the Shonai river basin, two similar hazard events occurred ten years apart. The first was the disaster called Tokai flood of 2000. The second was a minor flood event in 2011. With these two events and their consequences, it was possible to set an adaptation model for the 2000-2011 period, and analyze the changes in vulnerability and resilience in the Shonai river basin with a focus on Nagoya city.

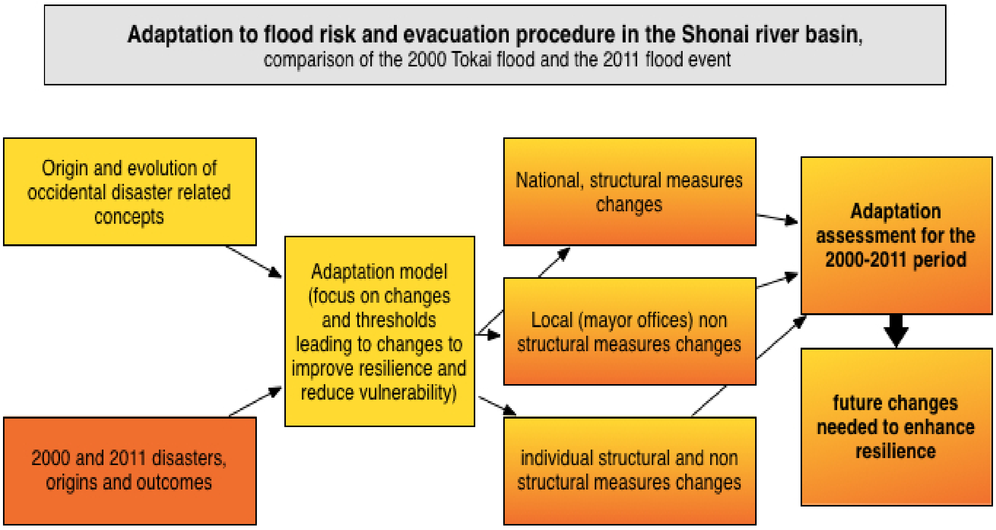

Figure 1-1 Adaptation to flood risk and evacuation procedure in the Shonai river basin

The adaptation analysis focused on both structural and nonstructural factors for national, local, and individual level. The different times of the disaster and times between disasters were divided in "before (preparation and mitigation)", "during (response, watch to crisis, and damage occurrence if the event changes into a disaster)", and "after (recovery)". Because the main focus was the human exposure and the evacuation process, an important focus on the mitigation, preparation, and response times had been applied here. And considering that there was a need to deal with intangible parts of the disaster like perception, and decision taking thresholds, the adoption of a systemic and qualitative approach was preferred to an analytic one, while recognizing the need for complementary analytical approach. Figure 1-1 shows the general structure of the thesis. In yellow are the purely theoretical parts, in orange the experiences of the disasters, and the two-colored sections correspond to the creation of model for analyzing flood risk management changes both from theoretical research and events analyses.

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Social background, flood risk situation nowadays

This study will focus on the creation of a conceptual framework intended to assess, or at least show, changes in the disaster risk management, with a focus on the evacuation process, in a megacity area. In order to study changes in disaster prevention, two events of same hazard intensity were taken as time limits: the Tokai flood of 2000 and the 2011 flood event in the Shonai river basin. This study focus on two concepts used in disaster management studies: vulnerability and resilience, and on one concept used in climate change studies: the adaptation. Adaptation is considered here the best concept to study changes.

In order to do so, this chapter will present the flood risk as a rising problem; then the flood risk will be linked to the climate change problematic. In order to study evacuation, a choice to focus on the concepts used in social sciences was made. One of the problems of risk assessment is the lack of agreement on the concepts to use and their meaning, another is that different countries will have different specific problems and finding integrative concept is difficult. To explain the focus on concepts used in social sciences and on the “adaptation” use concept, and because this study focuses on the evacuation process in the megacity of Nagoya and its neighboring towns, this studies aims to highlight problems in disaster prevention in megacities from a social sciences perspective. Finally a brief presentation of the following five chapters of the dissertation and their content will be made.

1.1 Flood risk in the world: the rising exposure to flood risk

The "**exposure**" concept will be defined here as: **the possibility for a society and its structural** (buildings and infrastructures), **functional** (economic, political, cultural and others activities of which depends the society), **and social** (human life and well-being) **characteristics to be harmed by a hazard if the measures taken to prevent a disaster are overcome.**

For example: the location of buildings, roads and underground trains (structural characteristics), of factories and enterprises, mayor offices, schools and museums (functional characteristics), and population (social characteristics) in a flood-prone area (possibility of flooding) if the structural (dams, levees…) and nonstructural (preparation, evacuation) are exposed to flood. Exposure depends of:

- the intensity of the hazard and the protection measures taken until the hazard lands on the area (overflow of structural protection measures)
- the density of human settlements (the bigger the city exposed, the more damages it will make if the hazard is not contained)

1.1.1 Flood risk in the world is a major problem

There is a general understanding that "floods are among the most devastating of all natural disasters" in Europe (Levy and Hall 2005); in the United States it is recognized that losses due to floods are "not only large (on average $115 million per week) but they have also been increasing dramatically" (Burby, 2002); Thomas et al. (Thomas et. al, 2013) pointed out that intense natural disasters are rising, and among them hydro-meteorological (floods and storms) and climatological (drought) disaster were the one increasing, not geophysical ones. Tingsanchali pointed out also that "more than half of global flood damages occur in Asia" (Tingsanchali, 2011).

The reasons why flood risk is occurring in Asia for Tingsanchali are:

- The installation of human settlements in floodplains
- The river water exploitation (water as resource and transport system)
- The development of cities and impervious areas causing large runoff and high flood levels.

In 2005, it was estimated that 20% of the world's population lived in coastal ecosystems (100m elevation inshore or 100km from the coastline), and the population density of coastal ecosystem zone (175 people per km^2) was estimated to be the highest among all ecosystems (Hall and Levy 2005). In 2005 "the world's urban population of 3.18 billion people constituted 49 percent of the total population" (Lee 2007), and De Sherbinin et al (2007) stated that the population living in megacities (10 million or more) should be 5% of the total population and represent more than 400 million people in 2015.

To summarize: **the floods are extremely damaging and might be increasing; with high urbanized cities in floodplain area at the river mouth, the risk of flooding is increased, and because the cities development in the world doesn't seem to be stopping, the flood risk should be an even bigger problem in the future.**

Because yhis study aims to study flood risk in megacities, the technological, political, and social advancements will be considered as one of the major factors influencing the outcome of a disaster. Therefore, this study will not take into account the peculiarity of the Asian continent, because the differences in development, hence the differences in risk management are too important. Concerning the external force at the origin of a disaster, **the hazard** (here, the precipitations and water level in a river), there will be considered that that Japan has its own characteristics and these characteristics will not relatedto geographical and hydrological characteristics of other Asian countries.

1.1.2 Flood risk in developed countries, what is at stake?

Rivers and their waters have always been a resource that human settlements were exploiting, for transport, for resource, or for recreational areas since the beginning of human civilization. Moreover soils in floodplain are good for agriculture, increasing the benefits for human settlements installed near rivers. Nowadays, many important cities or megacities in the developed world are for most of them coastal cities (New-York, Tokyo, London), or were built on a river (Paris, Kyoto, Dresden).

When it comes to Japan, studies have underlined how canals, rivers and water were important for a city such as Edo and then Tokyo before the 1960's (Wilson 2011, Tadashi and Pelletier 1990). A common point for many old cities developed on rivers since the past 300 years is the urban development of the second half of the 20th century and its consequences. In Europe the 20th century corresponds also to a century where extreme meteorological events were rare thus partly explaining the installation of urbanized settlements in areas known to be at risk and could be flooded. In Japan, the focus on flood reduction and structural measures were put into place after big floods since 1870's (Wilson 2011, Takahashi 1990), were interrupted during the war, and had to be adjusted again between 1945 and the end of the 1960's to face flooding problems from typhoons (Takahashi 1990), the structural enhancement improvements continued in strengthening the structural measures until the end of the 1990's ("high standard levees" setup until the beginning of the 2000's) and today flood disaster prevention in structural measures concerns levees enhancement, flood reduction dams, and underground flooding problems. A common point during the high economic growth period (1954-1973) to European and Japanese rivers is the focus on industrial and economic growth, the implementation of effective structural measures, and a high protection against flood risk. In Japan it is followed at the same time by river water resource management projects to support industry (Takahashi, 1990). In the following years, the settlement of population in urban areas will continue, and the number of flood event will largely decrease.

Concerning Japan, it has to be said that the urban sprawl during the high growth period was very important, and lead to a situation today that put many cities at risk. According to Zhai (Zhai, 2006) in Japan 49% of the population and 75% of the property are concentrated in floodplain areas.

To summarize: **Most of the developed cities in coastal area or near a river are at high risk of being flooded. The advantages explaining human settlements (transport, agriculture) do not compensate since the 20th century with the disadvantages of floods. Since the 20th century, structural measures like levees and dams have been built to protect population in cities. It helped cities development and also their current very high exposure to flood risk**.

1.2 Expectations for flood risk due to climate change, more dangerous hazards?

1.2.1 Climate skepticism or global warming, what position to take when confronted to natural disasters?

If the climate change theory has critiques, those critiques come most of the time from non-scientific fields (politics especially) and don't challenge the fact that globally temperature are rising, but that this rise is the effect of human impact (greenhouse gases). However the IPCC[1] (IPCC report 2014) states that: "warming of the climate is unequivocal, and since the 1950's, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen." (IPCC 2014).

Flood risk in Japan is highly related to climate change for two reasons

[1] IPCC: Intergovernmental Panel on Climate Change

- Increase of intense precipitation levels
- Increase of sea water level

Working on the risk, as it will be defined later (French and European definitions and application of “risk” concept, pp 21-28), means that managers have to be able to make decisions under uncertain parameters. Climate change and its impact are one of the factors that make the risk management difficult, because the evolution of the climate for the next decades is highly uncertain. However, in this study, the consideration will be that it is best to be prepared to face the worst scenario, and assume that precipitations intensity and sea level should rise. According to the IPCC (2014) “changes in many extreme weather and climate events have been observed since about 1950. Some of these changes have been linked to human influences, including (…) an increase in extreme high sea levels and an increase in the number of heavy precipitation events” (IPCC 2014)

To summarize: **there is no agreement in the public and political sphere that climate change is due to human activities, however scientific community agrees on the fact that climate is changing and that this should impact heavy rainfall risk and increase of sea water level. Risk management should prepare to face these uncertainties.**

1.2.2 heavy rainfall intensity growth expectation in Japan

Flood risk is expected to rise because the intensity of the hazard (the rainfall) is expected to increase in intensity (more intense extreme events, therefore more intense drought and more intense floods). According to Kimoto et al (Kimoto et al, 2005) the expectations for Japan is “an increase of mean precipitations, and frequencies of non-precipitating and heavy (_30 mm day–1) rainfall days increase, by about 10 and 5 days a year” while the number of rainy days are expected to decrease. Therefore they expect a rise in extreme events. This simulation information is confirmed by studies done by the MLITT[2] using JMA[3] data showed an increase in heavy rainfall events in Japan since the 1970's as shown in figure 1-1.

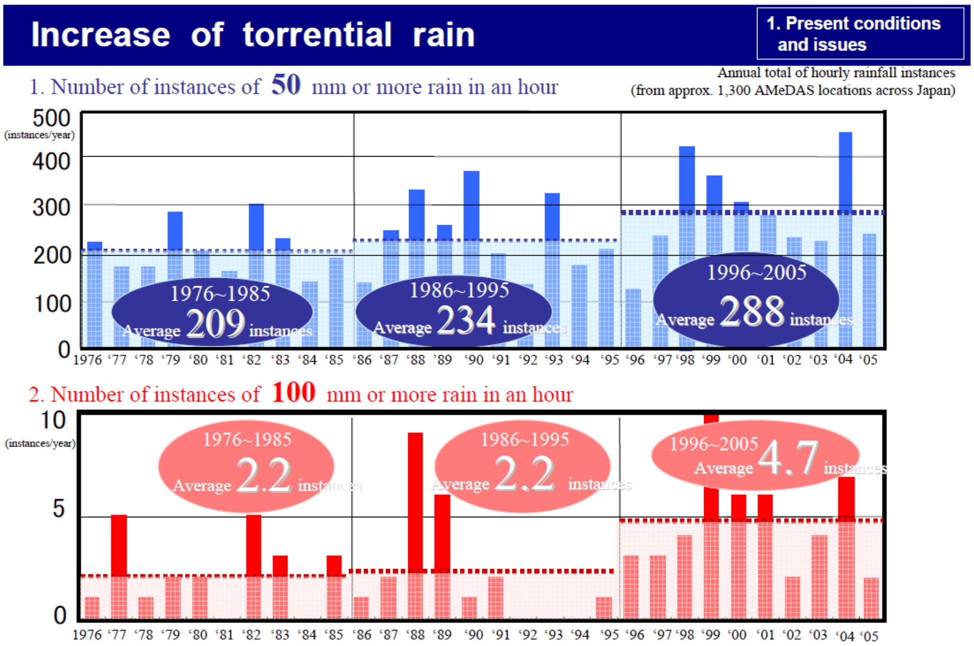

Figure 1-1 Increase in heavy rainfall 1970's-2000's (MLITT, Okazumi, 2008)

On another hand, Kanae et al (2004) argue that from precipitation record the extreme hourly precipitation events of the 1990's are "within the range of variation for the 110 years". They can argue neither in favor nor against the Climate change theory.

The impact of a rise in extreme events, like heavy hourly and daily rainfall would need a stronger response from cities, higher and more powerful structural measures to contain river floods and urban floods and faster decision-making under uncertain circumstances by all actors of the system (from national actors to individual ones).

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2 MLITT: Ministry of Land, Infrastructures, Transport and Tourism http://www.mlit.go.jp/en/index.html (English version)

3 JMA: Japan Meteorological Agency http://www.jma.go.jp/jma/indexe.html (English version)

To summarize: **although it is difficult to assess Climate change and its impact on heavy rainfall increase for these 100 years by meteorological data, if heavy rainfall level should be rising, this would be a problem especially for big cities.**

1.2.3 Coastal sea-level rise expectations

If there seems to be an agreement on global mean sea level rise since the 1980's-1990's (Gornitz et al 1982; Douglas B. C. 1991), it seems difficult to find mean sea level rise in Japan due to too many possible error factors, even if sea level is rising (Ishii et al. 2006).

Most of the actual research related to sea level rise and climate change founded concerned the **adaptation** of Social-ecological system to sea-level changes in the future, due to the fact that most of human settlements are on river mouths (de Sherbini et al 2007; Ericson et al 2006, Nicholls 1995; Nicholls et al 1999; Klein et al 2004; Nicholls and Cazenave 2010), but the relations between disaster and climate change and their influence on the way risks are managed and what words we use will be studied in Chapter 2 (pp 26-33).

To summarize: **when it comes to sea-level rise, the scientific community agrees that the global mean sea level is rising, but it is difficult to evaluate it in Japan. Climate change studies are linked to risk assessment studies because of the large number of cities and megacities in coastal and deltaic areas and this will have to be addressed in the thesis.**

1.3 Difficulty to date to establish clear assessments for the flood risk

1.3.1 Assessing (flood) risk in the world: different science fields, different study areas, and different non-scientific points of view make it difficult to assess risk

Climate change is part of what is problematic in the estimation and assessment of the future effects of disasters to come. Moreover, "human societies and globally interconnected economies rely on ecosystems services and support" (Folke, 2006), therefore very integrative and interconnected ways of evaluating the future of human societies in an uncertain environment like Social-Ecological-System (Folke, 2006) are invented. The problem of uncertainty and integrated studies in climate change studies is the same for risk and disaster studies, uncertainty is the common denominator and the link between the two different approaches and causes the same problems.

And disaster and risk management, just like climate change, is not only a scientific matter. This research postulate that

- the use of some concept instead of others is the result of the scientific research and definitions of these concepts and
- the way these concepts are used in the political situation or by society in general in case of a disaster (Rhegezza et al, 2012).

Its management will deeply depend on the level of technology and development of the society who faces it, therefore every study area has its own peculiarities, and an evaluation of the risk at the global level is difficult. The objectives of risk assessment and the use of some concepts instead of others may change from authors to authors and from country studied to country studied.

As a consequence it is difficult to assess flood risk in the world, due to the many concepts, protocols, and focuses that exist in disaster studies, because those studies focus on different aspects of risk assessment. The study of socially-related problems concerning risk and disasters use also many concepts. **The two most used concepts are vulnerability and resilience but many declinations and minor concepts are used as well**: adaptation (climate change) (Folke, 2006; Smit et al, 2000; …), vulnerability as root cause of the disaster (Wisner et al, 2004; Gaillard, 2007; …), vulnerability as exposure (Treby et al 2006), coping capacities (Burton et al, 1978; Daupras et al, 2014), robustness of a system (working even under degraded conditions) (Anderies et al 2004; Mens, 2011; Daupras et al, 2014), resilience in the context of climate change (Folke, 2006), its use in the political sphere related to disasters studies (Reghezza et al, 2012), its use in disaster studies (Klein et al, 2003; Wallace and Wallace, 2008; Barroca et al, 2013). If so many concepts are used, and if so many definitions exist, it is because there is, to date, no method to eliminate the risk, and to face the problem of the risk, many methods and orientations exist.

To summarize: **disaster-related studies have to face uncertainty in a field of study that is new in the sense that it concerns both environmental and social areas. Moreover, disaster prevention is with climate change a fashionable topic that has impacts and retroactions in the political sphere, and assessing risk depends heavily on the area studied. Currently there are many concepts used to assess risk in social sciences, but not one has a clear definition or is considered better than others. These problems should be addressed.**

1.3.2 Assessing flood risk in Japan

When it comes to Japan, the way of dealing with disasters always interested occidental (Western countries: Europe and United States) scientists. Flood risk is rarely studied alone therefore this research is based on integrative disaster prevention studies or on earthquake disaster prevention studies made by Western researchers (French, and American). However in our readings we encountered two different ways of describing the disaster prevention in Japan. The two perspectives[4] are coming from the following points of view:

- Japan is extremely exposed to natural hazards and therefore very vulnerable to risks.
    - This point of view can be found in many introductions of books destined to first year students learning about Japan, Japan can be described as a "hostile" environment, imposing on society a "heavy handicap" for development (Pezeu in Pelletier, 1991).
    - In the specialized book on the coming Tokyo earthquake of Hadfield (Hadfield, 1991) the environment is not described so much as "hostile" but the vulnerability of Tokyo megacity and the lack of prevention works against earthquake disaster is one of the major causes of the "catastrophe scenario" Hadfield developed in his book. In his scenario, his hypothesis was that the coming earthquake would not only be a major disaster for Japan, but for all the world economy as well.
- Japan is very exposed to natural hazards but also extremely resilient because Japanese culture is particular.
    - Berque calls for a "nature" perception that is more integrative than the occidental one (Berque, 1986) and therefore a "risk" acceptance higher in Japan than in the occidental world
    - Hollé (2009) also points out a different religion and general culture (the Shinto religion) closer (once again) to nature than the occidental

[4] The occidental research done on Japanese disaster prevention management in this thesis is mainly based on French works and may not reflect all the occidental perspectives. However, it has to be pointed out that until the 11.3.2011 disaster, disaster prevention in Japan was rarely the main focus of the researchers that have studied it. It may have led to some simplifications or the magnifying of the "Japanese particularities".

(mostly Christian) one. Others made the same remarks, but in very caricatured ways and not in the most accurate research

- Hollé (2009) calls for a "risk culture" and "risk perception" better in Japan than in Europe and links it to the short return-period of hazards with extreme intensity causing disasters (1 to 2 disasters during the human life)
- Pelletier (1991, 2003) and Augendre (2004, 2008) point out that the disaster prevention in Japan in general for Pelletier, and in case of volcanic activity for Augendre, is different from the occidental one in the concepts utilized: 災害、共存、and 共生, and in Japan there is a more integrated way of dealing with disasters, for example in the volcanic case: exploiting advantages from volcanoes for tourism to rekindle rural economy.

Dealing with flood disaster prevention in Japan using occidental concept is a choice made in order to look for vulnerability and resilience factors with an integrative viewpoint. The purpose here is that using occidental concepts (Vulnerability and Resilience) will help to not focus on "Japanese particularities" either in the "good" side or on the "bad" side. Moreover, the choice of using occidental concepts for this study is motivated by the urban environment studied.

To summarize: **Japanese disaster prevention is studied outside Japan, but with often a heavy highlight on Japanese society or Japanese environment specificity (good or bad). This was one of the foundings motivating the study of flood disaster prevention from the viewpoint of occidental concepts perspective (Vulnerability and Resilience).**

1.4 Urban environment influence on the flood risk, and overview of the problems

The second thing that motivated the use of occidental concepts for studying flood disaster prevention was the both unique (to megacities) and universal (all megacities have the same kind of "domino effect problem) characteristics of disaster in urban environments. The number of disasters per year for urban environment varies according to authors, 100 urban disaster per year, or 180 disasters per year (Reghezza, 2006) due to the difficulty to define what is an urban disaster and the specificity of an urban disaster. In the case of flood disaster prevention the urban exposure and the urban population characteristics consequences seem important factors to take into account.

1.4.1 Urban exposure and "domino effect" in case of a disaster

The works of Hadfield (1991) may be too focused on "catastrophe scenario" but it had the advantage of highlighting the "domino effect" in case of a disaster (Provitolo, 2005). The figure 1-2 gives an example of undesirable short and long-terms effects a disaster can bring for long-term on an area.

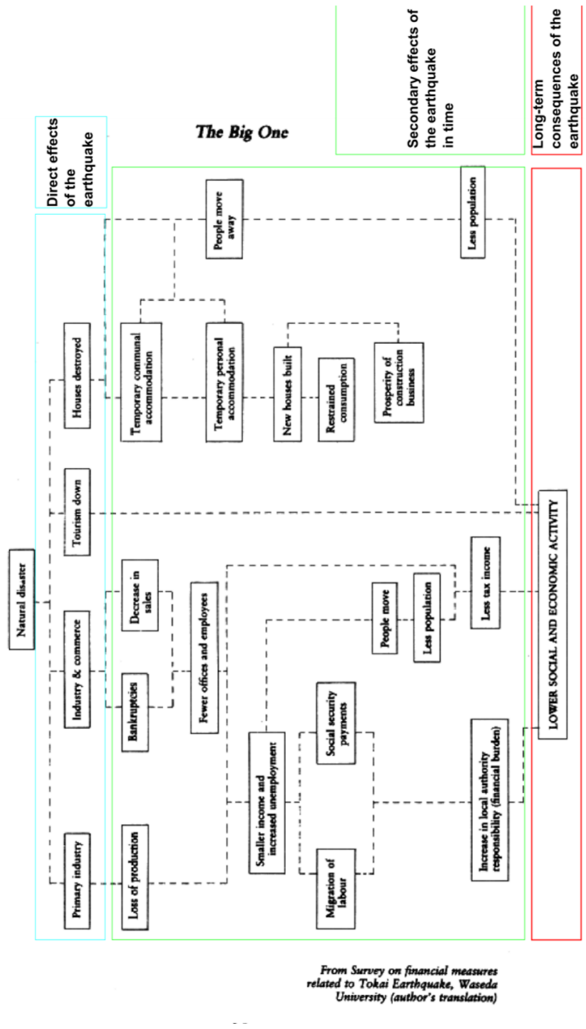


Figure 1-2 "the Effects of the Tokai earthquake on the Shizuoka economy" (Hadfield 1991), direct, secondary and long-term consequences highlights M. Thomas

The "**domino effect**" is a concept originating in industrial risks management and engineering materials. It can be defined as: "the physical effects responsible of possible accident propagation" (Cozzani et al, 2005). The domino effect concept was discovered in disaster studies at the end of the 1990's but was not conceptualized before the 2000's.

The main idea of the domino effect problem comes from the high urbanization, and the high exposure (structural, functional and social) of the urban environment. Any hazard can cause chain reactions that will exceed the hazard area (the floodable area for example), and can potentially injure not only buildings but also functions of an area, leading to loss in productivity, population …

Reghezza (2006) highlights the fact that if the hazard at the origin of a disaster is not different in rural or urban environment, and therefore there is no risk specific to urban areas (aside, maybe, for her, the industrial risk), **the environment determines the short and long-term effects of the disaster, and the megacities and urban areas have specific condensation of population, functions, and structures that makes them especially vulnerable to hazards**.

The domino effect idea, although not always described as “domino effect”, has been studied by Provitolo for conceptual mathematical model creation (2005), Hadfield for Tokyo case study (1991), Reghezza for Paris 1010 type of flood(2006), and D’Ercole and Metzger (2009) for multi-hazards assessment in Quito (Equator). These studies also stress out the fact that cities in general (from developing and developed countries, and for many hazards type) have **a specific vulnerability to disasters, and that one hazard can have many consequences due to the urban environment.**

To summarize: **cities are a concentration of many buildings, functions, and people. Therefore one hazard can have many consequences that exceed the hazard area alone. These consequences are specific to all cities around the world. These “domino effect” potential consequences should be considered even when studying only one specific type of disaster in urban area.**

1.4.2 Loss of risk awareness in urban environment for the population

As said in in chapter 1.3.1 (p. 8-13). It is difficult to clearly assess risk because the different sciences fields have different objectives when studying risk and even in similar scientific fields like the social sciences differences in methods and focuses are making difficult the creation of unique concepts on which everyone agrees (sociology tends to focus on decision process in a system of actors, psychology tends to focus on impacts on individuals or small communities of a disaster, geography tend to focus on the impacts of hazards on specific areas, …). Therefore in social sciences can be found reviews of negative effects of structural measures on risk awareness, especially when it comes to levees in urban environment (Dauphiné and Provitolo, 2007; Béthemond and Pelletier, 1990; Pelletier, 1991). The argument is that by installing structural measures:

- the flood risk is no longer experienced (Béthemond and Pelletier, 1990, Pelletier, 1991)
- the river cannot be seen anymore (Béthemond and Pelletier, 1990)
- intolerance for disaster, even small-scale disaster is rising (Dauphiné and Provitolo, 2007)
- flood risk is not eliminated and could even be increased (if there is a levee breach, consequences would be worse than from levee overtopping, or if there were no levee)

As a consequence, structural enhancements have been qualified as "not resilient" by some authors (Dauphine and Provitolo, 2007) for long-term disaster management, because they decrease risk acceptation and risk awareness and replace one risk by another (flooding by "simple" river flood replaced by flooding by structural measures failures).

This study will consider that high trust in structural measures, potential lack of experience of flood disasters, and lack of flood disaster awareness has impact in the evacuation procedure in particular and risk awareness in general. However, if the here above arguments considering structural measures as "not resilient measures" are not wrong concerning the effects on risk awareness and response from riverine inhabitants, this study will consider that structural measures are to this date the best and most efficient way to reduce the exposure to flood risk. Especially in megacities, transferring the city to another maybe less hazardous place is impossible. Structural measures have to be studied for their good impacts as well as for their negative impact, because the effectiveness in hazard mitigation is considered here as a resilience factor.

Social response to disaster has also to be studied and improved due to the rising difficulty to setup structural measures. The first reason is that the urban environment leaves no unoccupied space to setup new structural measures. The second reason is that according to the OECD report on floods in Japan (2009) the budget allowed for the MLITT has decreased and therefore considering the economic Japanese situation, highly costly structural measures are not to be considered for the next years. The problems are to be related to economy and space and not to technical advancements.

For all these reasons, this study postulates thata conceptual model highlighting both improvements and status quo situation for disaster prevention, taking into account structural measures and nonstructural measures (hardware and software) parts of the disaster prevention system is needed.

To summarize: **Due to different focus in disaster prevention, social sciences have highlighted the negative impacts of structural measures enhancements. These highlights are not false, but should not forget how needed are structural enhancements. On the other side, to compensate the potential undesirable effects of structural measures, attention to social response to disaster has to be considered. These observations motivated the creation of an adaptation model where improvements (or lack of improvements) in structural and nonstructural measures would be analyzed.**

1.5 Overview of the dissertation contents

The following five chapters of this dissertation are described in this section.

1.5.1 Theoretical background: linking society changes with concept in disaster studies changes (historical evolution of concepts by geographical areas)

In this section will be analyzed the different concepts utilized when it comes to disaster prevention. The underlying question we will try to answer to is the following one: **to what extend are there differences between “risk management” (France), disaster management (USA) and disaster prevention (Japan) concepts, and where do those differences or similarities come from?**

During the 1980’s social-related concepts like vulnerability and resilience appeared. They don’t have today definitive definitions, highlighting the fact that disaster prevention is still a problem and 100% adequate or effective methods and concepts have not been found yet. This part will try to answer to the following question: **if social-related concepts like vulnerability and resilience are “umbrella concepts”, and have almost a different definition for each author and each field study area, then how should they be used, and why, and how should they not be used and why?**

1.5.2 Goals, methodology and field study: for a study of “change” in disaster management

In this introductive chapter the goals of this study were very briefly addressed. This section is dedicated to the development of the goals of research, the methodology used, and the fields of study area chosen. The subsection dedicated to the selection of the field study will also briefly describe the two flood events of 2000 and 2011.

From the theoretical background we intend to find **clear and applicable definitions for the umbrella concepts (vulnerability and resilience) currently in use**. Closs is expected to be lost, but it is hoped that more applicability would be gained. Because occidentals concepts will be used to assess Japanese flood disaster prevention changes, it is hoped that we will be able to **look for vulnerability and**

resilience factors that could be applied to any megacity environment in developed country, and not focus our work on “Japanese characteristics”. The purpose of this research is an assessment of the changes that occurred in the disaster prevention between two events, in order to get out of a focus on disaster, and on a focus on theoretical work hardly applicable. By **highlighting changes and their impact, and the remaining challenges to face founded in this case study area, the intent is to propose some ways to enhance the disaster prevention system**.

The **choice for the field study area** had to correspond to several characteristics:

- It had to be a river basin where national and local actors were working together, and it had to be a river basin nowadays highly urbanized.
- There had to be at least two flood events that could have been studied in this river basin, preferably with the same hazard characteristics.

This is why the Shonai river basin was chosen for this study.

The methodology applied is a qualitative methodology. **Interviews to population and disaster reduction managers were performed** in order to have a clear view of the communication between the actors, the different problems they face confronted to flood risk, and the different ways the actors intend to solve these problems. From theoretical readings, official documents, and the interviews performed, **built a conceptual adaptation model was built**. After the adaptation model being built, on **GIS the building characteristics** of a chosen area in the Shonai river basin was inputted, the buildings information were gathered by field inspection between January and February 2014 and during the month of September 2014. Finally **qualitative research for evacuation thresholds and taking action thresholds from an individual point of** view was performed**.**

1.5.3 Proposal for the adaptation model

Firstly the adaptation concept will be briefly explained: its origins in hazard management studies (Burton et al, 1978) and its advantages for an integrated disaster prevention assessment before it spread into climate change studies.

Secondly a defininition of “vulnerability” and “resilience” concepts for the adaptation model as opposite concepts (vulnerability being the exact opposite of resilience) and the under-concepts they integrate was done.

Thirdly a brief definition of what adaptation can lead to, in terms of broad conceptual goals, as effectiveness, effectivity, risk governance and so on was done.

Finally the MLITT conceptualization for disaster prevention times (before, during, after …) was done to cut the adaptation model in different sub-models, one for each time of the disaster, stakeholders and type of enhancements (structural, nonstructural).

1.5.4 Application of the adaptation model on the Shonai River basin

This section was separated in 4 distinct parts:

The first under section will concern the National structural enhancements, the situation before 2000, the special project for 2000 flood (2001-2006) and the Master Plan project continuation since.

The second part concerns the enhancement of communication between the actors specialized in river and flood fighting structural measure managers and the actors specialized in social response and evacuation (State-mayor office).

The third part will concern the enhancements of social response to flood disaster, by the successive improvements between 2000 and 2011 done for information send to population, its purposes and the way they are distributed and accessible.

The last part concerns the individual response to flood risk, structural (building and housing enhancements) and nonstructural (preparedness, evacuation thresholds, understanding of accessible information).

1.5.5 Conclusive chapter, what did we learn, what should we learn more?

Firstly will be recognized the efforts being undertook to have a more integrated way of dealing with flood and a better risk governance, despise the small problems it can have brought during the 2011 event. This study also pointed out that there are still non official actors who are dealing with bottom-up response to flood disaster that could be integrated to the flood prevention management system to enhance communication reaching to the smallest level (the population) if some conditions like the focus on preparedness would be met.

Then statement of the remaining problems of the efficiency in risk management has been done, the efficiency is still difficult due to factors as evacuation threshold very high that might change for a few part of the population only, and probably only because of an acknowledgement of the difficulty to evacuate during the Tokai flood. Moreover even though this study was focusing on the emergency state of the flood disaster time (the crisis time), for a more efficient flood risk management studies on recovery processes and the actors participating to the recovery should be undergone to assess the adaptation level of the population during recovery time, which isn't taken into account in the evaluation of flood disaster assessment to date.

Finally an assessment of the conceptual gains and losses of using concepts that are rarely used in disaster prevention only (the adaptation) or concepts that are voluntarily simplified in order to be applicable (vulnerability and resilience) has to be made. The focuses on changes and on adaptation helped to establish the acknowledgementof the evolution of structural measures enhancing resilience. However the nonstructural factors resilience seems to be changing with more difficulties than the structural measures resilience factors. The hypothesis is that nonstructural factors change on a time-scale that is the one of the society (human life or more) whereas the structural measures resilience factors are changing in one decade (as soon as structural measures are changed). Concerning non-structural resilience and vulnerability factors evolution, the qualitative approach was preferred to the quantitative one, however, at the end problems due to “systemic approach” was faced: there is no clear way (analytical way) to assess human response to floods and the impacts that pamphlets and information can have on human responses. Keeping the concepts of vulnerability and resilience simple allowed to stress out the effectiveness of structural enhancements and the threshold for taking action for individual response. However, with simplified concept it was impossible to try to assess the dangers of “domino effect” when confronted to flood risk in megacities. Finally an understanding was gained for the conceptual application of occidental concepts in a Japanese environment.

2 CHAPTER 2

Theoretical background: linking society changes with concept changes in disaster studies or studies related to disaster management (historical evolution by geographical areas)

The purpose underlying this study is to **assess the changes in disaster prevention conceptual research and the influences that applied disaster management could have had on it**. It should help to identify the universal goals to achieve in disaster prevention, and the remaining problems and part of their origin of concepts and their application. Because a focus on occidental concepts was made, this chapter will be separated in three sections.

The first section will concern the evolution of concepts that were first put into place in disaster prevention studies in Europe; the way of conceptualizing disaster prevention being heavily based on what is called "that natural part of the disaster" (or "hazard") with concept either integrative (risk, conception of "Hazard" by Burton et al, 1978), or focuses almost solely on the hazard mitigation based on structural measures spread in the United States approach (dominant until the 1990's and nowadays complemented by more social focused or integrated studies), and finally how disaster prevention in Japan differs or not from disaster management or risk management elsewhere.

The second section will concern the ascension both in scientific fields and in media and politic fields of social-related concepts. They are linked to an assessment made in the 1970's: despite the enhancement in hazard containment made during the 20th century, the disaster didn't disappear. The two main concepts are the "resilience" and the "vulnerability". Because there is to date no unique and agreed definition, there is a need to know what the two concepts can mean in order to define them afterwards; moreover, because the definitions can change easily in these concepts, they may have been influenced by trends like climate change or sustainable development. The last subsection concerns a comparison between systemic and analytic approaches, how resilience and vulnerability are more and more used in systemic approaches and why.

2.1 1755-2000's, risks, hazards, disasters. Differences in non-social related and integrative concepts and their consequences on management and research

2.1.1 The European way of dealing with "risk", dealing with the unexpected

2.1.1.1 1755-1970, risk mitigation by hazards reduction

In French scientific and non-scientific literature, the word "risk" (natural risk management, industrial risk management, fire risk management, flood risk management…) will definitely be preferred to "disaster management". One of the reasons is an historical and cultural one. Following the Lisbon earthquake of 1755, European philosophers and scientists tried to explain why the catastrophe happened. Until 1755 natural disaster were perceived and understood as external action of the Divine wrath send to punish mankind (Hewitt, 1998), however no rational explanation would have explained why God would punish on of the most catholic cities in the European world, on the day of a catholic celebration. In terms of paradigm change in conceptualization of disasters, the 1755 Lisbon earthquake was one of the stepping stones of the current European and American risk and disaster reduction management. It destroyed the idea of a divine punishment for Christian, and with the European Age of Enlightenment of the 18th century, it encouraged people to look for rational and scientific explanations for disasters (Albouy, 2002). At that time, the seismic science was born but also the idea that a disaster can only happen if it occurs where people are present. Therefore, if people decide to settle in a place where a disaster can occur, they choose it. They “take a risk” meaning they bet that for an undetermined period of time (their life) no such disaster will occur. The idea of “risk” and “risk management” revolves around the idea of reducing the probability of occurrence of a hazard; therefore it is heavily related to the uncertainty, chance, and probability notions. It also focused primarily on hazard knowledge and understanding, leading to a science heavily based on applied hazard mitigation (Reghezza, 2006; Vinet, 2007; Wilson, 2011). The religious explanation for former disaster explanation doesn’t mean that before 1755 efforts were not made to reduce the effect of natural forces onto populations. However, because the scientific and technical enhancements were limited, the reduction of natural forces impact was limited. The best example is the transformation of a village into a natural park after a heavy disaster in the Netherlands (Mens, 2011).

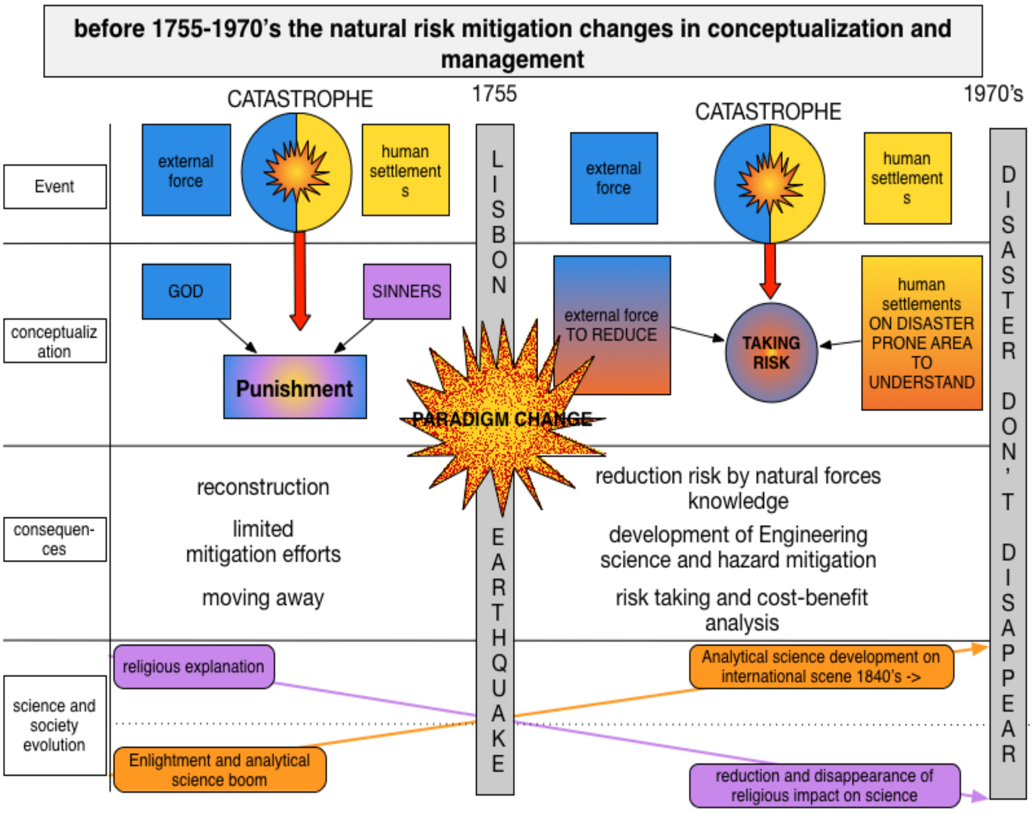


Figure 2-1 disaster management and society changes until 1970 in Europe (M. Thomas)

To summarize: **the first big paradigm the started the "risk management" in Europe was the Lisbon earthquake. It leads to a risk management based on probability, chance, and therefore lead to cost-benefit types of analysis. It leads also to a management based on risk mitigation with the progresses of applied sciences.**

2.1.1.2 1970-2000, old risks don't disappear and new risks appear

Concerning flood risk, between 1950 and the end of the 1970's most of the rivers of the world were heavily changed by technical enhancements. According to Vinet (2007), the technical enhancements focus corresponds to a "hazard paradigm" (focus on the natural part, or the "hazard" part of the event and the effort to prevent them) focus born in the United States. "Extreme natural destructive phenomenon which origins are external to human. (…) Natural extremes phenomenon are external elements perturbing (a space) against which it is necessary to fight. For flood risk, the containment of the hazard through embankments is the "natural" response to this vision" (Vinet, 2007).

"During the 1960's-1970's "risk" was defined as the probability for a given element (or ensemble of elements) subject to a damaging event" (Reghezza, 2005). The purpose is to determine losses to put a risk management based on a "cost-benefit" principle, which should correspond approximately to figure 2-2.

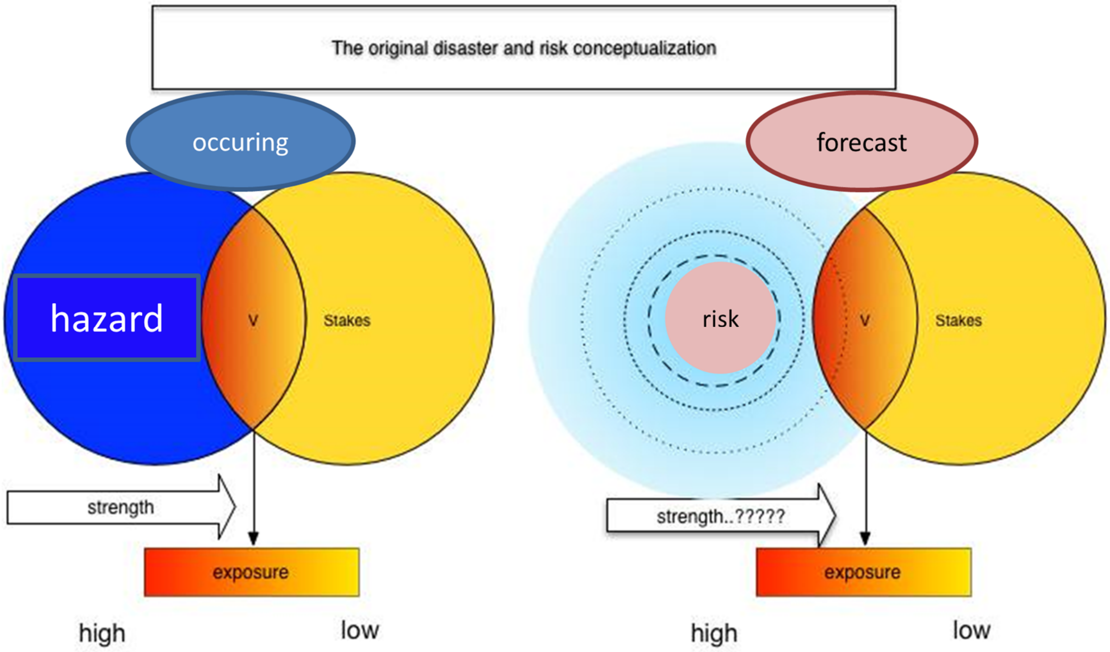


Figure 2-2 the original disaster (A) and risk (B) conceptualization (M. Thomas, done using omnigraffle, 10.11.2014)

Although, disasters don't disappear with structural measures enhancements alone: Earthquake and tsunami in Alaska in 1958 (Mogi, 1968), the 1966 flood of the Arno River in Florence (Morelli et al, 2012), the Romanian floods of spring 1970 (Poncet, 1972). On another hand, population and highly urbanized areas are developing during this same period. Moreover, undesirable effects of structural measure enhancements have been pointed out and the demand from the population in terms of protection and safety rise. Finally, the unknown effects of technological advancements in society shifted trust in the "Progress" characteristic of the Age of Enlightenment.

To this increasing lack of confidence in "progress", the arguments in disfavor of structural enhancement like levees are a good example. The most well remembered research on the undesirable effects of structural measures is the article of G. F. White et al. for the United States case in 1958, but the same assessment has been made for Europe, albeit a little bit later. It has become the object of disagreement between social sciences and applied sciences, for numerous social sciences researchers, the structural enhancement being not at all the solution for a "resilient" risk management (cf. Chapter 1, p 14).

Moreover, the more a civilization develops, the more it puts itself at risk. One of our "**postmodern" society's** characteristics is the permanent **creation of risk**, as well as the inventions to contain, avoid or try to eliminate it, in more and more complex systems in and on which any action could have unknown consequences, and therefore managing disaster and managing risk is also facing a double uncertainty (uncertainty of the hazard's occurrence, uncertainty of undesirable consequences of technologies development) (Beck, 2001; Albouy 2002). *The post-modern society, by its development, increase more and more undesirable effects for the environment (nuclear power, natural resources exploitation,…) and society (insecurity, terrorism, …). That's why our society is a "**risk society**"* (Ulrich Beck, 2001). Another "symptom" of the "postmodern society" would be the increasing demand in protection and safety as well as the decrease in risk acceptance (Beck, 2001; Vinet, 2007, Albouy 2002).

This lead to the rise of social-oriented research common to Europe and the United States since the 1990's, which will be studied through social-oriented concepts in next subsection (vulnerability and resilience pp 40-56). However, the rise of social-oriented concepts is not related to a possible withdrawal of a "hazard-oriented" research, in Europe as well as in the United States, social-oriented research is developed simultaneously to the applied "hazard-oriented" research. Therefore there is a development of two paradigms in disaster and risk studies: the principal hazard paradigm and the newer "vulnerability" paradigm.

In Europe, and moreover in the geography field, the "risk" concept has become too fashionable for its own good (Vinet, 2007). Therefore, the risk concept can have almost as much definitions as the vulnerability and the resilience concepts. In case of natural risks, though, an occidental particularity is to make a strong difference between the "natural" part of the risk (the hazard) and the "human" part of the risk (the vulnerability, the exposure, and other more social-related concepts).

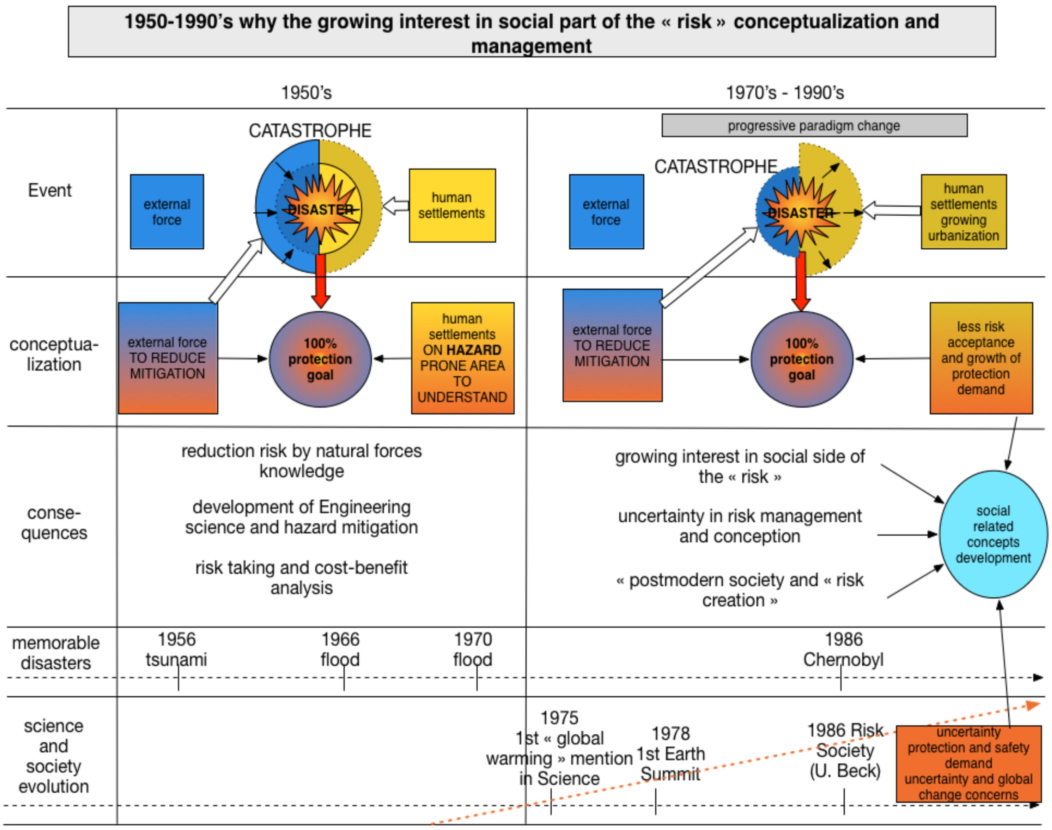


Figure 2-3 from hazard-oriented research to more social oriented interest

In France, the risk is linked to the climate change rising interest through the "uncertainty" and "undesirable" effects. However, linking the "risk" concept to the "adaptation" is not a connection made in France. The only time "adaptation" has been seen is in the doctorate thesis of Marie Augendre (2008), where the adaptation concept was linked to the Japanese "coexistence" concept, the author considered it the closest in sense to the Japanese coexistence.

The disasters, event, and the society interest have however, an impact on the concepts that researchers tend to use (argument developed pages 30). Vinet (2007) also points out that "the risk management being highly influenced by the representation that experts, deciding actors or population have of it, the evolution of these (fashionable) concepts influences highly the risk management."

To summarize: **the two subsections before try to link risk management in Europe with the willingness to respond to social problems. The rise of uncertainty, the dangerous side of progress with the Chernobyl, the analysis by Beck of a "post-modern society" creating risk, not willing to accept it but not knowing necessarily to deal with them has concurred to the rise of social-oriented research in social science on risks**.

2.1.1.3 An example of linkages between concept definitions, political and social linkages

In French scientific and non-scientific literature, authors use almost exclusively "risk management", there is an understanding that:

- The disaster is the occurrence of a hazard causing damages to human life and assets (vulnerable elements of an area) (Figure 2-2 a p. 27)
- The risk is the probability of said occurrence (Figure 2-2 b p. 27), it is defined in the French Major Risk Prevention website[5] as ": **the perception[6] of a possible danger, more or less predictable, by the social group or the individual who is exposed to it. A player perceive as a risk his or her decision to play, knowing the events that can happen and their probability**" (Veyret 2003),

[5] PRIM Prevention RIsques Majeurs http://glossaire.prim.net/definition/risque-0 (for the risk definition)

[6] The importance of the element of perception in some risk definition is linked to the disaster/risk separate conception and will be discussed later.

although this definition was extracted not only from a textbook but also from the "PRIM" (the French Major Risks Prevention) website, this definition has it flaws, as, for example, the fact that it doesn't take into account the coping and adapting capacities of a society, supposes that every actor in a risky area knows the occurrence probability of hazards and will take measures accordingly, and focuses heavily on perception of danger which is difficult to evaluate.

Defining risk, hazard and other disaster-related concept is not only theoretical; it has applications in the political world and consequences for the society. Therefore, it is difficult to define the risk as a concept free from political implications. The definition here above assumes that knowing that a danger could happen encourages people (we don't know who, is it the population? is it the government?) to gather enough information in order to be aware of the events that can happen and their probability. This definition does not take into account the cognitive dissonance[7] of people who live in risky areas (Schoeneich and Busset-Henchoz, 1998), but it implies that with available information, people will be aware and therefore be prepared to face a hazard. In short, it implies that that knowledge and disposal of knowledge might be sufficient to face the probability of a disaster.

Therefore, talking about risk, or disaster and all the concepts linked to risks and disasters (next subsections) is never something that is done with an objective eye, and the use of a certain concept in a certain context has to be carefully thought. This is one of the reasons motivating our research on adaptation, and not resilience, vulnerability, disaster, or risk. We consider the concept of adaptation in disaster prevention less subjective than the previously enumerated ones.

[7] Cognitive Dissonance exists when the behaviour or situation lived by the individual conflict with his or her's knowledge or convictions. (Schoeneich and Busset-Henchoz, 1998)

To summarize: **the two first subsections aim to link evolution and changes in society and evolution and changes in risk management. This was an example of how risk conceptualization can have meanings and objectives that have consequences in management and for the society. Risk here, but also vulnerability and resilience are heavy with ideals and political implications (see next chapters); the reason why we decided on the adaptation concept was to avoid those political or ideal implications.**

2.1.2 The United States research from "hazards" "external force" oriented (1930-1980) to more social-oriented "disasters" concepts

In scientific articles written by English-speaking countries researchers, we found 3 main terms: "at risk" (being at risk), "hazard management", and "disaster management".

The concept of "risk" is not discussed at length in theoretical research, and in the most famous works on disaster related theoretical research in the United States, there is a shift from the "hazard" concept to the "disaster" concept:

- In 1978, in their very popular book "the environment as hazard", Burton et al introduce the different ways to adapt to disaster, using principally the terms "hazard" and "disaster". As their research is based on post-disaster studies, they don't use the concept of "risk". Yet, they introduce socially related concepts as "vulnerability", "adaptation", "coping", "resilience"...
- In 1994, in their book "At risk, Natural Hazards, people's vulnerability and disasters", Wisner et al are presenting their PAR (pressure and release) model, and concentrated their works on vulnerability evaluation from empiric post-disaster evidence. Although the vulnerability concept is discussed at length, the concept of hazard is not defined, and the hazard itself is not considered to be the main origin of the disaster.

- In 2001, White et al discussed the consequences of "a move towards greater emphasis on disasters and correspondingly less on the broader concept of hazards", and on "the exploration and adoption of the concepts of vulnerability" (White et al 2001).

Shifts in definition of the concepts of Hazard, risk (in France), and disaster can be compared and is linked to the shift from hazard to vulnerability (and what is called "societal") studies in disaster management, but the shift of the social-related notions (will be discussed at page 43-57)

2.1.2.1 The Nature-society interaction and coping with the hazard studies point of view (Burton et al 1978)

The "hazard paradigm" (Vinet, 2007) in the United States is considered to be most of the time a model corresponding in figure 2-3 (p. 29) to the 1950's way of managing hazards and disasters, very technical and based mainly on the hazard knowledge and on structural measures to mitigate it. However, what we will study here is Burton et al (1978) way of conceptualizing hazard, where "hazard" is not the natural part of a disaster, but the process at the origin of the disaster (Reghezza, 2006), therefore: what makes the disaster, corresponding in Europe to the "risk" concept. They install the "hazard" concept in a daily-life situation and seek the diverse ways of coping, adjust and adapt to the hazard's probability. In that way, although not defined, the "hazard" concept as they use it is analyzed in many interesting ways.

To arrive at a truly accurate estimate of the degree to which the earth as the only home of mankind is becoming more hazardous would require a careful global count of loss in lives, health, property, and social functioning. It would also involve assessment of expenditure for flood-control works or hurricane warning services, to the extra-expenses of constructing office buildings so as to withstand earthquakes. It would take account of the benefits from these activities, and the opportunities – such as they are – to enrich life by means that would have been unavailable if people had not ventured onto hazard areas. (Burton et al, 1978)

Therefore:

- The hazard concept **regroup all of "before-during-after"** timings when the risk is often considered a focus on "before" and the "disaster" concept brings with it a focus on "after"
- The "hazard" is **peculiar to a place and the society who interact with it** (therefore the hazard is not only an "external force" nor is it just an indicative event that reveals the weakness of society[8])
- The hazard probability and occurrence **will cause changes in society**, technological, structural, and societal
- The hazard reduction brings **benefits as well as disadvantages**, that have to be understood to understand changes, or lack of changes.

In 2004, the same authors (White et al 2001) partly explain the lack of hazard conceptual definition as following:

"In general, hazard research has never been strongly theoretical, preferring instead empirical studies or policy applications. Over time, however, there has been a growing interest in theory (…)" (White et al 2001).

On an other hand, White et al (1958) are remembered to be the first ones to highlight the potential harm of effective short-term mitigation measures which might increase long-term vulnerability "the floodplain levee serves as the model for such effects: levees intended to prevent damages from a flood of stated magnitude, when over-topped actually increase catastrophe" (White et al 2001). However, Gilbert F. White is still considered today as a pioneer in hazard management in the geography field, and his willingness to consider hazard management as something that should consider advantages and handicaps, opportunities and inconveniences, in a management involving all actors of hazard studies seems still today a goal to achieve.

8 Seen in Gaillard (2007) and in a less strong position seen in Wisner at al 1994

"If the floodplains of the United States are to be developed progressively so as to utilize as fully as practicable the advantages afforded by them, and to minimize their disadvantages, it will be necessary to adopt a broad geographical approach (…). That approach will demand an integration of engineering, geographic, economic, and related techniques." (White G. F. 1945 in Kates and Burton, 1986).

To summarize: **the hazard paradigm usually depicts "technical and hazard management" with little regard to the social concepts. We chose to describe in length Burton et al (1978) way of conceptualizing hazard because their definition of hazard (daily-life interaction on the society, benefit as well as advantages to assess, causing change in society and response methods, should integrated all scientific fields – from engineering to social sciences) seems today still a goal to achieve.**

2.1.2.2 The "disaster studies", and the emergence of the social-only concepts point of view

On the other hand, the disaster is often view as a single shocking event that brings with it only undesirable things. Moreover, it is difficult to define clearly what a disaster is, what a catastrophe is and what an event is.

The "catastrophe" term is defined by Burton et al (1978) as "a disaster causing a major dislocation of the orderly processes of everyday social and economic life and requiring a long period for recovery", it can be linked to the "major disaster" term that is being used today to qualify international disasters with high economic, political, and social impact.

White et al (2001) linked the rising interest in scientific and political community to disaster to the rising social-linked concepts of vulnerability.

Since the 1980's the "hazard" meaning was extended. From natural phenomenon like earthquakes, floods, or drought, that was the original conception of the hazard, other meanings like biological phenomena (pest, disease, water and air pollution), technological phenomena (hazardous materials in the workplace, industrial accidents…) and social phenomena (war, terrorism, civil unrest) also can be qualified today as "hazard" (White et al 2001). The extension of the "hazard" signification can be linked with the rising awareness of the "risk society" of Ulrich Beck (2001) and the realization that society creates risks, and the crisis of 1986 with the nuclear accident of Chernobyl only confirmed the awareness of post-modern society risk building. It also can be linked to the complexification of rising risks like climate change at the same time. Concerning the multi-definition, then, "hazard" in English literature, according to White et al (2001) follows the same road than the French "risk" concept (Vinet, 2007).

White et al (2001) notice a growing emphasis on "disaster" studies instead of "hazard" studies (White et al 2001) and point out that originally "hazard" were studied by applied sciences (engineering) and "natural focused" science (geography in the 1950's), and "disaster" were studied by more social sciences like sociology. They link the rising of "disasters studies" to the political rising interest for disasters (International Decade for Disaster reduction 1990-2000 from the U.N.), the rising interest in disaster studies probably also have increase the use and conceptualization of social vulnerability (see pp 47-48).

The difference between hazard and disasters studies or hazard and disaster focus (media, politics) is that "the hazards orientation encourages attention to the beneficial as well as the adverse effects of natural variations. It also anchors responses into everyday life and avoids "disaster exceptionalism" (White et al, 2001). The same kind of distinction could be made replacing hazard by the "risk" concept, therefore between "risk" and "disaster" distinction (Gaillard, 2007).

To summarize: **the hazard's definition expanded between 1950's and 1990's with apparition of new disasters (Chernobyl) and complexification of disasters, as well as rising uncertainty (climate change). With the UNISDR, the studies of disasters increased, and it can be linked to the emergence of the social vulnerability paradigm. White et al (2001) criticize the disaster focus on the exceptional and the event only that prevent to have good perspective on changes because it focuses on emergency response. These changes in hazard and disaster (United States) are similar to changes in the French use of "risk" and "catastrophe" (disaster) concepts.**

2.1.3 Disaster prevention in Japan

2.1.3.1 Disaster prevention, the Japanese concept

The distinction between "daily life" (hazard/risk) and "exceptionalism" (disaster) has impacts in theoretical research and in society, but, in Japan, it is not a distinction that has to be made. The most accepted translation for 防災 is **disaster prevention**.

Hazard, risk, or disaster prevention, when it is applied, has to deal with past and future events, although as we seen before, some concepts focus more on events and their consequences, some focus on daily life and probability. In figure 4 (p. 38), while the disaster concept would correspond on its focus on the right part of the Japanese disaster prevention concept (Disaster=> emergency reconstruction => recovery and reconstruction) and the risk would correspond in its focus to the left part of the Japanese disaster prevention concept (the prevention => preparation). Therefore, Japan way of conceptualizing risks, hazards, or disasters, is interesting in the fact that the definition regroups both points of views in its "disaster prevention" concept. The disaster prevention concept includes all times of the disaster.

Figure 2-4 the Japanese disaster prevention concept (MLITT, Okazumi, 2008)

Another difference between the occidental conceptualization of risk/hazard/disaster and the Japanese concept of disaster or disaster prevention is that the Japanese concept of disaster doesn't make a differentiation between the "natural" part of the disaster (hazard) and the "social" part of the disaster (vulnerability, resilience), and therefore should be more integrative than the occidental concepts studied above.

Because the hazard/vulnerability difference seems not to be present, the "external – hazard"/ "internal – society, vulnerability" also doesn't seem very present. Therefore like in the Burton et al (1978) paradigm, disaster prevention is part of daily life, and therefore the disaster is not something external. Conceptually speaking, this shows a better acceptance of the disaster. Conceptually speaking only, because there is of course a very strong purpose of disaster impact reduction by decreasing the number of victims and the objective to reach the fastest recovery time possible.

When it comes to Japanese river management, Wilson (2011) argued that the rivers management (and therefore the flood disaster management) has been very much inspired from 1850 to the 1900's by European engineers. He goes further saying that the engineering science was built on international exchanges between Europe, The United States, and other countries (here, Japan). Therefore there could be an argument in favor of a disaster prevention concerning floods in Japan corresponding to a "hazard paradigm" in Europe and the United States.

Figure 4 (p.38) dates from 2008, but the 2011 Great Tohoku Earthquake impacted greatly the focus on some particular times of the disaster. Lately the recovery of the Tohoku area is focused on by NPOs researchers and officials. The prior recovery concept focuses on the recovery time but aims to built an efficient recovery through land and urban planning and promotion of disaster prevention. Therefore the recovery concepts in Japanese (復興 and 復旧) are similar to the resilience concept, as planning beforehand the most suitable restoration to a former state. Applied though, and especially since the Great Tohoku disaster, the recovery Japanese concepts concern essentially the post-disaster recovery.

Like said in the introductive chapter, it is difficult not to fall into extreme views of Japanese disaster management, either praising or criticizing Japan. Therefore, we looked for occidental concepts in Japanese disaster prevention.

To summarize: **because there is no big conceptual differentiation in the disaster prevention between the hazard, the risk, and the disaster, the "disaster prevention" seems to be a more integrative concept. It concerns all times of the disaster equally, and seems have more acceptance of disaster than occidentals concepts. However, it can also be seen as a very "hazard paradigm" oriented concept, therefore a study on occidental social related concepts in Japanese disaster prevention felt needed.**

2.1.3.2 Occidental concepts of vulnerability and resilience in disaster prevention (bousai.go.jp)

The most well known socially related concepts in disaster management in Occident are the **vulnerability** and the **resilience** concepts. Therefore, a research of those two concepts by year and number of occurrence has been made. For vulnerability the word 脆弱性 and for resilience the word レジリエンス were used. For the occurrence of these concepts in Japan, the occurrence of these concepts in the Japanese national disaster prevention website (bousai.go.jp) from the Japanese Cabinet Office were analyzed. The ordinate colum will represent the number of occurrences in figures 5 and 6 and the percentages in figure 7. The axis line represent the years during which the term occurs for all figures 5 to 7. The numbers of occurrences correspond to the number of times the word is quoted in a document, not the number of documents.

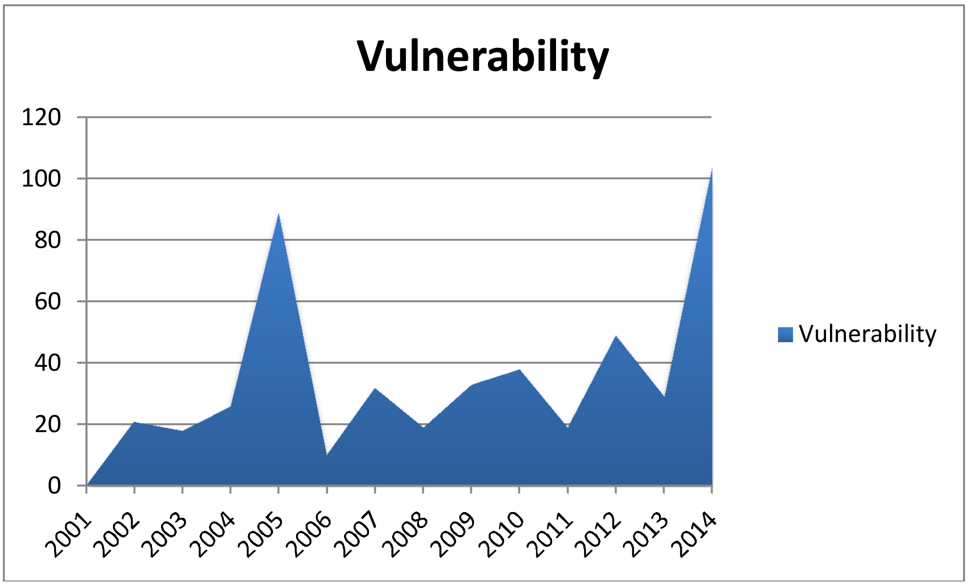


Figure 2-5 numbers of occurrences of the term "vulnerability" in disaster prevention documents on bousai.go.jp

In the figure 2-5 on 487 occurrences of “vulnerability”, the word has been very much used during 2005 and in 2014. There is no explanation for the high number of occurrences in 2014. But the peak of 2005 corresponds partly to the United Nations

International Strategy for Disaster Reduction (UNISDR) Hyogo Framework for Action (HFA) organized in Japan. An interesting fact in the HFA is that the vulnerability concept is translated in Japanese and exploited, when the "resilience" concept, in the title "Building the Resilience of Nations and Communities to Disasters" is not translated by the Japanese equivalent but by 兵庫行動枠組 2005-2015 ～災害に強い国・地域の構築～[9](Hyogo framework for action 2005-2015 – building strong countries and regions to face disasters) (cabinet office, 2005).

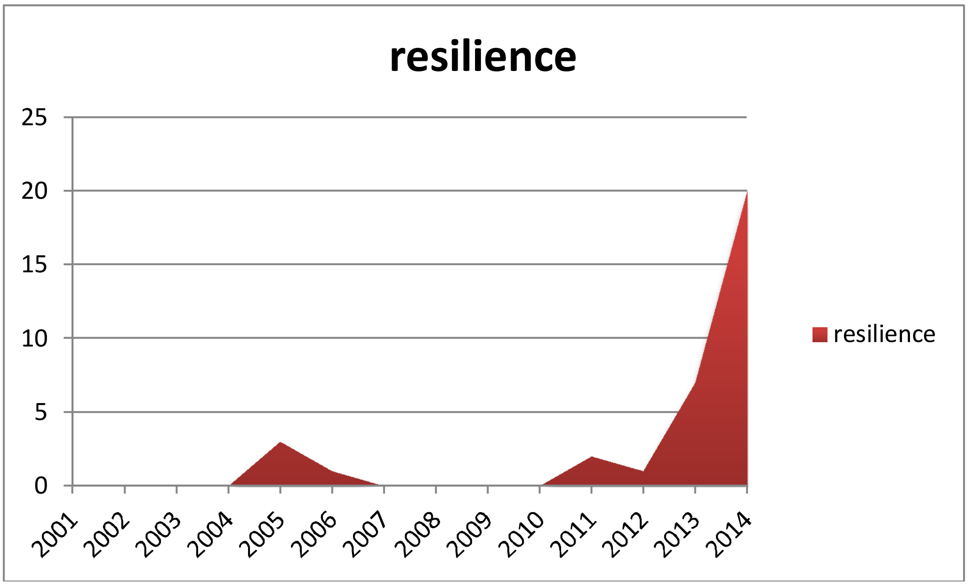


Figure 2-6 numbers of occurrences of the term "resilience" in disaster prevention documents on bousai.go.jp

The figure 6-2 shows the repartition of the 34 occurrences of "resilience" concept in bousai.go.jp. The low numbers of occurrences for resilience compared to vulnerability tend to show that this concept has not been acculturated in Japan as much as "vulnerability" concept has. But figure 2-7 compares the number of occurrences in percentages for resilience and vulnerability. It seems to show a trend for an acculturation of "resilience" very recent, but important.

[9] to be downloaded at http://www.bousai.go.jp/kokusai/wcdr/

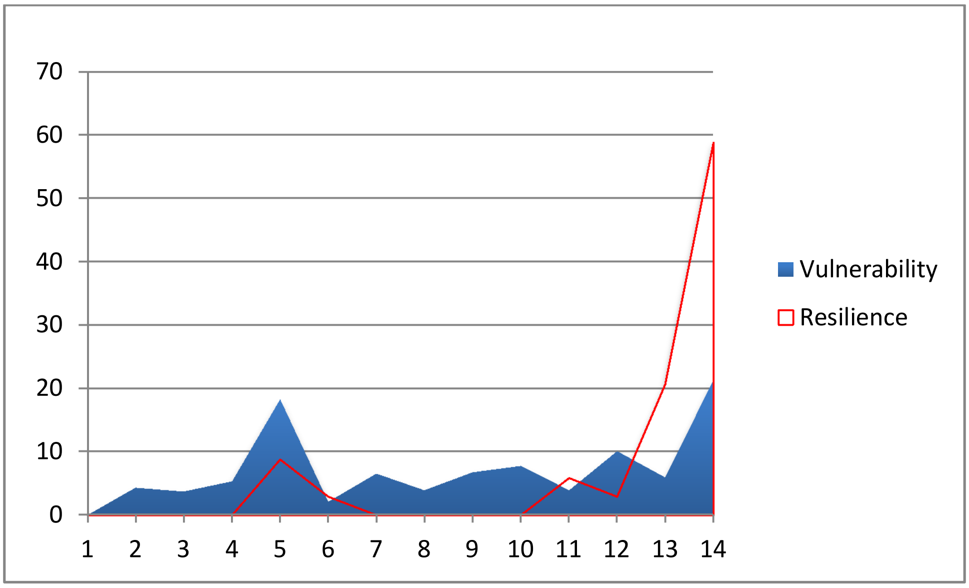


Figure 2-7 occurrences of resilience and vulnerability in percentages for the 2001-2014 period in bousai.go.jp

For 2014, there are 20 occurrences for resilience and 104 for vulnerability. Therefore the vulnerability concept is still more used than the resilience one. But it is to be expected a rise in the resilience concept use in the future, if is considered how fashionable a concept it is in the political, social, and scientific world, and other factors. Because there is a the probability that the resilience concept will be use more frequently in Japan in the future, a study of the evolution, definitions, advantages and disadvantages in the resilience concept felt needed and will be studied in the next section.

Concerning the differences between disaster prevention in Japan and risk or disaster management in the occidental world, the "vulnerability" concept gives keys to understand how there are links between Japanese and occidentals concepts. The vulnerability is considered to be a social related concept. The figure 2-8 shows the society's vulnerability to reduce in order to reduce damages. This conceptual figure is very close to the figure 2-2 p 27, even if the purpose is to reduce the society's vulnerability in Japan corresponds to the hazard (impact) reduction in figure 2-2. It corresponds to a cost-benefit vision of the disaster prevention. The difference is that "damages reduction", corresponding to structural and nonstructural measures is considered as part of the society, where in Europe there was until the 1990's a difference between "hazard reduction" for structural measures and vulnerability reduction for nonstructural measures. More qualitative analysis of vulnerability and resilience use is needed to understand their future uses and evolution (when are they used, for what type of disasters, are they more used after some special events or disasters …).

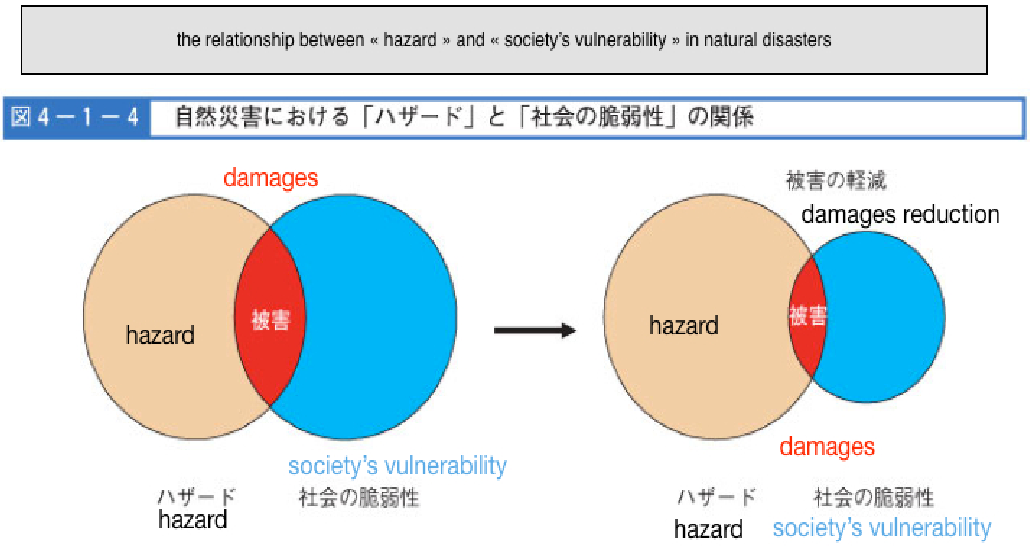


Figure 2-8 Vulnerability as social concept in Disasters prevention White book, 2004 (bousai.go.jp)

To summarize: **the vulnerability concept is used in Japanese disaster prevention more than the resilience concept. The resilience concept took time to appear in the disaster prevention conceptual framework, but its use is growing since 2014. The vulnerability concept shows that disaster prevention in Japan and disaster or risk reduction way of management are similar, but Japan keeps its particularities, especially concerning what concerns the differentiation between "natural" and "social" factors. The disaster prevention in Japan seems still more integrative than the others.**

2.2 1980's-today, the boom of social-related concepts, scientific and societal origins of vulnerability and resilience, and their "umbrella concept" status

2.2.1 1970's-2000's the vulnerability concept shift, from hazards studies vulnerability concept 1950-1990 to disaster studies vulnerability 1990-today

The vulnerability concept has always been considered as a concept that represents the society side of the disaster in occidental concepts. However, the origins of the vulnerability and resilience concepts were invented and used during the 1950-1990's hazard paradigm in Europe and the United States. They were just not as developed as they have been developed after the 1990's. This study is based mainly on the French doctorate thesis of Mrs. Magali Reghezza (2006) who specialized in the evolution and uses of the vulnerability concept and how to use it in megacities area (study of a probability of 1910 flood hazard occurring in Paris capital) for the evolution of vulnerability until 2008, and with complementary readings for the latest years. Every new definition does not replace but complement the formers. The changes in the vulnerability definition concept are shown in figure 2-9.

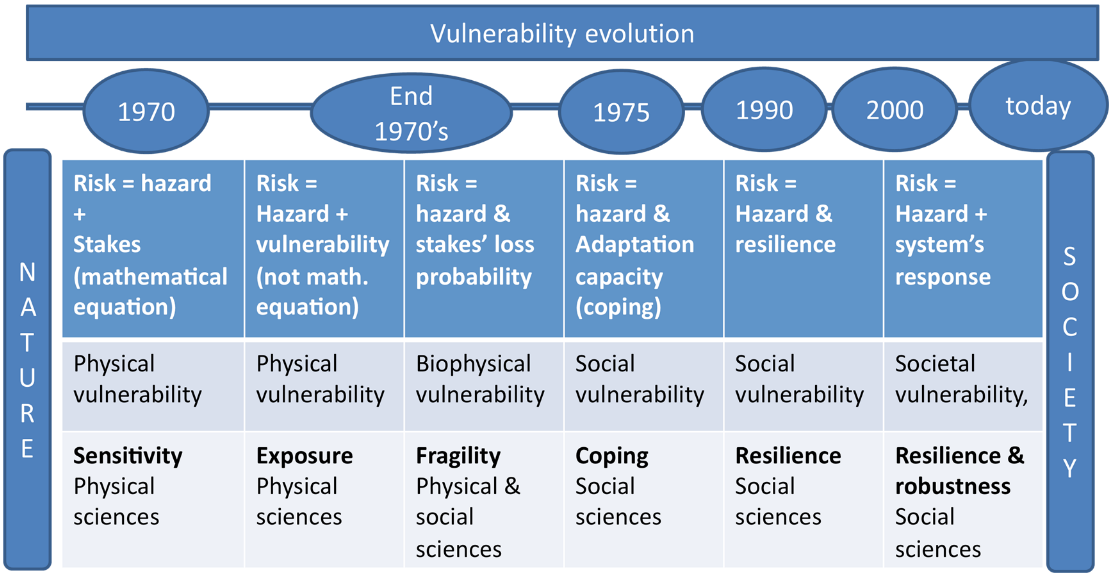


Figure 2-9 evolution of the vulnerability concept

2.2.1.1 Physical vulnerability

According to Mrs. Reghezza (2005, 2006) the first definition (1950-1970) of vulnerability was built to fit the cost-benefit analyses to reduce risk (hazard paradigm and structural measures focus). In these analyses:

- **Risk** = hazard * vulnerability
- **Hazard** = event probability of occurrence
- **Vulnerability** = damages degree the stakes suffer, in absolute numbers or percentages

The English expression "element at risk" comes from this kind of studies. Nowadays, this vulnerability concept is called "**physical vulnerability**". This concept is used in analytical and quantitative methodologies. Still used today, this method and concept limits come when "intangible" elements like human life, functions of the area that cannot be calculated (schools, museums …) are "at risk".

The second way to conceptualize physical vulnerability is through the "exposure" concept.

Vulnerability = susceptibility of stakes to suffer damages caused by their exposure.

And then vulnerability became:

Vulnerability = susceptibility of stakes to suffer damages caused by their degree of exposure.

This method consist not by a real mathematical equation, but by a spatial superposition of the “hazard” map” and the “stakes map”. In risks maps and hazard maps this method is still the most used. However, when there is uncertainty (global change, impact of hazard on a complex system), this method has limits.

In applied sciences, there is an acknowledgement that there are “**fragility**” thresholds above which a stakes suffers damages (material stake, like buildings, not human life). This leads to biophysical vulnerability:

Biophysical vulnerability = the function of the hazard, the exposure and the sensitivity to the hazard’s impacts of the stakes.

The physical vulnerability concept has been complemented by social perspectives since the end of the 1950’s, if we consider the article of White et al (1958) as relevant, however, the vulnerability concept development and the development of vulnerability concept as social oriented concept has to wait to be defined until the 1990’s.

2.2.1.2 Social vulnerability

According to Reghezza (2006) the vulnerability concept is established in 1976 by Wisner et al. Before, when used, the vulnerability concept was always used in regards to exposure, sensitivity, fragility … This doesn’t necessarily mean that “vulnerability” is defined as a concept.

In 1973 Burton et al develop in “the environment as hazard” a “**coping capacity**” framework, this framework tends to stress out the importance of adaptation and adjustment as part of a broader "coping capacity" concept. The adaptation and adjustment of a society depends on the vulnerability and resilience factors of this society (although neither vulnerability nor resilience are defined as concepts). Vulnerability is a part of the broader concept of coping capacity. In 1975 White and Haas (a geographer and a sociologist) state that economic, social and political factors have to be taken into account in natural hazard management. This article doesn't introduce the "vulnerability concept", but it opens the door for social sciences research on natural disasters and hazards. It is the beginning of the second paradigm change (figure 2-3, p 29). Probability of hazards' occurrence doesn't change, but vulnerability is rising.

Studies on vulnerability have been done, especially in developing countries, and three main approaches are developed between 1970 and 1980:

- The "**behavioral approach**": disaster = extreme natural event + perception of this event by populations
- The "**structuralism approach**", applied essentially in developing countries, where the focus is only and solely on socio-economic factors of vulnerability as first cause of disaster
- In 1983 poverty is supposed to one of the major vulnerability factors. This is called the "**constructivist approach**"

These studies consider that vulnerability is a product of society, an internal problem. Therefore the hazard only reveals the internal vulnerability of a system, and the vulnerability factors (poverty, economy, perception …) are the factors that should be focused on. This paradigm shift is complemented by some radical criticism against the "technocracy" of the hazard paradigm (Hewitt, 1980).

If in 1973 Burton et al want an integrated study of natural hazards, the new paradigm, (that we will be calling the "vulnerability paradigm") approach makes it difficult for the vulnerability concept centered solely on social factors to be linked to the former type of vulnerability (exposure, sensitivity, and so on). The social oriented paradigm did not replace the hazard paradigm. The vulnerability concept kept accumulating different definitions, some are more integrative than other in the scientific fields.

To summarize: **The vulnerability concept is born from natural hazard and disaster studies; therefore the evolution of the vulnerability follows the evolution of the risk/hazard/disaster concept. It shows a progressive separation of two paradigms in disaster related studies. For the hazard paradigm vulnerability concept concerns mainly "tangible" stakes (on which a value can be put on), it contains sensitivity, exposure, or degree of exposure. For the vulnerability paradigm, vulnerability can be related to coping, adaptation … and its factors can be poverty, social-economic, political… The two paradigms coexist but it is difficult to link the two approaches.**

2.2.1.3 Vulnerability, poverty, and political implications

According to Reghezza (2006), the vulnerability concept became very fashionable after the first INDNR (International Decade for Natural Disaster Reduction) 1990-2000, during the former 10 years many studies have demonstrated the vulnerability as "root cause" (cf the PAR model of Wisner et al, 2004) of disaster, principally in developing studies. At the same time, the resilience concept start to rise in disaster related studies (even if it was already mentioned in 1976). The vulnerability seems pertinent in a context where uncertainty is a handicap for future hazard and therefore future structural measure setup.

However, because resilience will be a concept developed on the ability to recover (principally), and vulnerability is a concept based at its origin on the capacity to be harm, vulnerability will keep a negative signification whereas resilience will not.

Moreover, because vulnerability is a concept that develops more and more related to purely social problems, it deals very much with (bad) policies (either inadvertently creating vulnerable areas or willingly creating vulnerable areas in hazard-prone areas), and according to Miller et al (2010) "vulnerability is a concept trying to link research with policy and practice in keys areas", moreover "vulnerability can be construed as negative and potentially stigmatizing, particularly if research is undertaken by outsiders with little community or stakeholder input or influence". Focusing on socio-economic factors tends also to point the vulnerable **population as victim** of a system (political or other), as can be seen in radical social vulnerability research (Gaillard, 2007) in developing countries. For all these reasons, the vulnerability concept has not the appeal the resilience concept can have. However, it is impossible to assess "good", or resilient aspects of disaster management without pointing out former or still current "bad" aspects of the disaster management. Therefore, even if the vulnerability concept is not as fashionable as the resilience concept can be nowadays, it is still difficult to do without it, despite its flaws and the difficulty to define it.

To summarize: **the vulnerability concept developed intensely due to its use during the INDNR (1990-2000), but its negative implications, its socio-economical focus, especially in developed countries made of the vulnerability concept a concept with "negative" meaning, while the resilience concept was becoming more and more fashionable. Today, however, despite its flaws, the vulnerability concept is still used. Partly because in order to point out good outcomes in disaster management through resilience, it is needed to compare with "bad" outcomes of disaster management, and vulnerability has become the "flipside" of resilience, or any concept related to resilience (robustness …).**

2.2.2 1973-2010 the resilience concept shift, ecological origin, and societal and scientific boom of the concept linked to the "climate change" and "sustainable development" concepts

2.2.2.1 Resilience, from ecology to disaster management through climate change

If the vulnerability concept origin can be somewhat clearly linked to disaster studies, the resilience concept origin is not something on what researchers agree on (Lhomme, 2012, Klein et al, 2003). The origin can be linked to engineering sciences, ecology or psychology. Everybody agrees that today, the concept is a multidisciplinary concept. Figure 2-10 shows the multidisciplinary aspect of the resilience concept. Vulnerability being one of the main concept in disaster management studies but being also founded in climate change studies (albeit in relation to disasters), the postulate here is that the figure 2-10 not only represents the multidisciplinary aspect of resilience but also the main sub-concepts that emerged from the resilience concept or were linked to it at its origin.

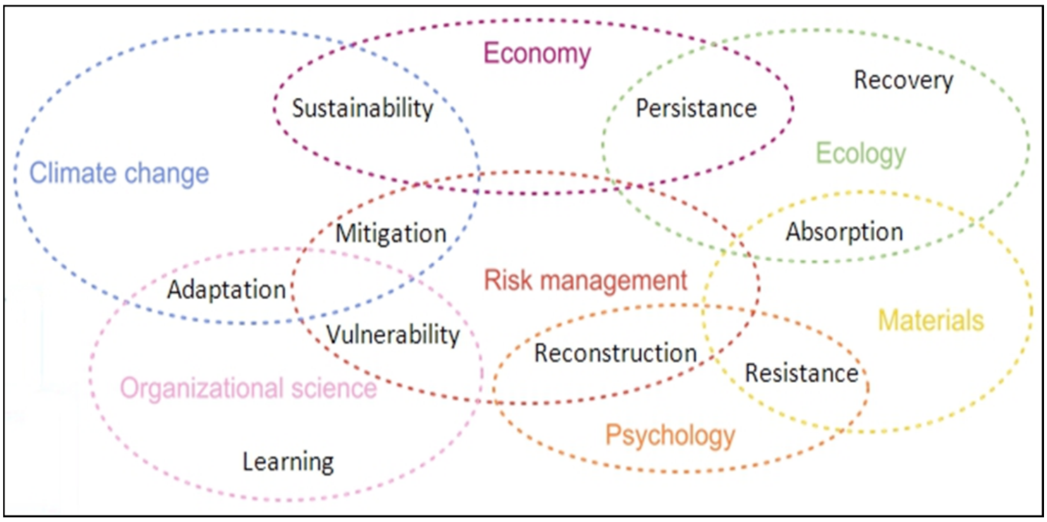


Figure 2-10 the multidisciplinary aspect of resilience (Rhegezza-Zitt et. al 2012 p. 3)

Reghezza (2005, 2006), Klein (2003), Aschan-Leygonie (2000), Barroca et al (2013) link the resilience concept's origin to Holling's article (1973) where a change in the ecology field happened. Therefore, in this study, we will consider the **origin of the resilience concept in the ecology field**, its links to climate change and the impact it can have had on disaster studies.

Holling's article in 1973 states that:

- **Resilience is opposed to stability**, for Holling a resilient system is a system with a high ability to change and be persistent (although he will abandon later the persistence concept)
- Populations participating to resilience are **not necessarily population in majority** in an ecosystem
- The **maintenance of an ecosystem in under uncertain circumstances** should be studied through resilience (leading to future research in Climate change)

Holling's works were pursued especially by the Resilience Alliance network (RA) (http://www.resalliance.org/) in **resilience**, **adaptive capacity** and **panarchy** concepts. Folke (2006) introduces the **Socio-Ecological-System** analyses (SES) following the works of the RA network, the SES is a conceptual framework linking social, and ecological factors explaining resilience and adaptation to climate change for a system, which is no longer an ecosystem anymore. However a "resilient" system is not necessarily a "good" system. In climate change studies, Folke (2006) has stressed out the fact that a "resilient" system has more difficulties to adapt when confronted to an unknown disturbance than a non-resilient system, because it has effective methods to cope for one type of disturbance and is not used to change.

The resilience concept is linked to disaster management in the studies concerning the impact of climate change on the resilience to disasters. It is linked in climate change studies to adaptation, robustness, durability, mitigation, and learning capacity and supposes that inside any system there are factors that enhance the mitigation, coping, and recovering of a disturbance. However there is still no agreement on the main and secondary concepts in use: resilience, vulnerability for disaster management, adaptive capacity, resilience and vulnerability in climate change related to disasters studies (see figure 2-11 here below).

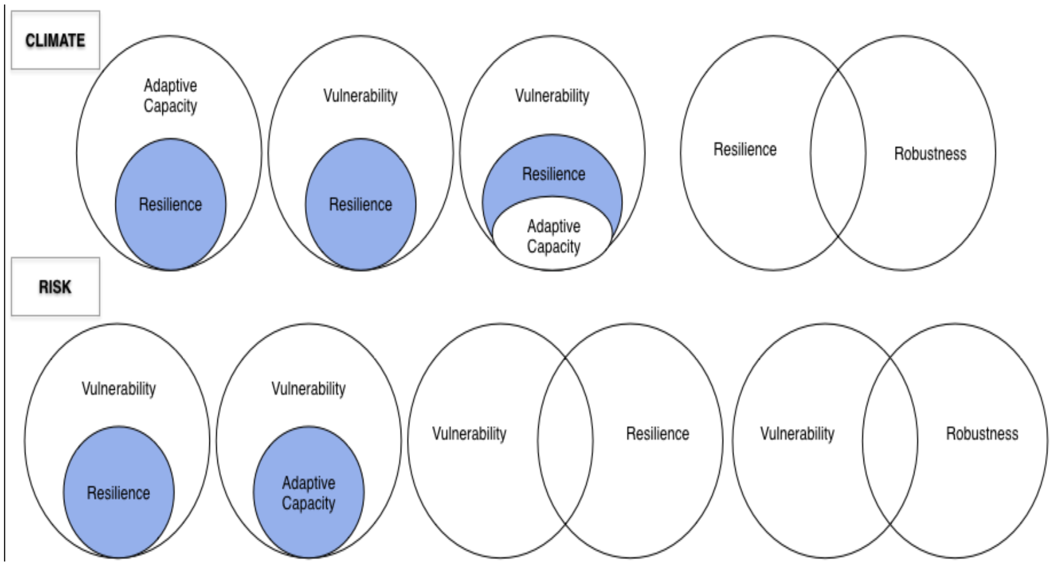


Figure 2-11 the concepts of resilience and vulnerability used in climate change and disaster management studies (from Lhomme 2012 and Cutter et al, 2008)

The resilience concept has been introduced in disaster studies since the 1970's after Holling's definition. However, the definitions of resilience in disaster sciences were not necessarily linked to Holling's resilience, and the concept was not fashionable until the disasters of the terrorist attacks on the Two Towers on September 11 2001 and the Katrina hurricane disaster in New Orleans (Comfort et al, 2010). It was conceptualized as "bouncing back" from a disturbance (original meaning of the word resilience in Latin), and linked to "engineering resilience". If resilience in ecology puts an emphasis on the chaotic and changing nature of an ecosystem which is never in an "equilibrium" state, the engineering resilience, according to Reghezza et al (2012) is defined by the ability to recover to the equilibrium state, the quicker, the more resilient the system is. Therefore, "resilience" in disaster studies have been criticized because many authors have stressed out that "returning to a state preceding the disaster" would be bad (Dauphiné and Provitolo, 2007).

However, despite the disagreements on what resilience means and where it does come from, the resilience concept is more and more used because it is a concept with "positive" meaning, that can mean either returning to a stable state or "undergo stress and have the ability to recover and return to their original state" (Klein et al 2003).

To summarize: **there is no agreement on where the resilient concept comes from; therefore it is considered as a multidisciplinary concept more than vulnerability. The origins of the resilience concept are numerous, but in the case of resilience concept use in disaster studies the closest and most used definition origins in the ecology field. The resilient concept in ecological science is used to study continuity of an ecosystem always changing, therefore it is applicable to change, uncertainty, and Climate change, and a resilient system is not necessarily a system with only good qualities. Resilient system could have more problems to adapt than non-resilient systems. Climate change studies link the ecological and social system through their SES concept, and from there adaptive capacity, learning capacity and so on developed. In disaster studies, there is no consensus on resilience definition, often seen as a "return to original point", and not necessarily focusing on change. However, the resilient concept has become very fashionable.**

2.2.2.2 Climate change, resilience, and "umbrella concept" problem

According to Lhomme (2012) "the (resilience) term becomes a sort of "portmanteau"[10]

[10] Lhomme uses the French term "mot valise", the English translation of "portmanteau word", originally the portmanteau word has the following meaning: s a combination of two (or more) or their sounds and their meanings into a single new word (example: psycho-sociology). In this context, however the "mot valise" or "portmanteau word" means that the concept is used so much and in so many occasions that it has lost its meaning.

word requested to very varied purposes like other fashionable notions (durability, governance, and so on).” More multidisciplinary and more fashionable currently than the vulnerability concept, “resilience” seems to be used for at least the next 10 to 20 years. However, the concept has been criticized for its use that sometimes makes it an empty word.

Miller et al (2010) point out that vulnerability and resilience have the same problem, being concepts that are:

- Either use as empty words when the research focuses on the methodology developed
- Or are much defined conceptually but the following methodology doesn't follow or is not linked to the conceptualization of the concept.

Klein et al (2003) calls the resilience an “**umbrella concept**” and link the resilience again to the UNISDR.

This conceptualization problem is a common problem to “risk” (Vinet, 2007), “vulnerability” (Reghezza 2005, 2006), and other fashionable concepts used in daily life like sustainable development, governance, and climate change. The use of resilience as an umbrella concept not necessarily defined neither in scientific fields nor in media and politics can hinder some problems that come with the resilience concept.

Like said above, Holling stressed out the role of small populations in ecosystem resilience. In the risks studies, it has been stressed out that the resilience concept differs from the vulnerability concept in one key aspect: **contrary to the vulnerability which stresses out the victim status of people at risk, the resilience concept is often used to emphasize the individual and community actions to take in order to cope better with disasters**. By extension, the resilience concept emphasizes the responsibility of the smaller common denominator of the disaster (Reghezza et al 2012): the individual or the small community, and how the decision they take has impacts. Therefore the danger with the resilience concept is the exact reverse as the danger with the vulnerability concept: to put on small communities and individuals a very high responsibility. This explains partly, in a global context where the State influence is replaced by the prefecture or regional responsibility, why the resilience concept is so fashionable and how it should be used with caution.

To summarize: **the multiplicity of definitions for the resilience concept masks some inherent problems inside the concept itself. If the vulnerability's concept problem is that it puts an emphasis on "bad" policies and management and victimize people at risk, the resilience concept can and sometime be used with the exact opposite effect, putting a huge responsibility on individual and local coping capacity. "Resilience" is not necessarily a synonym for "good" management.**

2.2.3 Problems in "vulnerability" and "resilience" uses in scientific fields and society are a product of their evolution and the "systemic" research emerging in social studies

The resilience and vulnerability concepts have changed in definitions and meaning following the society's concern, disasters, and major concepts. With the rise of complexity in disaster research more and more importance is given to "systemic' research. In parallel, the uses of vulnerability and resilience are more and more entwined, resilience being considered the proprieties of a system to enhance, and vulnerability the proprieties of a system to diminish.

According to Barocca et al (2013) vulnerability and resilience are more and more utilized in regard to urban planning and land planning. Their argument is that the "resilience" concept changed to end in resembling to the vulnerability concept. Considering that:

- The two concepts have very different origins

- The vulnerability concept has been conceptualized and applied since a longer time in disaster studies than the resilience concept,
- And that nowadays studies tend to systematically oppose resilience (good) versus vulnerability (bad) in disaster studies,

This argument makes sense.

However, the opposite argument could be made today. The vulnerability concept changed to include adaptation and coping capacities during the 1990's-2000's, and if used without regards to the resilience concept today, the definition for vulnerability can be very similar to the resilience concept ("vulnerability is seen as a more or less big incapacity of a society to take into account a hazard, before and after it occurs, in the time of the daily-life" or vulnerability is "a person or group of person's characteristics or situation influencing their capacity to anticipate, cope, resist, and recover after a hazard impact." (Bidou and Droy, 2009).

Therefore, while assessing that resilience and vulnerability are more and more concept that mirror each other, we will consider that the two concepts change confronted to each other to resemble today in almost every way to each other. The figure 2-14 illustrates how vulnerability and resilience are considered as opposite when used in a same paradigm.

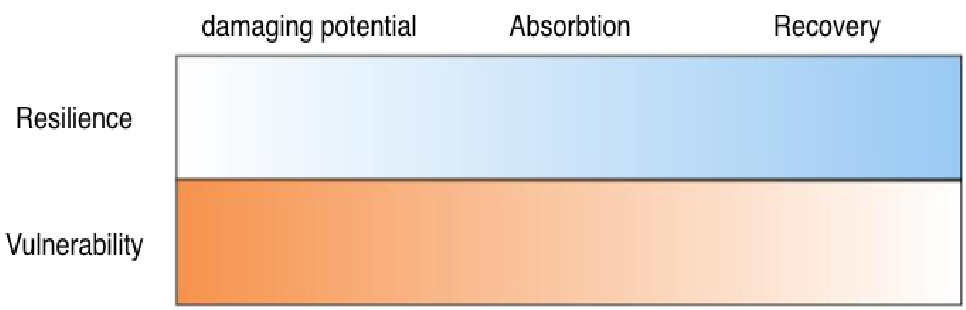


Figure 2-12 Resilience as opposite of vulnerability (translated from Lhomme, 2012)

Moreover, in France, "if the risk definitions revolve around the couple hazard-vulnerability, they evolve and vary from one researcher to another, still without being fully satisfactory. Therefore a profusion of definitions tend to reflect areas studied, field of study of each researcher. At the same time, an underlying trend favors the systemic approach in risks studies, instead of an analytical and fragmented one, but this latter is however the one which reappears the most often" (Pigeon, 2005).

As the figure 2-13 and 2-14 show it, the systematical approach is very different from the analytical one, correspond to two different paradigms, and relies very much on approaches that have not yet methodologies very much used or understood by everyone, contrary to analytical methods. However, the systemic approach in disaster reduction could be linked to the particular problem complex urban system pose to disaster prevention studies. The factors to take into account and the consequences of the relations between city's elements are too complex to be studied in an analytical way. It seems difficult though to link analytical and systemic approaches, and these different methodologies could lead to more difficulties to manage disaster between different scientific approaches.

Analytical approach	Causes of the changes of approaches	Systemic approach
Evidence: to be considered, everything has to be demonstrated	searching for evidence is not always possible	**Pertinence**: to be considered, objects have to be pertinent considering implicit and explicit intentions of the person building the model
Reductionist: decomposing the studied object in as much parts as possible	Doesn’t seem pertinent in all cases because sometime it doesn't allow to understand completely the object	**Globalization**: perception of the object inserted in a bigger picture. Implies opening to bigger scale
Causality: understanding of an object and its functioning is ruled by cause to effects relationship laws	is not informing on the object's finality	**Teleological**: understanding the object and its functioning through the relationship between the objects and the projects its linked to
Exhaustivity: complete count of studied objects in order not to forget anything	exhaustivity is not always possible	**Aggregative**: selection of pertinent elements for the study without assuring the totality of the interpretation

Figure 2-13 comparison between analytical and systematic approaches (translated from Berraud, 2013)

	Hazard paradigm	"Vulnerability" paradigm
stakes	Tangible stakes (buildings, people lives)	Intangible stakes (cultural, psychological, economical, …)
area	Hazard area limitation	Not limited to the hazard area
Related concepts	Sensitivity exposure, degree of exposure, fragility	Coping, adaptation, resilience,
fields	Applied sciences	Social sciences
Problems inherent to this paradigm	Reducing exposure does not reduce risk	Difficult to be scientifically applicable, focus on political, poverty problems

Figure 2-14 comparison between analytical and systematic approaches and the "hazard" and "vulnerability" paradigm

To summarize: **the evolution of the vulnerability and resilience concept lead to consider them today in disaster research as concept that mirror each other, or flip-side concepts (resilience is the opposite of vulnerability and its contrary). They are however more and more used in what is called "systemic" approaches. Since the 2000's systemic approaches are more and more utilized to study disaster, especially urban type disaster and in domino effect studies. However, it has to be said that the systemic approach is so different from the analytical one that the utilization of this type of approach could lead to more difficulty in science field communication.**

3 CHAPTER3

Goals, methodology and field study area: for a study of "change" in disaster management

3.1 Goals for this research, for an integrative framework in disaster prevention studies

3.1.1 Making clearest possible concepts to be used in disaster prevention research

In chapter 2 were defined the main concepts used in disaster prevention in Europe (mainly France) and the United States. Chapter 2 tried to link the occidental research to the Japanese conceptualization. Our goal is to **build a model in which the concept defined should be clear and limited, in order to assess the adaptation to flood risk, having a focus on the evacuation side of the risk**. Many definitions and many possible meanings is not necessarily a handicap for theoretical research only, but when applied the concepts should be clear, even if it means losing part of the multiple meanings they can carry.

3.1.2 Assessing vulnerability factors and resilience factors for flood risk in Japan as objective as possible

In chapter 1 and chapter 2 the differences in concepts used between Japanese and occidental developed countries and the difficulty for foreign researchers working on disasters has been pointed out. One of the objectives of this study was to give a clear understanding concerning the concepts origins, their evolution and their uses nowadays, in order to define concepts both fitting the current trends and focuses in disaster research, and having integrative and applicable definitions both for social and applied sciences.

Our goal with using the “adaptation” concept and build a model from it was

- To use a occidental concept as close as possible as the Japanese way of dealing with disasters
- Avoid excessive praise or excessive criticism and have the most objective assessment possible.

3.1.3 Focusing on the evolution of the disaster prevention through two flood events and the umbrella concept of “adaptation”

If change is a recurring theme of disaster studies, adaptation is a concept used almost exclusively nowadays in climate change studies in regards to disasters evolution expectations. We propose an **adaptation assessment** to underline the way disaster prevention may change between two disasters. Our study is not disaster focused, however assessing evolution without two defined point in time is difficult, therefore even if we are focusing on an evolution or changes in time, we need the disaster and especially the Tokai disaster experience to have a starting point for the evolution of disaster prevention.

The adaptation concept is inspired by the 1978 coping capacity model of Burton et al, we hope that our adaptation model will give as much attention to nonstructural measures than it does to structural measures.

The **adaptation concept will be considered to be an umbrella concept**; therefore it will be composed of vulnerability factors (reduced, to be reduced) and resilience factors (enhanced, to be enhanced). We hope to follow the latest trends in disaster studies:

- Vulnerability as flip-side of resilience
- Considering the evolution of a system instead of focusing on an event alone

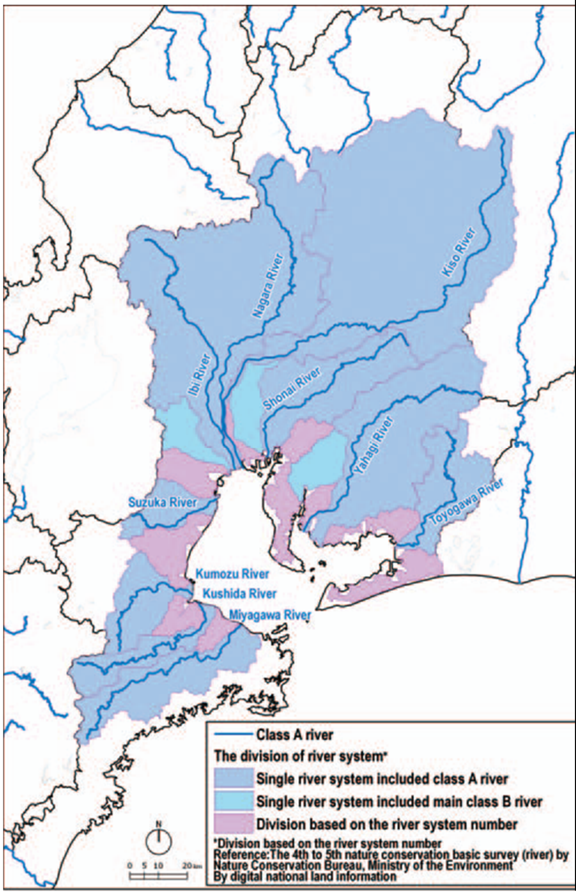
3.1.4 Propose ways to enhance the disaster prevention system by highlighting changes and their impact, and remaining challenges (no change)

From our adaptation model assessment, we hope to be able to propose ways to enhance the disaster prevention by highlighting the disasters impact, the changes they brought, and the remaining challenges. One of our purposes will be to assess thresholds for evacuation and try to explain the difference between clear changes in structural measures outcomes and nonstructural measures lack of impact.

To summarize: **this study aims at the construction of a conceptual model in which the concepts utilized are clearly defined in order to be understandable and criticized. The concepts also have to fit the goals for adaptation to flood risk with a focus on the evacuation process. The utilization of non-Japanese concepts (vulnerability and resilience) has been carefully thought and chosen in order to avoid over specificity focus on Japanese disaster prevention. The adaptation concept has been considered the occidental concept closest to Japanese concepts like coexistence and symbiosis. The adaptation concept is also considered useful to highlight changes between disasters in order to assess the evolution of risk management.**

3.2 Choice of the field of case-study: the two flood events of the Shonai River Basin in 2000 and 2011

3.2.1 Geographical and hydrological characteristics of the Shonai river basin



The Shonai river basin is located in the Nobi plain, as well and is one of the main A class rivers of central Japan flowing into the Ise-bay (see figure 3-1). Contrary to the other major rivers (Ibi, Nagara and Kiso, managed as a system called "the Three Kiso River system), the Shonai river basin is medium to small in size, but the reason why it is managed by a National River Bureau is its highly densely inhabited metropolitan lower reach.

Figure 3-1 the Ise-bay river basins (MLIT http://www.river.go.jp/)

The Shonai river basin is a medium river basin of 1010 km^2 in the center of Japan and covers two Japanese prefectures: the river originates in the Gifu prefecture in the Mt Yudachi (727 m) in Yamaoka town, the river length is 96 km, and the river mouth is located in Nagoya-city in Aichi prefecture. There are three main tributaries for the Shonai River:

- The Yada River is 56 km long and its catchment area is 121.7 km^2. The confluence of the Shonai and Yada river is located in Nagoya-city
- The Ori River is 23.5 km long and its catchment area if 97.2 km^2
- The Shin River is 22 km long and its catchment area is 232.2 km^2

Like most of the Japanese rivers, the rivers of the Shonai river basin have a steep longitudinal profile (figure 3-3) compared to European and American major rivers (figure 3-2). In terms of flood risk, this implies a very quick response of the river basin to precipitation, and a very short response time at the society disposal, therefore, very different from European floods that can be very early predicable, although unavoidable, and lasting for days and days causing major damages to any building by 10 days or more of flooding.

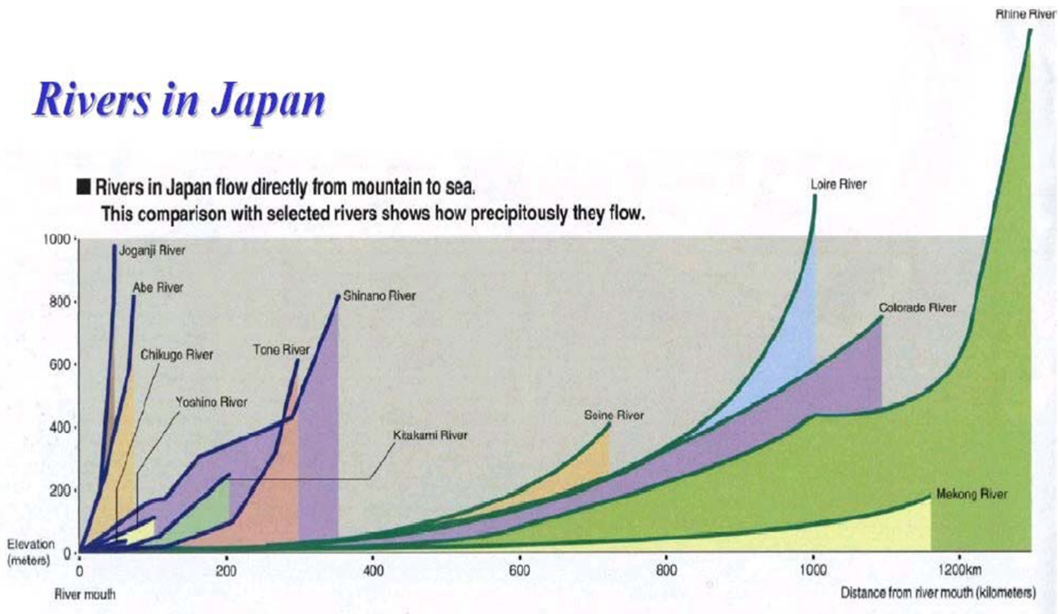


Figure 3-2 River profiles in the World (Japanese rivers in blue) (MLIT in Georgel 2005)

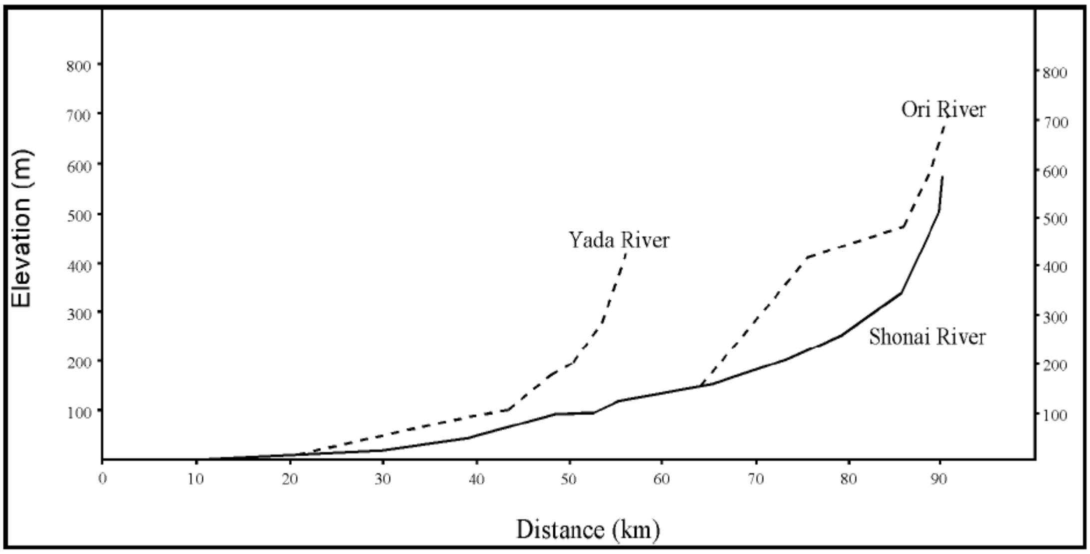


Figure 3-3 Shonai, Yada, and Ori Rivers profile (Pawittan et al 2000)

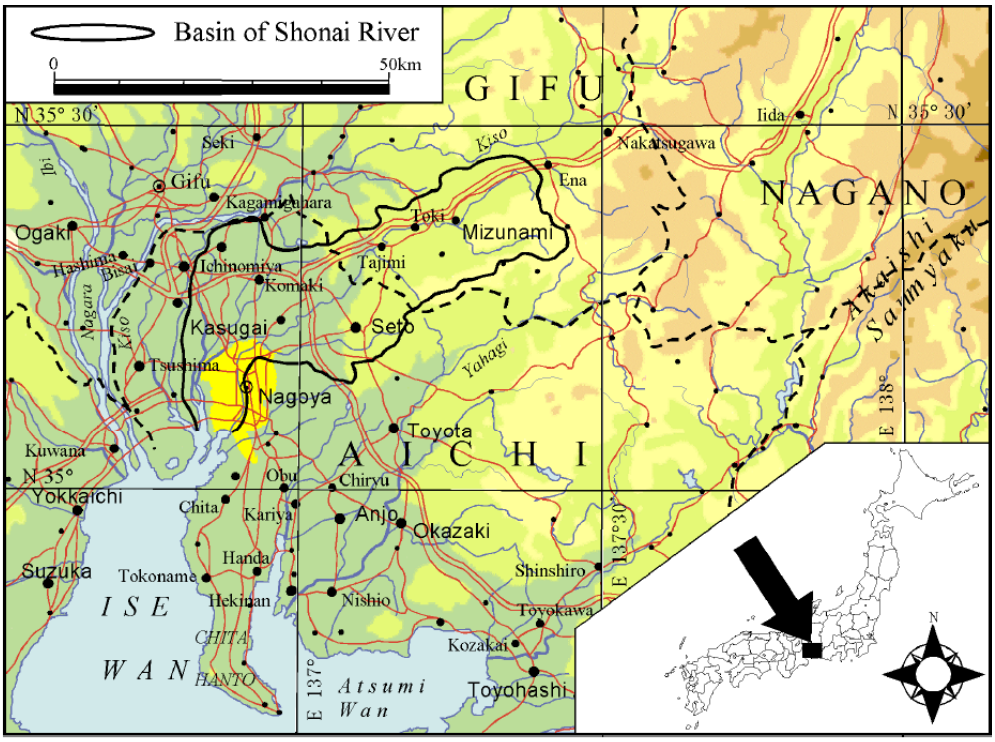


Figure 3-4 the Shonai River Basin in 1990 (Pawittan et al 2000)

No.*	Station	Location from the river mouth [km]	Catchment area (A) [km^2]	Observation period	Observation items [1] (frequency)
50909	**Biwajima**	15.7	705.0	1938~present	Q (10 day)
50919	**Shidami**	32.7	532.0	1974~present	Q (15 day)
50908	**Tajimi**	49.1	367.0	1971~present	Q (10 day)
50922	**Toki**	57.8	284.6	1977~present	Q (15 day)
50905	**Seko**	21.6 (3.6 from the confluence)	105.0	1960~present	Q (15 day)

No.*	$\overline{Q}$ [2] [m^3/s]	Q max [3] [m^3/s]	$\overline{Q}$ max [4] [m^3/s]	$\overline{Q}$ min [5] [m^3/s]	$\overline{Q}$ / A [m^3/s/100km^2]	Q max / A [m^3/s/100km^2]	Period of statistics
50909	26.59	2 196	1 017	4.84	3.77	311	1969~96
50919	20.02	2 279	984	2.99	3.76	428	1975~96
50908	13.86	1 836	718	2.26	3.77	500	1976~96
50922	10.96	1 672	673	2.07	3.85	588	1977~96
50905	4.57	816	263	0.91	4.35	777	1970~96

*: Serial number used by The River Bureau, Ministry of Construction
Q: Discharge; 2) Mean annual discharge; 3) Maximum discharge; 4) Mean maximum discharge; and 5) Mean minimum discharge

Figure 3-5 Shonai river basin meteorological stations and data (Pawittan et al 2000)

The precipitation data are available due to the implementation of several meteorological stations between 1938 and 1960, the oldest one being the Biwajima meteorological station located near the Biwajima bridge, west of Nagoya, which is since the Edo era the link between the East and the West of Japan and at high flood risk.

3.2.2 Social and human occupation characteristics of the Shonai river basin (1779-today)

3.2.2.1 River works related to Nagoya-city expansion (1779-today)

The particularity of this overall small river is that it is qualified as **one of the most urbanized river of Japan**. Because of several factors, the Shonai River and its tributaries place the city of Nagoya at risk since centuries.

- The **confluence between the Yada river and the Shonai river** caused several times in the past the flooding of the cities, up to the castle area (1779 flood[11])
- The **Biwajima Bridge** is since the Edo era part of the Tokkaido road, and allows transit between Osaka and Tokyo. Today, it keeps its status of high transit place, as the Japanese bullet train line crosses the Shonai River at the Biwajima Bridge.

The creation of a diversion canal for the Shonai River starts after the 1779 flood of Nagoya Castle, and the Shin River is created in 1787. At that time and until Meiji era (1868-1912) the city of Nagoya was not as big as it is today, and the Shin, Shonai and Yada rivers were outside the city limits.

It is important, because it explains the development of advanced protection measure on the left bank of Shonai River after the 1959 Ise-bay typhoon and the creation in 1964 of the Shonai River bureau between 1964 and 1969. Because the confluence of the Shonai River and the Yada River was still a problem, important levee constructions in Kita ward on the left bank of the Shonai and Yada rivers were put into place to avoid the risk of flooding from the confluence point. At that time, the right bank side of the levees being still a rural area, it has not been improved as much structurally speaking.

[11] Network Nagoya history association (available online (http://network2010.org/)

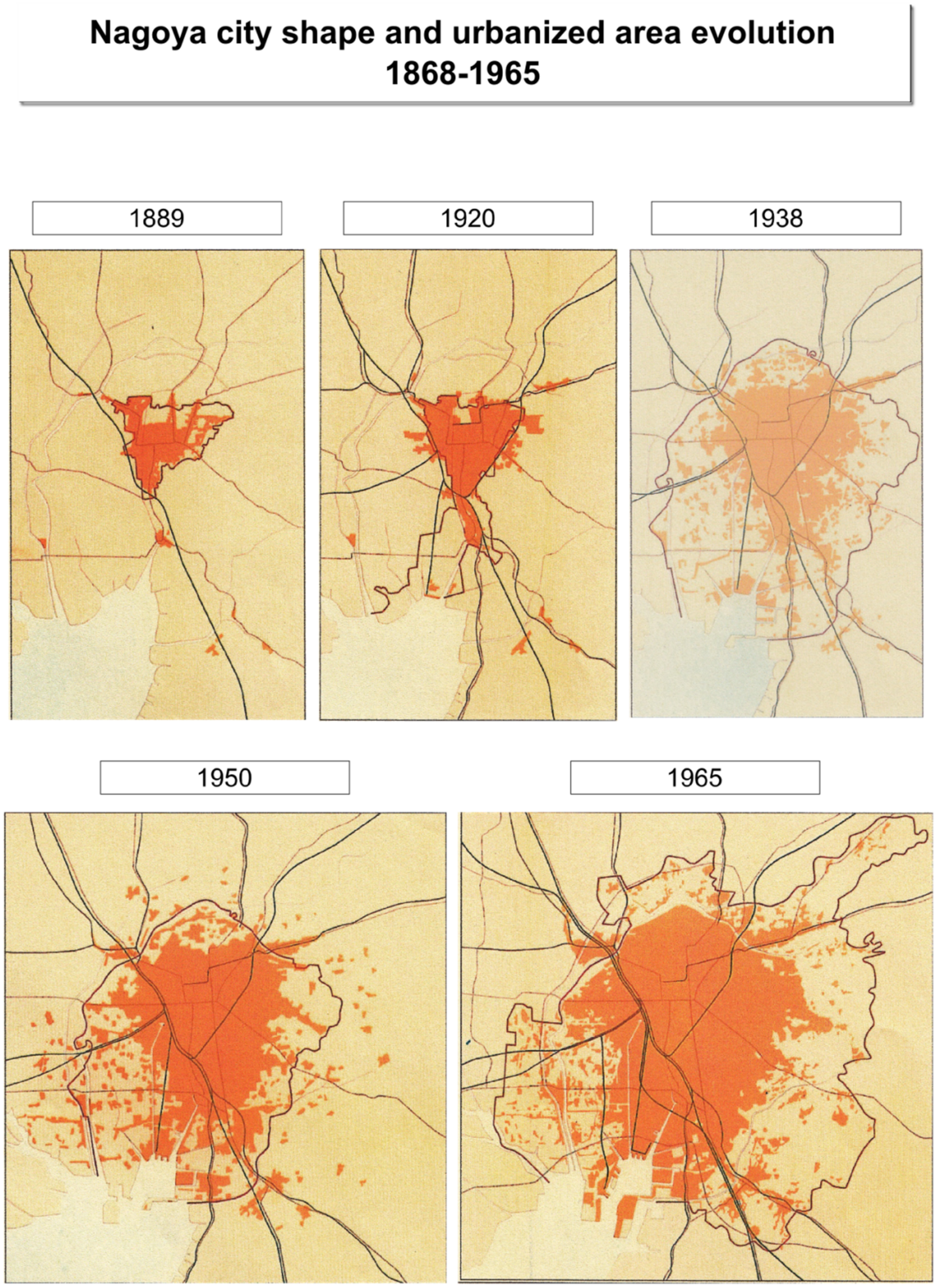


Figure 3-6 Nagoya-city evolution (source Nagoya-city website)

The figure 3-6 shows the rapid evolution of Nagoya-city, the expansion of the city concerns the city limits (annexation of neighboring towns and villages) as well as the urban development of industries, housings and transportation facilities. The more the city developed, the more it got close to the rivers. However in figure 3-6 and 3-7 it can be seen that the right bank of the Shonai River and of the Shin River were not urbanized in 1969.

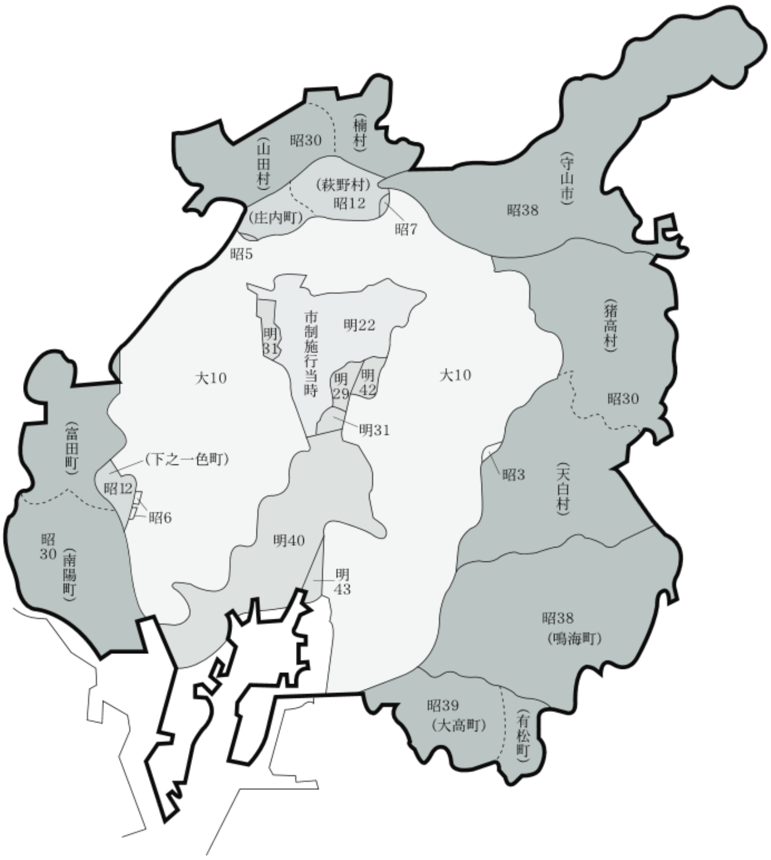


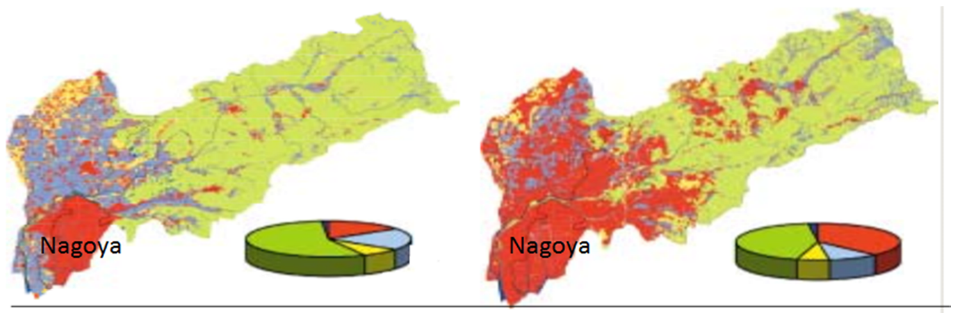
Figure 3-7 Nagoya-city growth and towns' annexation (source: Nagoya-city website)

The Shin River kept its derivation canal function until the 2000 Tokai flood, at which time it changed status. The communication canal between the Shonai and Shin rivers was transformed in a recreation park, the levees were elevated from both sides, and the Shin river gain a new and special status of "**particularly important urban river**" in 2006 (Nagoya mayor office website).

3.2.2.2 The Shonai river basin evolution 1945-2000

The development of Nagoya-city as an industrial capital and the 3rd city of Japan induced the development of the Shonai river-basin's towns and cities. A major change happened between 1945 and 2000, as the urban areas increased in the lower and middle reach of the river basin, reducing the absorbing capacities of the soil that the paddy field and part of the forest area could have. What was reduced most in the Shonai river basin were the paddy fields, which diminished by half. The mountainous areas didn't shrank as much but as is can be seen in figure (3-8), the middle part of river basin which was almost only paddy fields and mountainous areas in 1945 is highly urbanized in the lower parts of the valley, near the Shonai river.

The increased risk of runoff probability caused by urbanization is studied specifically in the Shonai river basin since the end of the 1990's.



	1945	2000
Mountains and forests	56%	44%
Water areas	1%	2%
Urban areas	15%	38%
(dry) fields	8%	6%
Rice paddies	20%	10%

Figure 3-8 Shonai river basin land-use changes (source: MLIT)

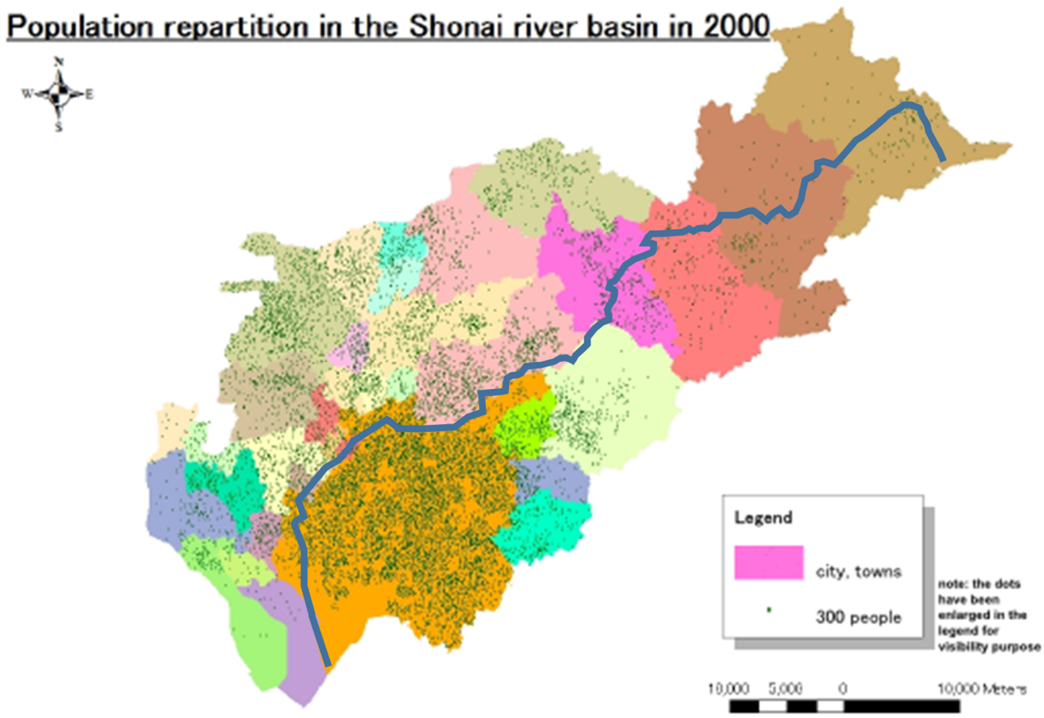


Figure 3-9 Population in 2000 in Shonai river-basin (source: 2000 Japanese census on Estat webiste, map creation ArcGIS M. Thomas)

3.2.2.3 Middle reach of the Shonai river basin situation (Taijmi area)

- Human occupation (population) evolution(seek statistics for population 1950-2000)
- Examples of the hazard maps in Tajimi

to summarize: **The Shonai river basin is a A class river basin managed by the National River Bureau. For a Japanese river basin, it is a small basin however it is at high risk of flooding because of the high urbanization since the 1950's. The Shonai river basin has mountainous characteristics (Shonai River and Ori River steep longitudinal profile in figure 3-3 and 3-4 p 65). The focus in flood prevention and disaster prevention can be linked to the Nagoya megacity development since the end of the 16th century and the latest attention on**

observatory settlements in the 1970's can be linked to the development of the river basin management as a whole after 1964 and the development of the middle reach urbanization between the 1970's and 2000's. The paddy fields and dry fields diminished importantly and the urbanization raised importantly raising therefore the risk of flooding by urban flood and the response time between the hazard occurrence (rain) and the flooding time.

3.2.3 The 2000 and 2011 floods, some raw data

3.2.3.1 Hazards at the origin of the disasters

The two events of 2000 and 2011 were caused by the same type of hazards and occurred in the same River Basin, which motivated greatly the choice of the Shonai River basin for the field study area. Some differences, like the highest intensity of the hazards are different though.

The figure 3-10 shows the weather maps for the events of the 11th September 2000 and the 20th September 2011. In both cases the weather conditions are considered very similar. A typhoon landing on the South east of the Kyushu Island encountered the autumnal precipitation front stagnating.

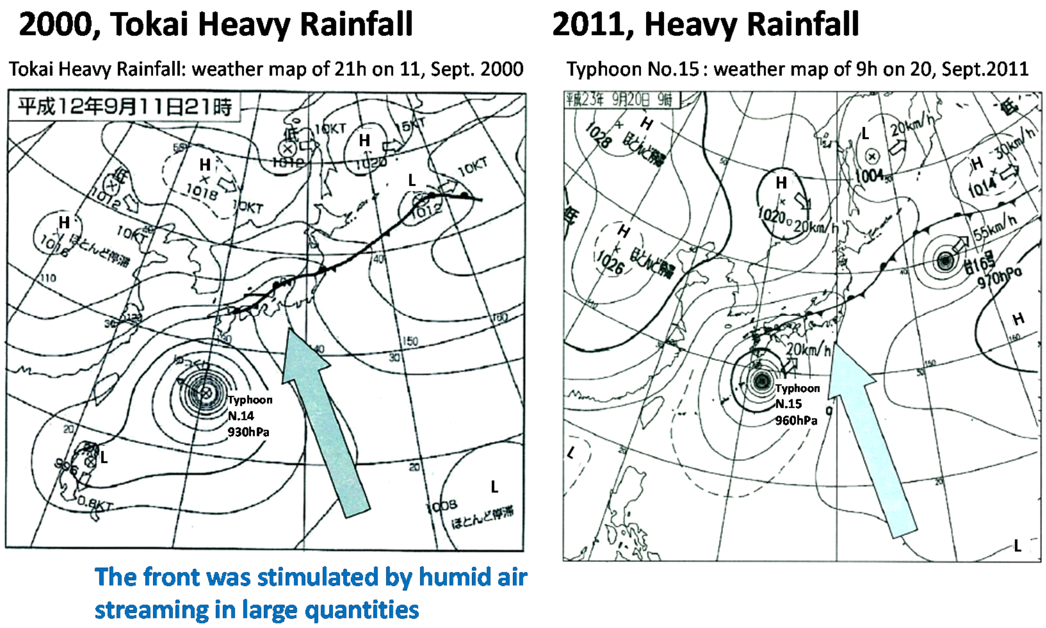


Figure 3-10 Weather maps for 2000 and 2011 of heavy rainfall (source JMA, in Thomas et al 2014)

Figure 3-11 and 3-12 show the rainfall precipitation per hour and distribution. The cumulated precipitation in both cases reached more than 450 mm (567 in Nagoya in 2000 and 477 in Shidami in 2011). The maximum of precipitation per hour was 93 mm/hour in 2000 in Nagoya and 64 mm in Shidami in 2011. The original hazards were therefore very similar in intensity (heavy rainfall of 2-3 days). The big difference lies in the area of the highest intensity.

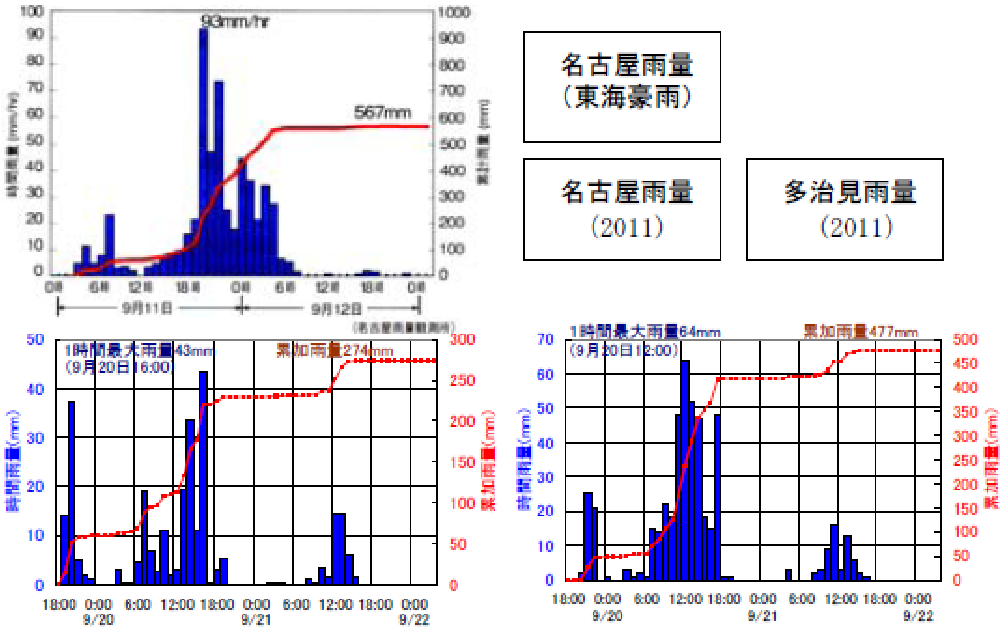


Figure 3-11 hyetographs for the Tokai rainfall event (top left) in Nagoya (lower reach), the 2011 event in Nagoya (bottom left), and the 2011 event in Tajimi (middle reach)

In 2000 the rainfall was the most intense in the lower reach, in Nagoya-city. **The degree of exposure was very high**.

In 2011 the rainfall was the most intense in the middle reach where the exposure degree wasn't as high as it was in 2000 in Nagoya (see figure 3-12 for the spatial distribution of accumulated rainfall).

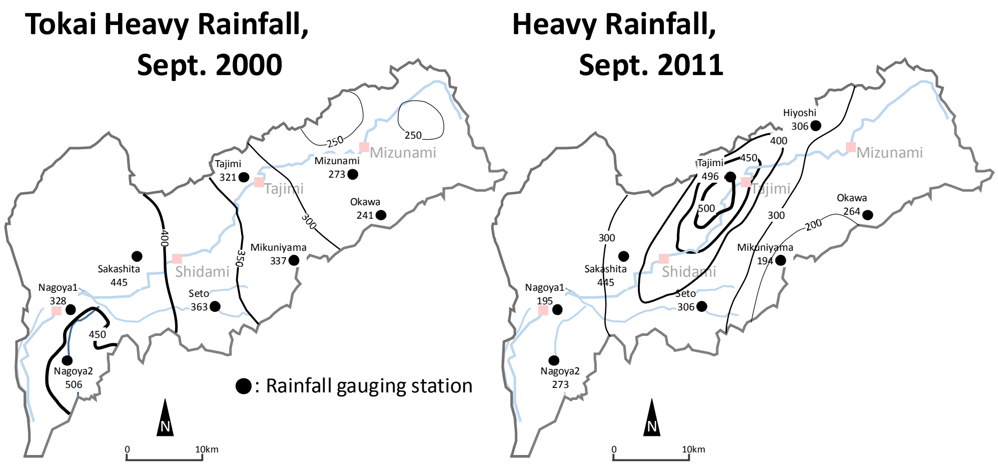


Figure 3-12 spatial distribution of accumulated rainfalls for 2000 and 2011 rainfalls.

The consequence of the precipitations on the river water level will be linked to structural enhancements and studied in the chapter 5 (pp 104-114).

3.2.3.2 structural measures ovewhelming causing flood disaster and areas flooded

In 2000 and in 2011 the hazards at the origin of the flood were of a similar nature. A typhoon occurrence concurred with the stagnation of an autumnal front, leading to heavy rainfall.

It caused in 2000 levees overflow in the Shonai, Shin and Tenpaku rivers, levee breaches in Nishi ward on the Shin River and urban flooding in the center of Nagoya. In 2011 the hazard was of a similar nature but occurred in the middle of the Shonai river basin. The areas flooded are very different as shown on figure 3-13 and 3-14. In Nagoya city, 37% of the total area was flooded in 2000, while in 2011 only small spots were flooded.

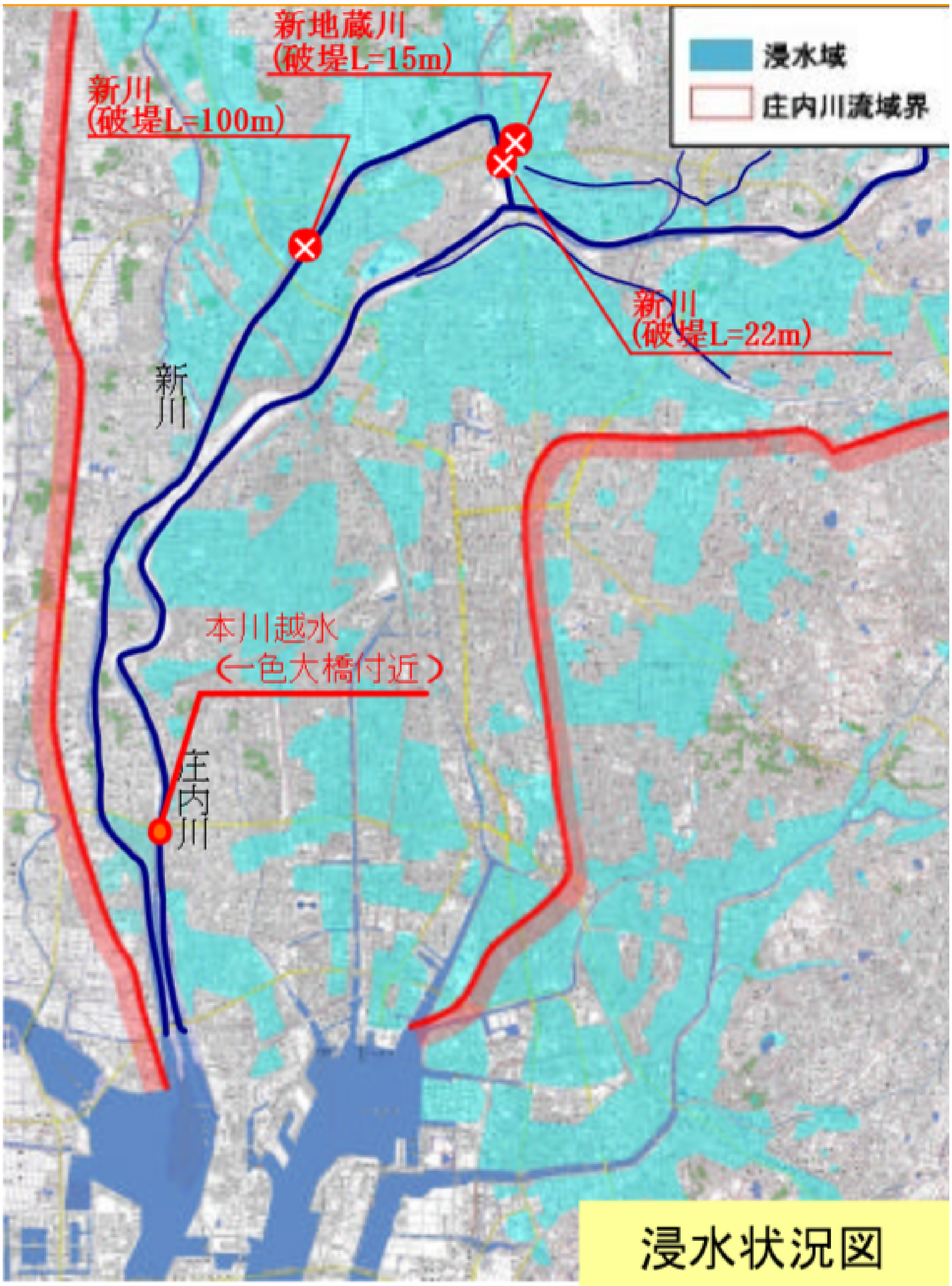


Figure 3-13 flooded areas during the Tokai flood for Nagoya city area (MLITT, 2005)

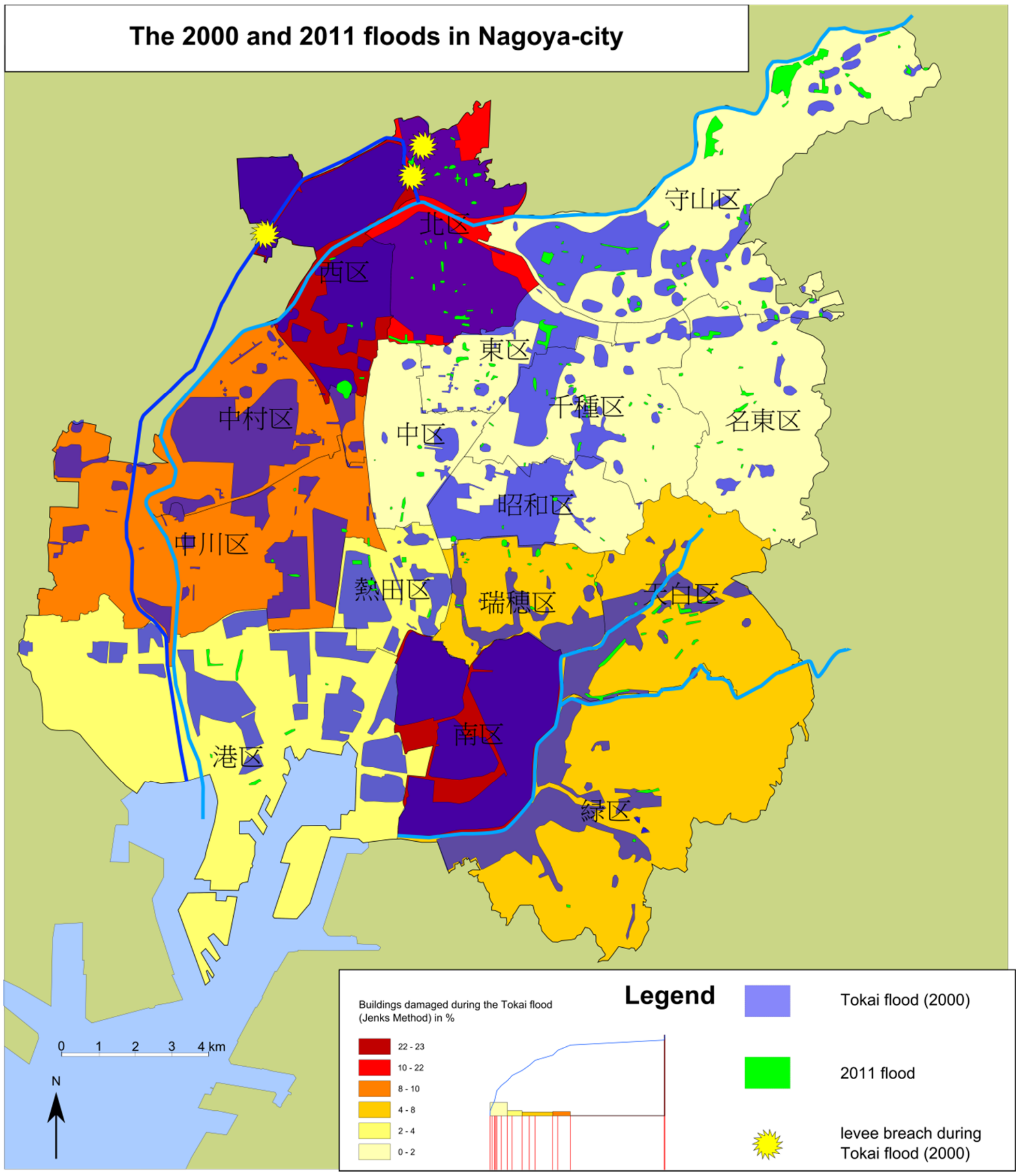


Figure 3-14 the 2000 and 2011 floods in Nagoya-city (M. Thomas, 2012, Inkscape and Philcarto)

3.2.3.3 Buildings damages and victims of the floods

In 2000 the Tokai flood caused 850 billions of yen of damages, 27,606 buildings were flooded above ground floor level and 41,154 buildings were flooded below ground floor level. The flood caused 10 deaths in the total lower river basin area and 4 deaths in Nagoya city. 155 people were injured in the total lower river basin area and 37 were injured in Nagoya-city (see figure 3-19 p. 81).

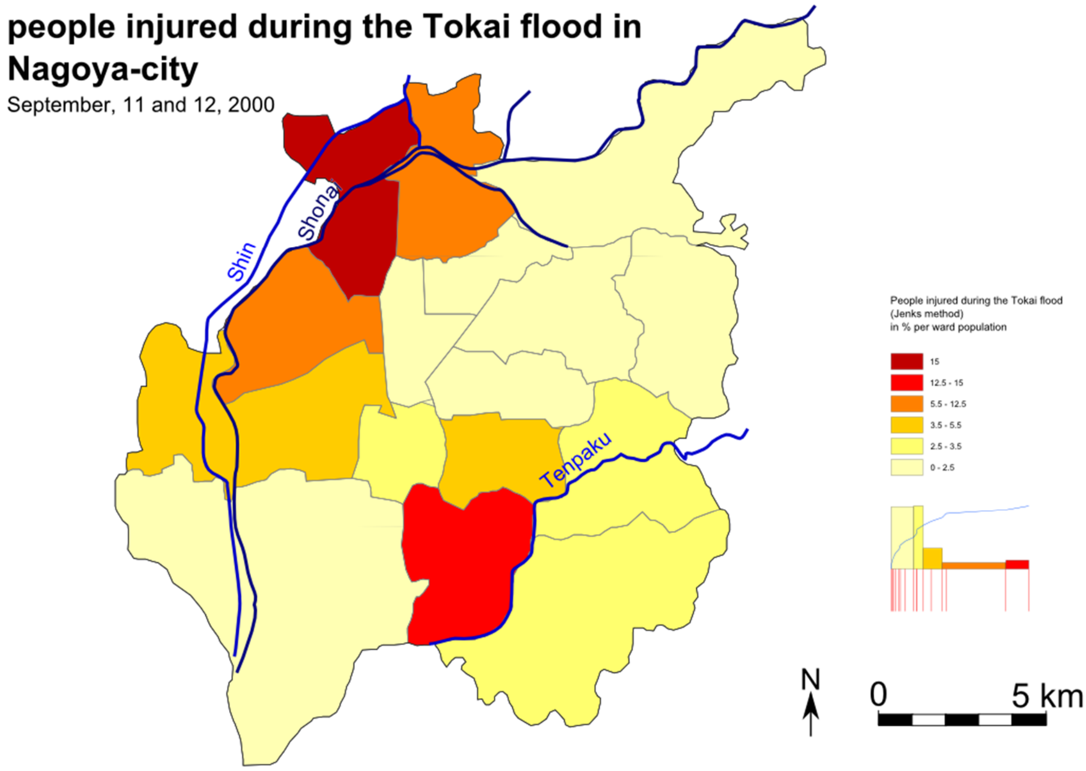


Figure 3-15 People injured during the Tokai flood in Nagoya-city (M. Thomas Philcarto and Inkscape, 2011)

Figures 3-15 and 3-16 illustrate the buildings flooded and people inured in Nagoya-city in 2000 Tokai flood. Because this study was concentrated on the Shonai river basin changes in disaster management, therefore the causes and consequences of the flooding on the Tenpaku River were not studied. However, there is a clear relationship between the levees breaches (figure 3-14 p. 77) in Nishi ward from the Shin River and the buildings damaged and people injured in the western part of Nagoya-city. There is therefore a clear relationship between the structural exposure and the social exposure to flood risk when the evacuation conditions are difficult.

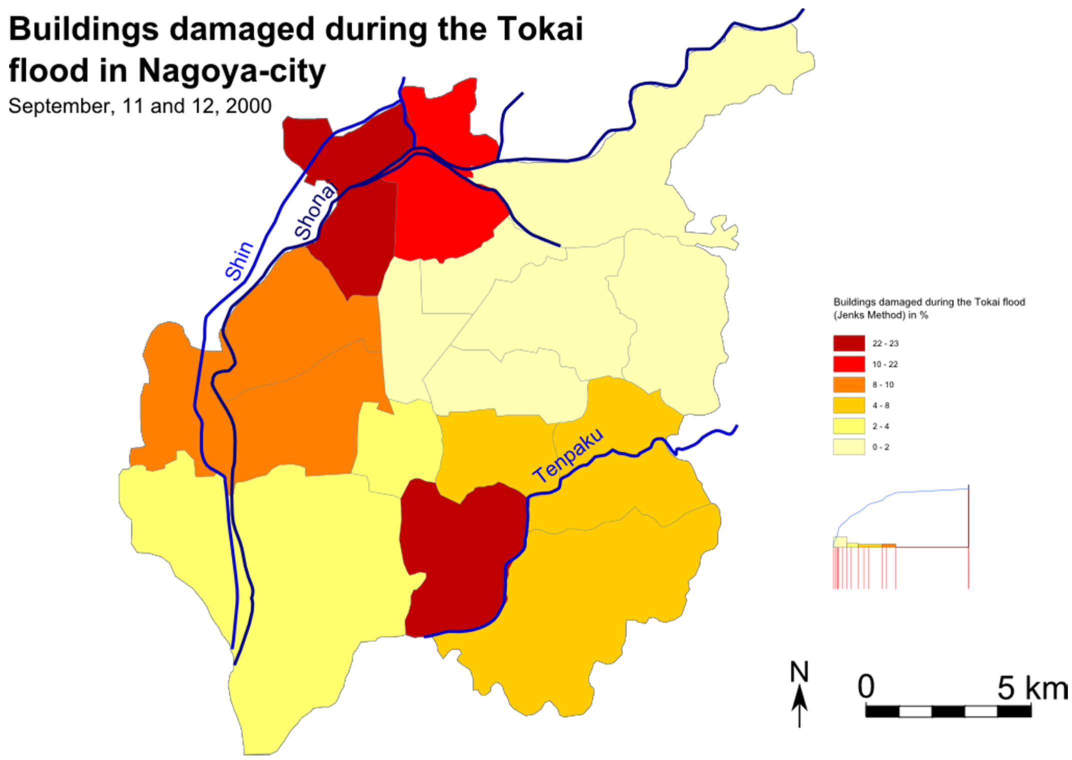


Figure 3-16 Buildings damages during the Tokai flood repartition by wards in Nagoya city (M. Thomas, Philcarto and Inkscape, 2011)

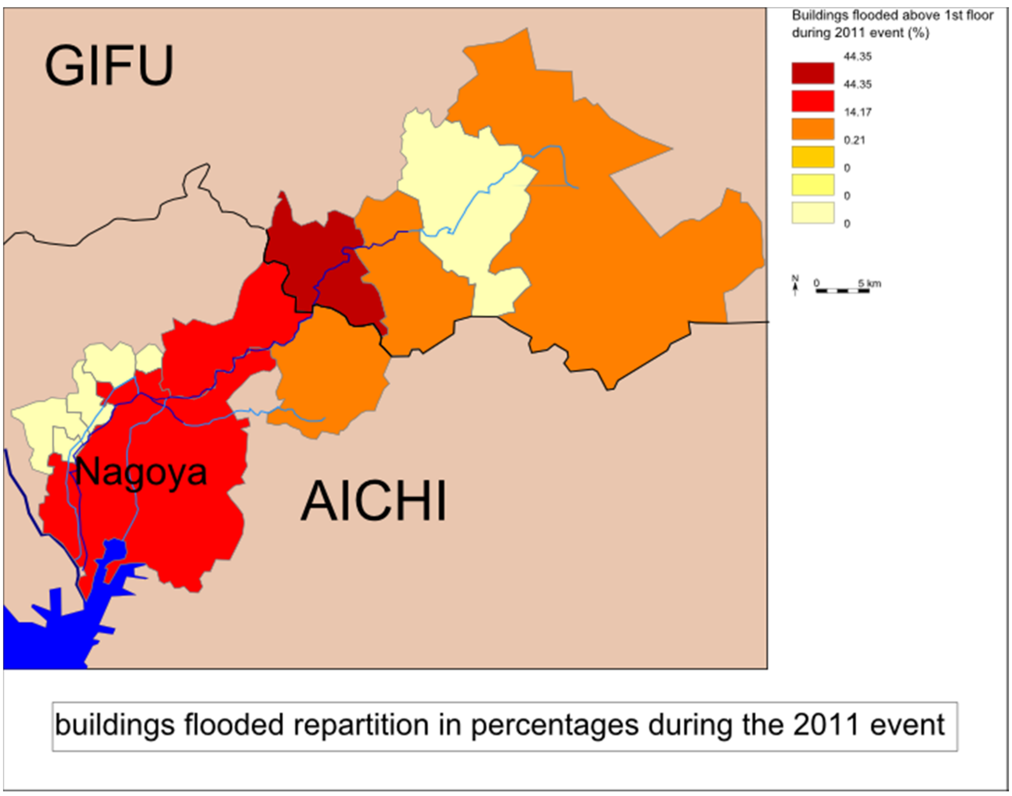


Figure 3-17 buildings flooded during the 2011 event (M. Thomas, 2012, Philcarto and Inkscape)

In 2011 for the total river basin there were 3 deaths, 4 injured persons, 335 buildings flooded below ground floor level and 69 buildings flooded above ground floor level (see figure 3-19 p. 81). The figures 3-17 and 3-18 show that the damaged area was situated in the middle part of the river basin.

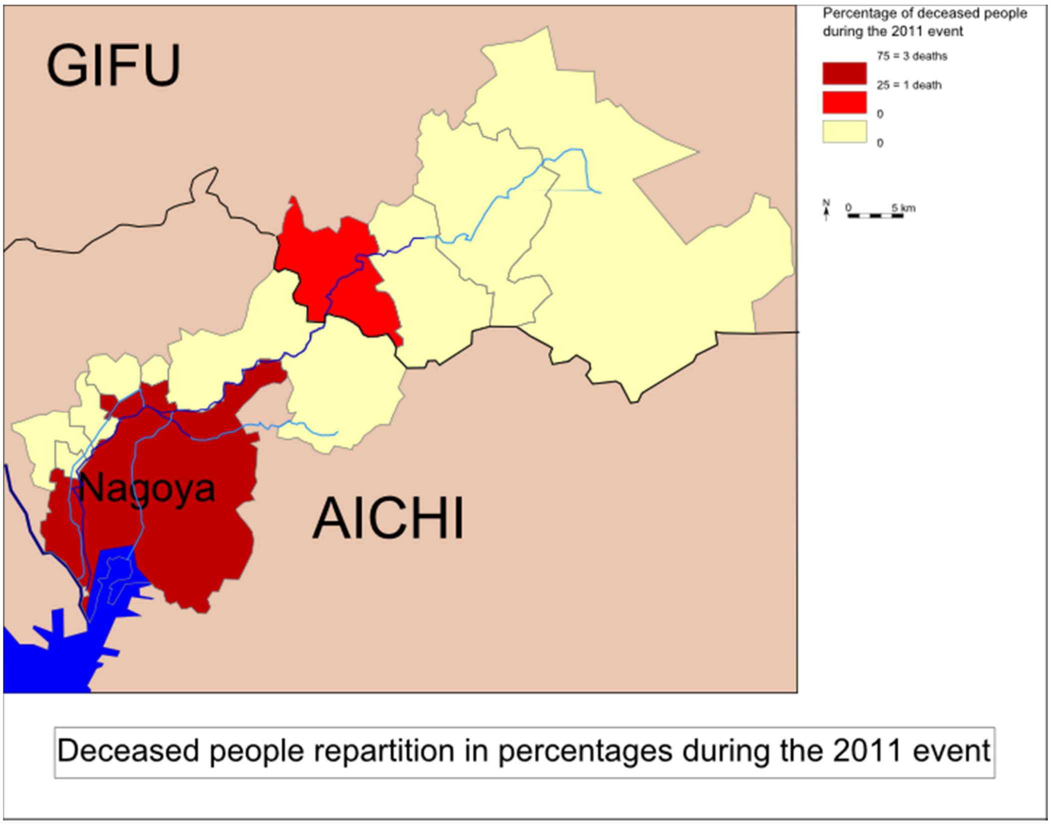


Figure 3-18 Deceased people (3 in Nagoya, 1 in Tajimi) during the 2011 flood event (M. Thomas Philcarto and Inkscape, 2012)

Damages and casualties 2000-2011			
	Tokai flood river basin	Tokai flood Nagoya	2011 flood river basin
deaths	10	4	3
injured	155	47	4
flooded above ground floor	27,606	9,818	69
flooded below ground floor	41,154	21,852	335

Figure 3-19 comparison of the damages due to the 2000 Tokai flood in the whole river basin and Nagoya-city and the 2011 flood event (adapted from Nagoya-city Mayor Office information center data)

Figure 3-19 illustrates the differences of damages and casualties in the Shonai river basin and in Nagoya city in 2000 and 2011.

- The blue circle highlights the death toll for the two disasters, for the Shonai river basin and Nagoya city in 2000 and for the whole river basin in 2011. The deaths toll is very small compared to the population exposed during both floods. The reduction of the exposure between 2000 and 2011 did not seem to play a particular role in the deaths numbers.
- The red circle highlight the very urban nature of the Tokai flood, with Nagoya-city consisting of 30% of the buildings flooded above ground flood and 35% of people injured, and 53% of buildings flooded below ground floor.

The yellow circle highlights the reduction of structural and human exposure in 2011, the injured people were reduced in 2011 by 97.5% compared to 2000, and the buildings flooded were reduced by 99%.

3.2.3.4 Evacuation numbers evolution between 2000 and 2011

In 2000 32,155 people evacuated during the Tokai flood. It has been evaluated that 182,309 people should have evacuated in order not to be flooded, therefore 8.43% of the population evacuated.

In 2011, 1,000,000 people were recommended to evacuate, but 4,749 people actually evacuated, therefore 0.47% of the population that received information concerning recommended evacuation evacuated. The figure 3-20 shows the percentage of people willingly evacuating after receiving information concerning evacuation recommendation. The data for a ward scale in Nagoya city was not available, but Ama city stands out, in the fact that more than 50 persons willingly evacuated for a 15 persons evacuation recommendation.

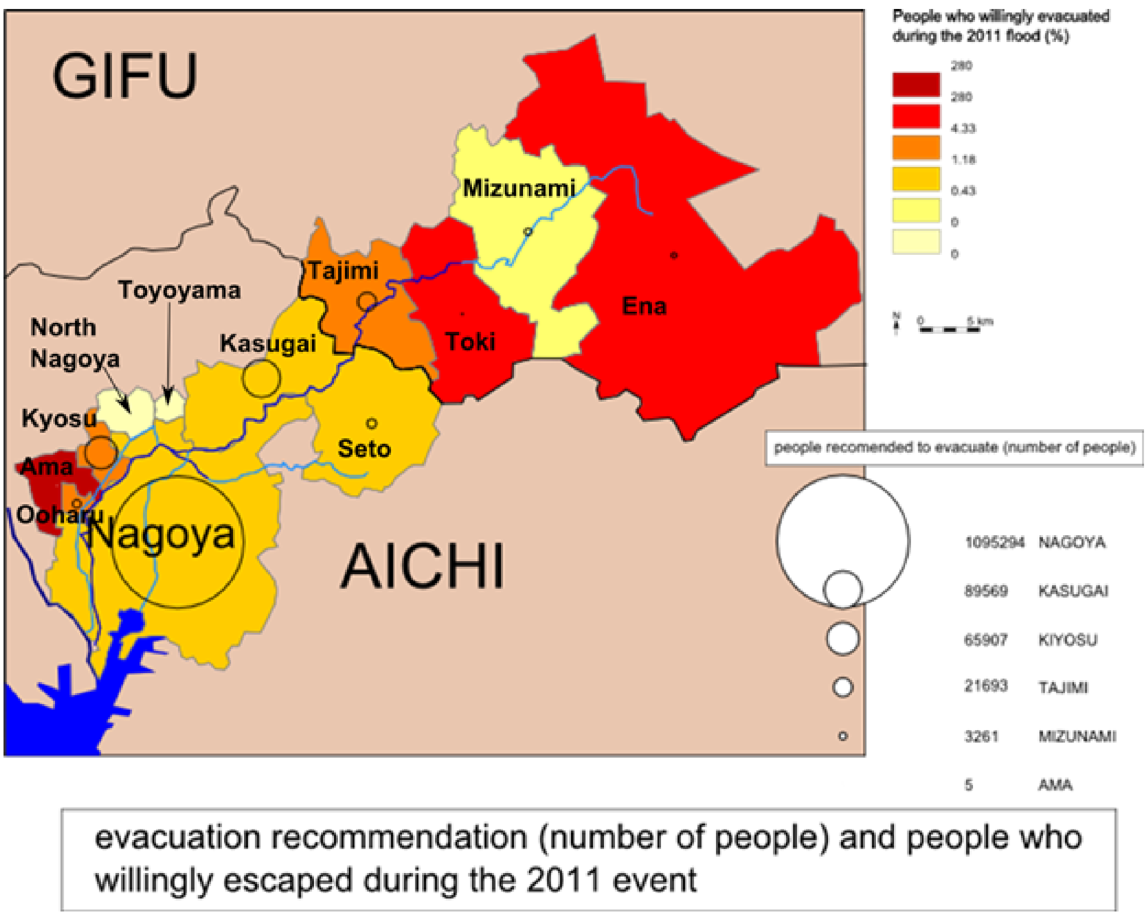


Figure 3-20 evacuation recommendation and people willingly escaping at river basin scale in 2011 (M. Thomas, Philcarto and Inkscape, 2012)

To summarize: **the hazards at the origin of the disasters are of very similar nature (typhoon and autumnal rainfall front stagnation in the Shonai river basin); while the hazards are of a similar nature, the areas where the rainfall was concentrated were very different. The 2000 flood was concentrated in the heavily urbanized lower reach while the 2011 flood event rainfall concentration occurred in the middle reach. In 2000 the causes for flooding were levees overwhelming the structural measures (Shonai River, Shin River, Tenpaku River), levees breaches on the Shin River and urban flooding in the center of Nagoya. The Tokai flood of 2000 was considered a disaster but the 2011 flood was considered a minor flood event. The damages and people injured diminished greatly between 2000 and 2011 however the death toll, although small was not considerably reduced. An apparent correlation between the reduction of structural and human exposure for buildings flooded and people injured seems to have been noticed, but there is no Relationship between the structural exposure reduction and the death toll.**

3.3 Applied methodology

A qualitative research was applied for the interviews in order to setup vulnerability and resilience factors for adaptation in a first time. Then was built an adaptation model based on the theoretical research and on the factors considered pertinent during the interviews in order to assess changes, lack of changes, and reasons explaining the potential lack of changes, especially in the response to evacuation. From the vulnerability and resilience factors identification, a small-scale GIS database of the building and hazard characteristics for 3 city-blocks in Nishi ward in Nagoya-city was built. Finally the response to qualitative interviews of the population members concerning their experience on flood disaster in order to setup resilience and vulnerability factors for decision making in personal structural enhancements and evacuation decision was analyzed in more details.

3.3.1 Interviews to the population and disaster prevention managers in order to setup adaptation factors

The interviews were conducted between the 01/04/2012 and the 01/03/2013 for 32 risk managers, actors and experts, for Nagoya-city and Kiyosu and 13 individuals either living in risky areas of with a past experience of disaster (primarily Tokai flood in 2000). During the months of September and October 2014, a few last interviews to one member of a local NPO (RSY Rescue Stockyard in Nagoya-city) and to 5 residents in Kiyosu-city having experienced the Tokai flood in 2000 were conducted[12]. For the interviews, three main topics were separated as shown in figure 3-20 (p 84): the original vulnerability factors (what hardware and software measure were available during Tokai flood, and for the population how was experienced the evacuation and in general, the Tokai flood or any disaster they lived). Then a focus was put on the adaptation through changes after the Tokai flood. Finally questions about the disaster prevention communication between all actors from the National state to the individual were asked.

Talking about past disasters and relating one's experience is not necessarily a subject people want to talk about. The interviews to people with experience of past flood (Tokai flood in 2000) was considered interesting on a qualitative viewpoint, as it revealed some vulnerability (unwillingness to evacuate and psychological refusal to acknowledge flood risk at a certain level) and resilience factors (high knowledge of hazards, ecavuation places, high social capital exploitation), however, the answers given by the interviewees were put in regard to the Aichi 2011 survey about evacuation in order to confirm trends discovered during interviews or eliminate them.

[12] The complete list of actors met and the date they were met as well as the questionnaire on which the interview was based is shown in appendix

		EXPLORATORY SEMI-CONDUCTIVE INTERVIEWS (01-04-2012 – 14-10-2012)	
		to disaster prevention managers and experts (32)	*to population (17)*
Effective-ness efficiency	**Original vulnerability factors**	software measures setup	last emergency evacuation lived
		hardware measures setup	willingness to evacuate in the future
			risk knowledge
	adaptive capacity and resilience factors	changes in the flood risk protection	enhancements to housing after 2000
		principal changes after 2000	emergency supplies
		main objectives of the flood risk management today	increase of the interest in risk management willingness to know more about floods
	risk governance	actors in touch with	access to different data and understanding data
		actors of the risk management communication	understanding communicated data
		personal goals and their integration to the risk management system's understanding	

Figure 3-21 framework for semi conductive interviews disaster prevention managers and experts, and population (adapted from Thomas and Tsujimoto, 2014)

3.3.2 From theoretical readings, official documents, and interviews, conceptual adaptation model construction

From the theoretical research exploitation in trends and interesting points, an adaptation model based on the current orientation of research on disasters and climate change related to disasters was built. The adaptation model vulnerability and resilience factors were identified for the field study area from interviews, and official documents gathered primarily in Nagoya city (disaster prevention office and the information center of Nagoya city) for the software and the data shared by the Shonai River Bureau for the structural measures enhancements.

3.3.3 Buildings characteristics listing and map building for 3 city-blocks on GIS

The hazard map of Nagoya city is the one the GIS evacuation response analysis was based on. The expected evacuation response to floods being a component of the maximum water level likely to be expected in case of a disaster should occurred, it is linked to the type of building the population lives in and an évaluation of number of people likely to live in these buildings. From November to December 2013 a total of 961 building were referenced in three city-blocks of Nishi ward in Nagoya-city. Nishi ward was chosen because a comparison between three flood events-type (flood by the Shin river, flood by the Shonai river and urban flood) could be put on GIS. The analysis was focused on Komoharachou, Ashiharachou and Nakaotaisanchoume. The buildings characteristics understand

- The number of floors
- The expected inhabitants living in the buildings
- The type of building
- The individual structural enhancements (elevated house or not)

The buildings were divided in housings and non-housings buildings, and non housing buildings were not taken into account. If buildings had double purposes (small industry and household), then it will be considered as household. Then the housing buildings were classified in 3 different types (one floor, two floors and more than 2 floors types of housings) with 3 different under-types (no elevation from ground floor noticeable or below 1,5m; more than 1,5 m elevation but lower than 1 floor, and 1 floor elevation).

The mapping and location of housings and industrial buildings on GIS was done through the GIS Arcgis tool and the use of Google Earth to imput an accurate geolocalisation of the buildings on GIS. The advantage of the use of Google Earth was triple:

- the latitudinal and longitudinal information reduce the risk of inaccurate geolocalization
- the use of google street view allowed a double-check of note prise during the study field by the author and reduced the risk of human error
- The google street view tool dating from 2012 the comparison bwetween the field in 2014 and the google street view images gave good idea of latest trends in newly constructed building types.

3.3.4 Mapping evacuation expected from hazard map information

Finally, a mapping of the reaction expected evacuation from the hazard map information was undertook. The hazard map information and the mapping of buildings done were compared to the qualitative interviews done between 2013 and 2014.

Building class (number of floors, evaluated number of apartments, function)	Housing enhancement	Type of flood to expect in Nishi area

C (1 floor)	1) no enhancement	Urban-type flood (o-1m)
B (2 floors)	2) 1,5 meter enhancement	Flood from Shin river (0-2m)
A (3 and more floors)	3) 1st floor enhancement	Flood from Shonai river (3-5m)
NO HOUSING (no photo)		

Figure 3-22 information type gathered by field research and hazard map information

Figure 3-23 (left) type A building protection type 3 (right) type C building no protection (type 1)

Figure 3-24 inherent problem to protection type 2 (0-1,5m) done on type B buildings

When it comes to housing individual enhancements the problem was the evaluation of 0-1,5m enhacements for individual 2 floors housings. These types of enhancements are mostly used for 2 floors types of housings. The elevation varies from small enhancements to 1,5 meters enhancements (photo on the right in figure 3-24). Because the evaluation of the exact enhancement was not calculable (on the left photo in figure 3-24 it is suppose to assume that the entore first floor is not a living area), it was decided that only enhancements like the one on the right photo on figure 3-24 would be taken into account based on the number of external stairs (more than 6 steps of stairs).

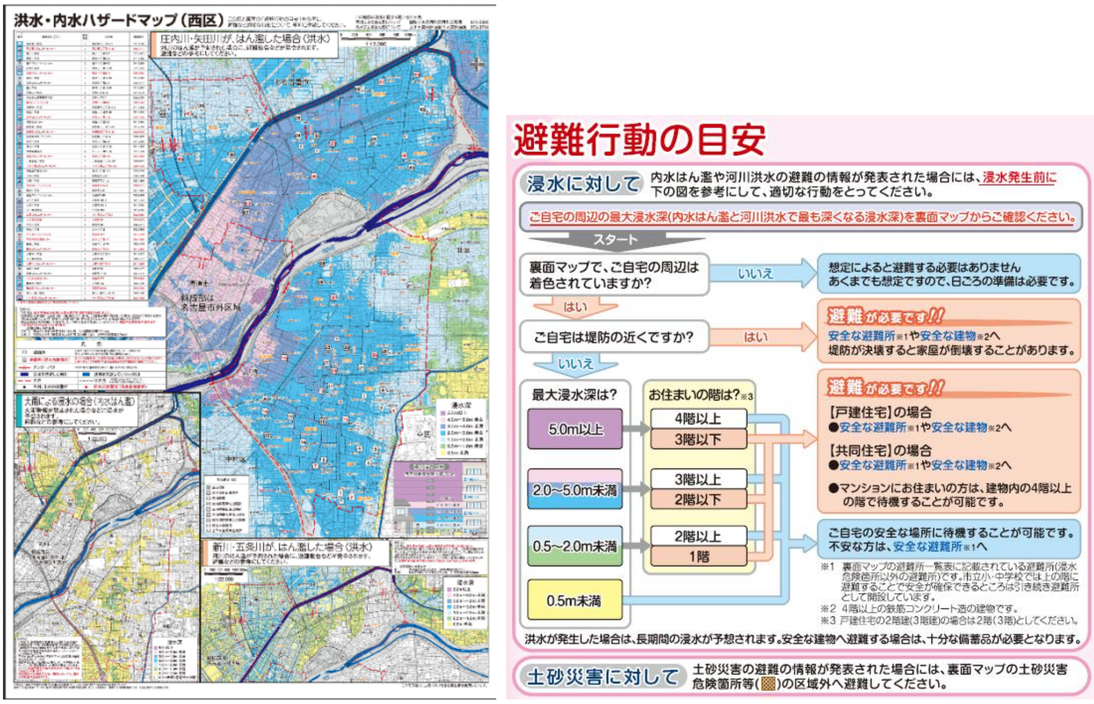


Figure 3-25 left: illustration of the hazard map (2010) of Nishi area; right: water level to expect, and information contained to evacuate in case of flood according to the building people live in

3.3.5 Evacuation and individual structural enhancement evaluated from qualitative responses patterns during interviews

The interviews to population are too few to be extrapolated quantitatively, but a qualitative analysis of the decision-making threshold for the population was done during the interviews (when they evacuated, when would they evacuate and why), and put in regards to the national and local structural and nonstructural enhancements for the 2000-2011 period.

To summarize: **the applied methodology aims to link structural enhancements to human perception and decision-making process in case of flood disaster. In order to link the two components of the risk (structural measures and non structural measures), firstly interviews to the population and the disaster prevention managers was undertook to setup the adaptation (vulnerability and resilience) factors. The components of the interviews were the originila**

vulnerability factors perceived and assessed, the resilience factors perceived and assessed and the information communication and actors system hierarchy. From theoretical readings an adaptation model was built. Put in regard to official documents from Nagoya-city Mayor Office, the Shonai river basin bureau and Aichi prefecture office, the responses to the interviews lead to classification of vulnerability and resilience factors identification to input in the adaptation model. Finally in order to compare the expected and actual evacuation process and protection measures taken against flood risks, a mapping of the housings and the expected evacuation from the type of housings following the hazard map information was done. This mapping was put in regards to latest interviews to people having experienced the Tokai flood disaster in Kiyosu-city in 2011.

4 CHAPTER 4

Proposal for the adaptation model

4.1 Adaptation definition, origins and uses: for an utilization of the adaptation model similar to the 1978 integrated coping model of Burton et al

4.1.1 Original coping model's advantages

The model proposed here comes from the integrated coping capacities model of Burton et al (1978) shown p 91 in figure 4-1. We chose this model as an inspiration in order to:

- **Highlight the positive and/or negative effects of both structural and nonstructural measures**
- **Build a model that can be assimilated to systemic research and take into account research done in analytical and applied research**

The modification made depend on the "system" propriety. Nagoya city being a megacity, the "change use" and "change location" factors seemed hardly probable. As for the "adaptation" model, it is preferred to coping capacities for the only reason that the adaptation concept has a focus on change.

Contrary to the model of Burton et al (1978), in the following adaptation model there is no difference made between "adjustment" and "adaptation". The postulate is that adpatation is a concept including the adjustments to flood risk, and is both purposeful and incidental process.

Concerning the thresholds, the figure 4-1 shows three levels of thresholds (awareness, action and intolerance). The postulate of this research is that the intolerance threshold is not accurate in urban environment.

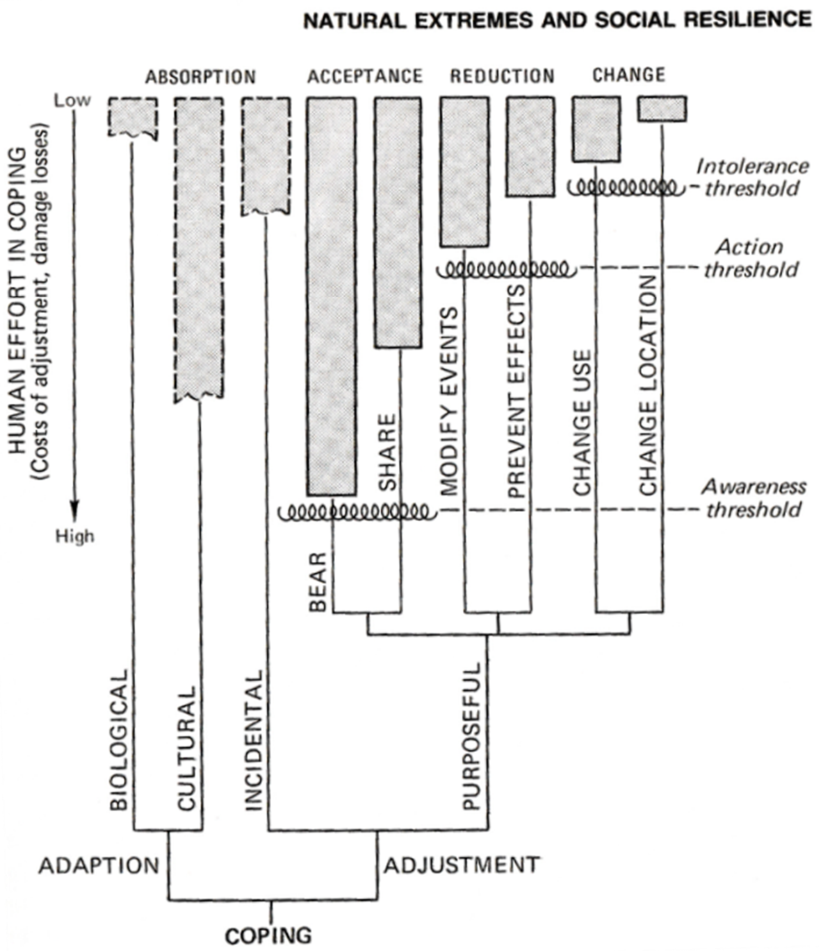


Figure 4-1 Coping capacities model by Burton et al (1978)

4.1.2 "Adaptation" definition for our study and modification to the original model

The "**<u>adaptation</u>**" will be defined as: "**the ability of society to learn and modify the components of their system in order to mitigate, prepare against, cope and recover from a disaster**". This definition is inspired of the definition of adaptive capacity of Turner et al (2003) and Gunderson and Holling (2002) where adaptive capacity is a key component of the vulnerability concept and is defined as "the flexibility of ecosystems and the ability of social systems to learn in response to disturbances".

A particular attention will be given to "thresholds" leading to change. In Burton et al model, "changes" occur once the intolerance threshold is reached. In their model, "change" could correspond (change of use or of location) to a "regime shift" of the system function (see figure 2) following the impact of a disaster. If the function of the system changes, the system is therefore not resilient anymore. The "change" of Burton et al is a radical change.

Figure 4-2 postulates that the system will have 3 kinds of response:

- resistance (effectiveness of structural measures in this case), no need for response
- "response and recovery" past a certain point the hazard overcomes the structural and nonstructural measures setup. This is a first threshold.

- If the response to flood hazard is not enough, the last threshold is the point of no recovery

The thresholds in figure 4-2 correspond therefore to the evaluation of the hazard impact for one disaster event. It aims to illustrate the resilience concept in case of a disturbance (hazard) occurrence of a certain magnitude.

The purpose of this research is to look for thresholds for change or reasons why the thresholds are not reached for actors in the Shonai River basin and the consequences the thresholds reaching will lead to.

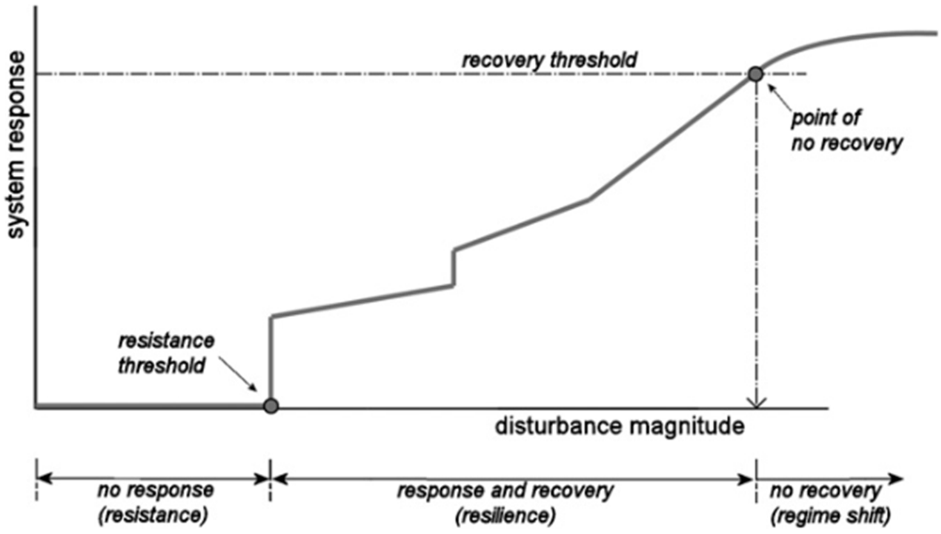


Figure 4-2 theoretic response curve, showing system response as a function of disturbance magnitude, indicating resistance, resilience, the point of regime shift, and the recovery threshold (Mens. 2011)

To summarize: **This adaptation model aims to assess changes increasing resilience and reducing vulnerability. It differs from Burton and Mens models by: focusing on what Burton et al call "adjustments", and ignoring the "intolerance" part of the coping model of Burton et al.; focusing on thresholds leading to change instead of thresholds for action during a disturbance; seeking thresholds that cause changes for 4 times of the disaster (mitigation, preparedness, response and recovery); assess the impacts of these changes.**

4.2 Integration of resilience and vulnerability concepts in our adaptation model and their definition

The "adaptation" concept used in this research being derived from climate change studies (Smit and Wandel, 2006, Folke 2002, Folke 2006, Adger 2005), the vulnerability concept in climate change was also briefly studied, and the main difference between disaster studies vulnerability and climate change vulnerability is **a stress put into the potential of change that the vulnerability concept supports**. Gallopin (2006) prefers the vulnerability concept to the resilience one in the sense that for him the vulnerability concept calls for change whereas the resilience concept doesn't[13]. The theoretical disagreement on the potentiality for the resilience concept to be a powerful concept for change or not depends on the threshold under which a whole system is considered to be able to change in its functions (Mens 2011). Most of the time, because a megacity is very vulnerable and very resilient at the same time, the resilience concept calls for changes inside a system, which means that a city, as long as it keeps it (economic, cultural, politic) functions, can change and will be called "resilient" because the city's functions don't change.

In this model:

- **Vulnerability** is defined as: *all the factors that will reduce the ability of a system (here the megacity) to change and adapt to flood risk, and therefore to mitigate, prepare, cope with and recover from a disaster. These factors can be socio-economic, cultural, structural, ...*
- **Resilience** is defined as "the flip-side of vulnerability", therefore: *all the factors that will enhance to ability of a system to change and adapt to flood risk, and therefore to mitigate, prepare, cope with and recover from a disaster. These factors can be socio-economic, cultural, structural, ...*

To summarize: whether "vulnerability" or "resilience" are concepts that can be used to assess change is difficult to assess because the conceptualization of vulnerability and resilience as concepts for change or concepts for stability differs from authors to authors. Vulnerability can be considered as a concept useful to study change because assessing vulnerability leads to setting up improvements. Resilience has evolved in climate change studies into a concept used to assess future changes

13 In the meaning of Folke (2002): a resilient system will have troubles to change because the resilient system is a system equipped to face one type of disturbance relatively well-known or in the meaning of "engineering resilience" where resilience is "returning to a former state"

with adaptive capacity, learning and so on. In this study, resilience and vulnerability concepts will be considered as concepts able to lead to change through their definitions.

4.3 Long-term goals in "risk governance", "effectiveness" and "efficiency" through the adaptation model

(Risk) governance, effectiveness and efficiency concept are originally concept used in climate change studies. They have problems in terms of "portmanteau words" that are similar to the resilience concept (they are rarely defined, but at the same time they are goals to achieve for the future and are very much used in scientific research and nonscientific literature, same thing could be said about "sustainable development" concept) . However, we will consider that in a highly complex system like the city and the very urbanized river basin that is the Shonai river basin, and with hazards very quick to happen and transform into disasters, it is **necessary to try and build the best communication between the different actors of the disaster prevention, and the most adequate (efficient and effective) management methods**.

Building **risk governance** is defined here as: "*collecting, analyzing and communicating relevant risk information (through a complex web of actors, rules, conventions, processes and mechanisms), taking risk management decisions at the right time, and for those information and decisions to be understood by the public concerned* (Thomas and Tsujimoto, 2014 inspired by Renn, 2008).

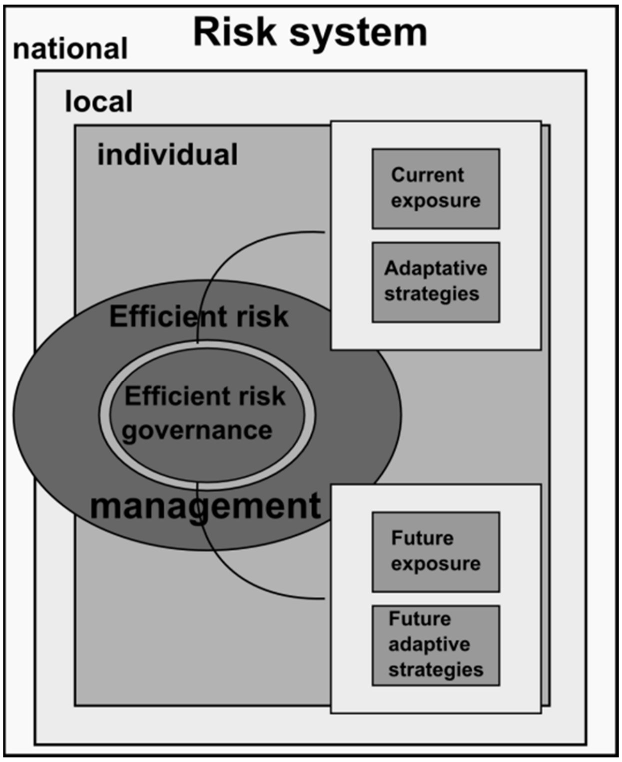


Figure 4-3 adaptation model in the more global point of view of risk governance and efficiency (Thomas and Tsujimoto 2014 inspired by Smit 2006)

Figure 4-3 illustrates the risk governance to achieve. The aim of a good risk governance is to assess current exposure and current adaptive strategies at hand by a good connection and communication between the actors of the risk system (national, local and individual level), through an efficient risk governance the efficiency of the risk management could be theoretically reached and assess better future exposure reduction and adaptive strategies.

To achieve risk governance a disaster prevention that is both effective (respond the in the fastest way possible to a danger with immediate results) and efficient (respond to the danger at a middle or long-term vision, by trying to achieve durability in disaster prevention) is needed. Therefore the figure 4-3 integrates the adaptation model at a wider scale. In the methodology setup one of the goals was to take into account both effective and efficient ways of disaster prevention.

To summarize: **The "risk governance" concept has been included to the**

methodology in order to concentrate part of the research on the communication between actors, the reception of the information, the impact information can have on thresholds reaching or not. "risk governance" concept can also lead to the differentiation between "effectiveness" in risk management and "efficiency" in risk management. In order to assess changes and adaptation in risk management, both long term resilience increase (efficiency) and short term resilience increase (effectiveness) has to be studied.

4.4 Defining times of the disaster to analyze changes based on the Japanese disaster prevention model (MLITT)

4.4.1 General adaptation model and vulnerability/resilience factors identified

The figures 4-4 and 4-5 are inspired by the times of the disaster (before, during, after) by Schelfaut et al (2011) and the Japanese disaster prevention concept (chapter 2, figure 2-6, p 38). Two conceptual models are built for two different types of events.

The **mitigation** is defined as: *all structural enhancements (national, local, individual) aiming at reducing the exposure to flood risk after a past disaster and before the next hazard.*

The **preparedness** is defined as: *all nonstructural measures (national, local, individual) aiming at reducing the exposure to flood risk after a past disaster and before the next hazard.*

The **response** is defined as: *all structural and nonstructural measures taken during the occurrence of a hazard. If the hazard exceeds the measures taken during the mitigation and preparedness time, the response time will correspond to the time of the disaster.*

The **recovery** is the *time it takes to "return to normal life" after the occurrence of a disaster.*

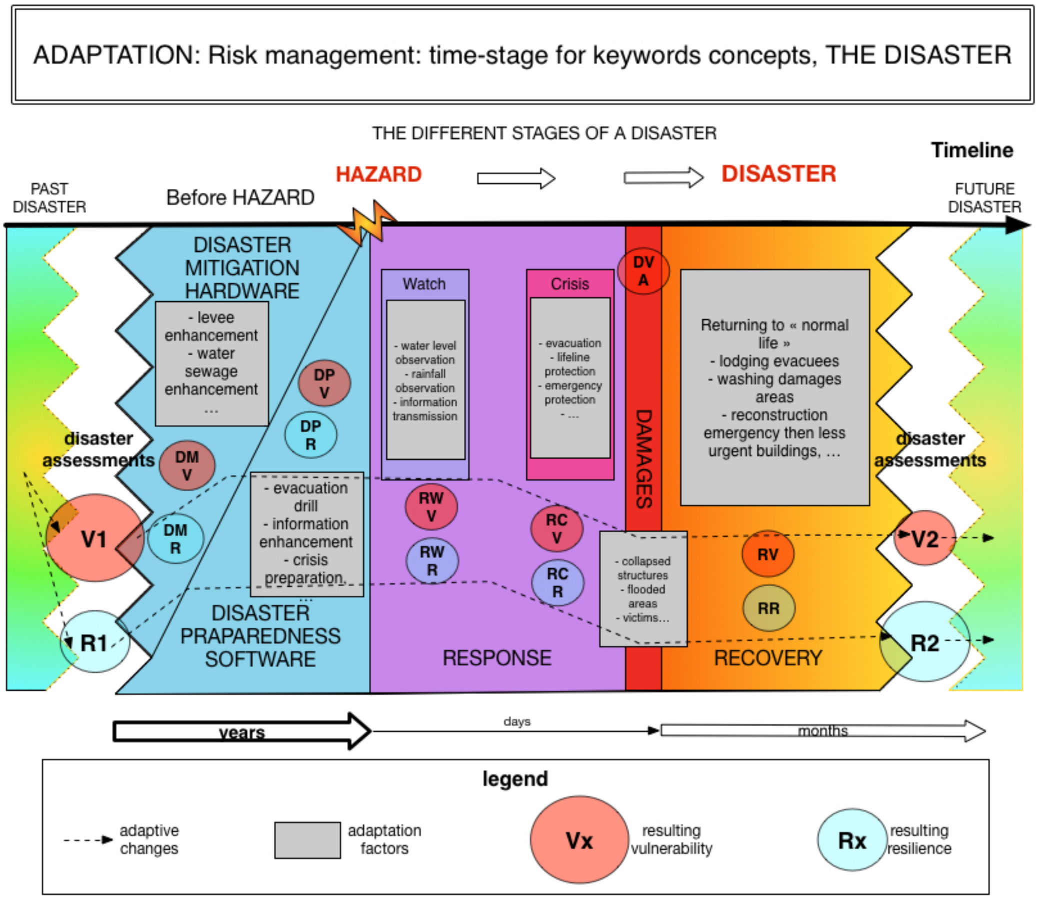


Figure 4-4 the times for the vulnerability and resilience factors in the adaptation model for the disaster

The figure 4-4 represents the disaster and corresponds to the Tokai flood disaster. During the disaster and after the disaster, factors of vulnerability and resilience, and focuses on increasing resilience have been setup. Because of the damages, a post disaster assessment is possible.

However, the figure 4-5 represents what happened during the 2011 flood. The impact of the event being low it is difficult to assess what could have happened. Because there are few damages and almost no recovery at large scale, only probability of vulnerability or resilience can be assessed (risk).

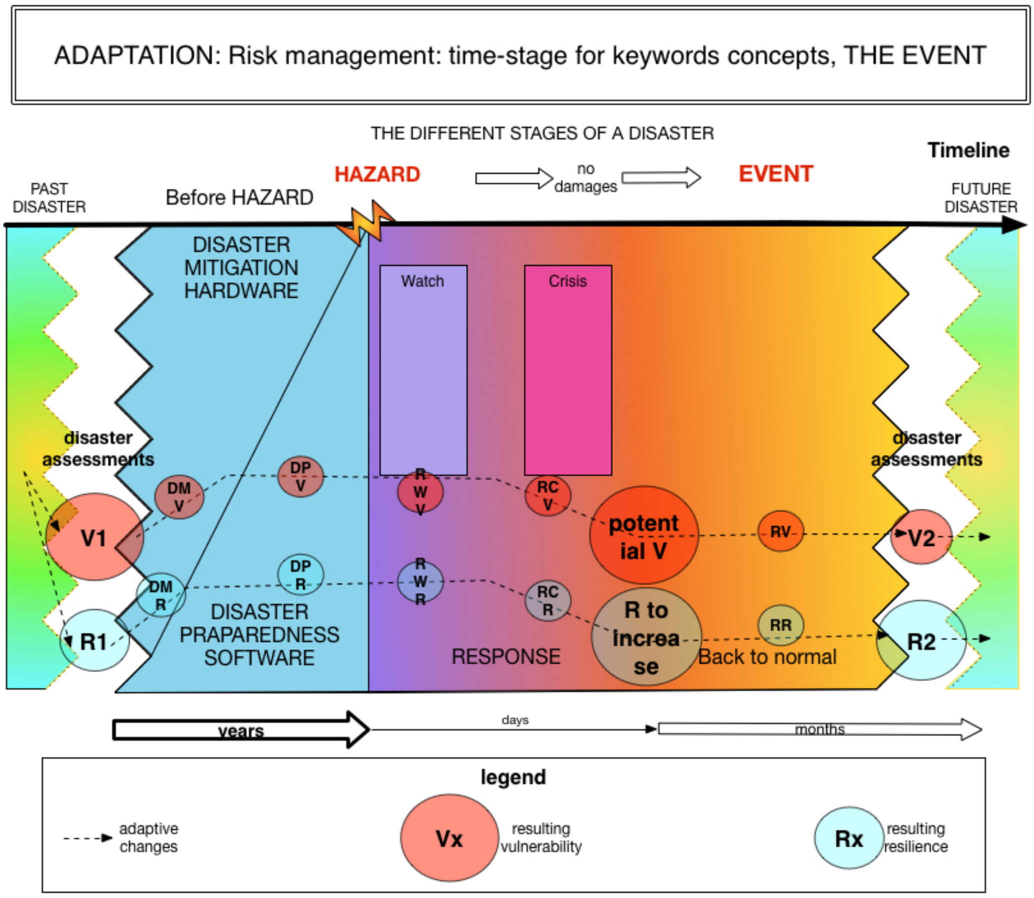


Figure 4-5 the times for the vulnerability and resilience factors in the adaptation model for the event

4.4.2 The evacuation problem during a disaster

4.4.2.1 Reducing the exposure to reduce the vulnerability to flood disaster, the evacuation will depend on the mitigation, preparedness and response times.

This subsection presents the relationship between structural, functional and human exposure, and the structural and nonstructural changes factors assessment. Because the structural and nonstructural changes factors were assessed through the analysis of the 2000 to 2011 changes in flood risk management, they will be developed in next chapter (Chapter 5 application of the model of the Shonai River Basin p. 108)

4.4.2.1.1 Detailed presentation of structural exposure and exposure reduction

The evacuation problem is a problem that can be prepared for, but it will focus essentially on the mitigation, preparedness and response time of the disaster or event.

Will be considered here that the exposition to flood can be of different natures:

- Human exposure (likelihood of loss of life, injury…)
- Structural exposure (likelihood for the buildings and structures – subway, roads – to be damaged)
- Functional exposure (loss of functions political, economic, management)

The 3 kinds of exposure are linked together:

- To keep its functional ability, a city needs the structures (buildings and communication routes) to be usable, therefore not flooded, therefore preferably not exposed, and it also needs population able to perform these functions.

The functional exposure depends on the structural and human exposure (the lower structural and human exposure are, the lower the functional exposure).

- The human exposure depends on the functional exposure (decision making during a disaster, for example) and the structural exposure (being able to evacuate in shelters not flooded for example).

The human exposure depends on the structural and functional exposure (the lower the structural and functional exposure, the lower the human exposure)

- The relationship between structural exposure and the others is difficult to clearly translate.

It relates to the problem of megacities being at the same time extremely vulnerable and extremely resilient. The general idea is that the more an area will be populated, the more structures are necessary to support this area. Moreover, the more an area is populated, the more it has a high probability of having important functions (economic, politic, cultural, at local national and potentially international scale). Therefore, the more human exposure and functional exposure are high, the more, logically, the structural exposure is high (therefore vulnerability is high). But, when exposure is extremely high, a focus on preserving and protecting the human life, functions and structures is setup. Moreover, according to Campanella (2008) the modern city is highly resilient because "the modern city has an almost magical capacity to rebound from every catastrophic destruction". Nevertheless, here it will be considered that the structural exposure can be reduced principally by structural enhancements, mainly hazard containment but not only (house elevation, using the 1st floor for activities that cannot be harmed by a flood …)

4.4.2.1.2 Reducing exposure through disaster mitigation (structural changes)

There will also be considered that the **first and most effective way of reducing the exposure to flood disaster and therefore to reduce the general vulnerability of an area will be to contain the hazard through structural measures** (see figure 4-6 p. 103).

- The **effectiveness** can be assessed by *comparing the impact of two similar hazards on an area before and after the changes in structural measures*
- The **factors leading to change** will *depend on the geographical factors* (geographical characteristics of the floodplain; assets at risk; hazards characteristics); *decision-taking factors* (thresholds leading to changes

decision, like damages during a former disaster, legislation evolution…) and *technical advancements*

- For the structural measures to be **efficient** as well as effective, *multi-hazard coherence, "good" perception of the measures by population at risk and maintenance of those measures is needed.*

DMV and DMR correspond to the structural enhancements (at national, local, or individual level) to mitigate the different kinds of exposure to flood risk. There will also be considered that DMV becomes DMR when the changes undertook for structural enhancement reduce the structural exposure of an area (hazard containment) or a building (individual structural enhancement) during a flooding event.

Finally the author would like to point out that DMV and DMR are therefore related to the hazard strength, expectation, and exceptionalism, and one DMR factor (enhancing a house in order not to be affected by urban floods 0-50 cm of water for example) can still be a DMV for either another type of flood (levee breach) or a future, unknown and unexpected type of flood. DMV and DMR are considered therefore only for the 2000-2011 studied period.

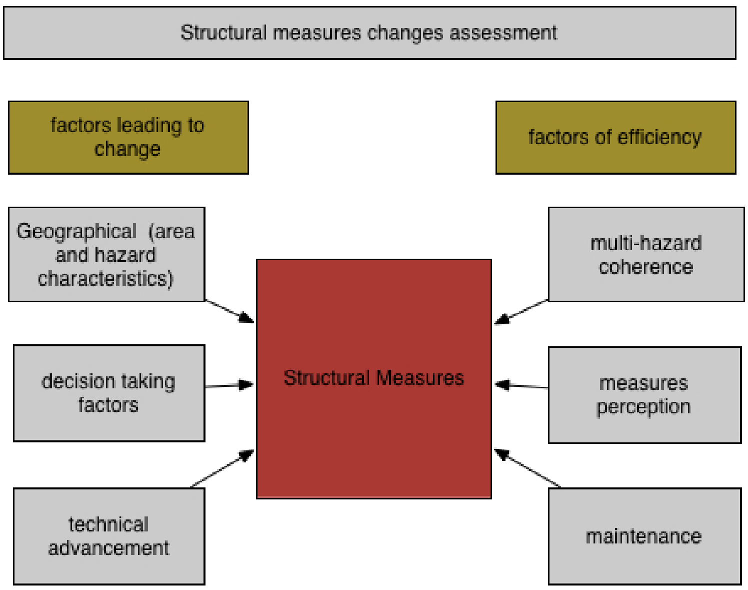


Figure 4-6 Disaster mitigation change assessment

4.4.2.1.3 Reducing the exposure through disaster preparedness

Considering the nonstructural measures changes assessment, will be considered here that the **factors leading to change are similar to the DM factors** (geographical and decision taking factors). The difference lies in the fact **that social and psychological reactions to risk, and measures to increase risk awareness and or acceptance effectiveness is hard to assess**, and especially methods to increase the resilience of the individuals are still difficult to setup.

Concerning the efficiency of the nonstructural measures, the measures perception is the only factor that DP and DM have in common. The **efficiency of the measures taken will depend on the communication between the different actors** (understanding the information, or what is considered the needed information, finding solution together…), and the **risk acceptance and culture** (see figure 4-7 p 104).

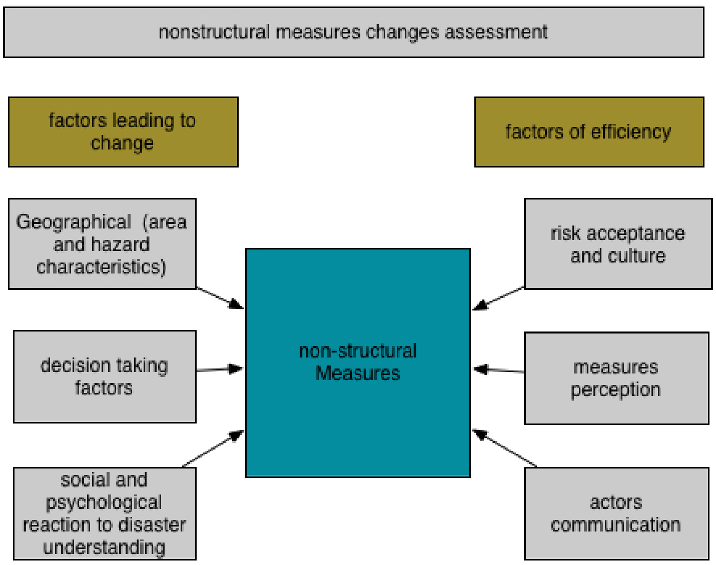


Figure 4-7nonstructural measures in disaster preparedness factors

4.4.2.1.4 Reduction of exposure through disaster response

Because disaster response corresponds to **emergency setup of both structural and nonstructural measures** (to slow down the flood, to evacuate…) we will consider that the factors for assessing the changes in the RW and RC will be a **combination of the two models abovementioned**. General factors don't change but the modalities of those factors change.

Then, for example, the "multi-hazard coherence" factor modalities

- For mitigation consist in the planning and executing between 2 hazard event of structural measures, like the lowering of the river bed or the expansion of the cross-section in order to withstand a hazard of x intensity causing urban flooding outside the rivers to pomp into the rivers and an elevation of the water level inside the levees
- For response, the ability of the structural measures to withstand a hazard while it happens, the water level in the river maintain under a danger level, the levees emergency reinforcement (sandbags), the ability to function of drainage pumps …

To summarize: **In order to assess adaptation and changes in the flood risk management system, two sets of distinction have been made. The first one is a distinction between the times for action in the risk management. It is assumed that the times are the same for disasters (assessing damages and measures to take in order to reduce the future exposure and damages linked to it) and simple events (assessing risk and measures to take in the future to reduce the supposed exposure). It leads to vulnerability and resilience factors for these different times of the disaster (DMV; DMR; DPV; DPR; …). The evacuation is linked to the exposure therefore the second distinction made concerning the reduction of the structural exposure (disaster mitigation vulnerability and resilience factors) and the reduction of the human exposure (disaster preparedness vulnerability and resilience factors).**

5 CHAPTER 5

Application of the adaptation model on the Shonai river basin

The adaptation model separates times of the disaster in order to establish factors of vulnerability, change and resilience. In this chapter, were separated the changes by times of the disaster and the level of action of the actors (national, local, individual) in a risk governance perspective.

5.1 National and prefectural enhancements, mainly structural, between 2000 and 2011 events

5.1.1 Structural measures situation in 2000 before the Tokai flood in the Shonai river basin and hazard's impact

Before the 2000 flood, the two lower reach rivers (Shonai and Shin rivers) of the Shonai river basin were at a "former Master Plan" level. The national Shonai river safety level of the structural measures corresponded to a 30 to 50 years return period. The prefectural Shin river derivation canal safety level of the structural measures corresponded to a 10 years return period. Moreover, before the Tokai flood, the Shin River was considered as a derivation canal for the Shonai River according to Pawittan et al (2000) and Tominaga (2006). Therefore, before the Tokai heavy rainfall of 2000, the Shin River was supposed to be able to contain excesses of Shonai river waters.

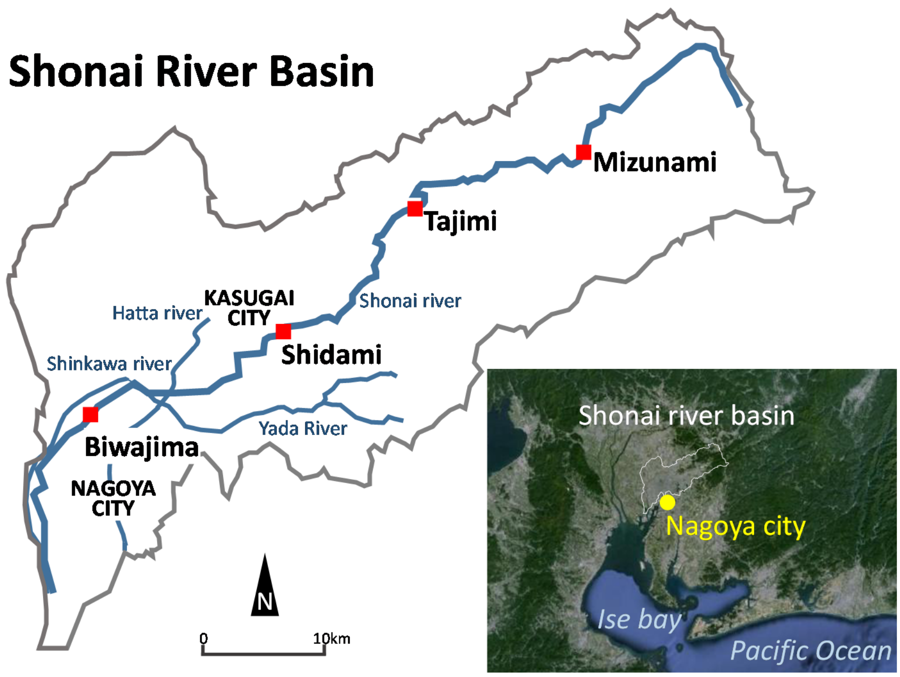


Figure 5-1 Shonai river basin (Thomas et al 2014)

5.1.2 Threshold for action and nonstructural measures at national and prefectural level

5.1.2.1 The threshold for action

As defined in chapter 3, the Tokai heavy rainfall flooded many places and was very costly. However, the number of casualties was low. The main problem is that on the damages caused by the flood, 90% were in the private sphere (general economic activities), not related to public works. Studied have been linking the damages loss due to the different type of floods in 2000 (Zhai, 2006). The urban flood and the Shin River levee breach caused more damages than the Shonai River overflow.

Measures have been taken to reduce levee breach and urban flood risk.

5.1.2.2 Nonstructural measures taken at national and prefectural level

According to the Cabinet Office, in charge of disaster prevention, the 2000 Tokai flood had influence at national scale, since it caused

- The amendment of the flood control act (2001)
- The Specified Urban River Inundation Countermeasures Act (2003)

At prefectural level, the utility and uses of the Shin was revised. Its former status of derivation arm for the Shonai River was abandoned, and the two rivers were separated by elevation of the levees, and transformation of the diversion arm linking the two rivers into a city park with high amenity purpose.

The Shin River itself gained a "**special urban status**" in 2006 (Nagoya city website).

These factors utility and impacts are not quantifiable but show how the problems of urban flooding and levee breach were important enough to:

- Change the river management at local level in order to have a more "integrated" river basin in DID area
- The realization of urban flooding as a real problem, and the legislative efforts to deal with it, despite the 2008 urban flood.

5.1.3 Structural enhancements at national level

Between 2001 and 2006 the Shonai River Bureau undertook river improvements to cope with a hazard similar to Tokai heavy rainfall in intensity and location: the "**special emergency recovery project against major disasters**". It was followed by a maintenance and enhancement project for all the rivers to fit the Master Plan structural enhancements.

5.1.3.1 *What is the designed safety level for structural measures on a river?*

The safety level of structural measures in a river is assessed through the return period of flood discharge the structural measures can contain inside a river. The flood discharge depends on the accumulated rainfall of the river basin for one meteorological event (a heavy rainfall). In the two cases we studied, the events were short in time (1 to 3 days). The **HWL** (High Water Level) is defined as: *the elevation of the water level at the top of the levee minus the freeboard. The HWL determine the probability of flooding: if the water level inside the river reaches the HWL, the likelihood of levee overtopping or levee breach increases dangerously.*

The HWL is linked to the return period determined for the maximum discharge that can be conveyed in the river without reaching the HWL. The higher the return period the structural measures are based on, the sager the floodplain.

5.1.3.2 *The "special emergency recovery project against major disasters"*

According to the interview realized with the representative of the Shonai River basin (12.12.2012) the main problematic areas in the lower reach are the protection of the city-center and the Biwajima bridge (main railway lines and bullet train line). The Shin river challenge was to achieve protection in a very highly urbanized small river basin. The project took into account the main rivers that caused damage in Tokai flood: the Shin river (levee breach), the Tenpaku river (south east of Nagoya city), and the Shonai river.

This project consisted in:

- The expansion of the cross section of the river, to reduce the levee overtopping likelihood (riverbed dredging, levees strengthening)
- A change in the expected return period on which are based the structural enhancement in the lower reach in order to be able to cope with a Tokai-flood type of hazard.

- The former derivation arm between the Shin and the Shonai river was transformed into a park, and the two river basin system were separated

Figure 5-2 p. 112 illustrates the changes in the "**special emergency recovery project against major disasters**".

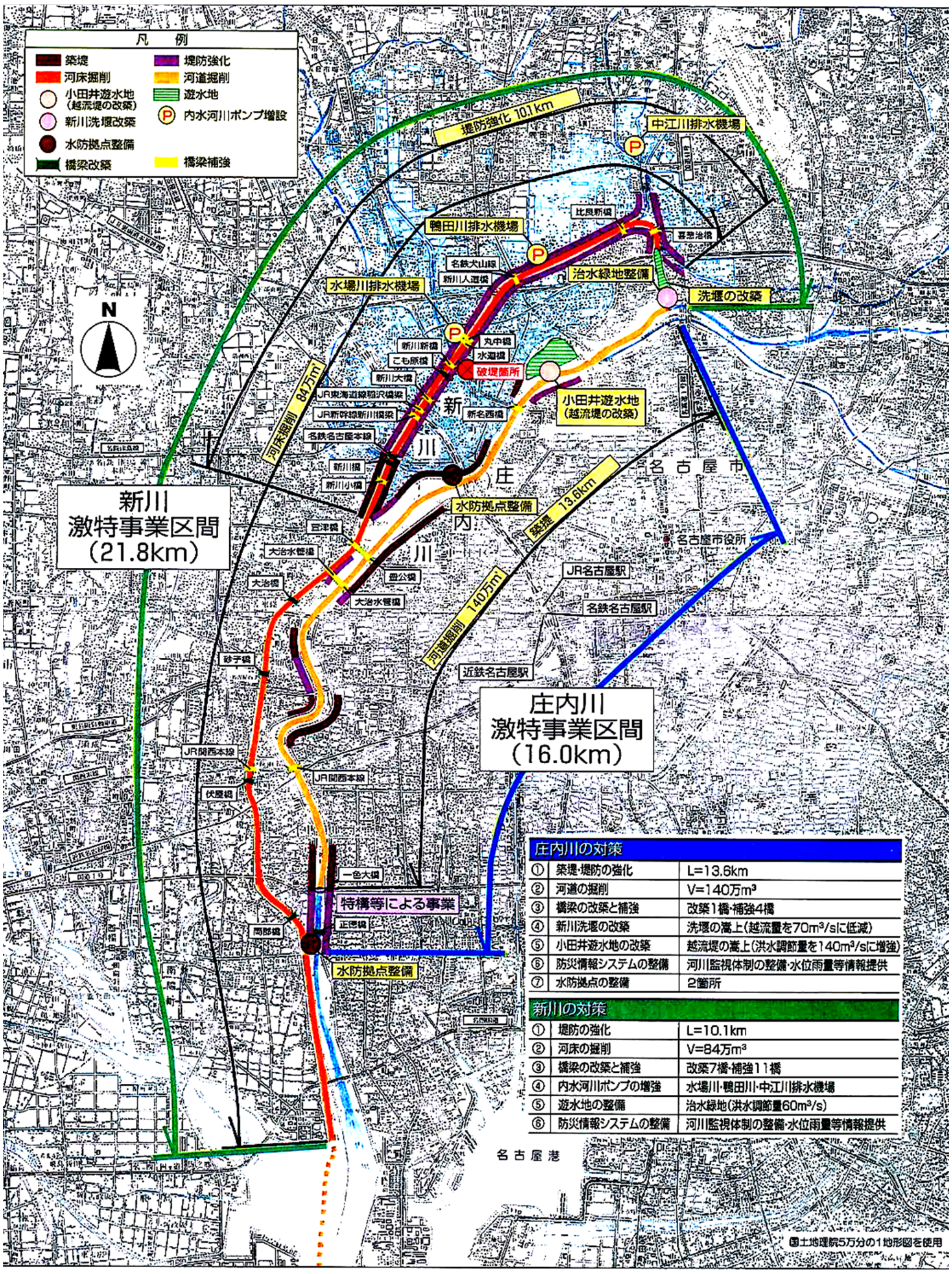


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Figure 5-2 the special emergency recovery project against major disasters 2001-2006 (MLITT)

5.1.3.3 Master Plan maintenance and structural adjustments

The structural adjustments corresponding to the Master Plan objectives should correspond to a 50 years Return Period structural measures on the whole Shonai River. It started after the "special emergency recovery project against natural disasters" project finished in 2006 and should be finished around 2035.

Because the structural measures enhancements are undertook by the same kind of actors (hydraulic engineers) who are working in integrated river basin management for Class A, B, and other rivers, there is no communication problems for the structural measures implementation.

The perception of structural measures by the population will be studied in the 5-.4 subsection (p.130).

5.1.4 Outcomes of the structural enhancements during 2011

5.1.4.1 Effectiveness of "special emergency recovery project against major disasters" in the lower reach (increased DMR)

A comparison between the 2000 and 2011 inundated areas in Chapter 3 showed that in 2011 most of the water was contained in the rivers in the lower reach. Punctual residual urban flood remained in Nagoya, and in the middle reach Tajimi was flooded, principally due to urban flooding and water stagnation along the levees. In Nagoya, in Moriyama ward, small flood by levee overtopping occurred.

Figure 5-3 illustrates the HWL for the Tokai flood and the 2011 flood. If we consider that the exposure depends principally from the HWL in the river (levee overtopping and likelihood of dike breach), then, due to the "special emergency recovery project against major disasters" in the lower reach, the containment of the hazard was effective.

In the middle reach, however, in Shidami district (Moriyama ward, where small flood by levee overtopping happened) the 2011 flood HWL was higher than in 2000.

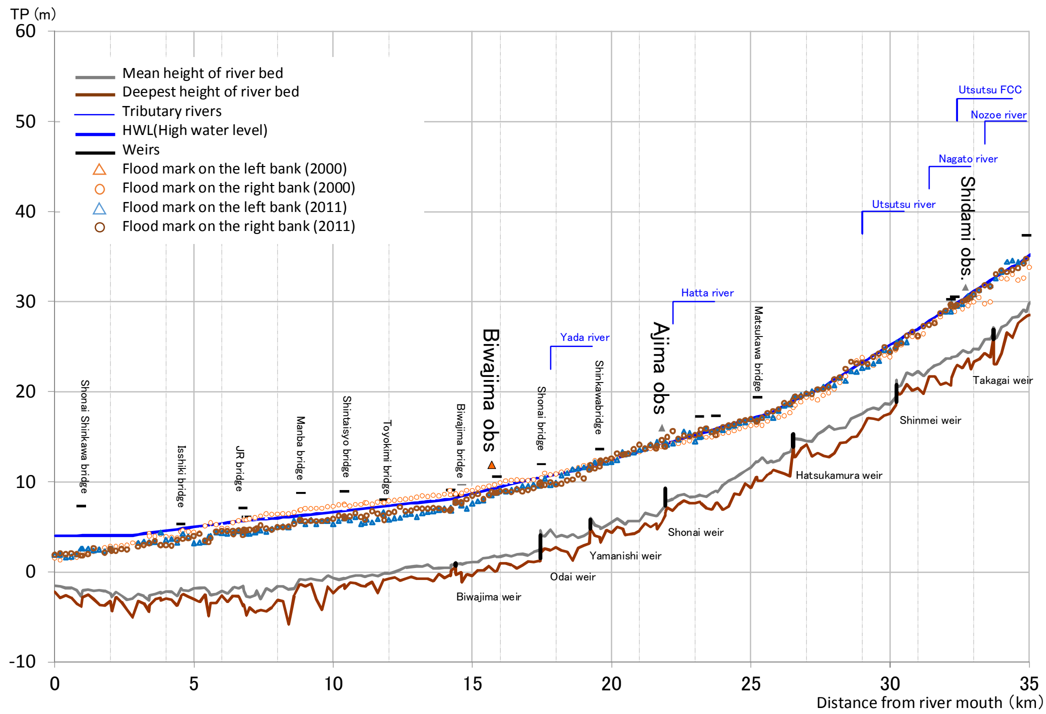


Figure 5-3 the longitudinal profiles of HWL with flood marks for 2000 and 2011 floods. (source: Shonai river bureau)

The figure 5-4 shows the relation between the actions to take in case of a disaster (developed in the next subsection) and the river water level. The figure 5-4 confirms that in the lower reach the hazard was effectively mitigated, the peak stage at Biwajima being lower in 2011 than in 2000. It also confirms that the hazard occurred more intensively in 2011, the peak stage in Shidami district being higher and more intense (duration of the flood event reduced) than in 2000.

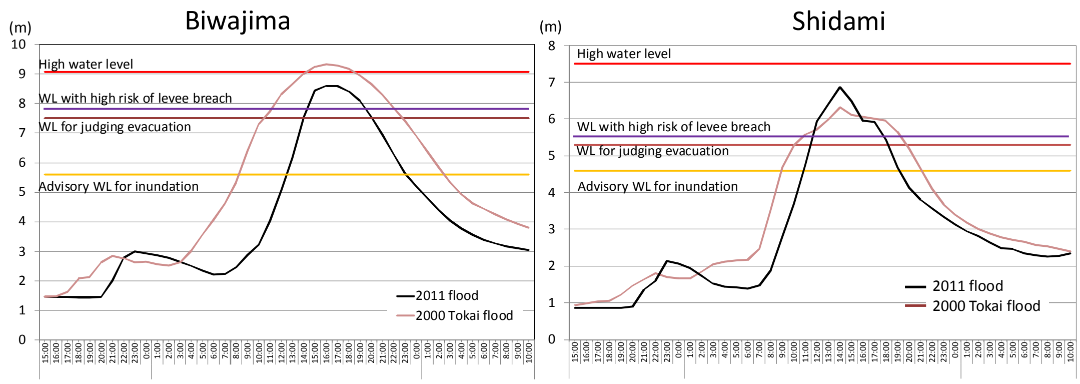


Figure 5-4 the stage hydrographs at Biwajima and Shidami for 2000 and 2011 floods

5.1.4.2 Master Plan structural enhancements impact in 2011 more difficult to assess (DMV in the middle reach)

Because of the downstream to upstream necessary logic of river improvement works concerning river improvements (cross expansion) the structural enhancements corresponding to the Master Plan have to follow a hydraulic logic from downstream to upstream.

The impact of the 2011 flood event is difficult to assess because of the potential changes the 2000 flood brought to the riverbed (morphological changes, vegetation invasion) leading to a higher hydraulic resistance and higher water stage consequences in 2011. The maintenance of the middle and upper reach structural measures while the structural enhancement progress from downstream to upstream is necessary to avoid risky situation like the Hatta river (tributary to the Shonai River) levee overtopping during the 2011 flood event. The low drainage and the levee overtopping caused serious damages and the levees were at high risk of breach at that time.

Figure 5-5Levee overflow in the Hatta river and consequent damages to private assets (Thomas et al, 2014)

5.1.5 The structural measures changes assessment factors setup and application

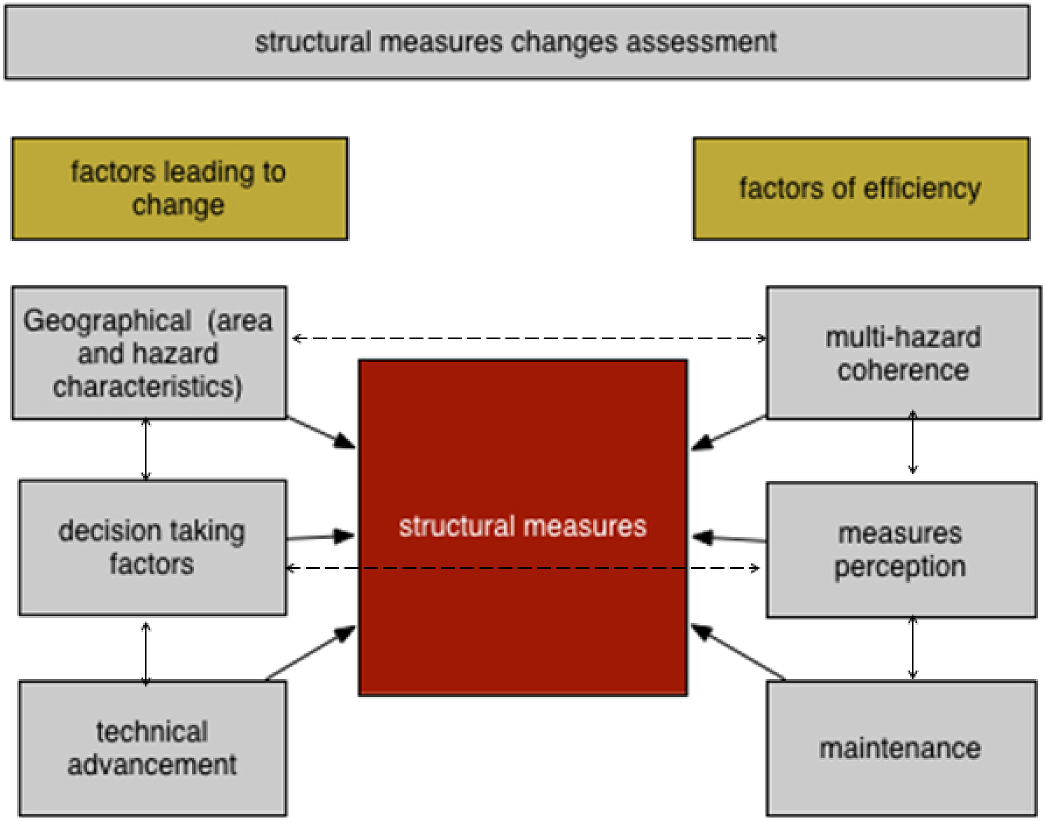


Figure 5-6 structural measures changes assessment (detailed description)

In this section are listed the different changes that happened after the 2000 Tokai flood at national and prefectural level. This subsection focuses on the national structural measures setup, and links the improvements or changes to their causes and the factors for efficiency for changes. The factors identified are considered to be all linked together the vertical arrows illustrate the obvious links between the factors resulting from readings and interviews and the horizontal ones resulting in less obvious links between the identified factors.

Because the nonstructural measures changes assessment depends on a longer evolution (time of the society), on more actor communication (different actors, different information), the nonstructural measures changes assessment will be considered in last at the end of this chapter after a study of the different structural and nonstructural changes from the national to the individual level.

5.1.5.1 Factors leading to change

The geographical factors:

The **major factor leading to change in the Shonai River Basin from a national and prefectural standpoint was the disaster of 2000**. The "geographical" factors are the factors that lead to the disaster. In the factors leading to the disaster, the **hazard characteristics unusualness** was highlighted by many authors (Global Water Partnership, 2004; Okada, 2002; Zhai, 2003, Zhai et al, 2005).

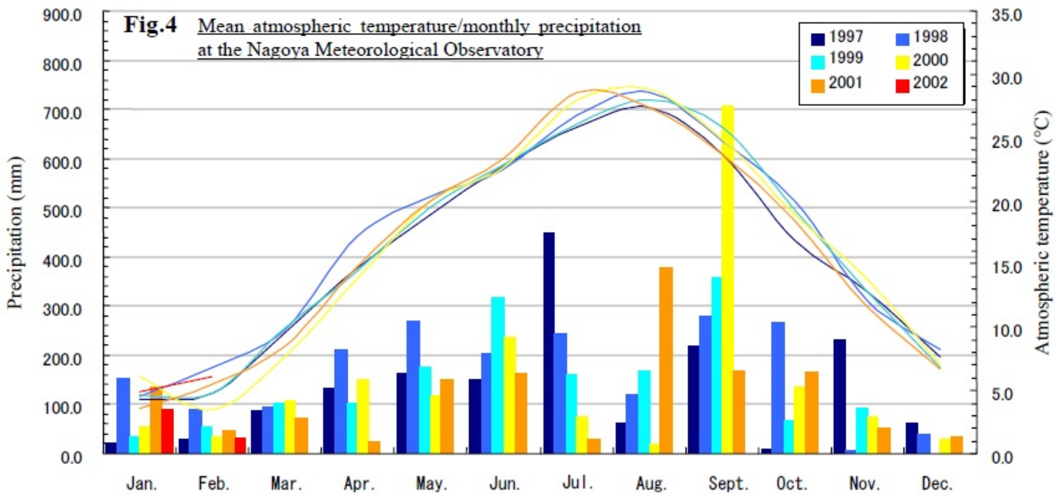


Figure 5-7 highlight on the unusualness of the 2000 rainfall in Nagoya-city in 2000 (Global Water Partnership, 2004)

The **urban vulnerability** of the exposed area has been highlighted not only by many authors in scientific papers (Zhai, 2003; Okada, 2003; Zhai et al, 2005; Wada and Hattori, 2009) but also by disaster prevention actors from the MLITT (Fukami, 2005; Atsumi, 2009).

The decision-taking factors

The **cost of the Tokai flood**, therefore the damages, the result of the occurrence of a hazard of strong intensity overwhelming the structural measures in a vulnerable area, and especially the **cost for private businesses and housing** has been highlighted mostly in academic papers or international reports (Zhai, 2006; Global Water Partnership, 2004). During the interview with the Shonai River Bureau representative of the 2012.12.12 the interviewee pointed out two major areas considered at risk from the Shonai river Bureau standpoint when it comes to urban flooding. The first one was the Biwajima area, because of the lowland ratio in this area, and the economic value of the Biwajima Bridge, and the second was the Shonai and Yada rivers confluence.

From the theoretical background study it has been pointed out that a major paradigm of risk and disaster management called the "**hazard paradigm" was based on the structural exposure reduction and the cost-benefit analysis**.

From the national level structural measures enhancements between 2001 and today, two logics seem to be followed:

1. The decision-taking factors when it comes to structural enhancements at national and local level will depend highly on the geographical area characteristics that determine the cost of a disaster. The special emergency recovery project against major disasters setup between 2001 and 2006 fits a hazard paradigm aiming at the reduction of the structural exposure **following a post-disaster assessment**
2. The Master Plan structural measures improvements is fitting both the post-disaster assessment for post-disaster assessment, and the prevision at larger scale in time and space of the flood risk on the whole river basin.

Like pointed out in Chapter 4, reducing the structural exposure will have consequence on the reduction of the human and functional exposure.

<u>The technical advancements</u>

The technical advancements are considered to be an important factor leading to change (or not). Under "technical advancements" factors, it is understood of course the scientific knowledge necessary to setup structural measures (although this factor is not considered to be the most important in developed countries) but also and especially in this context the ability to setup structures considering the lack of space resulting from the urbanization and the economic cost of said measures. This factor has been added to the model following the interview with the Shonai River Bureau representative and the explanation of the up to date abandoned project to improve the regular levees system on the left bank of the Shonai River in Nagoya into "super levees" in the 1990's. According to the OEDC report concerning floods in Japan in 2009 (OEDC, 2009) the trend in budgets allowed to river improvements should not increase in the following years, therefore the technical advancements should have to aim for effectiveness and efficiency in a more and more tight cost-benefit logic.

5.1.5.2 Factors of efficiency

In “factors for efficiency” side concerning the structural measures changes and enhancements were classified factors acting at a longer time-scale than the factors leading to change (depending on the past disaster and current general situation).

The multi-hazard coherence

The multi-hazard coherence in structural measures improvement have been added at national and regional scale because of the disaster of 2008 and its repercussions on the focuses and interests of the major structural measures actors of the Shonai river basin. The multi-hazard coherence factors consist in:

1. The creation of structural measures which can withstand different types of natural hazard (influence of the 1995 Kobe disaster in Nagoya-city stressed out by both the Shonai River Bureau representative, Shin River Bureau representative and the Nagoya-city disaster prevention bureau representative during the interviews)
2. The creation of structural measures which can withstand different outcomes from one original hazard. The Tokai flood causes were numerous: levee breach, levee overtopping, but also need to stop the pumping stations in order to reduce the HWL in the river increasing the urban flood in lowland areas. (illustrated in 2010 Hazard maps but not in 2001 hazard maps; increasing interest in urban flooding reduction stated by the Shonai River Bureau representative during interviews)
3. The creation of structural measures which can withstand a hazard with geographical river-basin logic. This last factor is enumerated because it has

important relations with the measures perception and maintenance (and maintenance perception) factors. It has been stated by Pawittan et al (2000) that the Shin River had a derivation purpose in the 1990's, however the interview from the Shin River bureau revealed that the Shin River had lost since a long time its derivation purpose.

<u>The measures perception and the structural measures maintenance</u>

The two remaining factors are linked together here, because the maintenance of structural measure was never doubted, either in scientific literature or in the interviews to officials. However, the maintenance of the structural measure have been called upon as perceived bad in specific areas (far from home) by two interviewees (Ken interview of the 2013.06.16 and Hideyuki interview of the 2013.03.10). The measures perception will depend of the understanding of the hazards at the origin of the risk, and therefore in urban system of the multi-hazard coherence (the understanding of multi-hazard coherence at the population level was not discussed in length, but at the national and prefectural level it is considered interesting in this study that the 2000 Tokai flood lead at national and prefectural level to nonstructural measures like the 2001 urban flood law and the 2006 Shin "Special urban river" status, but did not lead to a local focus on urban flood in the "special emergency recovery project against major disasters". By "measure perception" two types of perceptions are understood: "what structural measures should be setup to reduce the exposure" and "what is the effectiveness of the structural measures setup up until now?".

to summarize: **structural enhancements were decided after the 2000 Tokai disaster (high cost in public and especially private sphere) at national level (change in purpose of the Shin River former derivation canal, structural measures - levees - enhancements on Shonai and Shin rivers). At national and prefectural level non-structural measures (laws for urban floods, change in Shin River categorization). The structural measure improvement consisted in reducing the HWL to reduce the risk of levees overflowing and levee breaches, it**

consisted in the "special emergency recovery project against major disasters" concentrated in the lower reach area in the Shonai and Shin rivers (2001-2006). The Master plan objective of a 50 return-period protection is applied for all structural measures in the Shonai River basin, and should be achieved in 2035, but following a downstream-upstream logic, it has not reached the upper reach yet. During the 2011 flood event the effectiveness of the special recovery project in the lower reach could be assessed, as the HWL was lower in 2011 than in 2000.

5.2 Nonstructural enhancements: the disaster prevention actor system enhancement from National level to the Mayor office

5.2.1 Problems during the Tokai flood identified and threshold reached

During the Tokai flood, one of the identified problems was the late evacuation warning (prior evacuation with evacuation recommendation and evacuation order). Evacuation recommendation were send after some areas, especially in the lower part of Nagoya (Nakagawa, Nakamura wards) were flooded.

The nonstructural measures setup like risk culture enhancement and prior evacuation warning are the charge of the mayor office. In France, the same kind of problem can happen when mayors receive technical and scientific information from meteorological agencies and have to determine the proper time of the evacuation without proper tools for decision-making (Daupras et al, 2014). The evacuation is important because it is an effective and efficient tool to reduce the human exposure during a disaster.

A project concerning the improvement of prior-evacuation was setup in order not to have to face a “Tokai flood-like problem” when the evacuation was done while the areas were flooded above 1 meter, and the help of the National Self-Defense forces were needed.

5.2.2 Project to improve prior-evacuation

5.2.2.1 The making of hazard maps

In order to reduce human exposure to flood risk during the disaster (RWV and RCV), a focus was put on the improvement of the sending of information at the good moment. The useful information system has therefore been revised.

First, the Shonai River Bureau created an "inundation map for a designed flood", with a return period level for the hazard predicted of 200 years, therefore more extreme than the Master Plan structural measures could withstand if such hazard should occur, and gave it to the city disaster prevention managers (in charge of the evacuation management). The city disaster prevention bureau realized then "hazards maps" evacuation and river water level connections

Mayor offices are in charge of evacuation recommendation (not mandatory but advice to evacuate) or order (mandatory evacuation), but the mayor often hesitate to issue recommendation or evacuation for lack of knowledge of the hazard characteristics, delaying therefore the evacuation recommendation and order. In order to avoid a situation like the Tokai flood situation in 2000 when the evacuation recommendation and order were released after the area was flooded, the river managers (in charge of hazard knowledge and mitigation) and the mayor office released a concerted system.

In this system, the river manager will provide information concerning the real-time data of the water stage in the river and the forecasted future water level. After consultation with the mayor office to know what timing is needed to release evacuation, a framework in which actions to take and water level inside the river are linked together. The timeline of measures to take in case of river water increasing is shown in figures 5-4 and 5-6. This framework was created to help the mayor offices to release evacuation recommendation or order.

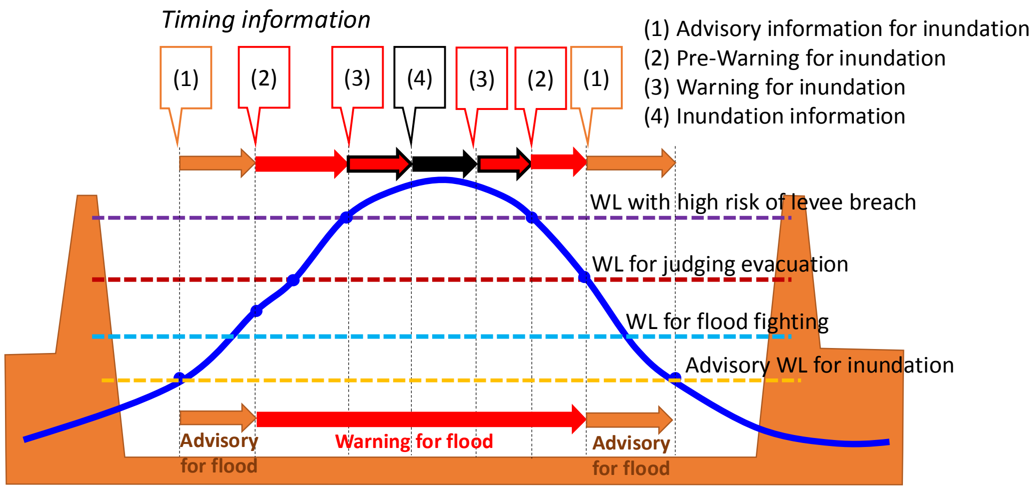


Figure 5-8 timeline for timing information for river manager in stage hydrograph

An interesting thing to point out is the very good communication between the mayor office and the hazard managers. Not only do the different bureaus communicate all the time during a flood event but also the river managers regularly update the predictions of future evolution of the hazard and the information transmitted to disaster prevention managers who can make decisions more efficiently, as illustrated by figure 5-7. This is a very effective method to dispatch flood fighting teams and evacuation recommendation, and respond to hazards like the 2011 heavy rainfall which was an event more intense and short in time than the 2000 flood event.

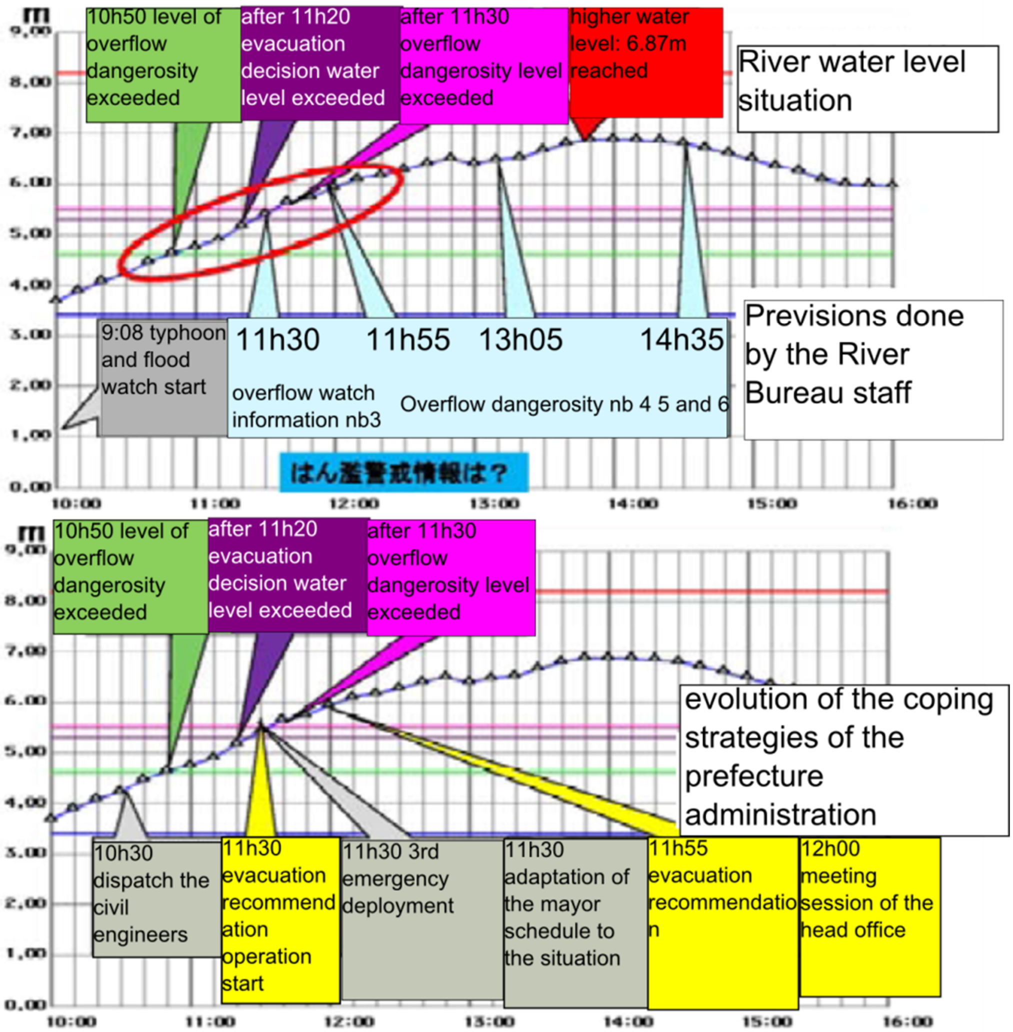


Figure 5-9 Water level and action taken timeline (up: river managers down: disaster prevention city managers in 2011)

To summarize: **The low evacuation ratio origin was supposed to be partly caused because of a low evacuation command release in 2000, when some places were already flooded. The threshold for the evacuation command enhancement was therefore the assessment that there was a difficulty for the Mayor Office to release evacuation advice at the right time. Therefore more communication between the River Bureaus and the Mayor offices has been setup in order to release the evacuation commands at a more effective time to the population. Levels to take action have been setup for the water level inside the rivers, and**

constant communication between different bureaus helped release more effective evacuation recommendation for the population in 2011.

5.3 From city to local level adaptation of nonstructural enhancements

At city level many improvements were done between the 2000 Tokai flood to the 2011 flood event in order to reduce the human exposure to floods. From hazard maps to improved cell-phone information, new information measures were invented for the preparedness time and the emergency.

However their effectiveness and efficiency is not yet achieved.

5.3.1 Hazard maps purposes, evolution, and impacts

The hazard map contains information about the expected inundation depth, the closest evacuation shelters, and general information about measures to take in case of a disaster. They are free, and send to every household in the city area directly in the mailbox. They are also free for download on every city's website. For Nagoya, the hazard map is realized at the ward level, for other Aichi prefectures cities, they are most of the time realized for the whole city.

It is hoped that with these information, inhabitants and stakeholders living in flood prone areas can acknowledge the flood risk, the expected damages it would cause, and take necessary measures to prevent those damages and prepare for evacuation. This research was not focused on the 2008 urban flood in Nagoya city, but it had to be taken into account in the quick evolution of the hazard maps between their creation in 2001 (after Tokai flood) and 2010 (after 2008 urban flood). The first hazard map was a map essentially showing the hazard. Information concerning private measure to take was joined to the map but not on the maps. Those maps contained however information about shelters (see figures 5-8 to be compared with figure 5-9 p.

121)

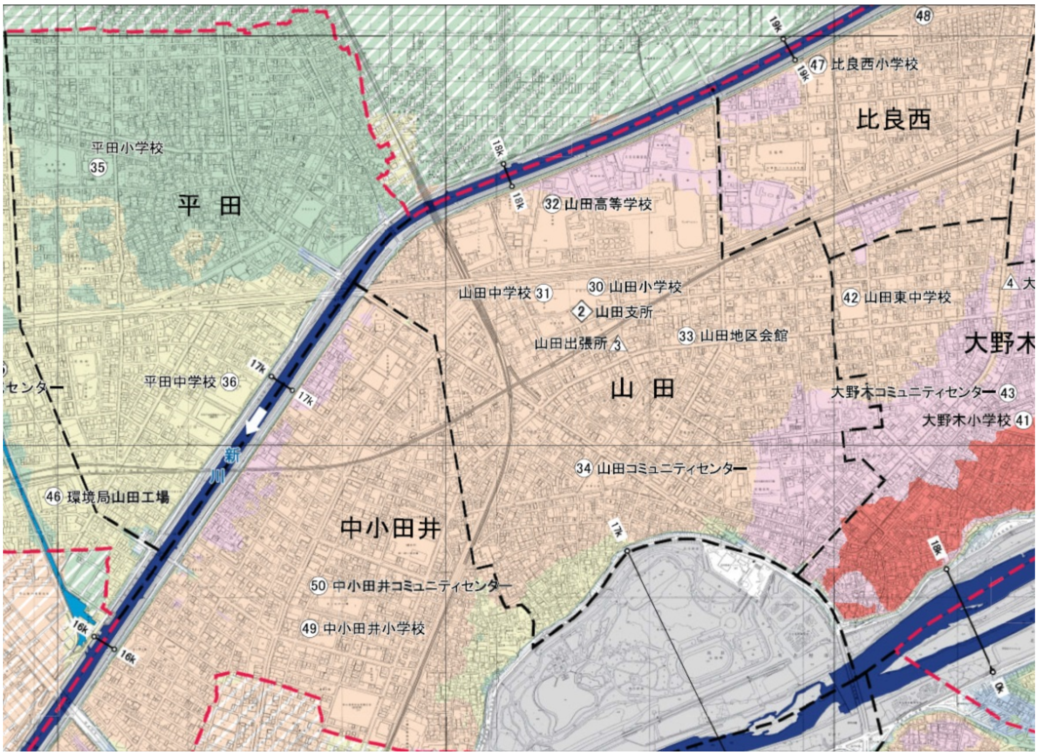


Figure 5-10 2001 hazard map for Nishi ward, details for Kami Otai (not available anymore)

After the 2008 flood, new hazard maps were realized (see figure 5-9 and 5-10 p. 121 and 122). They include:

- 3 different types of flood to expect (from Shonai river, from Shin river, from urban flood)
- Schema indicating danger level of the water level expected for floods, and instructions about evacuation to do depending on water level expected and the level of housing people live in
- Clearer indication of the shelters
- Less aggressive and more distinguishable color choice

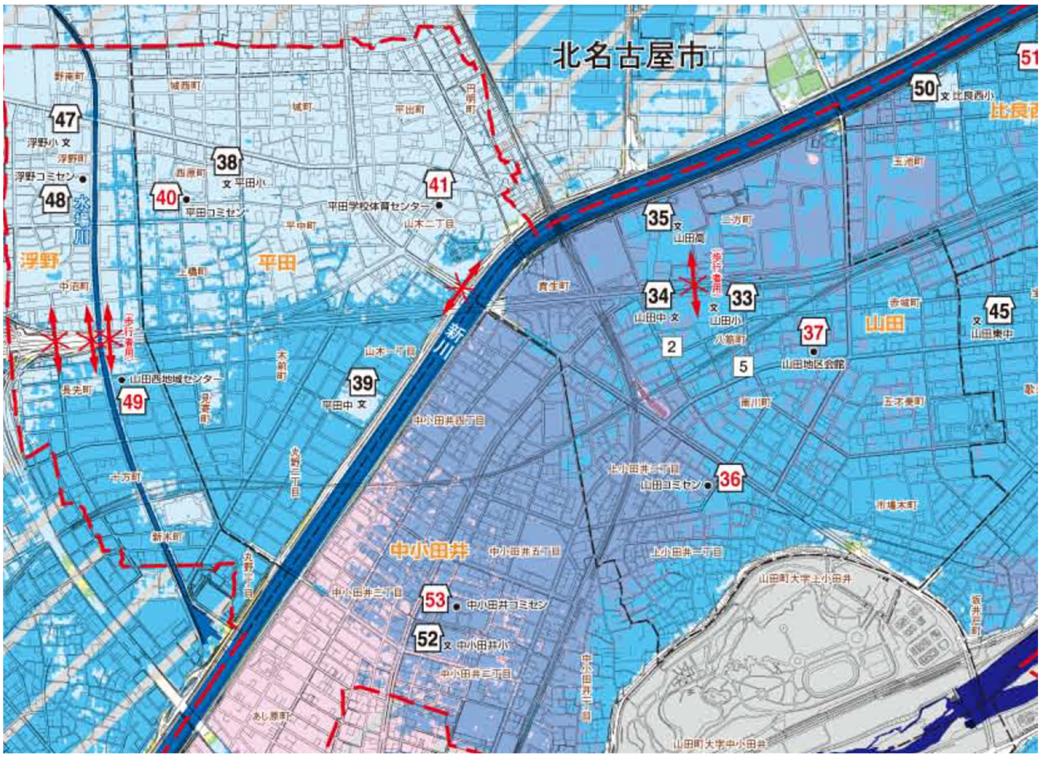


Figure 5-11 detail of the Nishi hazard map (2008) available at http://www.city.nagoya.jp/kurashi/category/20-2-6-6-0-0-0-0-0-0.html, consulted 20.12.2012

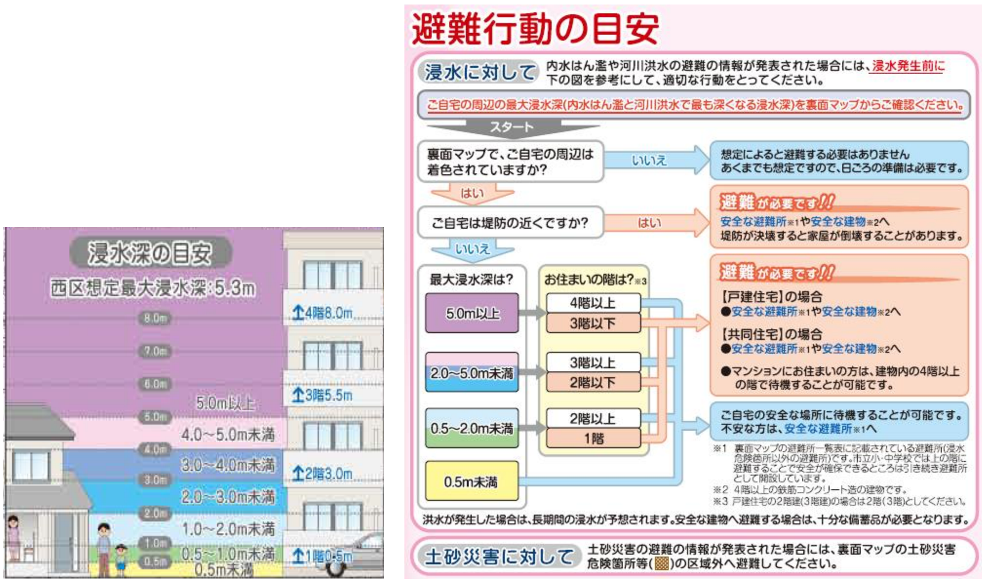


Figure 5-12 left water level and housing relationship. Right: what to do in case of flooding and when to evacuate

This information, coupled with the possibility to consult the river water level in real time on the Shonai River Bureau website was created in the hope that exposed population would take action for mitigation, preparedness and evacuation without incentive.

The impacts of the hazard map distribution is however relatively low. The 2011 Aichi prefecture survey indicates that only 15% of the surveyed population responded that they have, did read, and understood the hazard map. The reasons of the hazard maps lack of success will be examined in the 5.5 subsection (pp 138-142).

5.3.2 Shonai River Bureau free information and individual knowledge on hazards

The Shonai River Bureau website also has a real-time water level watch inside the rivers at numerous strategic points that every person can consult and can compare the evolution between upper reach and lower reach water level if they want (see figure 5-11), and information concerning emergency in case of flood disaster directly on the welcome page of its website[14]

Figure 5-13 real-time water level in the Shonai river in Kami-Otai (http://www.cbr.mlit.go.jp/shonai/kasen/web/ consulted 22.12.2014)

[14] See Appendices for detailed presentation of the Shonai River Bureau information communication

5.3.3 Medium of communication from mayor office to population

5.3.3.1 Distribution of information from the mayor office to the population and perception of the communication tool by the interviewees

The mayor office did develop mobile phone alert system to keep the population informed about evacuation in case of a disaster (area mail).

When asked about the best medium of communication during a disaster to be informed about the flood conditions and the evacuation information, the Aichi prefecture questionnaire answers prefer television and radio medium. During interviews, the same kinds of answers were received. According to our interviews results, the radio is the most useful information medium during a flood disaster because there is no need for electricity, the mobile phone is also considered useful in theory but the people we could interview who did experience the Tokai flood did not dispose of mobile phones during the Tokai flood event. Moreover, most of the people we interviewed who did experience a flood disaster were between 40 and 55 years old, and did not seem to use very much the new information technologies, even if they recognized their usefulness.

The television medium is the second most popular for the interviewees, the reason they gave was that television was the best way to have real time visible information at the city or river basin level. They recognize however the handicap of television, that doesn’t work in case of electricity shut down, which happened during the Tokai flood in 2000.

5.3.3.2 Does new information in case of response time increase evacuation ratio?

Concerning RCV and RCR, the assessment of new technologies of communication impact on the evacuation numbers during a flood event are mitigated.

On an official point of view, the new communication technologies have had effective consequences. During the 2011 flood event, one million people were asked to evacuate and the evacuation recommendation and order was send smoothly not only due to the very good communication between hazard mitigating managers and mayor office disaster prevention teams in charge of the evacuation, but also because via area mail, and associations between media companies and the mayor office in Nagoya, the information was send at the right time. However, according to an interview to the Nagoya disaster prevention managers (interview done the 2012.12.19), the number of people that were asked to evacuate was more than expected, due to a problem of communication between media companies and disaster prevention team (flood prone areas population understood instead of population exposed for the 2011 flood event).

Concerning the communication between actors at the local (city) level, then

- An improvement of communication is noticed (new technologies)
- A more integrated disaster management is being developed, that might lead to better risk governance (private and public actors), however, it will need time for the actors to understand each other. There can be hoped however that if a flood event should happen in the future, the lessons learned from the 2011 flood event will be useful for the disaster prevention and media communication

Concerning the number of evacuees:

In absolute numbers, as can be seen in figure 5-12, the 2011 evacuees were more numerous. Therefore there is an increasing RCR to flood risk since 2008. If the number of people willing to evacuate are increasing, there can be assumed that the communication is better and that the new technologies uses are efficient. However, the ratios are still low, therefore, there is a need to understand:

- The reasons why people might not want to evacuate

- The threshold over which population consider needed to evacuate
- The interpretation possible of the different communication methods used for evacuation (hazard map information, evacuation recommendation …)

	People who should have evacuated	People who have evacuated	Evacuation ratio
2000 flood	381,309	32,155	8.43%
2008 flood	360,000	375	0.10%
2011 flood	1,000,000	4,749	0.47%

Figure 5-14 Evacuation ratios for 2000 2008 and 2011

5.3.4 Needed population to evacuate considering the hazard map information

5.3.4.1 Method errors and adjustment

During the empirical field gathering data of buildings and households, the author could not take into account houses or apartment uninhabited. Comparing the empirical data and the statistical data available on Nagoya city website for households and housing, an error margin of 268 apartments was noticed (18% of all the potential apartments evaluated from the field empirical data). This margin error has been taken into account for the evaluation of the number of households and population that need to evacuated for the three referenced 200 years of return period flood showed on the Nishi area Hazard map.

On the three city blocks studied were also taken into account the differences in our model the number of family members living in one household. Because the Komoharachou district is more industrial than the other two, the average family members per household are 1.7 whereas in the other two it is 2.5 (Nagoya city statistics).

5.3.4.2 Needed evacuation evaluation from hazard map, buildings and population census made on field study

	Shonai flood	Shin flood	Urban flood	Total population
evacuation	1030	976	20	2499
no evacuation	1580	1583	2139	2499

Figure 5-15 Evacuation needed evaluation (number of persons)

The figure 5-13 represents the evaluation of persons that should need to evacuate in case of a flood of an intensity exceeding the structural measures should happen as advised in the hazard map. The hazard map advises people to evacuate if the floor they live in is susceptible to be flooded in case of a disaster of 200 years of return period should happen. It does not take into account the domino effect of the risk and therefore does not take into account:

- The electricity and water drainage problem a flood could cause
- The inaccessibility of evacuation roads and the impossibility to use cars

It is of course only an informal representation of the data that has to be considered as a tool to increase the flood risk culture of exposed inhabitants. However, considering that the hazard map flood is based on an extreme hazard (and therefore disaster) occurrence, the author can only point out the fact that the number of persons that should evacuate in case of such disaster is relatively low.

Figure 5-17 housing type repartition (C =1 floor, B = 2 floors, A = 3 floors and more) (Thomas and Tsujimoto, 2014)

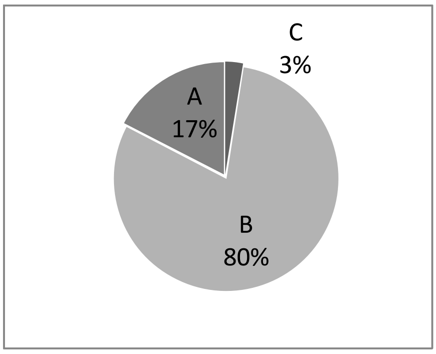
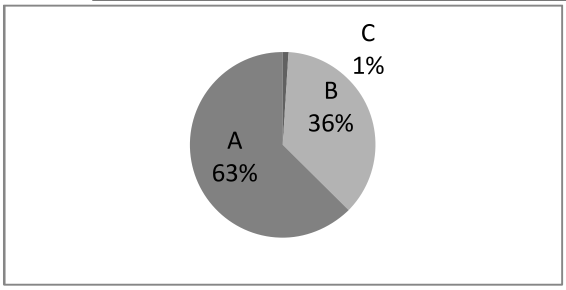


Figure 5-16

Apartments repartition by housing type (Thomas and Tsujimoto, 2014)



Most of the people living in the three studied districts are living in condominium of 3 or more stories. Even if the most represented building type is the more vulnerable two stories house type (80%), the population living in condominiums corresponds to 63% of the total population in the three districts. Considering that the hazard map advises to people living in condominium to evacuate in upstairs stories, more than half of the population would not need to evacuate.

However, 41% of the population would need to evacuate in case of a Shonai River type of flood, 39% for a Shin River model flood, and 0.8% in case of an urban flooding type of flood.

Concerning the geographical repartition in the three studied districts of people most at risk, we made a GIS map of houses needing evacuation in case of a Shonai type of flood occurrence (figure 5-16). The housing repartition is very homogenous and there are therefore no housing repartition patterns that could be noticed.

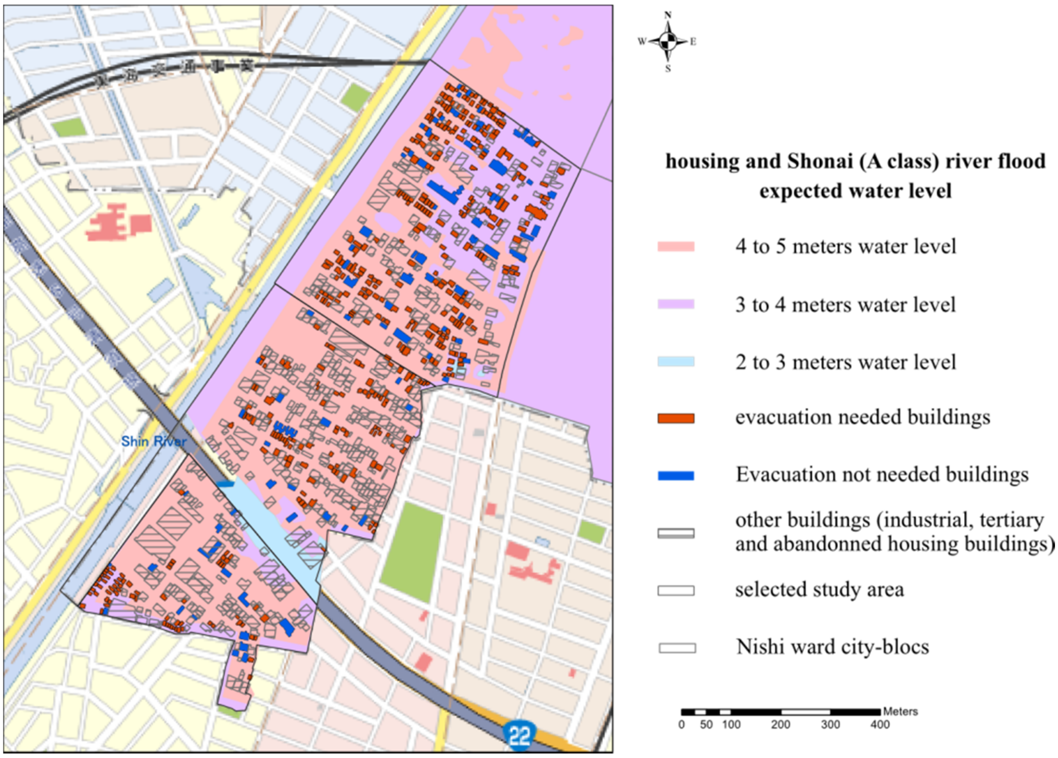


Figure 5-18 Housing evacuation needed for Shonai River model flood (Thomas and Tsujimoto 2014)

During the interviews to local ward disaster prevention managers, it was noticed that the repartition of vulnerable housings and population is a knowledge empirically created from past disasters, and a very good small-scale knowledge of the ward is imputed in maps reserved to the disaster prevention managers and the flood fighting teams in case of a disaster (maps not available to the public). This kind of map is therefore not helpful to understand what is already understood at the smallest scale of the disaster prevention management. But it is considered important to point out that:

- Compared to the ratio of people evacuating during the last flood, the hazard map scenario should encourage more people to evacuate
- Compared to the recommended evacuation information send the ratio of population in need of evacuation is lower

Therefore it is difficult to evaluate the RCR for evacuation needed, whished and actually done.

The hazard map scenario and the recommendation for evacuation are done under the hypothesis that for resident and population in general, the evacuation threshold should be the moment people receive the information. The last subsection is based only on qualitative interviews and will try to assess the evacuation threshold factors for different type of experiences of the Tokai flood.

To summarize: **the information communicated to population has been increased in access (free delivery in mailbox for hazard maps and direct internet access for water level in the river from the Shonai River Bureau) and in readability over the years. Nevertheless the impacts of the communication access on the evacuation willingness are not clear, if the evacuation level is rising, it is difficult to relate it to the information reception both from an analytical and a qualitative point of view. Moreover at the local level new actors and old actors communication is still enhanced currently and should lead in the future to more efficient evacuation recommendation launch. If the recommendations for evacuation from the hazard maps are adequate, then a smaller number of people (40% in the worst case scenario) should need an evacuation in case of a major disaster. Lastly, if population evacuating numbers seem to increase since 2000, it is difficult to relate it to the information access enhancements and other factors and thresholds leading to evacuation have to be looked for.**

5.4 Individual level adaptation of nonstructural enhancements and questioning the structural individual enhancements

5.4.1 Methods limits in interviews to population

The interviews that were made to population were difficult to setup and there are a few limits and handicaps that have to be pointed out before trying to assess potential factors for evacuation threshold.

First of all, the interviewees were not numerous enough in numbers and not necessarily representative of the whole population characteristics and it has to be noticed that the young and active part of the population is not represented in this study because young active persons to interview were not being found. people were asked to talk about how they lived the last big flood (most of them the Tokai flood), and if they had acquaintances that would be interested to talk about it as well, therefore the people interviewed were very similar in age, social status, and flood experience.

Secondly, the interviews were conducted in Japanese with the help of Mrs May Thiri for the translation. Therefore, it has to be expected that some errors in the translation occurred, and the lack of analysis or follow-up techniques that are usually used in interviews conducting has to be taken into account.

In order to assess with the minimum lack of loss due to these error factors the potential threshold factors for evacuation, the answers given by the interviewees were compared to similar studies (evacuation, risk culture, cognitive dissonance research) either in developed countries with highly mitigated flood hazards (like the Netherlands), or other studies done on the same field study area for the same disaster (works of Zhai et al, 2006, 2008 principally).

Thirdly, when the occasion was given people have been interviewed, often asking to the firsts interviewed persons to ask their contacts if they were willing to talk about flood risk and flood disaster experience. Because it was difficult to meet people that were willing to talk about their experience, the author could not choose to restrict the study to the Tokai flood in the Shonai river basin only. A few interviewees related their experience of the Tokai flood during the Tenpaku river overflow, but the experience wasn't considered too different from what could happen in the Shonai river basin to be ignored.

Finally, there is a difficulty in this methodology when confronted to interviews to public actors of the risk management at small scale relating their personal experience of the flood, the interviews questionnaires were separated in two distinct sheets, one for public actors and one for population. However, when confronted to middle school professors that had a role to play in the evacuation and the emergency management because their schools became shelters during the Tokai flood, it was difficult to separate in the interviews as "the role they were playing as managers" and "the experience they had as population member during the flood". In this subsection, they will therefore be considered as population member when we will relate their experience of the Tokai flood not as middle school professor or director.

5.4.2 Factors for individual structural and nonstructural measure taking threshold

In his study on the resident's perception and action for risk mitigation, Takao (2006) did a questionnaire survey to show that for homeowners there is a statistically significant relationship between the fear of flood and the individual mitigation measures taken while there is not for renters. He also pointed out that structural measures were taken at individual level if the house was damaged above flood level during the Tokai flood.

5.4.2.1 Fear of flood is difficult to evaluate after fifteen years and doesn't seem to play a role in disaster prevention, preparedness or evacuation for individuals

Every person interviewed said that they were considering flood among one of the most dangerous hazard (flood and earthquake are the usual pairing). One of them was relating the feeling of fear and the incapacity to know what to do next during the Tenpaku river levee overtopping. "So, I was in my car and it was night, and I was coming home, and everywhere everything was flooded. But I was in my car, so I didn't know what to do. I stopped when the cars in front of me stopped, and we get out of the cars, and no-one knows what is happening, where to go, and what to do …" (Akane, interview of the 09.10.2013); another one was relating her experience of evacuation on September 12th after the levee breach of the Shin river in Kiyosu-city "no the first day it was OK, the water level was low, so… But on the morning of the 12th there was a flood inside the house, and at least 1,50 meter high in the street. I saw someone trying to go somewhere and yelled at him to go home because it was so dangerous (…) we waited until the rescue boat came, when I saw them I opened the kitchen window and yelled "help! help! We are here, help" and they came to rescue us (…)" (Hanako, interview of the 09.18.2014). Although everyone interviewed also stated that during the Tokai flood they were not frightened and felt safe.

From the importance in the hierarchy of major disaster (earthquakes then floods) and some experiences related above, there will be considered that the need for cognitive dissonance to population inside exposed areas (Schoeneich and Busset-Henchoz, 1998) is a factor hindering the assessment of fear of flood disasters.

5.4.2.2 Hazard knowledge does not increase risk awareness, houses enhancements or evacuation decision taking

All the people interviewed have an excellent knowledge of local hazards in the Shonai river basin. This confirms the results of the Aichi prefecture questionnaire on evacuation (2011). However, during the interviews, the knowledge of hazards is always coupled with high trust that hazard

- **Could cause disaster before but not anymore**. The hazard map information has not changed the perception of risk in the area people live in. When people interviewed talked about the hazard in the area they live , they always referred to past hazards, and strongly felt that such hazards, like the Tokai flood, could not happen in the future. The main reason they gave was that because of the structural enhancements done on the Shonai and Shin rivers, there was no possibility of future flood disaster where they live. This demonstrates a high trust in the national and prefectural levees enhancements but also at some level a misunderstanding on the mitigation process.

- **Could cause disaster but somewhere else**. The first mention of disaster to people interviewed was always small disasters happening somewhere else than in the area they lived. This confirms a refusal of accepting flood risk and take measure against it despite a very good knowledge of hazards.

The current knowledge of hazard is therefore not a factor that could help enhancing resilience. It confirms the cognitive dissonance, and trends noticed since the second part of the 20th century in developed countries of a growing refusal of the risk and a demand for more protection and mitigation.

5.4.2.3 House ownership

During the interviews, only house owners were met; therefore there is impossibility in this research to comment on the relationship between measures taken and house renting. But because we talked essentially to house owners, we met only people living in the most common house type of building (building B) of individual household two stories house. And on the three persons who had damages in their houses during the Tokai flood (Hanako and Kaneyoshi in Kyiosu city in 2000, Ken in Nagoya city in 2008), the first ones did not do anything to enhance structurally their house after the Tokai flood, they rely on the house structural measures to fight urban floods (1 meter elevation) already in place in 2000 before the Tokai flood. However, when commenting on the neighborhood houses, they pointed out that heavily damaged houses (almost destroyed) were build anew with new flood structural measure enhancement but did not precise which type. Ken had his house damaged by the heavy rainfall accumulating on his house's rooftop in 2008. He made adjustments to the rooftop after the 2008 heavy rainfall but did not enhance his house at floor level. One last person we met was living in the northern part of Kiyosu city, and explained that the reason why he did not escape was that his house was destroyed during Meiji

Era due to a dam break in a pond north of Kiyosu, at that time his house was destroyed, and his family decided to rebuilt a house elevated in order to be able to withstand this kind of disaster (figure 5-17).

Figure 5-19 structural enhancements in Kiyosu city (photo M. Thomas, 09.18.2014)

The threshold level above which people will decide to structurally modify their house might therefore be linked to a former disaster if the damages were consequent enough to change the safety level of the house in order to withstand said disaster.

If so, this research points out the fact that after the Tokai flood very rare were the household enhancements and constructions that took into account the levee breach. The figure 5-18, 5-19 and 5-20 show photos of new houses complexes constructed near the Shin River. We used Google Earth street view to locate our photos with our GIS when we created the GIS maps, and the Google Earth Street view photo information is dated for our field study are for 2012 04. Those houses were built after 2012. Two interesting points come to mind, the first one is that urban growth continues in the northern part of Nagoya-city and new buildings (primarily buildings of type B) are constructed in risky areas. The second one is that those buildings do not take into account a potential levee breach (see figures 5-18 to 5-20).

Therefore, as for structural individual enhancement, there is a high probability that minor flood risk (less than one meter flood) is taken into account but not a potential levee breach, whereas in the northern Kiyosu neighborhood, houses rebuilt after the levee breach of the pound one century ago did take into account levee breaches (figure 5-17). Therefore an assumption can be made that the perception of national and prefectural structural measures (levees) and their hoped effectiveness had an impact increasing the vulnerability of housings exposition. It reflects a decrease the acceptance of flood risk by levee breach in general.

Figure 5-20 February 2012 construction on new housing complexes in Nishi ward near Shin River (google Earth street view photo)

Figure 5-21 houses constructed after 2012 with first floor inhabited (January 2014)

Figure 5-22 houses constructed after 2012 with first floor inhabited, structural enhancements for urban flood or small-scale flood (detail, January 2014)

5.4.2.4 Personal business ownership

The personal businesses have not been taken into account in the GIS mapping, it was considered that business were not households and therefore only households should be considered in the evacuation process, and if a building could have a double function (business and household), the household function would prime over the business function and these buildings have not been considered from a business point of view. However, during the last interviews (interview of 09.20.2014) a personal shop owner who told the author that in Kami Otai, the flood reached over one meter, and her shop (café) was flooded. She feared the flood for people in the streets; nevertheless she chose to stay and try to mitigate with tatamis her shop. This interview lead to understand that personal shop owners would have less inclination to evacuate than population who don't own shops in flood prone areas, because the stakes of protecting the business are more important than one's own life protection in case the first floor is still accessible and they can try to protect it.

5.4.2.5 Confidence in structural measures and disaster prevention system

The confidence in the structural measures and the disaster prevention system seem to have both good and bad impacts on the willingness to evacuate and recognize the flood risk.

5.4.2.5.1 Confidence in structural measures

Concerning the structural measures enhancement at the river level, there are many different perceptions according to the place people are living (more or less close to the levees, to Shin River or to Shonai River on Nagoya side). But most of the time, as a paradox, the structural enhancements between 2001 and 2006 are utilized as a reason not to mitigate or prepare for flood at the individual level.

5.4.2.5.2 Confidence in disaster prevention system

The good consequences of the confidence in disaster prevention system is that the communication between local flood disaster members and population, and between the population and middle school managers in charge of the evacuees is often considered as one thing that can be counted on during a disaster. More than the city level, the prefectural level or the national level, during a disaster the local level (family, school district acquaintances, neighbors) seem to play an important role in facilitating the return to a normal life for the population (shelter, help) and might be an explanatory factor for the "safe feeling" during a disaster despite the fear.

On another side, the intervention of the self-defense force was not praised, and very rarely mentioned by the population members interviewed.

5.4.2.6 Experience of the Tokai flood disaster

Some interviewed people relate neighbors, family or acquaintances' "bad" experience during the Tokai flood (stuck on a bridge with the car, impossibility to evacuate, or self-evacuating without help from flood fighting teams or national self-defense force encountered). In one rare occasion considered worth mentioning these bad experiences (real or not) were used as a reason explaining why evacuating was not something to be considered about. Paradoxically, the fact that nothing "bad" happened to people that didn't evacuate (in their words) but happened to people who evacuated (in their words) seems to lower the evacuation threshold.

Some other people, who did evacuate during the Tokai flood disaster, consider important to prepare better. If houses enhancements are still rare, decisions followed the Tokai flood that can impact many disasters like:

- Preparing in a better way emergency goods
- Putting the car in a safe high environment when heavy rainfall starts to pour
- Installing anti seismic protection against earthquake disaster in the house

The effectiveness of nonstructural measures like hazard maps is difficult to evaluate, because people who were willing to evacuate in 2000 did not face a problem concerning the place they should have evacuated to (like schools) but did evacuate at a difficult moment due to the levee breach. People not willing to evacuate during the

Tokai flood are not considering the place they should evacuate to as a factor worth mentioning either. Concerning risk probability assessment through hazard maps, the same kind of problem was encountered. There is a conscience at some level that flood risk is a probability, but there is also high cognitive dissonance and therefore lack of conscience that the hazard maps scenarios are a possibility.

To summarize: **Among the factors that do not seem to play a role in the decision-taking process to evacuate, the fear of flood and the hazard knowledge are two factors linkable to the "cognitive dissonance" occurring when people live in risky areas. The fear of flood is felt but not related to the decision-taking process and the hazard knowledge is more linkable to a need for assurance (comparison of "here" = safe to "somewhere else" or "in the past" = not safe). Comparing particular old households in northern Kiyosu-city and newly constructed housing in Nagoya, there is an acceptance of flood risk seemingly diminishing nowadays (acceptance of small flood but not major flood and structural personal enhancements in accordance to the flood level accepted). When it comes to evacuation alone, there is also a factor hindering the evacuation decision process when the housing is also used as a personal business, protecting the business assets will be preferred to evacuate. The confidence in national to local structural and nonstructural measures should be linked to the experience of the Tokai flood and the evacuation lived at that time. The factor increasing risk awareness and motivating people to evacuate sooner is the "good evacuation" process perceived during the last disaster. If the experience of evacuation during the Tokai flood was perceived as good, people seem to have fewer difficulties to improve their resilience and seem to be willing to evacuate sooner for the next flood.**

5.5 Threshold for evacuation and personal structural enhancements

The few people interviewed who evacuated or were evacuated were located in

Kiyosu-city. The interesting thing the author would like to point out is that there seems to have been two times in Kiyosu for the Tokai flood disaster: September 11th 2000 before the levee breach in Nishi ward and September 12th after the levee breach. People who did evacuate told (all three, two families, interviews of the 09.18.2014, and 09.09.2014) that they waited to evacuate feeling rather safe during the first day. However, the second day, due to the levee breach, water came up to the second floor quickly, electricity and water (toilet, baths, kitchen) were out of use, and it was then that they felt greatly the need for evacuation but they could not escape anymore and had to wait for flood fighting teams, and both families had to wait for the rescue boats to come.

The threshold seems not to be triggered by “minor” floods (below 1 meter), but by extreme major floods. All interviewees told that they were thinking about evacuating earlier if another disaster should happen, and have taken measures to mitigate floods. However, they told us that they did not felt danger in 2011, due to the structural enhancements after the Tokai flood.

There is a lack of data to back up the following hypothesis; however, the levee breach experience of 2000 could have been the triggering event for the evacuation in 2011 in the lower reach area (Kiyosu-city, Ooharu-city and Ama-city especially have evacuation ratios important for the lower reach population). Moreover, it was a frightening event that encouraged people to take individual measures to protect themselves. By extrapolation, it can be assumed that the higher ratios of people evacuating in the lower reach in 2011 could be related to the levee breach during the Tokai flood in 2000 and the willingness to evacuate earlier, see the reproduction of figure 3-20 p. 83: figure 5-21 (Ooharu, Ama, Kiyosu). The evacuation ratio was evaluated for the whole Nagoya-city and numbers were not accessible for the ward of city-blocks level, therefore no further comment can be added for the megacity evacuation willingness evolution from this map. The city of North-Nagoya stands out, because it was heavily flooded during 2000 (Zhai, 2006), however it was principally flooded due to Shin levees overflow, not levee breaches. It can be assumed therefore that the improvement of the evacuation ratio was caused by the experience of the secondary event of the Tokai flood (12th levee breaches in the morning). For the upper reach, especially Tajimi no further comment can be added.

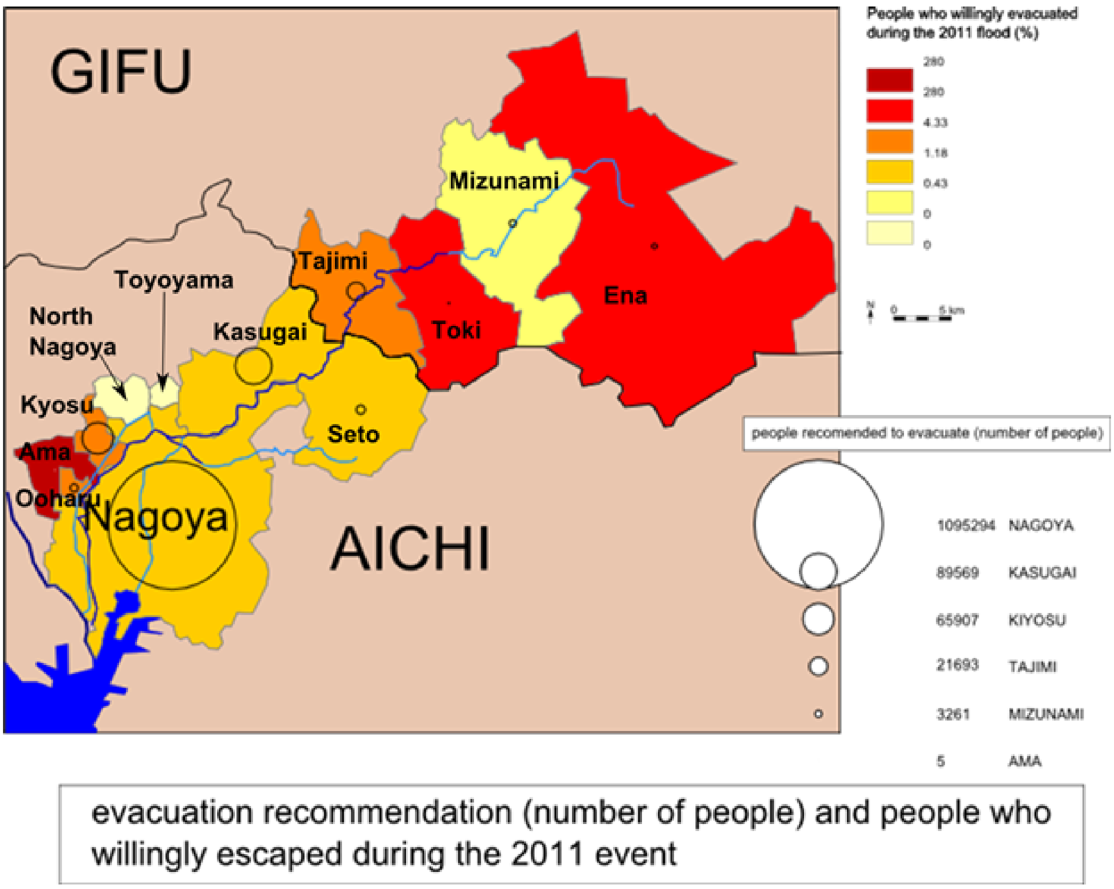


Figure 5-23 evacuation recommendation and people willingly escaping at river basin scale in 2011 (M. Thomas, Philcarto and Inkscape, 2012)

To summarize: **the thresholds for evacuation and personal structural enhancements seem to be linked together. If there is a willingness to protect one's own house for "small floods" like urban floods (1 meter flooded at most), the decision for evacuation during the Tokai flood by the residents interviewed living in Kiyosu-city followed the same logic: before a lack of electricity and water supply the evacuation is threshold was not reached during the Tokai flood. Therefore the evacuation for the residents interviewed in Kiyosu-city who**

evacuated did it after the 12th September when the levees broke on the Shin River. There is nevertheless in the lower reach of the Shonai river basin an increase in the population evacuation ratios in 2011 which could mean that the Tokai flood disaster increased the willingness to evacuate for population highly flooded.

5.6 The nonstructural measures changes assessment factors setup and application

5.6.1 The factors leading to change

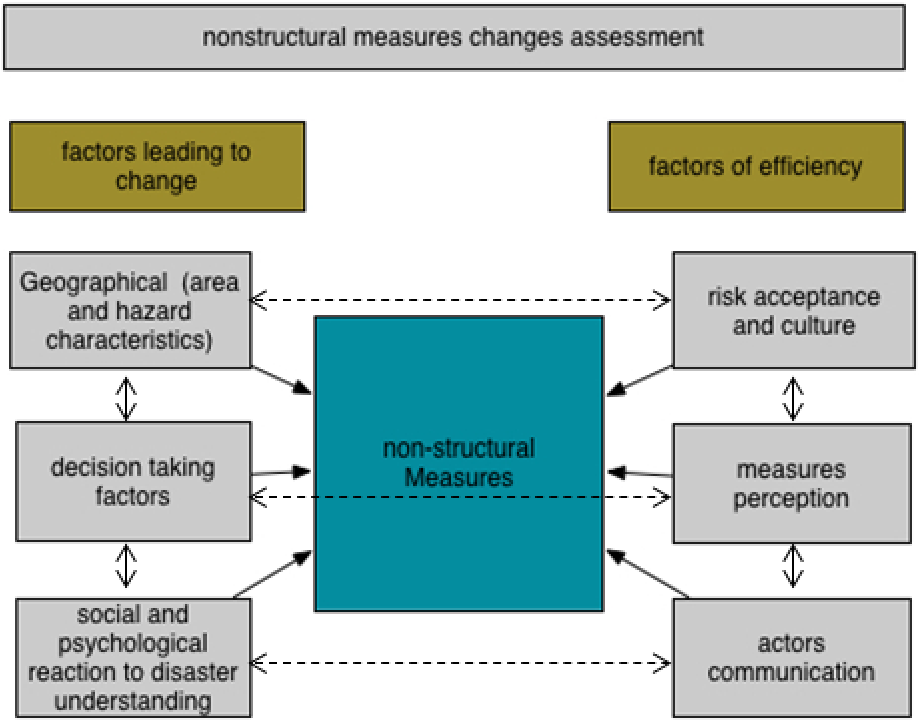


Figure 5-24 nonstructural measure changes assessment relations

The geographical factors (area and hazard characteristics)

The geographical factors are the same for the structural factors leading to change model and for the nonstructural factors leading to change model, it is the combination of a human settlement at high vulnerability and the probability of occurrence of a hazard of high intensity.

The decision taking factors

The nonstructural measures aim to reduce not only the structural exposure (buildings and general area exposed) but also the human and the functional exposure. Therefore, the decision taking factors did not only depend on the cost of the Tokai flood in terms of human lives, but also on an emergency response process evaluated not enough effective. The opinions can vary from interviews to interviews, for example, the Nagoya-city disaster prevention office representative interviewed stated that the evacuation should be enhanced and was not good enough, on the other hand the Nishi ward office social affairs representative (in charge of the evacuation process at local level) considered that considering the Tokai flood situation in 2000, the evacuation process was a success. These differences in evaluation can be linked to the responsibility some offices and especially the mayor office bears when it comes to the evacuation process and the information sending. The decision taking factors in case of the enhancements or changes in nonstructural measures seem therefore be linked to the reduction of the functional exposure (inability of the function of a system to work in case of a flood). Of course the casualties and therefore the human exposure reduction goal have played a role in the decision-taking process.

Social and psychological reaction to disaster understanding

The social and psychological reaction to disaster are considered a factor leading to change because under certain threshold the social and psychological reaction to disaster might not be the most adapted one. For example, the threshold is very high when it comes to evacuation decision making (for almost all interviewees that did evacuate, it was a flood hindering all function of the house and the water level in the urban area could reach up to 1.60 meter high). Past the threshold however, decisions will be taken, in regards to flood risk (placing cars in high spaces, preparing disaster goods for the case of a disaster). The limit of the nonstructural measure decision making in relation to social and psychological reaction to disaster understanding will be from a population viewpoint the most important one, the reduction of the household structural exposure, which seem to be setup only after a building has been damaged or worse and raise other questions.

From the viewpoint of the local and city offices these social and psychological reaction to disaster have to be understood in order to setup information measures that could help the increase the willingness to take action in case of a disaster and to prepare for it. However this understanding seems to be limited, and the nonstructural measures setup up to date contain information of give information that the population member either have difficulties to understand or already know, as it was the case for the hazard maps (knowledge of closest shelters for most interviewees and difficulty to acknowledge the hazard probability of occurrence).

Risk acceptance and culture

The risk acceptance and culture factors are to be linked to past history of the area (knowledge of a past event that lead to change or not from the northern Kiyosu interview of the 2014.09.08), or to past history of the individual or family (experience of a former disaster during one lifetime should increase the risk awareness according to Holle, 2007) the resilience through social capital (people who evacuated did not used the official shelters like schools as permanent shelters but as stopping area where they stayed one night before going to a family member living in a near city that wasn't flooded) and general national risk acceptance (arguments in favor of a "Japanese specificity" for risk acceptance described in chapter 1).

Measure perception

The nonstructural measure perception will depend of other (structural national) measures perceptions (arguments against evacuation because of structural national enhancements), of the decision taking factors (for evacuation the threshold for evacuation is very high, therefore all measure corresponding to a potential low threshold for evacuation like deciding to evacuate when receiving an evacuation recommendation and not when the area starts to be flooded have a low impact), a social and psychological reaction to disaster understanding (difficulty for information at population disposal to achieve its purpose because unwillingness to accept “dangerous” – more than one meter – flood risk in the area lived in) and of course the geographical factors at the origin of the flood risk.

Actors communication

The actors communication depends on the ability to create and diffuse understandable and usable contents for the local official actors, and the willingness of the population to accept the flood risk and therefore past over the cognitive dissonance to flood risk.

The actors’ communication can also be hindered by different formations, purposes and actions in the risk management system (difficulty for Medias and disaster prevention to be understood by each other for example like it was the case during the 2011 flood event evacuation recommendation launch according to Nagoya disaster prevention representative, 2012.12.19).

Systemic point of view and difficulty to assess the nonstructural measures changes

The structural measure aim primarily at the structural (building, housing, structures) exposition reduction and can be geographically localized and quantitatively analyzed. The nonstructural measures aim at the reduction of human and functional exposure, which is very much depending on retroactions in a system which limits are still difficult to assess today. Therefore the assessment of nonstructural measures changes is still very difficult.

5.7 Conclusion of chapter 5: different timelines for the changes and different thresholds for the different actors of the flood risk:

To conclude this chapter, the author would like to point out that the main differences between the structural measures impact and the nonstructural measures impact might be related to the different timeline they act upon.

- National and prefectural Structural measures effectiveness can be determined as soon as the enhancement works are finished
- Personal structural measures could have the same effectiveness level, however the threshold that lead to high enhancements on personal housing depends on several factors:
  - The type of disaster people will enhance their house against (urban flood, river flood, levee breach)
  - The time people do put structural enhancement in place (enhancements for 2 meters a century ago when today enhancements at one meter or less seem to be more the norm for personal houses)
- Nonstructural measures aim to increase efficiency by developing risk awareness and decision taking threshold evaluation is even more difficult to evaluate
  - The hazard knowledge and the disaster fear does not seem to play a role in decision making and evacuation
  - The experience of a disaster seems to play a role however
    - More than the disaster experience, the knowledge of one's area and the social capital (neighbors, friends, family) seems a motivating factor for threshold reaching and decision taking
    - The Tokai flood experience can have had very bad consequences on some people who considered the evacuation too dangerous and their home too safe to want to evacuate

- The experience of a disaster and the impact it has on population does not seem to be limited to flood only, but seem to be part of a general risk culture understanding earthquake protection as well
- The objectives of everyone (saving the business, saving the kids) will have an impact of the evacuation willingness.

Concerning the personal resilience, it should be pointed out that **the resilience level of the population facing flood was high before the Tokai flood, and is still high, even if it could be enhanced**. During the Tokai flood, only four people perished. Two people died due to heart attacks in their houses, one died in a small landslide, and only one supposed death (disappearance) could have been caused by the flood when a young 20 year old disappear in the Nagoya Shonai-gawa Park that was at the time flooded.

Therefore the 2000-2011 period shows **high enhancements in structural national and prefectural measures and as a consequence resilience increase for the mitigation, preparedness and response in terms of flood risk general exposure**. Those measures effectiveness is quite easy to evaluate, even without quantitative analysis, only by the comparison of area flooded between 2000 and 2011.

However, the resilience of individuals is more difficult to assess, **depending on a longer history of flood risk culture and acceptance**. Being relatively high in 2000, it is difficult to say that it increased in ten years. What is possible to say, though, is that there **were no clear improvements of the nonstructural measures setup by the mayor office concerning their perceived reception by the population.** It seems that the information given by the mayor office fits the needs for information only partially.

In order to enhance the nonstructural measures impact, **more integrated risk governance at the bottom of the risk management pyramid could be enhanced**. Between 2000 and 2011 enhancements in risk governance were realized still in a top-down way of thinking disaster management, and these enhancements have been proved extremely effective during the past flood events, transforming flood disaster into simple flood events. However, there is a very high social resilience and the social capital (volunteers, NPO commitment to help, and very local emergency support for evacuees) are extremely developed; social capital and resilience could be more exploited at the neighborhood and local level, by a closer inclusion of past disaster experience assessment of population representative, local ward disaster prevention and firefighting teams and NPOs in order to create tools that fit in a better way needs for both the mayor office and the population. The major remaining problem seems to be the risk acceptance level, and the willingness to accept major flood disasters.

6 CHAPTER 6

conclusive chapter what did we learn, what should we learn more?

6.1 Shift towards a better risk governance

6.1.1 Inclusion in the disaster prevention management official system of more diverse actors brings long-term resilience

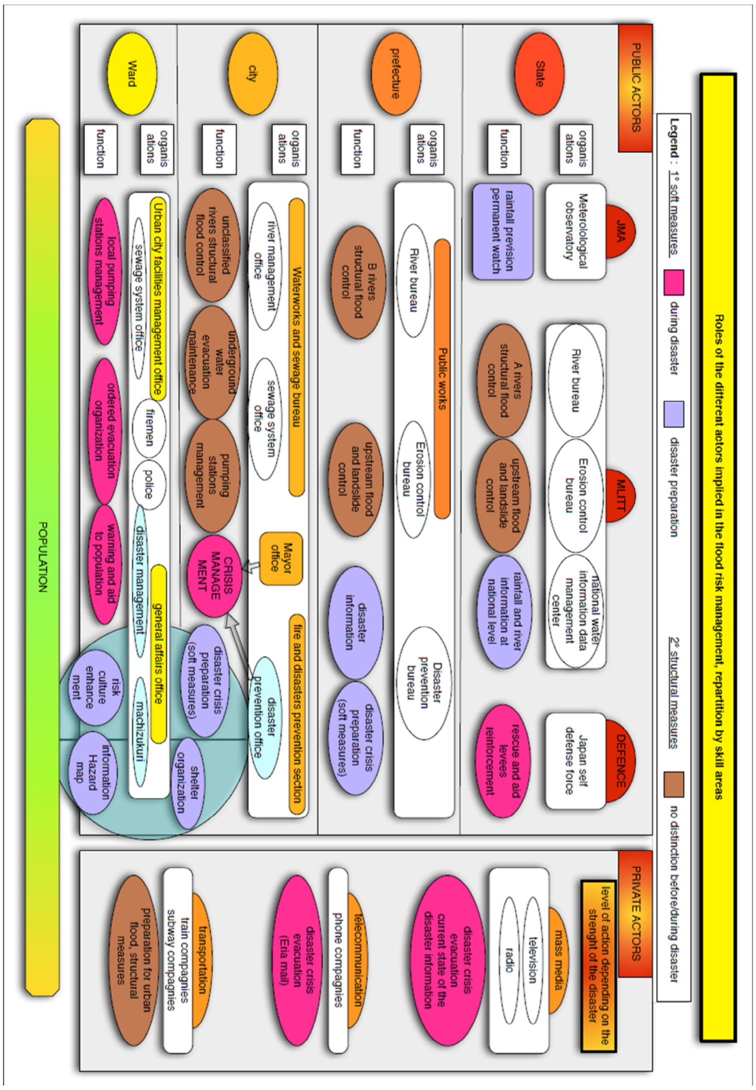


Figure 6-1 different flood disaster actors and their roles in disaster management

The structural improvements on the Shonai and Shin river adaptation proved effective during the 2011 flood disaster, and there are now integrated in a better way to the whole disaster prevention.

Since the 2000 disaster a focus has been put on integrating in a better way disaster prevention managers and hazard mitigation managers through consultation and action-to-take scenarios based on the hazard evolution in the river and the time actions take to be setup. This has greatly improved the evacuation warning and it will improve more the disaster management resilience at long-term bringing more risk governance for flood risk in Japan.

6.1.2 Unofficial actors and official actor communication contribution to disaster resilience is changing too

Unofficial actors of the disaster management here are the actors that have a role in disaster prevention but are not yet fully integrated to the disaster prevention system. The different Medias full integration has been largely developed through the evacuation area mail sending system and the enhancement of television and radio network to diffuse information to residents living in risky areas. Their integration should lead to quicker and clearer information release in the future

The NPO role is not as well defined yet in disaster prevention. NPO actors are somewhat integrated to risk governance but from a more bottom-up perspective and there is yet no official system that integrated them. They could help in setting up assessment on coping during the response time and the recovery time, and be a good link between small scale and large scale actors.

6.2 Difficulty to reach efficiency in risk management

6.2.1 Individual information acknowledgement and adaptation difficult

Since the Tokai flood has been experienced in many different ways, the adaptation assessment is difficult to setup. However, we consider worthwhile to notice that people who lived an integrated evacuation during the Tokai flood and have been taken care of by small scale actors (flood fighting teams, evacuation in shelters…) tend to take more responsibilities in their resilience to flood risk than the one unwilling to evacuate in the first place. From risk governance viewpoint it would be interesting to do more research about the relationship between the way people take responsibilities to mitigate, prevent, cope with and recover from disaster and their experience and/or perception of the risk management system as a whole.

The efficiency of evacuation warnings and hazard maps is difficult to assess too, because the threshold for evacuation during the Tokai flood was increasing the vulnerability to floods (waiting to have water at the second floor in some cases), the urban flood seem not to be a flood risk considered as worth evacuating for, and the empirical personal knowledge of shelters seems to be good enough. Therefore the pertinence of hazard maps information is very relative and complementary research on the factors that can improve evacuation mitigation or preparedness decision taking would be useful.

6.2.2 Evacuation process as an example of effectiveness at short term could be integrated in a better way to the recovery process, especially considering the elderly who have more difficulties to be resilient.

Studying the changes in disaster prevention, we had to focus on the "response" time of the disaster. This can hinder some of the vulnerability factors of the whole disaster prevention process. By focusing on structural enhancements and evacuation effectiveness, we have to assess

- The **effectiveness of the structural measures enhancement** in the Shonai river basin, especially for the emergency structural measures setup between 2001 and 2006 which are a major factor of exposure reduction and resilience enhancement

- The difficulty to assess population explaining factors for low evacuation numbers and difficulty to pass threshold to setup personal structural measure enhancement on their propriety. However it is also necessary to stress out that the evacuation is not the most important factor of vulnerability for a Tokai flood type of event, du to housing building type (often evacuation upstairs is possible even if water and electricity could be a problem – but in shelters the same problem would happen and the disaster time is short).

Focusing on the changes in adaptation and on disasters like we did through the evacuation helped to contain our research subject. Nut more research should be underdone on the long term recovery projects, especially for the elderly people who are more vulnerable and often have less social capital to strengthen their resilience to flood disasters.

6.3 Contribution to concepts enhancements: dealing with complicated disaster with simple concepts?

6.3.1 The focus on changes in adaptation allowed us to distinguished several types of vulnerability and resilience factors

From a focus on change, we had to focus on thresholds that lead to change. Thresholds leading to change are difficult to establish at population level, however considering the low numbers of fatalities per flood disaster, we have to assume that the general resilience of population to disaster is high. The residual vulnerability can be caused by

- House ownership
- Confidence in structural measures and disaster prevention system (communication understood and perception positive)
- experience of the Tokai flood disaster revealing the actions to take and encouraging personal decision making

However, keeping the concepts and the factors that can modify vulnerability or resilience is difficult, especially when confronted to changes as different as changes in structural enhancements and changes or lack of changes in risk awareness, perception, and decision taking.

6.3.2 But the human interactions (risk management, risk governance) poses still a problem, as the evaluation of human behavior cannot be clearly calculated

From an integrated viewpoint, analytic and quantitative research is needed concerning the human behavior changes and the threshold reaching point more clearly. We hope nevertheless that a systemic approach helped to highlight factors that can hinder or increase the long term resilience of a disaster prevention system in flood risk management.

6.3.3 Keeping the vulnerability and concepts simple, were useful but we have to notice a loss in terms of "domino effect" acknowledgement

The domino effects of the disaster have not been studied in detail in this research. However, the Tokai flood is a good example of domino effect disaster at small scale, since it was at the same time an urban flood, a flood by levee overflow and especially a flood by levee breach. The levee breach in Nishi near Kami Otai and in Kiyosu had consequences that handicapped the response time of the disaster (water supply problem, electricity breakdown) to the recovery process (evacuation of garbage after the flood due to water level reaching households).

Considering the increasing studying of "systems" of risk or on which the disaster occurs, and considering the latest big catastrophe of the 21st century being the Tohoku earthquake and its consequences on 2011 Mach 11, the domino effect of disasters should definitely be assessed and confronted to studies concentrating on only parts of the disaster, or of the disaster management.

6.4 The evolution of Japanese risk management should be also studied from the viewpoint of Japanese concepts in metropolitan situation

From a risk/disaster conceptual viewpoint, the flood risk management changes tend to show a management that is both dealing on the disaster, and more specifically the most recent disaster that just passed, and the long-term risk management and risk governance improvements.

From a vulnerability and resilience viewpoint in adaptation to flood risk, a focus on different thresholds leading to changes, or lack of thresholds reaching should help to reach better understanding of the disaster prevention system and the moment and reason vulnerability factors are possible to change into resilience factors.

This study helped enhance conceptual research on occidental concepts in foreign field area, however, the contribution of Japanese concepts should be assessed too in order to be able to make a comparison of the advantages and disadvantages of the two approaches, and maybe create a hybrid methodology for adaptation.

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ACRONYMS

PRIM: Prevention des RIsques Majeurs (major risks prevention office website) www.**prim**.net/

JMA: Japan Meteorological Agency http://www.jma.go.jp/jma/indexe.html (English version)

MLITT: Ministry of Land, Infrastructures, Transport and Tourism http://www.mlit.go.jp/en/index.html (English version)

IPCC: Intergovernmental Panel on Climate Change

OECD: Organization for Economic Cooperation and development

UNISDR: United Nations International Strategy for Disaster Reduction

HFA: Hyogo Framework for Action

INDNR: International Decade for Natural Disaster Reduction

HWR: High Water Level

DID: Densely inhabited district

APPENDIX

1. Interviews list

For population members, the names have been changed in order to preserve their anonymity.

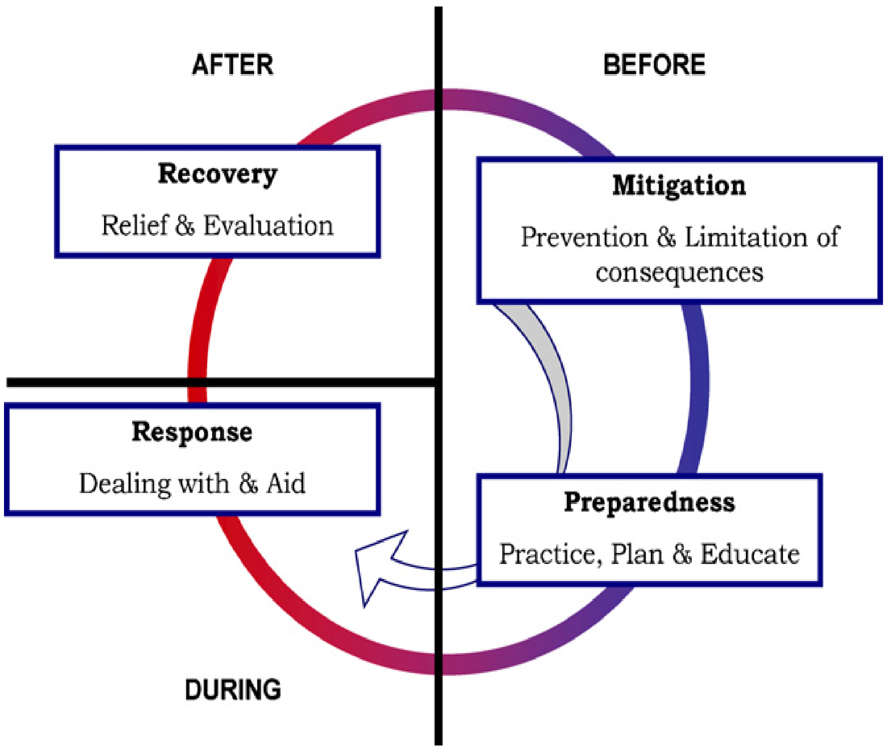
INTERVIEW LIST		
INTERVIEWS TO RISK MANAGERS		
	function	date
1	Shonai River bureau representative	2012.12.12
2	Japan meteorological agency representative	2012.11.21
3	Shin River bureau representative	2013.02.13
4	Rescue Stockyard NPO member (action during Tokai flood)	2014.08.22
5	Rescue Stockyard NPO member (action on Tohoku area after 2011.03.11)	2014.09.18
6	Nagoya-city River Bureau representative	2012.12.19
7	Nagoya-city disaster mitigation bureau representative	2012.12.19
8		2012.09.20
9	Nagoya-city underground water management department representative	2012.12.19
10	Nagoya-city Nishi ward social affairs representative	2012.04.04
11	Nagoya-city Kita ward social affairs representative	2012.06.06
12	Nagoya-city Moriyama ward social affairs representative	2012.10.03
13	Nagoya-city Nakamura ward social affairs representative	2012.11.14
14	Nagoya-city Nakagawa ward social affairs representative	2013..03.15
15	Nagoya-city Showa ward social affairs representative	2013.02.06
16	Nagoya-city Minato ward social affairs representative	2013.02.28
17	Kiyosu-city social affairs representative	2012.11.29
18	Nagoya-city Nishi ward underground water management sub-department representative	2012.04.04

19	Nagoya-city Nishi ward fire-fighting team member representative	2012.04.12
20	Nagoya-city Kita ward underground water management sub-department representative	2012.06.06
21	Nagoya-city Kita ward fire-fighting team member representative	2012.06.20
22	Nagoya-city Moriyama ward underground water management sub-department representative	2012.10.03
23	Nagoya-city Moriyama ward fire-fighting team member representative	2012.10.22
24	Nagoya-city Nakamura ward underground water management sub-department representative	2013.01.30
25	Nagoya-city Nakamura ward fire-fighting team member representative	2012.12.03
26	Nagoya-city Nakagawa ward underground water management sub-department representative	2013.03.28
27	Nagoya-city Nakagawa ward fire-fighting team member representative	2013.04.19
28	Nagoya University environment system analysis and planning laboratory professor	2012.08.23
29	Nagoya University geography laboratory urbanism professor	2013.10.17
30	Kiyosu-city middle-school director (flooded situation)	2014.09.18
31	Kiyosu-city middle-school teacher (flooded situation)	2014.09.18
32	Kiyosu-city middle-school teacher (not flooded situation)	2014.09.08
INTERVIEWS TO POPULATION		
1	Akane (Tenpaku river flooding experience)	2013.10.09
2	Hanako (flood evacuation in Kiyosu-city)	2014.09.19
3	Kaneyoshi (flood evacuation in Kiyosu-city)	2014.09.19
4	Ito (no evacuation in Nishi ward in 2000)	2013.03.10
5	Hajime (self-evacuation after levee breach in 2000)	2014.09.20
6	Yoshie (café owner in Kami Otai)	2014.09.20
7	Masao (non-evacuation in northern Kiyosu in 2000)	2014.09.08

8	Ken (no evacuation because no flood in 2000 but flooded in 2008)	2013.06.16
9	Izumi (flood evacuation in Kiyosu-city in 2000)	2014.09.19
10	Miki (flood evacuation in Kiyosu-city in 2000)	
11	Makoto (evacuation to family during 2000 flood)	2014.09.25
12	Azumi (evacuation to family + child experience of 2000 flood)	2014.08.22
13	Yui (Evacuation in Kiyosu-city after levee breach in 2000)	2014.10.08
14	Hanna (evacuation in Kiyosu-city after levee breach in 2000)	2014.10.09
15	Hideyuki (no evacuation in Nishi ward in 2000)	2013.03.10
16	Koide (evacuation in Kiyosu-city after levee breach in 2000)	2014.10.08
17	Kai (evacuation in Kiyosu-city after levee breach in 2000)	2014.10.09

2. Times of the disaster model

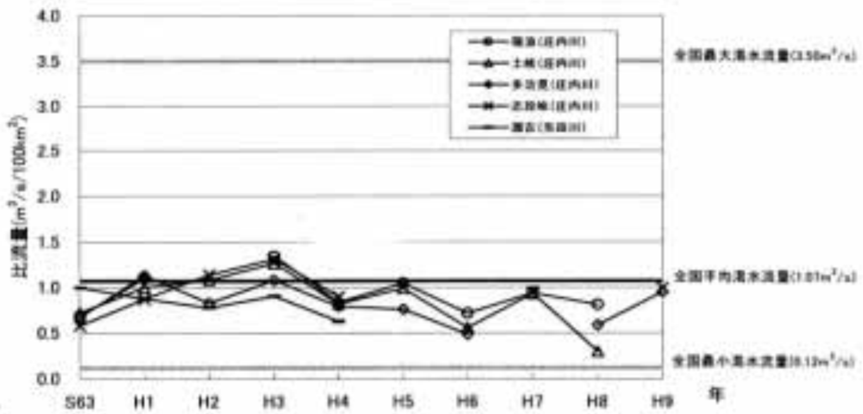
"Resilient communities have an improved capacity in each of the phases of flood management cycle" (Schelfaut et al 2011)



3. Flow regime changes 1988-1997 in the Shonai river basin (World meteorological Organization, 2004)

河川名	地点名	流域面積 (km²)	流況 (m³/s)				対象年
			豊水	平水	低水	渇水	
庄内川	枇杷島	705. 0	25. 98	15. 17	10. 68	6. 76	S63～H9
	(比流量)		3. 68	2. 15	1. 51	0. 96	
	志段味	532. 0	21. 21	12. 15	8. 22	5. 15	
	(比流量)		3. 99	2. 28	1. 54	0. 97	
	多治見	367. 0	13. 89	8. 07	5. 20	2. 97	
	(比流量)		3. 78	2. 20	1. 42	0. 81	
	土岐	284. 0	10. 33	5. 99	4. 11	2. 43	
	(比流量)		3. 63	2. 11	1. 44	0. 85	
	瑞浪	209. 0	7. 92	4. 76	3. 22	1. 96	
	(比流量)		3. 79	2. 28	1. 54	0. 94	
矢田川	瀬古	105. 0	4. 17	2. 69	1. 98	1. 32	
	(比流量)		3. 97	2. 56	1. 89	1. 26	

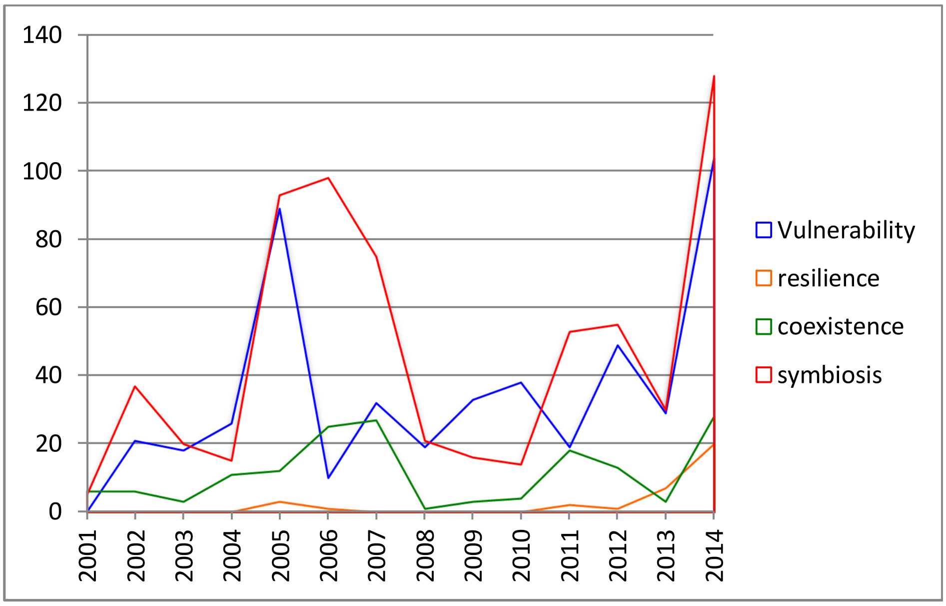
*比流量の単位は、m³/s/100km²



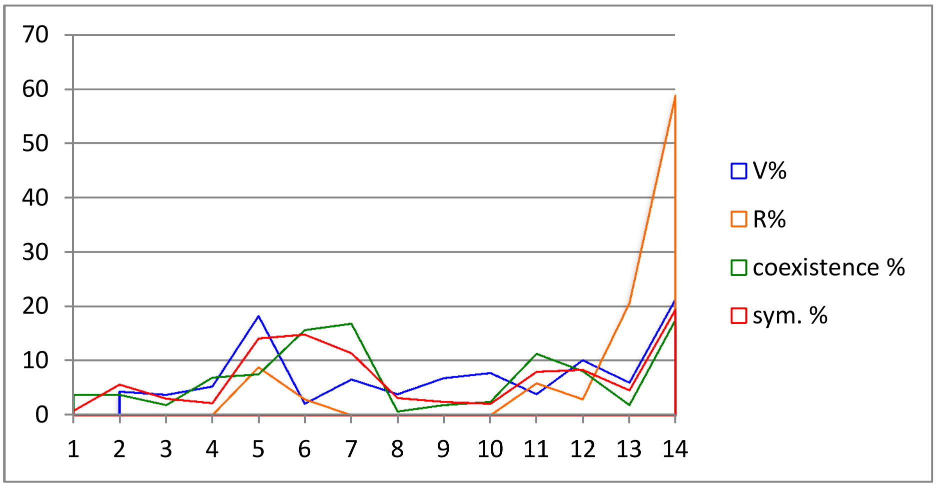
注) 全国の渇水流量は一級河川（109 水系）の基準点における渇水流量（観測年全年平均）の最大値、最小値、平均値を示した。

4. Land-use changes in Nagoya-city (World meteorological Organization, 2004)

5. Occurrences and percentages of occurrences of concepts in grey literature on the disaster prevention website



The Above figure shows the occurrences of the occidental concepts vulnerability and resilience in regard to the Japanese concepts symbiosis and coexistence for every year from 2001 to 2014.



Occurrences of the occidental concepts in percentage per year for the 2001-2014 period (V% = Vulnerability and R% = Resilience) in regard to the Japanese concepts of symbiosis and coexistence.