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Research Master Planning and Sustainability: Urban and Regional Planning

Mobility analysis of shelters distribution in the city of Nice

Emergency situation & Evacuation

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Table of Contents

List of Figure

List of Annexure

Chapter 1: Introduction

An evacuation plan allows one to analyse and reduce risk and its relative exposure component. Evacuation planning has been developed for different systems (single building, land system, transport system and industrial system). In recent years, modelling tools, Decision Support Systems (DSS) and real experimentations (or exercises) to simulate and to implement an evacuation have been developed. These tools assist decision makers in preparing evacuation plans.

A generic evacuation plan is characterised by means of different elements (resources, strategies, objectives ...). Single elements can be analysed by means of specific indicators. Based on these elements and relative indicators, different evacuation plans can be compared.

In this research our main aim to analyse the evacuation plans using different methods. Therefore, we chose to use two methods, the first is to use network analysis using GIS and the second using algorithm using Python programming language.

Chapter 2: Literature Review:

2.1 Disaster Risk Management:

UNISDR10 defines a disaster as a serious disturbance in the community of a community or society that causes human, material, economic or environmental losses that exceed the capacity of the community or society affected to meet its own resources. A disaster arises from the combination of the hazard event or episode, the conditions of vulnerability to this risk and the insufficient capacity or measures to deal with the danger.

According to the statistics of reported disaster data (EM-DAT11), the global trend over the last four decades shows a considerable increase in the number of natural disasters (floods, droughts, wildfires, etc.) and an increase in the number of people affected by these natural disasters. Disaster impacts have an upward trend as a result of the combination of increasing populations, greater concentrations of people and the placing of assets in vulnerable areas, modification and degradation of natural environments, for instance, soil erosion, deforestation, river channelling and land fertility decline. On the other hand, vulnerability to hazards is aggravated by poverty, conflict, diseases and population displacement.

Figure 1 reports that the number of natural disasters has more than tripled since 1975 in the world; however, it can be appreciated that there has been a slight reduction in recent years. In terms of the number of people affected by natural disasters, the trend shows an increase but there is huge variation between years. Although the reported number of people killed by natural disasters has halved since 1975, there is also a significant variation between years.

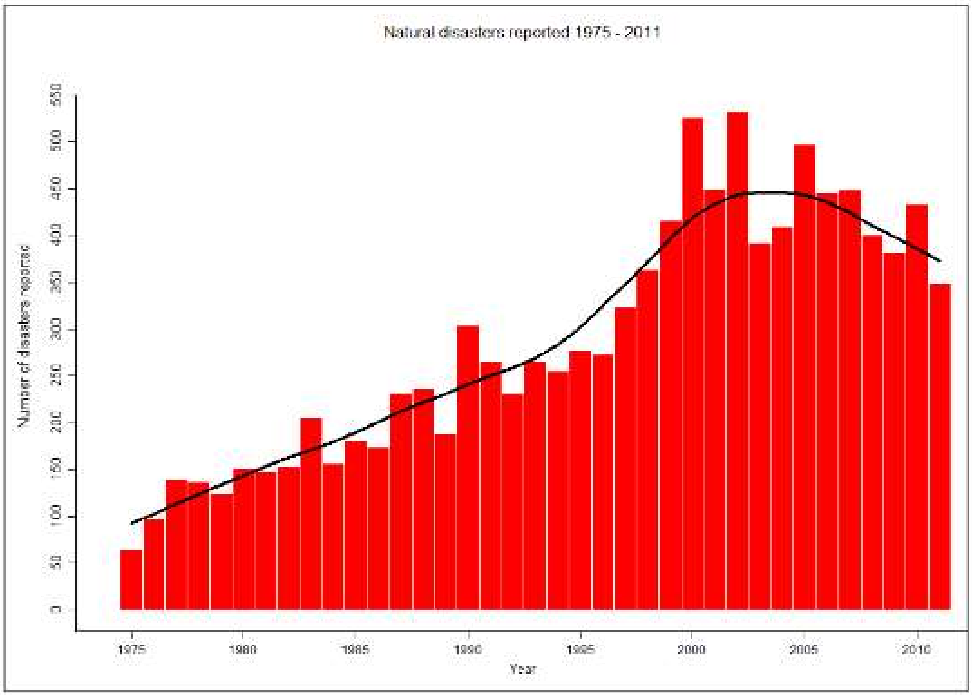

Figure 1: Number of natural disasters since 1975

Source: reported disaster data (EM-DAT11), The definition of a flood as used by the World Bank12 is “An overflowing or irruption of a great body of water over land in a built-up area not usually submerged”. These natural disasters are the most destructive events in terms of lives and damage losses. In Bolivia, it is now increasingly accepted that flood risk cannot be eliminated. However, disaster risk management activities can reduce the likelihood of flood events and can reduce the impact of floods.

Due to the fact that disaster occurs when hazards and vulnerability meet, defining these components is crucial to the basic understanding of disaster management. According to UNISDR13, a danger hazard can be defined as a serious disturbance in the functioning of a community or society that causes human, material, economic or environmental losses. that exceed the capacity of the affected community or society to manage its resources. It is important to note that hazards are dynamic and with highly varying potential impacts. Hazards can be classified into natural disasters or manmade disasters. Because this MSc Thesis focuses on natural disasters, manmade disasters are not further described.

Natural type of risks hazards can be separated into three broad categories: hydrometeorological, biological and geological. All over the world, hydrometeorological risks are the most common and flooding alone accounts for two thirds of people affected by natural hazards. Hydrometeorological hazards are defined by UNISDR as natural processes or phenomena of atmospheric, hydrological or oceanographic nature. Some examples are floods, droughts, temperature extremes, tropical cyclones, etc.

Most of the disaster management, from an operational point of view, has focused on the development of an emergency plan (Quarantelli 1986, Faupel 1987); however, according to Aguirre (1994, 2), “despite its obvious relevance to preparedness activities, planning for disasters has not received a great deal of research attention in the social sciences.” Much of the research has been devoted to post-disaster sociological or psychological studies (Pearce 2000).

Drabek (1986), Quarantelli (1986) and Faupel (1987) said that the disaster management process consists of a series of activities that precede, continue during and after a disaster. Drabek (1986) expands the concept of disaster management to conform to the nomenclature proposed in the 1979 National Governors’ Association report entitled
Comprehensive Emergency Management: A Governor’s Guide. This concept includes four phases:

1. Preparedness Planning Warning	**2. Recovery** Restoration (6 mos. or less) Reconstruction (6 mos. or more)
3. Response -Evacuation and Pre-Impact Mobilization -Post-Impact Emergency Actions	**4. Mitigation** Hazard Perceptions Adjustments

Figure 2: Concept of Disaster Management

Source: (Pearce 2000)

This framework suggests a linear approach to disaster management, while others praise a circular (Quarantelli 1981). Drabek also omits the reference to the development, training and testing of the plan. According to Quarantelli, I declare that the disaster management process includes activities in six areas: (1) hazard, risk, and vulnerability (HRV) analysis; (2)

mitigation; (3) response (including alert and warning, impact, immediate post-impact, and rescue); (4) recovery and reconstruction; (5) education and training; and (6) exercising or testing of emergency plans.

The HRV analysis is included as a step in a circular disasters management process in which, even if an activity clearly leads to the next one, the activities in a given pass influence those of all the steps. (see Figure 3). In other words, Figure 3shows that (1) the disaster management process is circular rather than linear; (2) each step in this process is distinct; and (3) each step affects every other step.

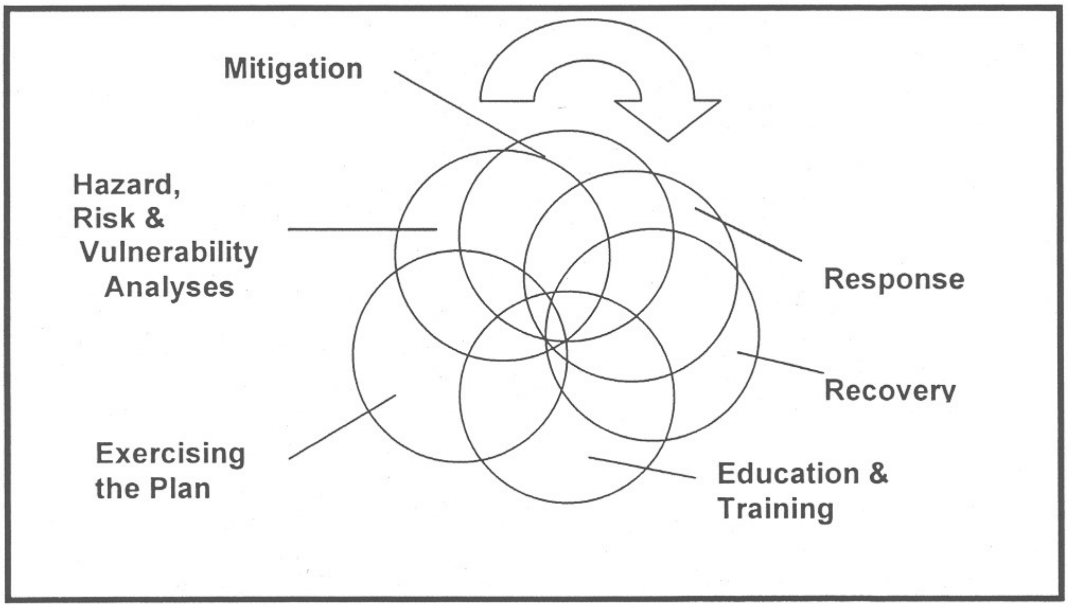

Figure 3: The Disaster Management Process

Source: (Pearce 2000)

2.2 Vulnerability:

Vulnerability reflects the state of the individual and collective physical, economic, environmental and social conditions at hand. These are shaped continually by attitudes, behaviour and cultural, socio-economic and political influences on individuals, families, communities and countries. Vulnerabilities can be classified into physical, socio-economic and environmental vulnerability (Goldblatt 2005).

Physical vulnerability can be described as a natural disaster but is only a disaster because people are in the wrong place at the wrong time and had no choice but to be in the way of a disaster or were caught unawares when it struck. It can be determined by features such as population density levels, remoteness of a community, site, and resources used for critical housing and infrastructure.

Economic status, reserves, levels of debt and the degree of access to credit, loans and insurance for individuals, communities and nations establish the level of economic vulnerability. Generally, the poor are far more vulnerable than economically better off segments of society. As a result, the probability of proportional losses when a disaster occurs is higher among the poor. Moreover, poorer people tend to have a more limited capacity to recover from disasters.

Social-economic vulnerability is further divided into economic and social vulnerability. Vulnerability can be determined by aspects related to levels of literacy and education, the existence of peace and security, access to basic human rights, systems of good governance, social equity, positive traditional values, customs and ideological beliefs, and overall collective organizational systems. Institutional organizations and their governance structures also play an important role in levels of social vulnerability. Generally, people less privileged in class or caste structures, ethnic minorities, young and old people, women, disabled and other disadvantaged and marginalized segments of the population are more vulnerable. Traditional knowledge systems and some cultural aspects, for instance, indigenous beliefs and traditions are decisive factors in people's perception of risk. Furthermore, environmental vulnerability includes relationships with the level of agitation in recourses, the state of degradation of recurrences, the crisis of resilience in ecological systems and exposure to contaminants and addicts.

2.3 Risk:

Risk is defined by UNISDR as the probability of harmful consequences, or expected loses (deaths, injuries, loss of property, livelihood, disruption of economic activity or damaged environments) resulting from interaction between natural or human-induced hazards and vulnerable conditions. Risk is a function of both hazard and vulnerability.

The mathematical form of defining Flood Risk is by multiplying the probability that a potentially damaging event occurs by the expected damage due to the event (Goldblatt 2005).

$$FloodRisk = \int_0^1 p(E)D(E)dp$$

Where:
p(E): Probability of event E occurring
D(E): Expected damage because of event E

However, the most common terms used to define flood risk are hazard and vulnerability as shown in the equation:

$$FloodRisk = hazard \cdot vulneravility$$

As a result, risk analysis involves hazard and vulnerability assessments. While hazard evaluation frequently requires the knowledge of technicians, for monitoring and storing data of geological and atmospheric conditions; vulnerability assessment make use of community-based methods, for instance, risk maps, to involve the community in the risk analysis.

Disaster management

Disaster management includes the combination of all activities, programs and measures that can be performed before, during and after a disaster in order to avoid disaster, reduce its impact or recover from it. The disaster management cycle establishes the various stages followed before, during and after a disaster. Figure 8 displays the variant of disaster management cycle defined by IHE-UNESCO.

Pre-disaster initiatives are classified into prevention and mitigation. These include structural measures, including dykes and channel measures, amongst others, and non-structural measures, for instance, spatial planning, flood protection, vulnerability and risk assessments.

Early warnings, risk communication together with emergency management and evacuation plans are activities included in preparedness in the short term. All these activities are taken to reduce human and property losses caused by a potential hazard. Moreover, during a disaster some initiatives are taken to ensure that the needs of victims are met, provisions found, and suffering are minimized. Warning, evacuations, rescue, operational measures (e.g. storage reservoirs) and emergency aid are some of the initiatives that establish intervention and are worldwide known as emergency response activities.

Post-disaster activities are taken in response to a disaster to achieve early recovery and rehabilitation of affected communities. These are called response and recovery activities. Damage and needs assessments, restoration and reconstruction are part of these post-disaster activities.

2.4 Hazard:

Hazard Identification

In disaster management, a hazard refers to the potential for a disaster. I use the definition developed by Harris et al. (1978), who conclude that hazards "are threats to humans and what they value: life, well-being, material goods, and environment." Harris et al. indicate the need for judgment when determining whether or not a potential hazard exists. If, for example, a meteor was to fall on a desolate barren area of northern Canada (even if it killed no one, destroyed no property, and left minimal damage to the environment), then it would be considered a potential hazard. This contradicts Hewitt's (1983) view that "hazard" refers to the potential for damage to a vulnerable human community. Following Harris et al., it is not important for a hazardous event *actually* to take place; it is only important that it is *likely* to take place. (Pearce 2000)

Since the 1960s, the literature on disaster management has discussed risks without considering their origin. This changed in the 1980s, when the dangers began to be described as natural or technological (Lindsay 1993). Though natural hazards have been called "God Acts", technological risks have been defined as adequate in four categories: hazardous materials, hazardous waste, hazardous substances and extremely dangerous substances. As Parker (1992, 237) points out, however, "the significance of these classifications varies across countries and even among agencies within the same country."

Hazard Classifications

Why is it important to classify hazards? Primary, Scientific castigations tend to be limited and have a narrow focus: atmospheric researchers do not necessarily communicate with hydrologists and other natural scientists. By failing to classify hazards, research may be duplicated and gaps may go unnoticed. Second, and perhaps most important, as "the type of hazard affects the choice of mitigation strategy" (Godschalk 1991, 40), failure to accurately classify types of hazards may lead to the misapplication of mitigation strategies. For example, if one is trying to combat an increase in the number of forest fires by installing additional lightning monitors when, in fact, the fires are being caused by careless campers, not only will the strategy not work, but it will also waste resources. Third, failure to correctly classify hazards leads to failure in other parts of the emergency management process. For example, in order to receive FEMA funding, communities must conduct at least three exercises every four years and must include in them "a natural, a technological and a civil disaster" (Daines 1991, 187). Because of the way in which hazards are defined, communities are not encouraged to think about, or to consider how they would deal with, an epidemic.

According to these explanations, I suggest that hazards be classified. Though, a number of academics (e.g., Kreps 1991; Quarantelli 1991they questioned the need to separate the causes of the dangers from each other. Jovanovic (1988), for example, believes that person-induced and natural hazards are interrelated because humans can influence natural events and natural events can change and modify human activities. However, I believe that although in many cases there are similarities between the consequences and the responses to natural disasters caused by people, because their causes are different, the mitigation strategies adopted to reduce them will also be different—thus the importance of classification.

As can be seen, hazards have been classified in a number of ways—usually by cause. Fischhoff et al. (1978) recognize that, in terms of both events and consequences, natural hazards differ from technological hazards. Similarly, Britton and Oliver (1991) differentiate between natural and technological hazards. According to them, natural risks are the result of a lack of control, while technological risks derive from a loss of control. They conclude that hazards have three origins: (1) natural; (2) failure or misuse of technological processes; and (3) misapplication of technology, medicine, or biology. While it is important, in terms of applying mitigation strategies, to determine the origin of technological hazards, it is difficult to justify, in the planning stages, the use of Britton and Oliver's typology. For example, an aircraft can crash as a result of mechanical failure, metal fatigue, poor maintenance, a bomb explosion, pilot error, and so on. Defining hazards by origin seems unsatisfactory, as they have numerous possible origins—only some of which may actually lead to a disaster. With the current emphasis on carcinogens and other similar concerns, it is important to distinguish between these hazards and those leading to major disasters such as earthquakes and explosions. Therefore, it seems more suitable to classify hazards by general cause rather than by specific origin. though, I suggest that the risks are classified as: (1) natural; (2) diseases, infestations and epidemics; besides (3) induced person.

White (1979, 15) defines natural hazards as "any extreme events in natural systems which have the potentiality of causing major perturbations in social systems." This definition appears to be accepted within the disaster management community, and it is the one used throughout this dissertation.

Interestingly, while natural hazards are the focus of much current research, diseases and epidemics are usually overlooked. Yet the latter can affect people, plants, or animals. While some diseases, such as the bubonic plague, have existed for centuries, others, such as acquired immune deficiency syndrome (AIDS), are quite new. Some diseases are the result of bacterial or viral infections (e.g., meningitis) that have natural causes, while some are the result of human manipulations. Locusts have been swarming in Africa for hundreds of years, but threats of an Asian gypsy moth infestation in British Columbia have only occurred in the last few years. Moreover, genetic researchers are able to create new diseases. As a result, diseases and epidemics do not adapt well to the natural hazards or risks induced by people. As well, while controlling other hazards typically means evacuating people, animals, and property, controlling diseases and epidemics typically means containing them. Though according these reasasons, diseases and epidemics must be classified separately from natural hazards .

Drabek (1991) emphasizes that researchers have traditionally identified three types of disasters based on the type of potential risk: (I) natural, (2) technological and (3) civil. He adds that a fourth type of disaster—ecological—has now entered the picture. Ecological disasters are events "that are caused principally by human beings and that initially affect, in a major way, the earth, its atmosphere, and its flora and fauna" (xxi). Whereas The need for natural hazards has already been discussed, the term "human-induced risks" includes the typology of Drabek's technological, civil and ecological risks, as well as those commonly referred to as "artificial hazards". I use the term "human danger". dangers induced by the person "because: (1) it is gender-neutral and non-sexist; (2) people do not" make "disasters, but" induce "them, either through acts of commission (e.g., planting a bomb, crashing a plane, or spilling chemicals) or through acts of omission (e.g., not building a dam able to withstand seismic conditions, failing to maintain a proper watch at sea, or using poor construction techniques); and (3) it addresses the issues presented by Britton and Oliver (1991).

2.5 Mitigation:

Current research defines the concept of mitigation as central to the success of disaster management. In the mid-1990s many of the United States' top hazards experts met and collaborated on the *Reassessment of Natural Hazards in the United States,* which was completed in 1998 (Mileti 1999). Based on its findings, Mileti concluded that a shift in the field of disaster management must take place so that it would be possible to focus on "mitigation of sustainable in hazard" (2). Mileti argues that there are six objectives that must simultaneously be reached

in order to mitigate hazards in a sustainable way: (1) maintaining and enhancing environmental quality (i.e., human activities should not reduce the carrying capacity of the ecosystem), (2) maintaining and enhancing people's quality of life, (3) fostering local resiliency and responsibility, (4) recognizing that vibrant local economies are essential, (5) ensuring inter- and intra-generational equity (i.e., not precluding a future generation's opportunity for satisfying lives by exhausting resources in the present generation), and (6) adopting local consensus building.

The importance of mitigation is recognized in FEMA' s major initiative, "Project Impact" (FEMA 2000), which was developed as a partnership between communities, government, and businesses in order to build disaster-resistant communities. Sustainable hazard mitigation warrants an inter-disciplinary approach that encompasses environmental, social, and economic considerations as well as technical analysis in order to determine hazards, risks, and vulnerabilities. This actuality the circumstance, It is clear that adequate HRV analysis is critical to the success of sustainable risk mitigation.

This concept of mitigation parallels the conclusions of MacCrimmon and Wehrung (1986, 10) concerning risk: "There are three components of risk—the magnitude of loss, the chance of loss, and the exposure of loss. To reduce riskiness, it is necessary to reduce at least one of these components." Taking into account Mileti's conclusions regarding mitigation, one could reword

MacCrimmon and Wehrung to state that the components of mitigation strategies are to eliminate or reduce (1) the consequences of loss, (2) the probability of loss, and (3) the sharing of loss. In most cases it will be impossible to eliminate the probability of loss (i.e., the probability of a natural hazardous event taking place), but it may be possible to make in the circumstance of person-induced risk of hazards.

According to Mileti's suppositions, any classification of disaster management must be able to incorporate the perception of the mitigation. As will be seen, mitigation is also central to the definitions of "hazard," "risk," "vulnerability," and "risk management.

2.6 French Emergency Management System:

The system emergency management in France is constructed on the regular assessment of hazards and hazard management strategies. These plans have evolved mostly through European Union (EU) commands, land use, industry and environment. Today, the European Union is moving towards becoming one nation with its social and economic systems including the possible adoption of one constitution. France perform as the principal EU country that dynamically makes and applies risk hazard management strategies. Moreover, French management system of emergency now is grounded on the view that emergency management efficiency requests the assessment of social, economic as well as environmental hazard risk adequacy by the community. This is accomplished by exploratory the victims and the damage caused by every key disaster and by knowledge and incorporating lessons learned from failures in remedial strategies.

2.7 Vulnerabilities and Hazards in France:

The overwhelming French disasters are mostly climatic. Among them, floods are prevalent and have dramatic human and economic consequences. Floods have been the main hazards that have formed emergency management strategies in France, meanwhile about a third of the French land is subject to risk of flood. The second half of the 20th century saw a high number of water-related disasters. The nature of these disasters has changed from the slow rise of water in the Sena and Louire rivers, to damaging floods in the newly urbanized elevation areas in the south of France. Another big natural risk is the seismic activity that includes the south-east of the French urban region.

Usually, the populations of a country with a long history of catastrophes grow some risk responsiveness which translates into specific local strategies to reduce vulnerabilities. This is not the case in France, where risk culture is rare and where, unlike the EE. UU., Nothing similar to strong neighboring communities can be found, except in the deep rural areas. In France, the sensitivity of people to risk is often too low or excessive. However, the French have the ability to easily compare and balance the vulnerabilities and benefits they can have in a dangerous environment, by choosing rationally to expose themselves or not. It is a kind of paradox.

One main cause for this irony could be due to the fact that the disasters in France are responsible only for a few victims but for large financial and social costs. In support of this topic, statistics show that between 1980 and 2008, 21,533 people died due to natural disasters. 19,490 of these casualties (about 90%) were in one year alone during the 2003 extreme heat waves. Only about 2% people have been killed from other natural disasters (Preventionweb.net). On the other hand, total economic damages per year amount to a whopping 1 billion US dollars in France (PreventionWeb.net).

Since centuries, floods in have changed from classical slow water risings of the Seine and Louire to extremely damaging flashfloods in recently built-up hilly areas south of France. Examples of more recent large flooding incidents include Nimes (1988), Vaison-la-Romaine (1992), the Aude (1999), and the Gard in 2002. For example, on September 8, 2002, 670 millimetres of rainfall occurred in Gard which is equal to more than 50% of an entire year's precipitation amount in just one day in that region, according to Feunteun et al (2000).

2.8 Disaster Policy:

Before, France emergency management system stringently eminent between natural hazards and man-made threats that involve risks produced by manufacturing, farming activities and transport hazards. Though this differentiation seemed convenient, it turned out to be unrealistic over time (Mancebo and Renda-Tanali, 2009). When an incident causes a disruption, no matter the cause of occurrence, it may lead to other significant hazards in a cascading manner. Research and evidence has shown that it would be more feasible to manage complex risks as a whole system rather than managing them according to incident type (Godart et al, 2002). Therefore, following several incidents of disasters over the past two decades and with further impetus from the EU, French policy has evolved from the disaster-specific risk management approach to the complex approach to risk.

Also, until the beginning of the 1970s, French public policy had a 'zero hazard' dogma that was centred around the idea that as long as enough money is invested in disaster risk mitigation, it was possible to live in an all safe universe. This Promethean attitude was based partly on a self-assurance rooted in a post-World War II technical advancement and demagoguery. It was also what could be called 'safety monergism' which proved unrealistic. Moreover, EU directives with the severe reality of numerous disasters (mostly floods) have changed French policy (Cohen de Lara and Dron, 1998). Another accelerating factor for policy change was due to the 1970s oil embargo causing the abrupt ending of an incredibly prosperous period when there was money galore for everything.

A more pragmatic approach was brought about more recently which is based on the more notion that disasters cannot always be avoided. Therefore, acceptable levels of risks are determined, and disaster preparedness and recovery plans should be prepared around the accepted risks. couple of the milestones in French hazard disaster policy are emphasised beneath

2.9 Evolution of natural hazards policy:

Natural hazards affect more than 50% of the French territory. Poor risk policies in sustainable local development planning and greater exposure of wealth in dangerous areas over the past 50 years have led to increased losses in property and dozens of deaths. Understanding the hazards, French policymakers focused their risk mitigation policies around the following four spheres:

a. Risk identification and preparing zoning and settlement strategies based on identified risks.
b. Consideration of natural hazards as part of urban planning process.
c. Eliciting input from residents.

d. Preparation of emergency response and preparedness plans.

Related to the issues above, between 1935 and 1994, a large number of zoning instruments designed to control urbanization were developed (Dauge, 1999). However, they were conceived and adopted without any cohesiveness or coordination. The complexity and the disparateness among the policies prevented their proper implementation and use. To end this chaos, a law called "Loi Barnier' (the name of the person that sponsored the bill) was issued by the French Congress in February of 1995 that replaced those discordant instruments with what is called a Major Risks Prevention Plan (*Plan de Prévention des Risques Majeurs – PPR*). PPR covers all types of natural hazards including avalanches, storms, forest fires, floods, landslides, earthquakes, and volcanic eruption. The plan was meant to be a flexible approach that would easily adopt to the needs of local, communal, and river basin authorities.

The PPRs are used to prevent new construction and other settlement activities in areas designated as dangerous and to regulate in less exposed areas. For example, to mitigate the effects of flooding, the spreading of agricultural land use is controlled by the local PPRs in order to diminish surface water runoff. Also, the standard minimum first story heights are also specified in the local PPRs.

The communes (smallest French administrative division) are required to have their PPRs prepared according to the specifics of their region and approved. In fact, the procedure of having communal risk plans was established in April of 1994 even before the 1995 introduction of Loi Barnier. According to the 1994 legislation, French regional prefects are required to setup a structure in their *département* (French administrative district) called the Risk Analysis and Preventive Information Unit (*Cellule d'Analyse des Risques et d'Information Préventive – CARIP*). The role of CARIP is to assess the natural hazard risks to the community, decide on the hazard risk mitigation options, and impose and implement them. Towards this purpose, each commune in France has been required to prepare a synthetic document named Communal Information File on Major Risks (*Dossier d'Information Communal sur les Risques Majeurs --DICRIM*) to be added to the Departemental File on Major Risks *(Dossier Départemental sur les Risques Majeurs – DDRM).* DDRM is a final département level document worked out by CARIP. Both the DICRIM and DDRM are made available at the city halls of each département.

If there are several types of hazards that the commune is prone to, it is highly likely that it has a PPR and is in an approved status. When some risks are determined to exist in a commune, then this commune has to create a PPR which defines the exposed areas and bring prohibitions or restrictions to constructions or activities in the exposed areas. PPR is a planning tool). However, those communes that are prone to only one type of natural hazard are likely not to have a PPR or a PPR that is in an approved status. According to Callon et al, in 2001, 26% of all of the French communes affected by four types of risks had a plan versus 6% of those affected by just one hazard. Moreover, the existence of PPR was directly proportional with a commune's population: 35% of all of the communes with population of 20,000 to 100,000 inhabitants had a PPR, versus 6% of those with 100 to 500 and 3% with less than 100 inhabitants. This could be interpreted as: the more urbanized a commune is, the more is the risk of potential losses from hazards.

Additionally, in terms of PPR coverage, there has been a discrimination against the type of hazard. According to IFEN (Institut Français de l'Environnement –French Environmental

Institute), in 1999, 36% of avalanche affected zones in France were covered by a PPR versus only 12% of those zones affected by landslides, and 11% of those affected by floods. Strangely enough, forest fires had not been covered in many PPRs. To illustrate the imbalance, 2001 statistics show that 11,699 French communes have flood risk; 6,038 have landslides; 5,189 earthquakes; 3,905 forest fires, and only 355 communes are prone to avalanche risk.

2.10 Organization of Emergency Management:

toward understanding over the years that: (1) it is essential to work on complex risks deprived of detaching them as normal and technological while interrelating, (2) procedures and plans prove to be inefficient, therefore they must be differentiated enough as to be adapted to local conditions and specific situations, and (3) disaster and post-disaster recovery should be clearly defined and fully operational. Based on the above premise, a new risk and disaster management mechanism was created into law on July 30, 2003. The new mechanism is centered on French communes: the smallest French administrative territorial division. Accordingly, a commune's mayor is given authority over risk prevention, mitigation, risk warning, and emergency planning with the help of a local document called *Plan Communal de Sauvegarde* – PCS (Safeguard Communal Plan). The PCS details actions and measures to be taken in case of emergencies as well as post-disaster recovery actions. If the emergency situation crosses several jurisdictions, then PCSs of all of the affected communities can be unified to issue an inter-communal PCS (Urfalino & Hubert, 2000).

while special instruments and plans as PCS, PPR, ICPE or DICRIM are not adequate to mitigate an emergency or hazard, the ORSEC-Organization des SECours Plan is used which is the French general emergency strategy which is actually a civil security emergency plan. The ORSEC plan is for widespread and long-lasting disasters such as storms, floods, earthquakes or major industrial disasters. ORSEC is carried out by gendarmerie. The gendarmerie is a French police force with a military commandment coming under the control of the French Defense Department. Its missions can be partly compared to those of the US National Guard**,** fire and police departments under the joint authority of the prefect and mayor. It organizes population **evacuation and relief operations**, medical assistance, and other technical interventions to address the causes of the disasters and further mitigate its consequences. ORSEC is articulated at two levels: 1) a standard plan that is applicable under any circumstance and at any place, and 2) a specific plan that is adapted for the local context at French département level. Moreover, at the same moment there are several other emergency actions that can similar ORSEC plan such as *Strategies Particuliers d'Intervention* – and PPI (Specific Intervention Plans) to deal with highly localized danger sources such as ICPE installations; *Plans de Secours Spécialisés* – PSS (Special Emergency Plans) that deal with diffused hazards such as flooding, transportation accidents involving hazardous materials, tanker oil spills, etc.

During the past three decades, French hazard and risk management policies have evolved from nationwide standardized procedures discriminated according to type of risk (natural or man-made) into "complex risks" management strategy that is based on assessing and managing all potential hazards affecting each local administrative district. These procedures have become more integrated covering all phases of disaster management from mitigation to preparedness to response and to recovery. Furthermore, these policies and procedures have become part of local sustainable development public policies.

2.11 Accessibility:

The accessibility idea has established and develops indicators, similar with the idea of mobility. Hansen (1959) credits Bhat et al. (2000) with the main important theoretical work on the topic. While mobility is connected to the presentation of transportation systems, and accessibility enhances the interaction of land use and transportation systems as well as models as an added level of examination. Therefore, accessibility measures are able to evaluate the feedback effects between transport infrastructure and modal participation, on the one hand, and the urban form and spatial distribution of activities, on the other. many accessibility procedures likewise contain behavioural determinants for time and space activity models and transportation users responses to any physical circumstances.

Litman (2003) highlights that traffic development and mobility have conventionally addressed the movement of motor traffic or people and goods in overall , whereas accessibility clearly contains the link among land use and travel numbers and time of travel as pointers. There are many conflicts between mobility and accessibility: for instance, roads planned for maximum mobility have limited access for together land-uses, whereas zones where accessibility has been capitalizing on traffic overcrowding and parking limits might occur.

Van and Geurs (2001) outline accessibility as "the extent of the land use scheme uses. In contrast, Bhat et al. (2000) uses the following definition:

The accessibility measure of the ability and one of an individual to perform an activity of the type desideratum, in a desired position, in a desired and at the desired mode. It is interesting that Noting Geurs and van Eck (2001) Do SPECIFIC the land to use Reference and Transport, Which the accessibility involves intrinsically linked and determined mainly or "enabled" by the transport INFRASTRUCTURES and by the urbanization models, I quote this spatial dimension not all emphasized, still implicit, in Bhat's et al. (2000) definition. Geurs and van Wee (2004) make a greater differentiation by clarifying the terminology: "ACCESS is used when we talk about the Perspective a person, when we accessibility uses the perspective of a position". (P128) Bertolini, LeClercq and kapoen (2005) define the accessibility they eat "the number of the diversities can be places that reached entered a definite time and / or the cost of travel" (p.209) and eaten accessibility sustainable accessibility " with the least possible use of non-renewable or hard-to-renew resources, including land and infrastructure.

while reading the ideas of Geurs and van Eck (2001), accessibility contains four mechanisms. The component transport if planned to measures the travel time, space and costs and effort. The Measure Soil component use the Distribution of space activities or Opportunities and contains a competitive nature of EVALUATION of the Activity of the Demand in the DESTINATIONS and the Offer of potential Users. The time component examines the time limits that the users experience for their activities of models and availability of activities or opportunities in the hour base, week or year. The single component investigates and protects, enables the use of transport users and, in relation to socio-economic and demographic factors.

Bhat et al. (2000) and Geurs and van Eck (2001) classify numerous mutual types of accessibility measures and discuss the appropriate range and limits of their application. Geurs and van Eck (2001) differentiate among infrastructure based, and activity based and utility-based accessibility indicators and preserve that whereas the infrastructure type is easiest to measure and construe, it is also the most incomplete when it derives to taking the interplay of land use and transport. Likewise, the sort of activity-based indicator contains the land use element from the beginning, nevertheless tends to be more multifaceted and sometimes fewer legible. The type of indicator based on utility intersects with economic and social disciplines, as well as with the use of land and transport and is characterized by Geurs and van Eck (2001) as an emerging model that still requires research and substantial development. Therefore, accessibility is a multifaceted concept, not easily packaged in a single indicator or size index. In the words of Litman (2003), "there is no single way to measure transport performance that is comfortable and complete" (p.32). Though, van Wee and Geurs (2004) produced a list with references on how an accessibility amount should perform, nevertheless of their viewpoint (combinations):

1. Accessibility must be related to changes in travel opportunities, their quality and their impediment: "If the level of service (travel time, cost, effort) of any mode of transport in a zone increases or decreases), accessibility should increase or decrease any activity in that zone or from any point inside that zone.

2. Accessibility necessity have to be connected to the changes in land use: " In case the number of chances for an activity increases or decreases in any area , access to this activity must increase or decrease from anyplace.

3. Accessibility must be related to changes in asset demand restrictions: "If the demand for opportunities for an activity with certain capacity restrictions increases (decreases), access to this activity should decrease (increase).

4. Accessibility must be related to personal skills and limitations: "Increasing the number of opportunities for an activity in any place should not interrupt access to that activity for an individual (or groups of people) who cannot participate in that activity, the time budget

5. Accessibility must be connected to individual access to land use and travel chances: "Enhancements in a means of transport or growth in the number of chances for an activity must not disturb the access to any individual or groups with inadequate skills or capabilities (eg driving license, educational level) to use this mode or participate in this activity.

Bertolini et al. (2005) debate the balancing act that is the expansion of suitable indicators for accessibility: ‘to be useful for applied planning drives, an accessibility amount necessity has to meet two requirements: it obligation to be consistent with the uses and perceptions of the populations, visitors and workers of an zone, and it must be comprehensible to the planners.

‘A main methodological encounter is finding the correct equilibrium between a measure that is hypothetically and empirically sound and one that is adequately basic to be practically employed in interactive, original plan-making procedures wherever contributors typically have dissimilar degrees and types of knowledge. It is the contributors, though, who make or break effective accessibility valuation and its volume to inform the maker of decision, as integral correspondents within the procedure. A clear and legible method is thus serious in the opinion of Bertolini et al. (2005), ‘not because of a general independent concern, but also because of the standing of mobilising knowledge of different contributors in the identification of the key problems and the pursuit solutions.

2.12 MOBILITY:

Mobility is a main dynamic of growth and the related with infrastructure unvaryingly forms the urban form: the spatial footprint definite by roads, spaces, transportation systems and buildings in towns. In 2005, around 7.5 billion trips were made every day in cities around the world. In 2050, there could be three or four times more passengers-kilometers traveled than in the year 2000 (allowing infrastructure and energy prices). The movement of the load could also increase more than three times during the same period.

However, despite the increasing level of urban mobility in the world, access to places, activities and services has become increasingly difficult. Due to urban sprawl, horizontal growth and low density of cities in large areas, the distances between functional destinations such as workplaces, schools, hospitals, administrative offices or shops have become longer, which generates an increasing dependence on transport. motorized private and other mobility centered on the car. As a result, extensive overcrowding and traffic inactivity have become the standard in many capitals, touching urban life through harmful externalities like pollution, accidents and noise. (UN-Habitat, 2018)

In some cities, the physical separation of residential areas from workplaces, markets, schools and health services forces many urban residents to spend more time, and up to a third of their income, on transport.

Mobility challenge

Many cities have not yet developed efficient public mobility systems, if any. Even when available, public transport often suffers from stigmatization caused by high access costs, lack of reliability and lack of security. Furthermore, administrative boundaries do not always coincide with the entire metropolitan area, as each administration has separate mobility policies and transport systems.

This often leads to inefficiencies and lack of attractiveness due to uncoordinated operations, such as non-matching calendars or multiple rates. So far, the standard response to addressing the problems of urban mobility has generally been increasing infrastructure, especially for automobiles, such as the construction of multiple roads, highways, overpasses or tunnels. Unfortunately, these developments generate a vicious circle: more infrastructure favors urban sprawl because it facilitates access to peripheral urban areas, increasing car use, which in turn requires further infrastructure development, and so on.

If it is true that all residents should have access to your home, work, services and places of entertainment or personal fulfillment quickly and efficiently, and that the construction of roads is essential for the development of cities and low-income countries. Adding infrastructure is not necessarily a panacea for the current challenges of urban mobility. (UN-Habitat, 2018).

2.13 Resilience in Evacuation Planning:

Holling (1973) was the first to describe resilience in the ecological context as a "measure of the persistence of systems and their ability to absorb changes and disturbances". Over time, many other definitions of resilience have been published according to the research approach.

For a general description and other definitions of resilience, we refer to Reggiani, De Graaff and Nijkamp (2002) and Haimes (2009). Subsequently, Reggiani, Nijkamp and Lanzi (2015) provide an overview of the concept of resilience with respect to transport systems. Analyzing 19 different jobs, they argue that there is no coherent definition of transport resilience and that there are "serious limitations in terms of operability and measurement of resilience." "To our knowledge, no existing work explicitly considers resilience. Evacuation planning However, there are works that deal with related approaches.

Goerigk and Hamacher (2014) define resilience in general as "the ability of a system to tackle change" and distinguish two concepts to improve solution resilience: model uncertainty directly in the stochastic model (Li and Ozbay 2014; Yazici and Ozbay, 2007; Yazici and Ozbay, 2010) or robust optimization (Ben-Tal et al, 2011; Yao, Mandala and Do Chung, 2009) or taking into account the multiple conflicting objective functions. Although there are many uncertainties in case of evacuation of the environment (for example, the number of displaced people, the ability of the road, the effects of the disaster), there are only a couple of models of macroscopic optimization considering these uncertainties directly in the context of planning the Yazici and Ozbay evacuation (2007) apply an opportunity restriction approach to a cell-based SO-DTA formulation. Assume that the uncertainties in the ability of the streets are known, the probability distribution of these random abilities and the distribution and the number of displaced persons. An E p (p-LEP) level method is applied and solved as an example for a hurricane evacuation problem. Li and Ozbay (2014) propose a SO-DTA evacuation model based on cells that incorporates the flow-related uncertainties of capacity. These features are modeled as variables that adapt dynamically over time based on the assigned flows. A network flow algorithm is applied based on the mean approximation approach of the sample. Ben-Tal et al. (2011) and Yao, Mandala and Do Chung (2009) apply a robust optimization approach to an evacuation model based on cellular transmission. Their assumptions are reversed by those of Yazici and Ozbay (2007) and Li and Ozbay (2014): the distribution of demand is uncertain, and the capabilities of the streets are deterministic. A cohesive adjustable counterpart approach (AARC) is applied to the problem and the presented approach is compared to a deterministic and sampling-based stochastic programming solution. Yazici and Ozbay (2010) provide a model for the uncertainties in road capacities and the source of demand for a cell-based SO-DTA model. Probability distributions of random requests and capacities are assumed to be discrete. A limited programming approach is applied by chance. Ng and Waller (2010) present a completely different approach when considering uncertainties indirectly in the number of displaced persons and in the ability to bow. They propose a cell-based evacuation model simply by planning for more displaced people and lower street capacity. Although these (presumed) reliable evacuation plans are designed in a fairly conservative manner, they guarantee a predefined level of trust.

2.14 Earthquakes (Seismic area):

The earthquakes are caused by a sudden release of stress along the crust defects. Due to the continuous movement of the tectonic plates, the voltage accumulates in the rock on both sides of a fault. When stress exceeds the strength of the rock, it is released in a sudden and sudden movement. The released seismic energy spreads like waves through the earth and along its surface, and these waves cause the shaking that we feel.

The level of Danger discusses to the power of an earthquake in a specific warning zone. Intensity and power are a measure of the effects of an earthquake. Using a 12-point scale, describe the consequences of an earthquake for people and buildings in a particular place. An earthquake has a magnitude value (energy released) and usually different intensity values. The maximum intensity is usually recorded near where the earthquake occurs (epicenter) and decreases with the distance from the epicenter.

Two parameters allow to calculate the danger of an earthquake:

2.14.1 Its magnitude:

Richter scale is common measurement standard for earthquakes. It was designed in 1935 by Charles F. Richter of the California Institute of Technology as a scientific device to compare the magnitude of earthquakes. The Richter scale is used to measure the magnitude of an earthquake, which is the total energy released during a hazard earthquake.

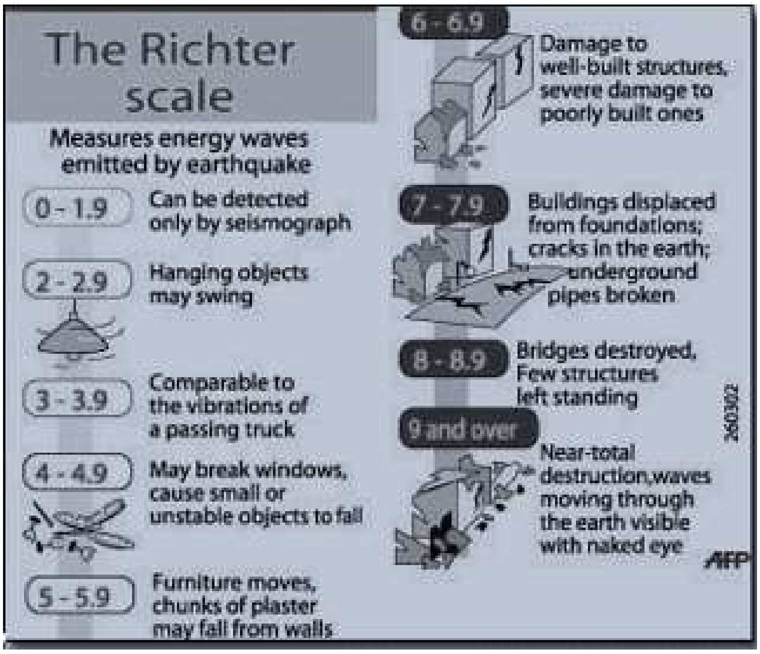

Figure 4: the amount of energy released during an earthquake

Source: Sms-tsunami-warning.com, 2018

The Richter scale doesn't measure quake damage which is dependent on a variety of factors including population at the epicentre, terrain, depth, etc. An earthquake in a densely populated area which results in many deaths and considerable damage may have the same magnitude as a shock in a remote area that does nothing more than frightening the wildlife. Large-magnitude earthquakes that occur beneath the oceans may not even be felt by humans.

Richter Scale of Earthquake Energy:

Each level is 10 time stronger than the previous level

	Description	Occurrence	In Population	Movement
1	Small	Daily	Every minute	Small
2	Small	Daily	Every hour	Small
3	Small	Daily	Every day	Small
4	Small	Daily	Every week	Moderate sudden
5	Moderate	Monthly	Every 10 years	Strong Sudden
6	Moderate	Monthly	Every 30 years	Strong Sudden
7	Major	Monthly	Every 50 years	Severe Sudden
8	Great	Yearly	Every 100 years	Very Severe
9	Great	Yearly	Every 300 years	Very Severe
10	Super	Rarely	Every 1.000 years	Extreme

Figure 5: Richter Scale of Earthquake Energy

Source: Sms-tsunami-warning.com, 2018

2.14.2 Its Macro seismic intensity:

The severity of an earthquake is not only related to its magnitude, but also to the geographical position of the measure in relation to the epicenter. The measurement of the macroseismic intensity thus focuses on the real effects (on the people, the building, the environment ...) with regard to this parameter. In France this is the energy scale released from the earthquake according to European Macroseismic Scale, which includes 12 degrees corresponding to reactions of the population and increasing material damage

EMS-98 Intensity	Felt	Impact	Magnitude (Approxi-mat Value)	Building Damage (Masonry)
I	Not felt	Not felt		
II-III	Weak	Felt indoors by a few people. People at rest feel a swaying or light trembling.	2 3	
IV	Light	Felt indoors by many people, outdoors by very few. A few people are awakened. Windows, doors and dishes rattle.		
V	Moderate	Felt indoors by most, outdoors by few. Many sleeping people wake up. A few are frightened. Buildings tremble throughout. Hanging objects swing considerably. Small objects are shifted. Doors and windows swing open or shut.	4	
VI	Strong	Many people are frightened and run outdoors. Some objects fall. Many houses suffer slight non-structural damage like hair-line cracks and falling of small pieces of plaster.		
VII	Very strong	Most people are frightened and run outdoors. Furniture is shifted and objects fall from shelves in large numbers. Many well-built ordinary buildings suffer moderate damage: small cracks in walls, fall of plaster, parts of chimneys fall down; older buildings may show large cracks in walls and failure of in-fill walls.	5	
VIII	Severe	Many people find it difficult to stand. Many houses have large cracks in walls. A few well built ordinary buildings show serious failure of walls, while weak older structures may collapse.	6	
IX	Violent	General panic. Many weak constructions collapse. Even well built ordinary buildings show very heavy damage: serious failure of walls and partial structural failure.		
X+	Extreme	Most ordinary well built buildings collapse, even some with good earthquake resistant design are destroyed.	7	

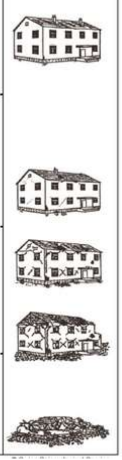

Figure 6: the energy scale released from the earthquake

Source: Seismo.ethz.ch, 2018

2.15 Earthquakes Risk :

The seismic risk refers to the risk of earthquake damage in a building, system or other entity. The seismic hazard risk defined, for the most part of management purposes, as the environmental economic, social and economic consequences of the dangerous actions that may happen in a given period of time. (Carreño 2005)

2.15.1 Level of damage:

A damage pattern of building strongly depends on the type of building structure.

Name of scale	Organizer	No. of class	Building type
Damage grade	***EMS-98***	6	Masonry buildings
Grade 0:Nodamage Grade 1:Slight damage (Hair-line cracks in few walls) Grade 2:Moderate damage (Fall of large pieces of plaster) Grade 3:Heavy damage (Large and extensive cracks in walls) Grade 4:Very heavy damage (Serious failure of walls) Grade 5:Destruction (Total collapse)			
Damage statistics	**Japan Prime Minister's Office**	4	Wood frame buildings
No damage Moderate damage (A part of building is damaged) Heavy damage (Structural damage cost occupies from 20 to 50% of total repair cost) Major damage (Structural damage cost occupies over half of total repair cost)			
Damage rank	***Architectural Institute of Japan***	6	RC buildings
Rank 0:No damage Rank 1:Negligible damage (Hair line cracks in columns and beams of frame) Rank 2:Slight damage (Shear cracks in non-structural walls) Rank 3:Moderate damage (Shear cracks in columns and beams and in structural walls) Rank 4:Major damage (Spalling of concrete cover, Buckling of reinforced rods) Rank 5:Collapse (Collapse of total or parts of building)			

Figure 7: **Examples of existing damage scale**

Source: Seismic risk evaluation for an urban centre, 2018

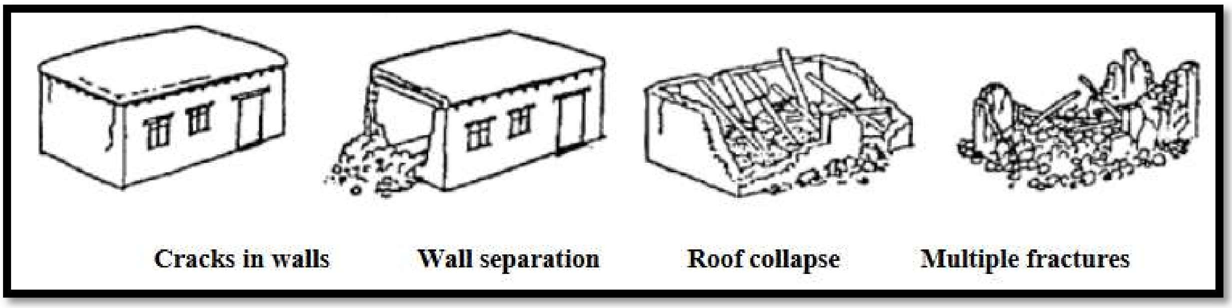

Figure 8: Typical damage pattern of unreinforced masonry buildings after Coburn (1986)

Source: Seismic risk evaluation for an urban centre*, 2018*

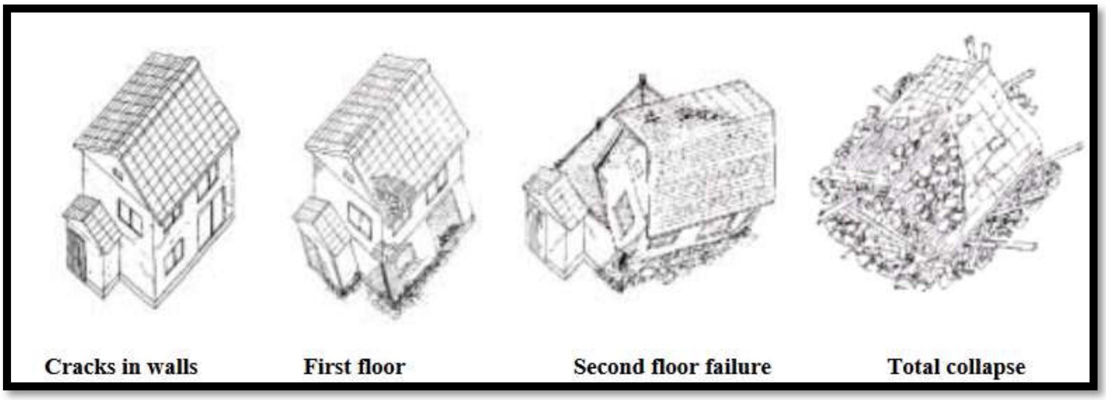

Figure 9: Typical damage pattern of wood frame buildings

Source: Seismic risk evaluation for an urban centre*, 2018*

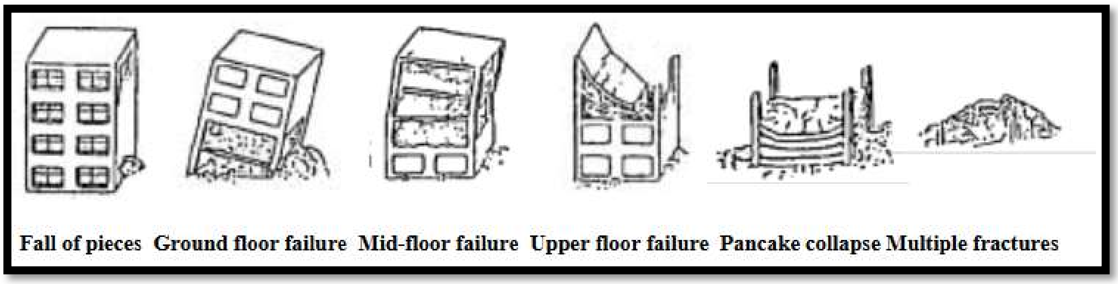

Figure 10: Typical damage pattern of reinforced concrete with moment-resting concrete frame buildings

Source: Seismic risk evaluation for an urban centre*, 2018*

2.16 Seismic zoning:

In order to identify the regions of France most vulnerable to seismic hazards, the government has set up various zones relating to a specific level of risk. Since 22 October 2010, France has a new seismic zoning dividing the national territory into five areas of increasing seismicity.

-Zone of seismic activity 1 (very weak) where there is no special seismic risk

-Zone of seismic activity (2-5) where there is seismic risk on the buildings and bridges.

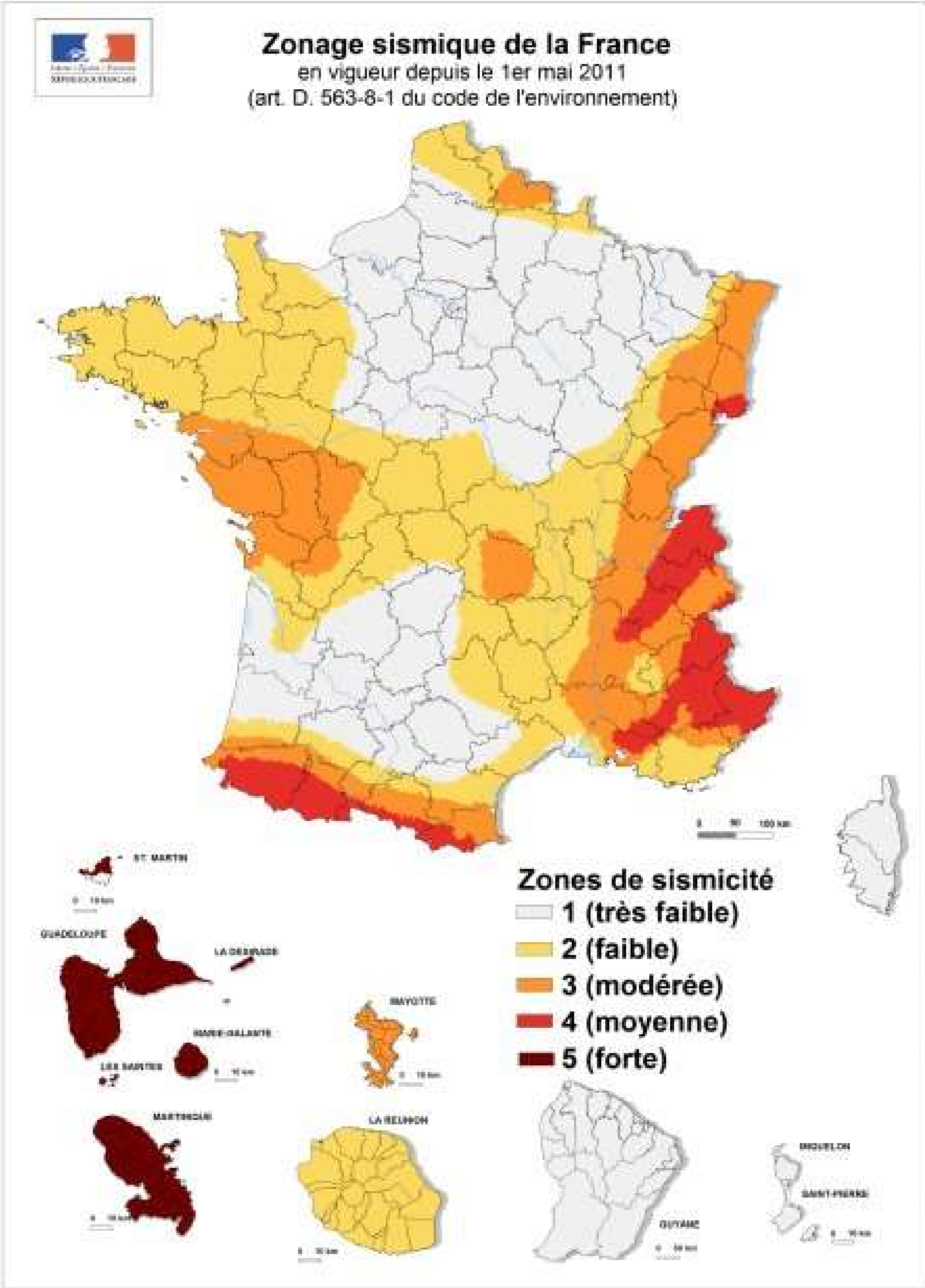

Figure 11: Seismic zoning in France

Source: Planseisme.fr*, 2018*

Chapter 3: The City of Nice

Through its long history, the city of Nice has changed hands fairly frequently. It was not till 1880 that the city was finally claimed by France and became a part of the country. Throughout Nice you can see evidence of the influence of various cultures in the architecture of the city. Nice is home to a substantial population and many of the high society families in France call the city home, or at the very least vacation there throughout the year.

Demographics

Today, Nice is one of the largest cities in France. It currently occupies the fifth place based on population and size. According to the last census conducted in 2012, the population of Nice is 343.629. With an estimated annual growth rate of 0.29%, the expected numbers for 2017 are around 338.611. According to the 2012 census, the number of women exceeds the number of men in the city. Women amount to 183,222, whole men make up 160,407 of the total population.

Transportation

As in all cities in France and Europe, pedestrian traffic and bicycles are very common. The city could be a bit crowded in different parts of the day, and it is usually better to take the bus or one of the trains. There are many bus lines around Nice, and costs four euros for a full-day pass. This includes both traveling by bus and traveling by train. Bus timetables can be a bit difficult to follow, but the train system works like clockwork and trains run every 30 minutes. The main transit center is the Gare de Nice Ville. It takes about 20 minutes to walk from the beach to the train station at this place, but it will allow you to reach any place within Nice where you want to go.

Nice Population Growth

The population of Nice in 2018 is now estimated at 987,000. In 1950, the population of Nice was 400,000. The city of Nice has grown by 20,000 since 2015, representative an annual variation of 0.68%. These approximations and demographic forecasts come from the latest revision of the UN World Urbanization Outlook. These estimates represent the urban agglomeration of Nice, which usually includes the inhabitants of Nice in addition to the adjacent suburban areas.

Year	Population	Growth Rate (%)	Growth
2030	1,091,000	0.81%	43,000
2025	1,048,000	0.84%	43,000
2020	1,005,000	0.91%	18,000
2018	987,000	0.68%	20,000
2015	967,000	0.53%	25,000
2010	942,000	0.52%	24,000
2005	918,000	0.51%	23,000
2000	895,000	0.48%	21,000
1995	874,000	0.46%	20,000
1990	854,000	1.62%	66,000
1985	788,000	1.46%	55,000
1980	733,000	0.98%	35,000
1975	698,000	1.85%	61,000
1970	637,000	2.32%	69,000
1965	568,000	2.79%	73,000
1960	495,000	3.05%	69,000

Figure 12: Nice Population Data (Urban Area)

Source: World Urbanization Prospects, 2018

Location

Nice is a city found in Provence-Alpes-Cote-d'Azur, France. It is located 43.70 latitude and 7.27 longitude and it is situated at elevation 18 meters above sea level.

Figure 13: Location of Nice on a map

Source: www.worldatlas.com, 2018

Seismic zoning of Nice

Nice Classified in a zone of medium seismicity (zone 4 out of 5), the department of Alpes-Maritimes is the territory most exposed to the seismic risk of metropolitan France (NERON et al, 2012).

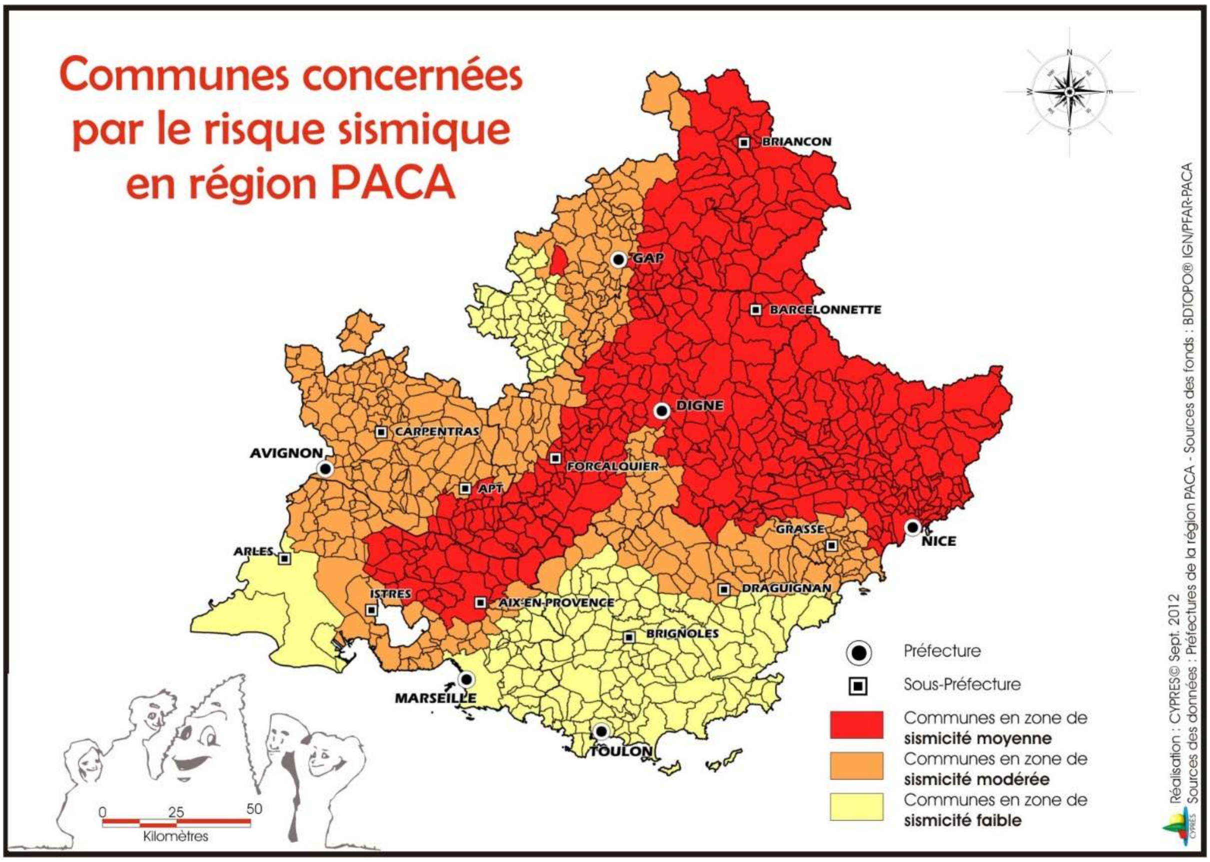

Figure 14: Seismic zones in the PACA region

Source: Planseisme.fr*, 2018*

ZOOM ON OUR STUDY TERRITORY

The Provence-Alpes-Côte d'Azur region is Most vulnerable to seismic hazards of all metropolitan France. Within this region, the Alpes-Maritimes represent the largest area exposed to the strongest hazard. According to a seismic zoning of France Released in 1989 from the study of 7,600 earthquakes, the agglomeration of Nice is the most exposed of metropolitan France. Indeed, the city of Nice was exposed to the strongest known earthquake of the whole metropolis, which occurred on February 23, 1887 and whose magnitude is estimated between 6.3 and 6.4 on the Richter scale, it hit 80 000 inhabitants, caused 635 dead and 555 wounded. Considering this risk, which can strongly affect the city of Nice (from a probabilistic point of view), a Seismic Risk Prevention Plan (PPRS) was carried out by the State and in collaboration with the municipality. This plan is focused on hazard awareness, but future seismic PPRNs will take into account the vulnerability of existing buildings and infrastructure.

In addition to this plan, a Communal Information Document on Major Risks (DICRIM), was produced under the responsibility of the Mayor of the municipality which is a mandatory document for the people of Nice to inform them of all natural and technological risks. present on the territory as well as the actions that will have to be carried out by the inhabitants to reduce the consequences of this risk. The fundamental difference with other natural hazards is that earthquakes are unpredictable phenomena that impose a post-disaster evacuation; the population must leave the buildings to go to the Reception and Regrouping Centers (CARE). This information is mentioned in the Nice Municipal Protection Plan (PCS), which indicates a crisis management plan (Figure 14) following a post-earthquake, internal and pedestrian evacuation.

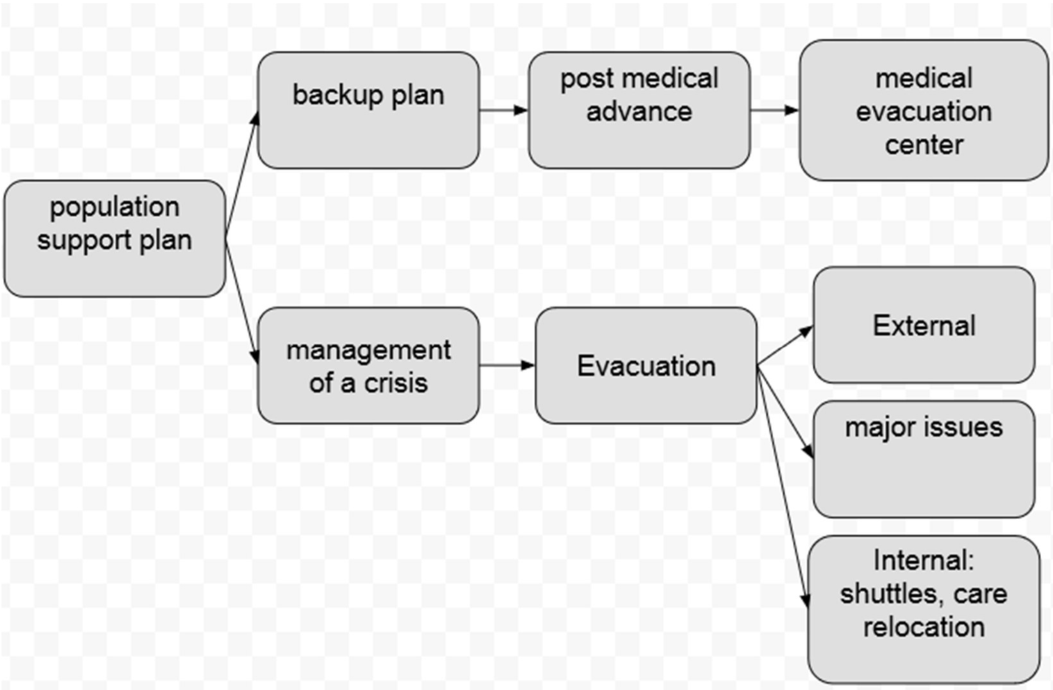

Figure 15: NICE Crisis Management Scheme

Source: (k.Serrhini) .

As previously mentioned, a zoning was carried out in the municipality of Nice, showing different rates of damage and thus making it possible to estimate the number of non-sheltered people per building.

In our study we only consider buildings whose damage is greater than D3

Number of buildings	51760
Number of people	99314
Number of shelters	187
Capacity of shelters	83731

Chapter 4: MODELING

4.1 MODELING APPROACHES

There are three basic approaches to modelling a traffic network: macro, meso and micro. These three approaches are distinguished primarily by their ability to model a geographic area (scale) and the precision of analysis (detail level). Choosing a certain approach is a trade-off between these two criteria.

1. MACRO

The earliest evacuation planning models were developed in response to major incidents such as the Three Mile Island Nuclear Power Plant accident4. These models focused on overall travel demands for a defined evacuation area and examined key measures such as evacuation clearance
times and overall system capacity. Due primarily to computing power, only macro level models were developed that would describe the overall traffic flow on a link of the network and not the movement of individual vehicles.

Today, macro-level models are still used in evacuation planning and prove useful in analysing large-scale events such as a hurricane, flooding or nuclear power plant accidents that threaten a large geographic area. Many of the metropolitan-area planning organizations (or MPOs) currently use macro-level forecasting models that could be used for evacuation planning purposes. However, macro-level models are difficult to use if very specific traffic control plans are to be implemented (e.g., reversible lanes) or a better understanding of queue formation on specific roadway links is desired.

Thirteen macro-level models that have been used for emergency evacuation planning. Five of these models (DYNEV, MASSVAC, NETVAC and PDYNEV) were developed specifically for evacuation planning purposes. Emme/2 is a fairly popular macro-level travel forecasting program that is used by transportation planners. EVACNET4 is a software tool designed specifically to model building evacuations and has not been applied to transportation networks. Four of the models (Emme/2, OREMS, PCDYNEV, and TRANSIMS) are actively supported and available for use as an emergency evacuation planning tool. The other four are legacy tools that are not currently supported or available.

In addition, a sub-set of macro-scale models are real-time decision support tools (also referred to as decision support systems). Decision support tools for evacuation planning were developed to assist local leaders and decision makers in the real-time operation of an evacuation event. Researchers identified five macro-scale decision support tools that are relevant to evacuation planning. Three of the five (ETIS, HEADSUP and HURREVAC) are designed specifically for hurricane events. The other two (REMS and TEDDS) were developed more generally for evacuation management.

2. MESO

Mesoscopic transportation planning tools evolved from a need for a level of detail needed for microscopic simulation programs and the analysis fidelity not afforded macroscopic models. Mesoscopic models that tend to characterise the relative flow of cars on a network link, but do not represent individual lanes on the link. Mesoscopic simulation models have been used in evacuation planning primarily as a means more accurately represent congestion conditions and temporal effects than macro models yet still cover a larger geographic region. This allows the modeler replicate congestion development/dissipation cycles during previous evacuation events to better understand steps that should be taken in future evacuation operations.

Researchers found five mesoscopic simulation programs being used for emergency evacuation planning. All but one of the models (Simulex) are designed as general transportation planning tools that can be adapted or applied for evacuation events. Simulex was created to model human behaviour within a building during emergency evacuation conditions. Two of the models (Cube Avenue and DYNSMART-P) have been used to model emergency evacuation conditions. TRANSIMS has been identified by two organizations to be used for proposed research projects on better modeling evacuation scenarios. TransModeler, a relatively new mesoscopic tool, has not been used specifically for evacuation modeling. All these tools are actively supported and available.

3. MICRO

Microscopic simulation models were developed to accurately model transportation systems at the individual vehicle level. Microscopic models move these individual vehicles through a network where the vehicles have their own characteristics and respond to the presence of other vehicles and to traffic control devices. Available computing power and a requirement for extensive data on roadway geometry and traffic control represents the primary limitation of microscopic models. Many transportation agencies currently use microscopic models in conjunction with macro-level models to better understand the impact of roadway geometry modifications on level of service and carrying capacity. Today, micro-level models are extensively used in evacuation planning to analyse the implementation of innovative roadway management techniques, such as contraflow and reversible lanes on roadways. While micro level models are limited in the geographic coverage, they are useful in analysing key bottleneck roadway segments and corridors where the movement of each individual vehicle needs to be represented to better understand the impact on roadway conditions.

The use of microscopic simulation has primarily focused on the validation of preconceived transportation evacuation plans and policies. These usually represent the implementation of contra-flow lanes for hurricane-prone cities. In these situations, transportation agencies were concerned with how the policies developed for evacuation would actually play-out in real world conditions. Microscopic simulation models were used to model these scenarios.

Researchers identified 12 micro-level models that have been used for emergency evacuation planning. Nine of these models were developed for traffic simulation in general, with four having been successfully used in an evacuation-related study. One of the models (EXODUS) was developed to model the evacuation of enclosures, including buses and trains. Five of the models (AIMSUN II, CORSIM/TSIS, Paramics, SimTraffic and VISSIM) are actively supported by a commercial entity. INTEGRATION 2.0 is actively supported, but primarily through a university research environment.

3.2 Multi-Agent models versus Cellular Automata

At first sight, the two formalisms look very similar and are often confused. One may find several works where the names “cellular automata” and“multi-agent systems” are used without distinction. This is easily understandable since CA are often used to model the environment of a MAS, and, reciprocally, one may see a CA as a particular kind of MAS where agents do not move. We now clarify the differences between CA and MAS in the context of research. We compare them at two levels: (1) the modeling level: What in a model makes CA or MAS more

suitable to express it? (2) the simulation level: How intuitive is the implementation of CA and MAS?
MAS and CA, as modeling tools. In their definition, CA are uniform objects: there is a unique neighbourhood shape for each cell and a Unique transition function. As a consequence, CA are fitted to model phenomena that involve homogeneous spaces; CA have been used for example to model physical systems (Chopard and Droz, 2005), biological systems (Deutsch and Dormann, 2005), spatially embedded computations (Adamatzky, 2001), etc. Note that it is always possible to take into account inhomogeneities, for example by encoding the heterogeneity in the cell states, but this is generally not straightforward to do so.

MAS are preferred for expressing a heterogeneous population of entities. They necessitate to make a distinction between the agents' behaviours and the environment where they are embedded (Ferber, 1999). This distinction allows us to focus on the specification of particular and localized events, namely the agents actions. They offer a methodology for designing systems, at the level of algorithms, programming languages, hardware, etc. Examples of MAS applications range from the simulation of natural systems, from ants (Resnick, 1994) to human behaviours (Regelous, 2004), to the design of massively distributed software and algorithms like web-services, peer-to-peer technologies, etc. Nevertheless, we must note that contrarily to CA, no universal definition of MAS has been accepted so far. From the modelling point of view, translating MAS in the cellular automata formalism has (at least) the advantage of fixing the mathematical expression of the model and removing ambiguities of formulation.

MAS and CA, as simulation tools. The key characteristic of complex systems is the difficulty, if not the impossibility, of inferring their global behaviour from the local specification of the interactions. Few mathematical tools are available to predict the evolution of complex systems in general, more especially those which involve self-organization. This gives to simulation a central role to find the mechanisms that explain how complexity emerges from simple local interactions. We thus have to pay attention to the quality of simulations and to detect ambiguities that may be hidden in the way they are implemented.

The agent-based programming style is somehow intuitive and natural as the programmer takes the point of view of the agent. There is a form of anthropomorphism that makes MAS programming particularly attractive. Nevertheless, we emphasize that once all the agents behaviours are individually specified, there are still many ways to make the agents interact and play together in the environment. The implementation of such systems raises many questions, like assessing the importance of the synchronicity in simulations: are the agents updated all together or one after the other? The design of spatially-extended computing devices will require to imagine a new type of computer science, where the computations do not necessarily rely on the existence of a synchronization between the components.

By contrast with MAS, CA lead to shift the programmer's point of view from the "eyes" of the agents to their environment. The benefits of this shifting effort are twofold: (1) the CA formalism forces the programmer to solve conflicts between concurrent agents actions at the elementary level of the cell and forbids the use of any global procedure. (2) As a consequence, the implementation on massively distributed devices is easy. Indeed, CA provide the programmer a cell-centered programming style where the set of cells represents computing units that are regularly organized. Recent works have shown that it is possible to have a good efficiency by using parallel architecture to run CA simulations for FPGA (Halbach and Hoffmann, 2004) and for GPU (Permalla and Aaby, 2008). In other words, CA provide an easy to implement framework, but expressing the local rule necessitates a method to “blend” the different components of a complex system.

4.3 Multi-objective optimization models

Multi-objective optimization models for evacuation planning with conflicting objective functions are presented in Al¸cada-Almeida et al. (2009), Coutinho-Rodrigues, Tralh˜ao and Al¸cada-Almeida (2012), Fang et al. (2011), Georgiadou et al. (2010), Goerigk, Deghdak and Heßler (2014), Saadatseresht, Mansourian and Taleai (2009), Stepanov and Smith (2009) and Tzeng, Cheng and Huang (2007).

Coutinho-Rodrigues, Tralh˜ao and Al¸cada-Almeida (2012) consider a multi-objective approach for identifying evacuation paths and the location of shelters for urban evacuation planning. A mixed-integer linear model is formulated, thereby minimizing the risk of the selected paths and locations, the evacuation path lengths and the number of shelters. Also minimized is the length of a secondary path, which is used if the primary path becomes impassable. The problem is solved with the weighted method. Fang et al. (2011) propose a multi-objective optimization approach to plan an evacuation of a stadium on the basis of a hierarchically directed network. The total evacuation time, the total evacuation distance and the cumulative congestion degree are minimized simultaneously. A modified ant colony optimization (ACO) algorithm is presented to solve this problem. Saadatseresht, Mansourian and Taleai (2009) propose a three-step routing and assignment approach for evacuation planning. Regarding the assignment procedure, two objective functions are considered: On the one hand, the potential overload of the shelters should be divided among these shelters evenly and on the other, the total travel time should be minimal. The problem is solved using a multi-objective evolutionary algorithm (MOEA). Stepanov and Smith (2009) generate an evacuation plan with three objectives including the minimization of the total clearance time, of the total travelled distance and the congestion on road segments. An integer programming (IP) model is presented to generate the evacuation routes and the travel times are evaluated with an embedded M/G/c/c state-dependent queuing model. Tzeng, Cheng and Huang (2007) present a relief-distribution model in a post-earthquake environment with three objective functions: minimizing the total cost, minimizing the total travel time and ensuring a fair distribution of the relief commodity to all demand points. A fuzzy multi-objective linear programming approach is applied.

4.4 Knapsack

Definitions:

The problem of knapsack is an optimization problem used to show both problem and solution. It originates its name from a scenario wherever one is constrained in the number of substances that can be located inside a fixed-size knapsack. Given a group of items with exact weights and values, the aim is to get as much amount value into the knapsack as possible given the weight constraint of the knapsack.

The knapsack problem is an example of a combinational optimization problem, a topic in mathematics and computer science about finding the optimal object among a set of objects. This is a problem that has been studied for more than a century and is a commonly used example problem in combinatorial optimization, where there is a need for an optimal object or finite solution where an exhaustive search is not possible. The problem can be found real-world scenarios like resource allocation in financial constraints or even in selecting investments and portfolios. It also can be found in fields such as applied mathematics, complexity theory, cryptography, combinatorics and computer science. It is easily the most important problem in logistics.

Suppose a hitch-hiker has to fill up his knapsack by selecting from among various possible objects those which will give him maximum comfort. This knapsack problem can be mathematically formulated by numbering the objects from 1 to n and introducing a vector of binary variables xj (j = 1, ,n) having the following meaning:

$$x_j = \begin{cases} 1 & \text{if object } j \text{ is selected;} \\ 0 & \text{otherwise.} \end{cases}$$

Then, if pi is a measure of the comfort given by object j, its size and c the size of the knapsack, our problem will be to select, from among all binary vectors x satisfying the constraint

$$\sum_{j=1}^{n} w_j x_j \leq c,$$

the one which maximizes the objective function

$$\sum_{j=1}^{n} p_j x_j .$$

The problem considered so far is representative of a variety of knapsack-type problems in which a set of entities are given, each having an associated value and size, and it is desired to select one or more disjoint subsets so that the sum of the sizes in each subset does not exceed (or equals) a given bound and the sum of the selected values is maximized.

Knapsack problems have been intensively studied, especially in the last decade, attracting both theorists and practices. The theoretical interest arises mainly from their simple structure which, on the one hand allows exploitation of several combinatorial properties and, on the other, more complex optimization problems to be solved through a series of knapsack-type subproblems. From the applied opinion, these kind of problems can model many manufacturing situations: cargo loading capital budgeting, capital budgeting, as well as cutting stock, to mention the most classical applications. In the following chapters we shall examine the most important knapsack problems, analysing relaxations and upper bounds, describing exact and approximate algorithms and evaluating their efficiency both theoretically and through computational experiments.

4.5 P-median

The p-median model is used to locate P structures to serve a geographically distributed population. Conventionally, it is assumed that the population frequents the closest structure and that the distance between the resident and the structure can be measured by the Euclidean distance. Carling, Han and Håkansson (2012) compared two network distances with Euclidean in a rural region with a dispersed and heterogeneous network and a non-symmetric distribution of the population. For a thick network and Psmall, they found, in contrast to the literature, that the Euclidean distance was problematic.

Distance measures in the *p*-median model

Consider the problem of assigning P structures to a population geographically distributed to Q question points, in order to minimize the average or total distance of the population from the nearest structure. Hakimi (1964) considered the task of locating the telephone exchanges and showed that, in a network, the optimal solution of the p-median model existed in the nodes of the network. Subsequently, the p-median model was used in a considerable variety of localization problems (see Hale and Moberg, 2003).

However, there are three main challenges when applying the p-median model to a specific localization problem. The first is computational due to the combinatorial characteristic of the problem. The enumeration of all possible positions, looking for the best, is a formidable task, even for the small P and Q. Therefore, many researches have been devoted to efficient (heuristic) algorithms to solve the p-median model (see Handler and Mirchandani 1979, Daskin 1995 and Murray and Church 1996 as examples).

The second challenge is the aggregation error that derives from the common practice of adding question marks. Hillsman and Rhoda (1978) analyzed the errors that can arise by measuring the distance between the population to be served and the structures. A source of error derives from the aggregation of the population of an area in a single point, where the point must represent the position of all the members of the population in the area. His research has stimulated an ongoing investigation into this error and techniques to reduce the error (see Francis, Lowe, Rayco and Tamir 2009 and references in it).

The third challenge is to measure the distance between the question mark and the nearest structure. In his seminal article, Bach (1981) conducted an in-depth investigation into how to measure distance. Several competitive alternatives are the Euclidean (the shortest distance on the plane), the straight line (or the distance of Manhattan), the network distance (the shortest distance along an existing road or the public transport network) and the travel time (or cost) shorter than an existing network. Surprisingly, Bach (1981) found that the correlation was close to that of the network and Euclidean distances when he made an empirical examination of two densely populated German cities. Therefore, their results indicate that it does not matter if the distance of the network or of the Euclidean is used as a distance measure. After the publication of Bach (1981), there is little research on the consequences of the choice of distance measurement, while some studies, even in rural settings, provide suggestions for the relationship between distance measures (see Love and Morris 1972). , Brimberg and Love 1993, 1995 as examples).

Mathematically, the P-Median problem can be summarized as follows:

Inputs

h_i = customer i demand
d_{ij} = distance between customer i and candidate facility j
P = number of facilities to locate

Decision Variables

$$X_j = \begin{cases} 1 & \text{if we locate at candidate site j} \\ 0 & \text{if not} \end{cases}$$

$$Y_{ij} = \begin{cases} 1 & \text{if customer i is served by facility j} \\ 0 & \text{if not} \end{cases}$$

Minimize

$$\sum_i \sum_j h_i d_{ij} Y_{ij} \qquad \text{(a)}$$

Subject to

$$\sum_j Y_{ij} = 1 \qquad \forall i \qquad \text{(b)}$$
$$\sum_j X_j = P \qquad \text{(c)}$$
$$Y_{ij} - X_j \leq 0 \qquad \forall i,j \qquad \text{(d)}$$
$$Y_{ij} = 0, 1 \qquad \forall j \qquad \text{(e)}$$
$$X_j = 0, 1 \qquad \forall i,j \qquad \text{(f)}$$

The objective function, (a), minimizes the weighted distance from the total demand between each "customer" and the nearest structure. The restrictions ensure that the various properties of the problem are met. in particular:

- (b) requires that each client be assigned to only one installation
- (c) requires that the P installations be positioned exactly
- (d) links the position variables and the assignment variables
- (e) and (f) ensure that the position variables (X) and the allocation variables (Y) are binary

Because of the binary constraints (e) and (f), the above formulation cannot be solved with standard linear programming techniques. This is where Lagrange relaxation comes into play. Lagrange relaxation is based on the premise that eliminating the limitations of a problem makes the problem easier to solve. Therefore, to solve a problem, Lagrangian relaxations eliminate a restriction but introduce a penalty to violate the eliminated constraint. This revised problem is optimized accordingly. The following is a breakdown of how the Lagrangian relaxation technique was implemented to solve the P-Median problem:

Step 1: Setting up:

We eliminate constraint (b) and add the restriction and a vector of variables called Lagrange multipliers to the objective function. For this particular implementation, all Lagrange multipliers have been initialized to a value of 300. So you get the following problem:

$$\max_{\lambda} \min_{X,Y} \sum_{i}\sum_{j} h_i d_{ij} Y_{ij} + \sum_{i} \lambda_i \left[1 - \sum_{j} Y_{ij}\right]$$

Step 2: Resolving the simplified problem

For the fixed values of the Lagrange multipliers, the objective function in the previous step is reduced to a minimum by calculating the value of the setting of each of the position variables (X) to 1. This value is given by:

$$V_j = \sum_{i} \min\{0, h_i d_{i,j} - \lambda_i\}$$

for each candidate location j. The P smallest values of V is then determined and the corresponding location variables (X) are set to 1 and all other location variables (X) to 0. The allocation variables (Y) are then set to:

$$Y_{ij} = \begin{cases} 1 & \text{if } X_j = 1 \text{ and } h_i d_{ij} - \lambda_i < 0 \\ 0 & \text{if not} \end{cases}$$

Step 3: Updating both lower bound also upper bound

For each iteration of this process, it is necessary to determine an upper limit of the objective function (worst case estimate) and a lower limit (an optimistic estimate of the best case). An upper limit is a solution that has been found to satisfy the restrictions of the original unmodified problem. The lower upper limit (best estimate for the worst case) is searched for the purposes of this algorithm. The upper limit can be determined simply by determining the closest position to each customer. The corresponding allocation variables (Y) are set to 1, while the others are set to 0. Next, we evaluate the function of the P-Median target as originally established.

Please note that a solution to the simplified problem as described in Step 2 may or may not satisfy the limitations of the original problem. Since the modified problem does not need to respect the original constraints, the modified problem will produce an answer that will always be better or equal to the solution of the original problem. Therefore, a lower limit in the P-Median problem can be determined simply by evaluating the original P-Median objective function using the values for the variables determined in Step 2.

Step 4: Adjusting the Lagrange multipliers

A technique that directs iterations to an optimal solution that meets the limits of the original problem called subgradient optimization is used to update the value of Lagrange multipliers; whose details are beyond the scope of this section. Based on the optimization of the subtype, a new variable t is introduced and defined as follows:

$$t^n = \frac{A^n (UB - L^n)}{\sum_i \left\{ \sum_j Y_{ij} - 1 \right\}}$$

A^n = a constant on the nth iteration, with A^1 generally set to 4

t^n = the stepsize at the nth iteration of the Lagrangian procedure

UB = the best (smallest) upper bound on the P-median objective function

L^n = the value of the objective function using the solution obtained from the relaxed problem

Y_{ij}^n = the optimal value of the allocation variable, Y_{ij}^n on the nth iteration

The Lagrange multipliers are then updated according the following equation:

$$\lambda_i^{n+1} = \max \left\{ 0, \lambda_i^n - t^n \left(\sum_j Y_{ij}^n - 1 \right) \right\}$$

Step 5: Assessing the results

If at any time the lower limit is equal to or very close to the upper limit, it is very likely that the optimal solution to the original problem has been found and that the algorithm in this case ends. To put a reasonable limit on the execution time of the algorithm, this applet limits the number of iterations to 100 and the values of A to not less than 0.01. If the upper limit has not decreased after 4 consecutive iterations, A is configured as A / 2. If none of the previous holding conditions are met, the implementation is repeated starting from step 2.

Chapter 4: Problem Solving

4.1 Problem Solving with ARC GIS LOCATION-ALLOCATION MODULE:

Location-allocation (LA) models use deductive algorithms to optimize the location of one or more facilities, like warehouses, manufacturing plants or public service facilities. In general, they are concerned with the question of how to serve or supply a given set of demand points across space in an optimal fashion. The algorithms typically do so by repeatedly assessing sets of potential locations for facilities against spatially dispersed sets of demand for these facilities. The models thereby aim to satisfy predetermined objective functions (e.g., maximizing coverage of space or minimizing overall transportation costs), given several criteria (e.g., number of facilities, facility capacities or transportation thresholds). In doing so, LA models typically combine data on facility, travel, or consumer characteristics. This wealth of data benefits the location decision, but it also implies that the model outcome heavily depends on the availability and accuracy of the input data.

The resolution tool in this module chooses the best locations or allocations from a set of input locations. Input resources produce goods or services and demand points consume these goods and services. The purpose of this module is to locate the resources that best meet the demand. The problem-solving tool is used to analyze different ways of allocating resources at the demand points. The solution is the scenario that allows to allocate the greatest demand to available resources while minimizing the total impedance8. The solution includes the resources, the demand points associated with them, and the lines linking the demand points to their resources.

This tool can be constructed to solve exact problem types. Samples include the following:

- A fire section desires to control where it should locate fire stations to reach 90 percent of the public within a five-minute reply time.
- Afterward a tornado, a disaster response agency desires to find the best locations to set up triage amenities, with partial patient sizes, to tend to the affected population.
- in the event of an earthquake, a municipality wants to identify the best locations to deploy reception centers of limited capacity to take care of the population
- The supermarket chain wants to see what potential points of sale it needs to develop to attract 15% of the region's market.

Impedance definition:
Impedance is the amount (or cost) required to move from one network element to another. Impedance can be a measure of distance traveled, time, speed of movement multiplied by distance, etc.

MODELING OF THE MULTI-OBJECTIVE MODEL AND APPLY IT ON THE CITY OF NICE

list of the different problems that can be solved with the "Location-Allocation" module:

- Minimize impedance
- Optimize coverage
- Optimize capacity coverage
- Minimize resources
- Optimize attendance
- Optimize market share
- Target market share

MINIMIZE IMPEDANCE: -

Defining the problem:

For each building (point of request) a shelter (resource) is allocated to minimize the sum of all the weighted (unit cost) distances between the buildings and the Shelters from the final solution.

The Minimize Impedance problem type selects the resources so that the total sum of the weighted impedances (requests allocated to a resource multiplied by the impedance of the resources) is minimized.

This type of problem is often used for warehouse location because it minimizes distances and therefore reduces the cost of transporting goods to their point of sale. The tool is, since it allows the calculation of the minimum distance traveled, often used in the public sector to analyze the distance of a population to a resource such as an airport, a bookstore, a museum or health centers.

The following list describes how this type of issue handles the request and how to assign it to a specific resource: (The list below is from ArcGIS Help)

- If an impedance limit is set, any request outside the impedance limits of all resources is not allocated.
- All request weight of a request point within the impedance limit of a resource is allocated to that resource.
- All request weighting of a request point within the impedance limit of multiple resources is allocated only to the nearest resource

Application on the area of our study:

Calculation parameters:

Resources to select	187
Impedance parameter	<None>

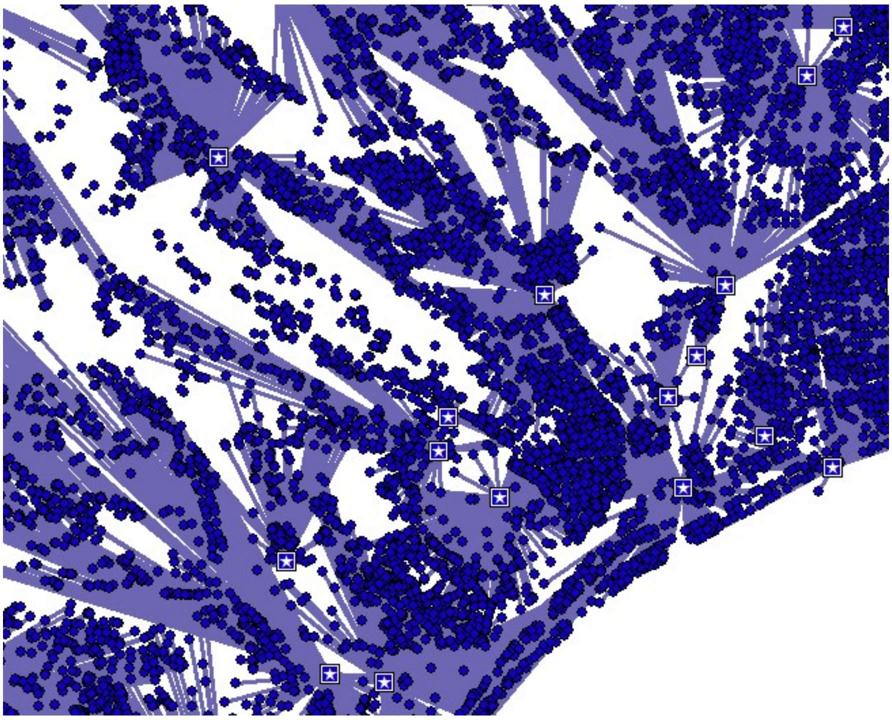

Figure 16 - Result of the Minimize impedance tool part of the full Map

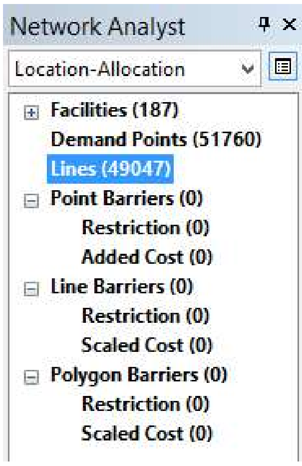

Figure 17 - Result of the Minimize impedance tool

With this tool we can obtain in the attribute table the total sum of the distances between the demand points and the resources, is 49445,56km. but the number of building covered is 49047 out of 51,760, that's mean there is 2713 building are not covered in the evacuating plan which is 5.24% of the total building.

A major limitation of this tool is the lack of consideration of shelter capacity. In fact, during calculations each building is assigned to the nearest shelter without considering their capacity. If we can consider that this is a limit, this tool is provided at the base for a mono-objective resolution: the distance. A tool comes in addition to this first tool and is based on a multi-objective resolution.

Another limitation, this one being graphic because one notices in the properties of the layer during the configuration of the parameters of analysis that it is possible to choose only 2 types of forms of exit either none, or lines. The results are therefore not easily interpretable with these choices. It is therefore preferable to use Network Analyst's "Closest facility" function if you want a network-based display.

This problem can also be easily solved with Python. Therefore, if we first determine a text file containing IDentifier buildings, ID Shelter and distance. It is easy to find the minimum distance from a building to a Shelter. This calculation can be done with the network distance or the Euclidean distance.

Maximize Coverage

Defining the problem:

The installations are positioned in such a way as to assign as many demand points as possible to the installations of the solution within the impedance limit.

Maximize Coverage is often used to locate firefighters, police stations and ERS centers, as emergency services are often required to reach all demand points within a specific response time. Keep in mind that it is important that all organizations, which are critical to emergency services, have accurate and accurate data so that the results of the analysis correctly produce real results.
Pizza delivery companies, unlike consumer pizzerias, try to find shops where most people can cover them within a certain driving period. People who ask for pizzas for delivery usually do not worry about how far the pizzeria is; They are mainly concerned about the arrival of pizza within an announced window of time. Therefore, a pizza delivery company could reduce pizza preparation time from announced delivery times and solve a problem of maximum coverage to choose the candidate structure that would capture the largest number of potential customers in the coverage area. (The potential customers of consumer pizzerias are more affected by the distance, since they need to go to the restaurant, therefore, the maximization of presences or the types of problems of participation in the market are better adapted to the restaurants they eat in).

The following list describes how the maximum coverage problem handles the application: (The following list is taken from the ArcGIS Guide)

- Any demand point outside all the facilities' impedance cutoffs is not allocated.
- A demand point inside the impedance cutoff of one facility has all its demand weight allocated to that facility.

A demand point inside the impedance cutoff of two or more facilities has all its demand weight allocated to the nearest facility only.

Identifier: It's a number that uniquely identifies an object or record

Application on the area of our study:

Calculation parameters:

Resources to select	187
Impedance parameter	500m

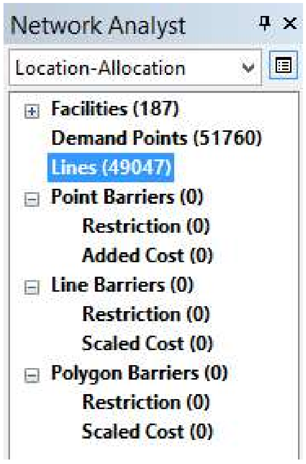

Figure 18 - Result of the Maximize Coverage tool

The total sum of the distances between the demand points and the resources, remained the same and did not change which is 49445,56km. and the number of building covered also remained the same 49047 out of 51,760, that's mean there is 2713 building are not covered in the evacuating plan which is 5.24% of the total building. That show us that even if we used this tools with defining the impedance 500 meter and less the result will be the same

In fact, result that can be obtained with the "Minimize Impedance" tool, with defining the impedance: 500 m the result will be the same.

<u>Maximize Capacitated Coverage</u>

Problem Definition:

This tool allows you to allocate as many buildings (demand points) as possible to the resource Shelters in the solution that are within the impedance limit. In addition, the NSA (weighted application) allocated to a Shelter cannot exceed the capacity of the same Shelter.

This function allows multi-objective optimization because it takes into account the distance as well as the capacity. The "Optimize Capability Coverage" problem type selects resources so that the completeness or, where appropriate, much of the demand can be met, but without exceeding the capacity of the resources. This type of problem works like the previous tools (Minimize Impedance) but with an additional constraint: capacity. If no impedance limit is set in the input parameters, then the tool functions as a capacity version of Minimize Impedance.

The type of capacity coverage optimization problem can be used in different cases:
• the location of hospitals or the capacity of each is limited

• the identification of warehouses whose stocks are not unlimited

Here are the main steps of this analysis function:

• Unlike Optimize coverage, the problem type Optimize Capacity Coverage does not need an impedance limit; however, when an impedance limit is specified, the demand points outside the impedance limits of all resources are not allocated.

• The demand weight of an allocated demand point is entirely (or not at all) assigned to a resource. This means that with this type of problem, the demand is not distributed. There is no subdivision possible, in our case a building is affected or not.

• If the total demand within the impedance limit of a resource is greater than the capacity of the resource, only the demand points that optimize the total captured demand and minimize the total weighted impedance are allocated.

Application on the area of our study:

Calculation parameters:

we make this Calculation twice once with none impedance and second time with impedance of 500 meter or less .

1st calculation

Resources to select	187
Impedance parameter	<None>

2nd calculation

Resources to select	187
Impedance parameter	500 m

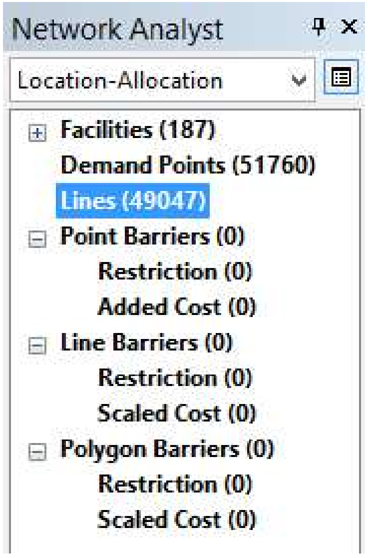

Figure 19 - Result of the Optimize Capacity Coverage tool

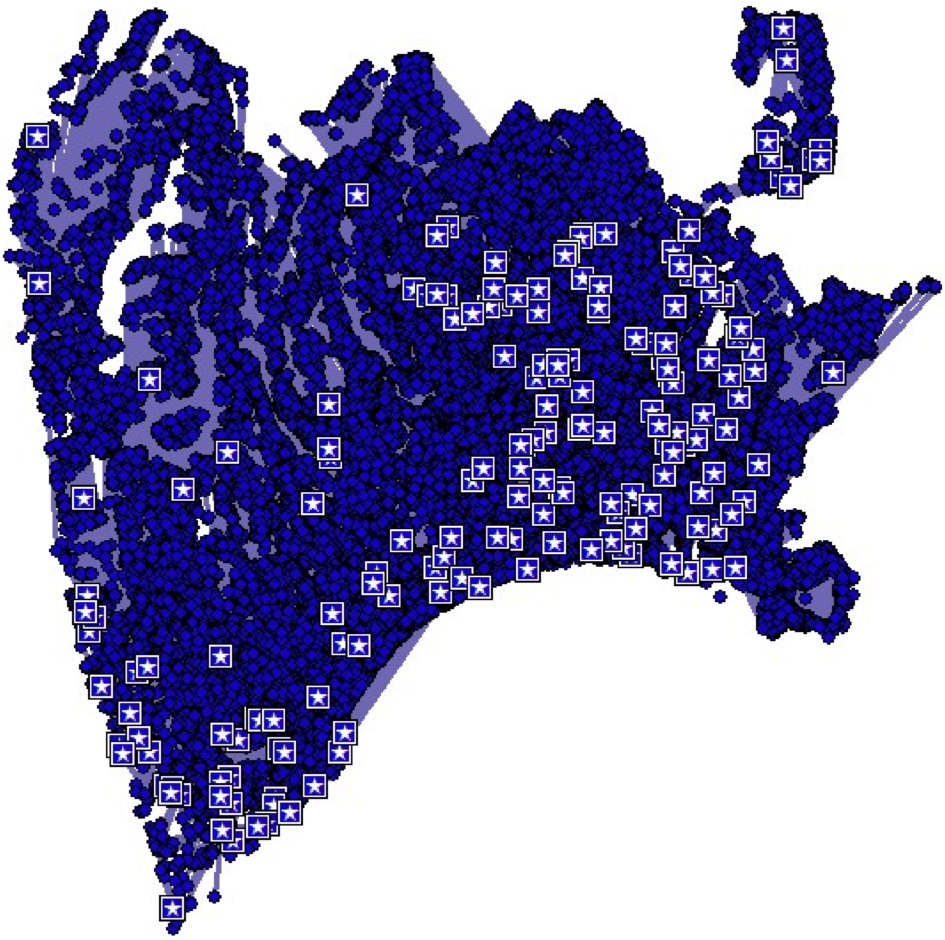

Figure 20 - Result of the Optimize Capacity Coverage tool on Map

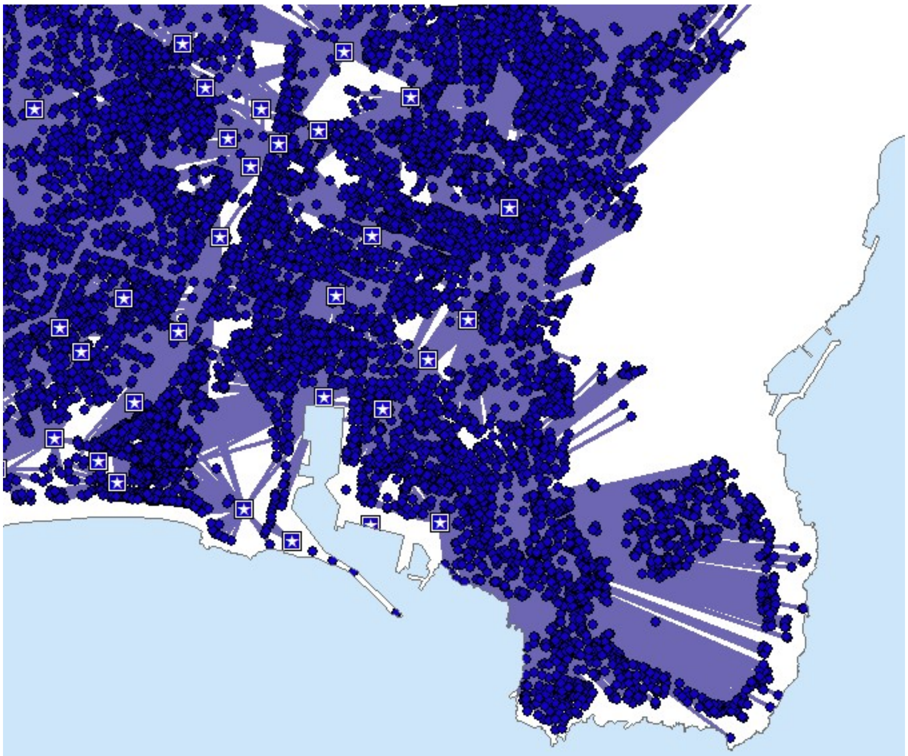

Figure 21 - Result of the Optimize Capacity Coverage tool part of the full Map

The total sum of the distances between the demand points and the resources, remained the same and did not change which is 49445,56km. and the number of building covered also remained the same 49047 out of 51,760, that's mean there is 2713 building are not covered in the evacuating plan which is 5.24% of the total building in both cases with impedance of 500 m and without impedance.

Limitations of the problem:

The problem is that this function is based in part on the Minimize impedance and p-median similarity function. the larger the size of the network to be solved, it becomes difficult if not impossible for the computer to calculate all the possibilities.

In our case of the city of NICE the number of possible combinations to examine is 51760! (Factorial) hence the accuracy of the search wouldn't be accurate because all possible combinations.

4.2 Problem Solving with Algorithms and Data Structures using Python

What Is Algorithm Analysis: -
To answer this question, we must remember that there is an important difference between a program and the underlying algorithm that represents the program. An algorithm is a list of generic step-by-step instructions to solve a problem. It is a method to solve any instance of the problem in such a way that, given an input, the algorithm produces the desired result. A program, on the other hand, is an algorithm that has been coded in some programming languages. There may be many programs for the same algorithm, depending on the programmer and the programming language used.

The hypotheses are based on the interpretation of our authority, so we have chosen to develop three scenarios to better respond to our initial problem: how to influence all those who do not have a shelter in Nice in a shelter? These scenarios are as follows and use the Python language
Euclidean Distance

- Network Distance
- Using multi-objective optimization
- Multicriteria assignment

1- Euclidean distance

the Euclidean distance or Euclidean metric is the "ordinary" straight-line distance between two points in Euclidean space. With this distance, Euclidean space becomes a metric space. The associated norm is called the Euclidean norm.

In Cartesian coordinates, if p = (p1, p2,..., pn) and q = (q1, q2,..., qn) are two points in Euclidean n-space, then the distance (d) from p to q, or from q to p is given by the Pythagorean formula:

$$d(\mathbf{p},\mathbf{q}) = d(\mathbf{q},\mathbf{p}) = \sqrt{(q_1-p_1)^2 + (q_2-p_2)^2 + \cdots + (q_n-p_n)^2}$$
$$= \sqrt{\sum_{i=1}^{n}(q_i-p_i)^2}.$$

First case: -Assignment of buildings to nearest Shelter without taking in account of the capacity constraint (isochronous) = mono assignment

The data we have from the municipality of Nice:

1	#FID	X_Centr	Y_Centr	NSA
2	0	1044953.605	6298368.991	16.58222713
3	1	1044906.373	6298356.35	270.8277856
4	2	1044962.683	6298338.916	79.33891047
5	3	1044925.633	6298307.129	39.56848675
6	4	1045233.756	6299188.221	244.6703033
7	5	1045723.783	6299024.996	20.02886639
8	6	1045708.928	6299010.162	59.64974169
9	7	1045363.396	6299211.797	3.139427098
10	8	1045323.861	6299220.956	19.94304648
11	9	1045403.961	6299275.065	11.96573458
12	10	1045391.337	6299221.916	1.749842019
13	11	1045325.349	6299232.799	0.102931641
14	12	1045331.698	6299220.23	0.411727458
15	13	1045356.344	6299207.861	34.45651086
16	14	1045366.92	6299249.403	191.6066967
17	15	1045381.275	6299273.634	5.30094681
18	16	1045349.95	6299213.349	2.007171282

Figure 22 - Location of Nice buildings and its capacity

1	#FID	X_Centr	Y_Centr	Cap_Shelters
2	0	1042948.971	6300904.27	270
3	1	1040854.602	6299040.462	197
4	2	1041872.368	6301102.986	110
5	3	1043228.065	6299198.136	28
6	4	1040657.377	6295038.051	656
7	5	1043257.073	6297670.342	375
8	6	1045217.533	6297621.659	625
9	7	1045391.233	6298595.857	625
10	8	1045534.108	6298833.982	431
11	9	1044547.607	6298582.495	188
12	10	1044382.242	6298373.474	275
13	11	1044294.929	6298470.047	231
14	12	1043462.284	6298338.946	206
15	13	1043591.93	6298006.893	144
16	14	1043076.256	6298038.643	655
17	15	1043154.308	6298561.858	150
18	16	1042277.61	6301001.718	300

Figure 23- Location of Nice Shelters and its capacity

Annexure 1 Using Python to prepare the date

```
def ecrit_fich_care(fich_care,m_c,c):
    # fich_care = open("ecrit_c.txt", "w")
    for i in range(-1,c):
        ligne = ""
        if i == -1:
            ligne = "#ObjectID" + "\t" + "X_Care" + "\t" + "Y_Care" + "\t" + "Capacite"
            ligne = ligne + "\n"
        elif i < c-1:
            ligne = str(int(m_c[i,0])) + "\t" + str(m_c[i,1]) + "\t" + str(m_c[i,2]) + "\t" + str(m_c[i,3])
            ligne = ligne + "\n"
        else:
            ligne = str(int(m_c[i,0])) + "\t" + str(m_c[i,1]) + "\t" + str(m_c[i,2]) + "\t" + str(m_c[i,3])
        fich_care.writelines(ligne)

    fich_care.close()

    print("nb cares c = ", c) # ;print(m_c)
    #m_c.resize(c,4)
    fich_care.close()
```

```
def ecrit_fich_bati(fich_bati,m_b,b):
    fich_bati = open("ecrit_bjlo.txt", "w")
    for i in range(-1,b):
        ligne = ""
        if i == -1:
            ligne = "#FID_1" + "\t" + "X_bati" + "\t" + "Y_bati" + "\t" + "NbPersB_NSA"
            ligne = ligne + "\n"
        elif i < b-1:
            ligne = str(int(m_b[i,0])) + "\t" + str(m_b[i,1]) + "\t" + str(m_b[i,2]) + "\t" + str(m_b[i,3])
            ligne = ligne + "\n"
        else:
            ligne = str(int(m_b[i,0])) + "\t" + str(m_b[i,1]) + "\t" + str(m_b[i,2]) + "\t" + str(m_b[i,3])

        fich_bati.writelines(ligne)

    fich_bati.close()

    print("nb batiments b = ", b)

    fich_bati.close()
```

Then calculating the evacuation plan according to the distance without considering the capacity of the shelters.

Annexure 2: **Python evacuation plan calculation (Euclidean distance)**

```python
import time
import numpy as np
from math import sqrt
# from random import*
import Lit_fich_bati
import Lit_fich_care
# import Lit_fich_matriceOD

debut = time.time() ; print()
print("Le temps du début de calculs en secondes :",debut);print()

fich_bati = "C:/Users/max/Desktop/all the data and the gis/Qst1_DE/2_51760_BATI_JOUR_LIGURE_OBSTRUCT.txt"

m_b,b = Lit_fich_bati.lit_fich_bati(fich_bati)

fich_care = "C:/Users/max/Desktop/all the data and the gis/Qst1_DE/187_CARE.txt"
m_c,c = Lit_fich_care.lit_fich_care(fich_care)

nom_f = "Affect_DE_Daher_"+ str(b) + "_np" + ".txt"
fichier3 = open(nom_f, "w")
ligne = "#FID_1" + "\t" + "IdCare" + "\t" + "DistEucl" + "\t" +"NbPersB" + "\t"
ligne = ligne + "Capacite" + "\t" + "xp" + "\n"
fichier3.writelines(ligne)

nom_xp = "Affect_DE_Daher_" + str(b) + "_xp" + ".txt"
fichier4 = open(nom_xp, "w")
ligne = "#NbBAffecter" + "\t" + "Xp" + "\n"
fichier4.writelines(ligne)

d = 0;np_k = 0

m_d = np.array([[0.0 for e in range(0,5)] for f in range(0,c)])

list1_xp = np.array([],dtype = float) # vecteur
```

```python

for i in range(b):
    j = 0
    for j in range(c):
        d = d + 1          # inrementation
        dist_eucl = 0
        dist_eucl = sqrt((m_b[i,1] - m_c[j,1])**2 + (m_b[i,2] - m_c[j,2])**2)

        m_d[j,0] = m_b[i,0]          # ID Batiment
        m_d[j,1] = m_c[j,0]          # ID Care
        m_d[j,2] = dist_eucl         #  distance eucl
        m_d[j,3] = m_b[i,3]          # Nb Pers Bati
        m_d[j,4] = m_c[j,3]          # Capacite Care

    # Tri avec sorted et lambda
    lambda colonnes: colonnes[2]
    m_d2 = sorted(m_d, key=lambda colonnes: colonnes[2])
    m_d3 = np.asarray(m_d2)

    xp = 0
    xp = m_d3[0,2] * m_d3[0,3]
    list1_xp = np.append(list1_xp,xp)
    ligne = ""
    ligne = str(int(m_d3[0,0])) + "\t" + str(int(m_d3[0,1])) + "\t" + str(float(m_d3[0,2])) + "\t"
    ligne = ligne + str(float(m_d3[0,3])) + "\t" + str(float(m_d3[0,4])) + "\t" + str(float(xp))
    if d < b*c:
        ligne = ligne + "\n"
    fichier3.writelines(ligne)

np_k=0
NbBAffecter = np.size(list1_xp)
np_k = np.sum(list1_xp)
```

```python
ligne = ""
ligne = str(NbBAffecter) + "\t" + str(np_k) + "\n"
fichier4.writelines(ligne)

fichier3.close()

fin = time.time()
temps_sec = fin - debut
print("La durée en seconde pour ",1," simulation-s est : ",temps_sec);print()
temps_min = temps_sec / 60
print("La durée en minutes pour ",1," simulation-s est : ",temps_min)
ligne = ""
ligne = str(temps_sec) + "\t" + str(temps_min)
fichier4.writelines(ligne)
fichier4.close()
```

Result

1	#FID_1	IdCare	DistEucl	NbPersB	Capacite	xp
2	16785	132	1056.5062861814502	5.61e-05	1719.0	0.05927000265477936
3	13069	32	541.3365429011955	7.31e-05	38.0	0.03957170128607739
4	16786	132	1269.6166628983297	7.38e-05	1719.0	0.09369770972189674
5	7805	110	218.85818817941447	9.63e-05	225.0	0.021076043521677613
6	16022	130	1523.6047564804344	0.000108481	569.0	0.165282167587754
7	15878	32	2243.506695835279	0.00011209	38.0	0.2514746655361764
8	16783	132	463.9278886470218	0.000121506	1719.0	0.05637002203794503
9	16784	132	1297.1971990491527	0.000121506	1719.0	0.15761724286766635
10	16494	130	1795.5655739810973	0.000121935	569.0	0.2189422882633851
11	25285	157	335.9619653487495	0.000136219	43.0	0.04576440295784131
12	15882	130	1346.8447351122575	0.000141742	569.0	0.1909044664442816
13	15203	32	1889.273990806939	0.000149226	38.0	0.2819288005521563
14	17418	156	895.8449891860989	0.000153908	156.0	0.1378777105956541
15	15914	130	1627.8913065893444	0.000157319	569.0	0.25609823246132907
16	8909	42	1418.5718652369192	0.000160771	63.0	0.22806521734600474
17	19008	72	685.8451645105185	0.000169948	469.0	0.11655801401823361
18	28866	121	736.9281362391454	0.000171121	150.0	0.12610387960137878

Number of affected building	Total cost meter per person
50634	20438762.8617

Figure 24 - evacuation plan for each building Showing the total number of affected building and the cost

2-Network Distance

For any two locations in a spatial network, their network distance is the length of the shortest path between these two locations along the network. The shortest path is computed based on the travel weight, such as travel distance or travel time, of network edges.

Assignment of buildings to nearest Shelter without taking in account of the constraint of capacity and using the Distance Table Network which has been conducted in Arc Gis (Network Analysis) according to the Network distance.

1	ORI_ID	DEST_ID	TOTAL_METE
2	2750	188	3729.31
3	2750	189	5374.30
4	2750	190	4678.76
5	2750	191	2304.59
6	2750	192	5949.55
7	2750	193	2117.48
8	2750	194	788.94
9	2750	195	659.78
10	2750	196	931.22
11	2750	197	626.92
12	2750	198	742.64
13	2750	199	782.78
14	2750	200	1760.30
15	2750	201	1647.43
16	2750	202	2133.81
17	2750	203	2128.40
18	2750	204	4180.30

Figure 25: Distance Table Network

Annexure 3: python evacuation plan calculation (Network Distance)

```python
import time
import numpy as np
import Lit_fich_bati
import Lit_fich_care
import Lit_fich_LignesOD

debut = time.time();print()
fich_bati = "C:/Users/max/Desktop/all the data and the gis/Qst2_DR/Rq22_51760B_TriCrOID.txt"
m_b,b = Lit_fich_bati.lit_fich_bati(fich_bati)

fich_care = "C:/Users/max/Desktop/all the data and the gis/Qst2_DR/Rq33_187CareMoveID188.txt"
m_c,c = Lit_fich_care.lit_fich_care(fich_care)

## ce fichier est parfait
fich_LignesOD = "C:/Users/max/Desktop/all the data and the gis/Qst2_DR/Rq11_MOD_Tabulaire.txt"
m_od,dr = Lit_fich_LignesOD.lit_fich_lignesOD(fich_LignesOD)

nom_f = "Affect_DR_Daher"+ str(b) + "_np" + ".txt"
fichier3 = open(nom_f, "w")
ligne = "#FID_1" + "\t" + "IdCare" + "\t" + "DistR" + "\t" +"NbPersB" + "\t"
ligne = ligne + "Capacite" + "\t" + "xp" + "\n"
fichier3.writelines(ligne)

nom_xp = "Affect_DR_Daher"+ str(b) + "_xp" + ".txt"
fichier4 = open(nom_xp, "w")
ligne = "#NbBAffecter" + "\t" + "Xp" + "\n"
fichier4.writelines(ligne)

d = 0 ; np_k = 0 ; i = 0

m_d = np.array([[0.0 for e in range(0,5)] for f in range(0,c)])

list1_xp = np.array([],dtype = float) # vecteur

for i in range(b):
```

```python
    j = 0
    for j in range(c):
        d = d + 1
        # dist_eucl = 0
        # dist_eucl = sqrt((m_b[i,1] - m_c[j,1])**2 + (m_b[i,2] - m_c[j,2])**2)

        m_d[j,0] = m_b[i,0]           # ID Batiment  m_b[i,0]
        m_d[j,1] = m_c[j,0]           # ID Care ???  m_c[j,0]
        m_d[j,3] = m_b[i,3]           # Nb Pers Bati
        m_d[j,4] = m_c[j,3]           # Capacite Care

        a = int(j+(i*c))              # distance réseau tabulaire, fonctionne bien

        m_d[j,2] = m_od[a,2]          # OU distance RESO #  m_od[i,j+1]  dist_eucl

    # Tri avec sorted et lambda
    lambda colonnes: colonnes[2]
    m_d2 = sorted(m_d, key=lambda colonnes: colonnes[2])
    m_dr3 = np.asarray(m_d2)
    xp = 0
    xp = m_dr3[0,2] * m_dr3[0,3]
    list1_xp = np.append(list1_xp,xp)
    ligne = ""
    ligne = str(int(m_dr3[0,0])) + "\t" + str(int(m_dr3[0,1])) + "\t" + str(float(m_dr3[0,2])) + "\t"
    ligne = ligne + str(float(m_dr3[0,3])) + "\t" + str(float(m_dr3[0,4])) + "\t" + str(float(xp))
    if d < b*c:
        ligne = ligne + "\n"
    fichier3.writelines(ligne)
np_k = 0
NbBAffecter = np.size(list1_xp)
np_k = np.sum(list1_xp)
ligne = ""
ligne = str(NbBAffecter) + "\t" + str(np_k) + "\n"
fichier4.writelines(ligne)

fichier3.close()
```

Result

1	#FID_1	IdCare	Dist	NbPersB	Capacite	xp
2	2750	323	358.16	16.58	569.0	5938.2928
3	2751	323	558.59	270.82	569.0	151277.3438
4	2752	323	422.45	79.33	569.0	33512.9585
5	2753	323	472.15	39.56	569.0	18678.254
6	2754	225	403.41	244.67	200.0	98702.3247
7	2755	196	295.91	20.02	431.0	5924.118200000001
8	2756	196	292.88	59.64	431.0	17467.3632
9	2757	225	253.19	3.13	200.0	792.4847
10	2758	225	212.8	19.94	200.0	4243.232000000001
11	2759	258	84.86	11.96	50.0	1014.9256
12	2760	258	250.35	1.74	50.0	435.609
13	2761	225	210.43	0.1	200.0	21.043000000000003
14	2762	225	220.46	0.41	200.0	90.3886
15	2763	225	247.77	34.45	200.0	8535.676500000001
16	2764	258	46.44	191.6	50.0	8897.903999999999
17	2765	258	62.13	5.3	50.0	329.289
18	2766	225	239.95	2.0	200.0	479.9

Number of affected building	Total cost meter per person
51760	**34899440.4449**

Figure 26: evacuation plan for each building Showing the total number of affected building and the cost

Total cost meter per person Using Euclidian distance	Total cost meter per person Using Road Network distance	Increasing Rate
20438762.8617	**34899440.4449**	**70%**

3-Combinator

Using multi-objective optimization

Objective function1 = $\Sigma\Sigma(Pij{*}Distanceij{*}xij)ij$ min

Objective function1 = ΣWjj max

the first objective function serves to minimize the distance traveled between a building and its allocation Shelter, and the second serves to maximize the capacity of the Shelter

#ObjectID	X_Shelter	Y_Shelter	Capacite
0	1042948.971	6300904.27	186.687136496
1	1040854.602	6299040.462	146.463909847
2	1041872.368	6301102.986	11.075082057
3	1043228.065	6299198.136	22.070929908
4	1040657.377	6295038.051	499.488179601
5	1043257.073	6297670.342	220.475266121
6	1045217.533	6297621.659	615.181871816
7	1045391.233	6298595.857	123.602940738
8	1045534.108	6298833.982	28.182987103
9	1044547.607	6298582.495	2.116210596
10	1044382.242	6298373.474	171.260783093
11	1044294.929	6298470.047	37.794434808
12	1043462.284	6298338.946	62.891668083
13	1043591.93	6298006.893	1.476576134
14	1043076.256	6298038.643	416.943505917
15	1043154.308	6298561.858	37.194812683
16	1042277.61	6301001.718	185.907181102
17	1042790.109	6300878.686	166.289687444
18	1043396.006	6300824.447	331.263204842
19	1043478.313	6299352.532	254.1667608

Figure 27 - Location of Nice buildings and its capacity used in multi-objective optimization

#FID_1	IdShelter	DistEucl	NbPersB
15683	1039931.554	6301424.269	0.067219756
15577	1039456.848	6302810.976	0.067296684
12630	1041537.575	6303133.086	0.067519032
13032	1040862.332	6301873.714	0.067546871
12806	1040503.472	6301094.077	0.068239978
12618	1041721.073	6303291.479	0.068453045
13064	1040988.249	6301520.814	0.068810432
15432	1039615.616	6301565.018	0.068845479
11637	1041702.081	6303866.582	0.069163102
14747	1039444.988	6302627.921	0.070215236
14286	1040640.139	6301490.816	0.070483532
12877	1041091.593	6302480.059	0.070749592
12989	1040679.939	6302218.228	0.071028844
14619	1040719.069	6301449.787	0.071408326
14880	1040043.989	6301228.418	0.07166468
13052	1040900.187	6302551.945	0.071768501
14408	1040838.446	6302191.372	0.072753447

Figure 28 - Location of Nice buildings and its capacity used in multi-objective optimization

Annexure 4: python evacuation plan calculation

```python
import time
import numpy as np
from math import sqrt
from random import*
import Lit_fich_bati
import Lit_fich_care

debut = time.time();print()
print("Le temps du début de calculs en secondes :",debut);print()

fich_bati = "C:/Users/max/Desktop/all the data and the gis/Qst3_DE_C/6645BatDif_50634NSACr_43989Com.txt"
m_b,b = Lit_fich_bati.lit_fich_bati(fich_bati)

nom_xp = "Affect_Daher"+ str(b) + "_xp" + ".txt"
fichier4 = open(nom_xp, "w")
ligne = "#NbBAffecter" + "\t" + "Xp" + "\n"
fichier4.writelines(ligne)

for k in range(10):

    nom_f = "Affect_Daher"+ str(b) + "_np" + str(k) + ".txt"
    fichier3 = open(nom_f, "w")
    ligne = "#FID_1" + "\t" + "IdCare" + "\t" + "DistEucl" + "\t" +"NbPersB" + "\t"
    ligne = ligne + "Capacite" + "\t" + "xp" + "\n"
    fichier3.writelines(ligne)

    fich_care = "C:/Users/max/Desktop/all the data and the gis/Qst3_DE_C/187Care_Daher_maj1.txt"
    m_c,c = Lit_fich_care.lit_fich_care(fich_care)

    liste,list_b = [],[]
    liste = [w for w in range(b)]
    list_b = np.random.choice(liste, b, replace = False) # tirage aleatoire sans remise

    d = 0;np_k=0
    m_d = np.array([[0.0 for e in range(0,5)] for f in range(0,c)])
    list1_xp = np.array([],dtype = float) # vecteur

    for i in list_b:
        j = 0
        for j in range(c):
            d = d + 1
            dist_eucl = 0
            dist_eucl = sqrt((m_b[i,1] - m_c[j,1])**2 + (m_b[i,2] - m_c[j,2])**2)

            m_d[j,0] = m_b[i,0]       # ID Batiment
            m_d[j,1] = m_c[j,0]       # ID Care
            m_d[j,2] = dist_eucl      # distance eucl
            m_d[j,3] = m_b[i,3]       # Nb Pers Bati
            m_d[j,4] = m_c[j,3]       # Capacite Care

        # Tri avec sorted et lambda
        lambda colonnes: colonnes[2]
        m_d2 = sorted(m_d, key=lambda colonnes: colonnes[2])
        m_d3 = np.asarray(m_d2)

        for l in range(c):
            if m_d3[l,4] >= m_d3[l,3]:
                m_d3[l,4] = m_d3[l,4] - m_d3[l,3]
                xp = 0
                xp = m_d3[l,2] * m_d3[l,3]
                list1_xp = np.append(list1_xp,xp)
                ligne = ""
                ligne = str(int(m_d3[l,0])) + "\t" + str(int(m_d3[l,1])) + "\t" + str(float(m_d3[l,2])) + "\t"
                ligne = ligne + str(float(m_d3[l,3])) + "\t" + str(float(m_d3[l,4])) + "\t" + str(float(xp))
                if d < b*c:
                    ligne = ligne + "\n"
                fichier3.writelines(ligne)
                for m in range(c):
                    if m_d3[l,1] == m_c[m,0]:
                        m_c[m,3] = m_d3[l,4]
                        break
                break

    np_k=0
    NbBAffecter = np.size(list1_xp)
    np_k = np.sum(list1_xp)
    ligne = ""
    ligne = str(NbBAffecter) + "\t" + str(np_k) + "\n"
    fichier4.writelines(ligne)

fichier3.close()

fin = time.time()
temps_sec = fin - debut
print("La durée en seconde pour ",k+1," simulations est : ",temps_sec);print()
temps_min = temps_sec / 60
print("La durée en minutes pour ",k+1," simulations est : ",temps_min)

ligne = ""
ligne = str(temps_sec) + "\t" + str(temps_min)
fichier4.writelines(ligne)
fichier4.close()
```

99.9% buildings, 43430 (85.77%) have the same allocation as the reference plan (cost 9464.71 km.p). These buildings of the same assignment correspond to only 19090 unsheltered (19.22%).

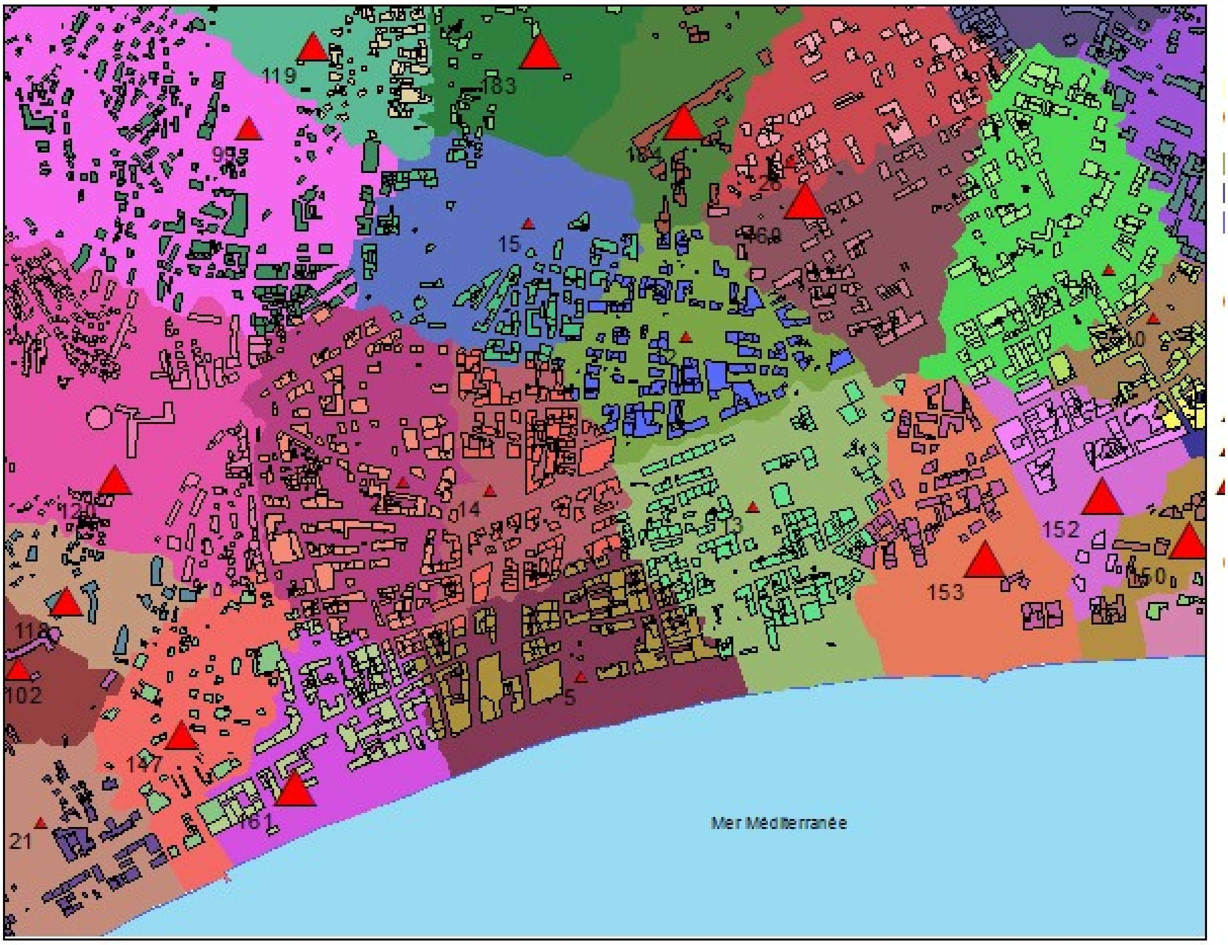

Figure 29 - Superposition of two single and multi-objective evacuation plans with a zoom on the center of Nice.

With an optimal multi-objective allocation, the 43,430 buildings are removed from the original site of the Nice site ("separation"). Thus, the new instance consisting of 7204 remaining buildings will this time be affected in a combinatorial manner ("evaluation") after updating the Capacity of the shelters (64640).

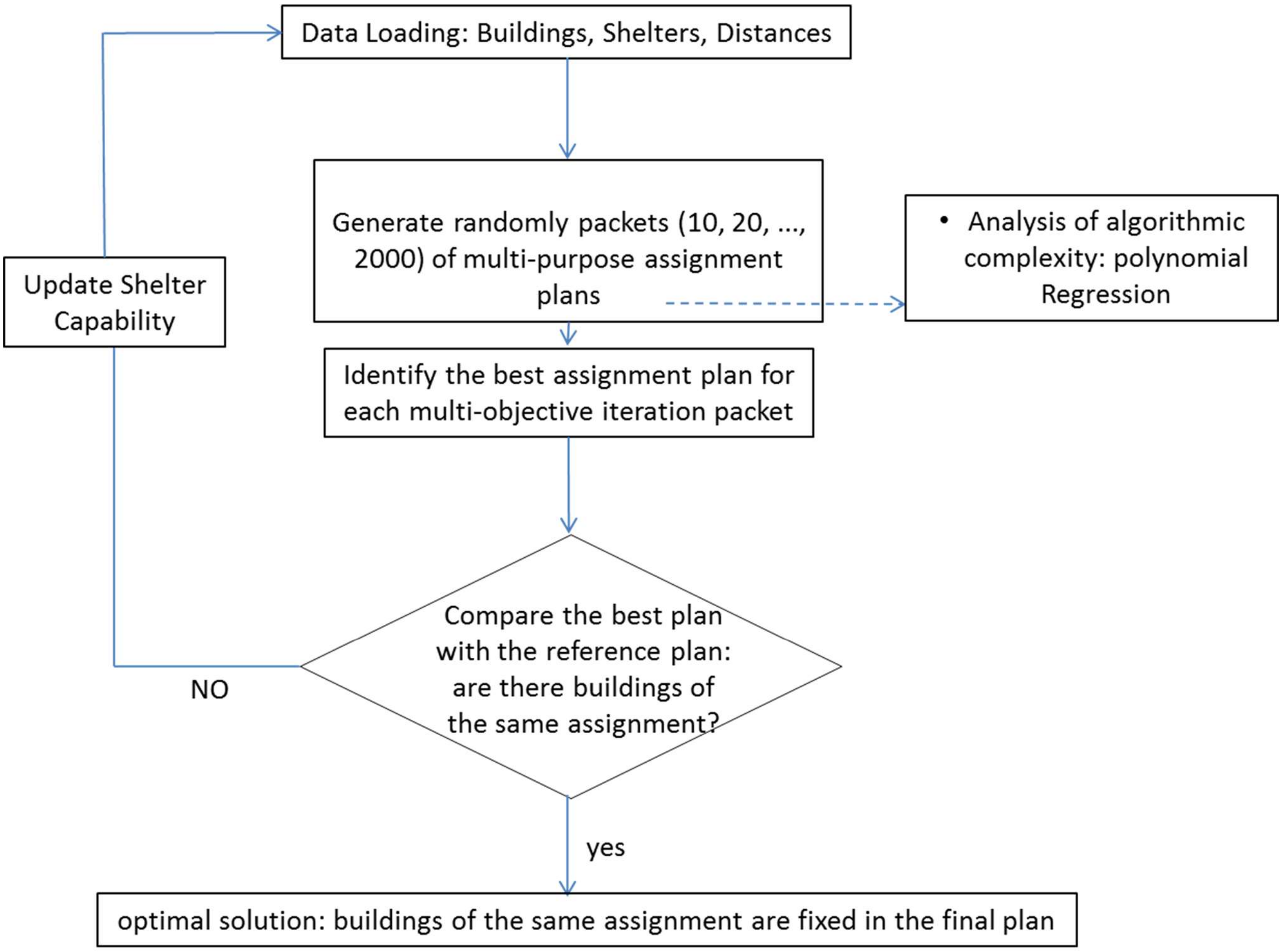

Figure 30 Logogram: combinational assignment

we make it Random for 5 time and we got 5 evacuation plans each one with different cost

As we can see in the table the random plan number 4 has the lowest cost (meter/person)

Random choosing of evacuation plan order	Number Building affected	Cost
1	5415	185068444.383
2	5315	183518409.241
3	5504	186923413.779
4	**5444**	**179649497.956**
5	5593	186761877.913

Then 55900 plans were calculated for this second instance!

the best compromise obtained: the smallest ratio (38.44) between the cost function (241067.37 km.p) and the number of buildings affected 6270 corresponding (64624 Unsheltered)

So, the value of the optimal solution is the plane p1025 / i1100

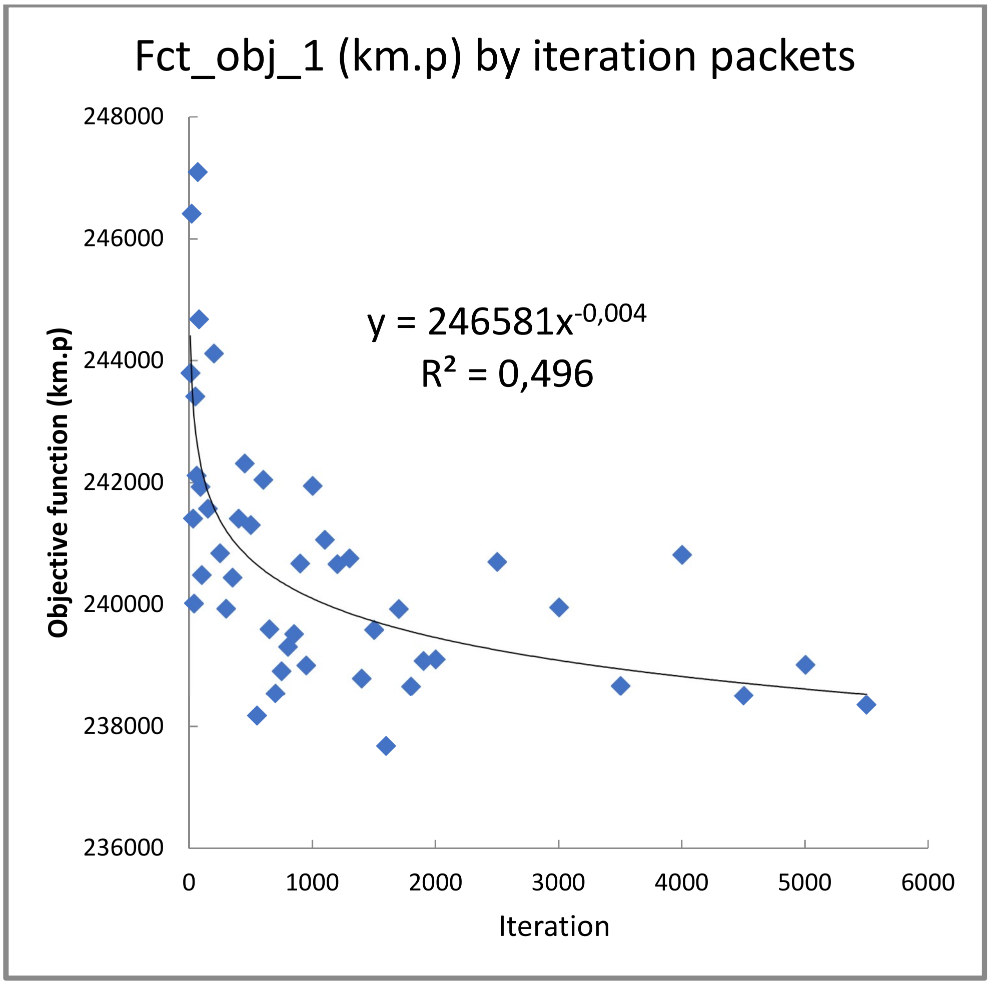

Figure 31 - Random choosing of evacuation plan order iteration packets

The high value of the cost of plan p1025 / i1100 is explained by:

- the NSA per building of this second instance is on average more than 20 times larger
- and the network distance between each building (7204) and the nearest Shelter is on average more than 3 times greater than for the assignment of 43430 buildings.

Conclusion : plan global

	Number of buildings affected	Cost of the model (km. p)	Number of buildings not affected	Average network distance (meters)
Same assignment as reference plane	43430	9464.71	19090	945.45
p1025/i1100 optimal plan	6270	241067.37	64624	3412.82
Total (global plan)	49700 (98 %)	250532.08	83714 → 99,9 % total capacity of the shelters	

Since seismic risk is an unpredictable natural phenomenon that can cause immense damage as well as loss of life and whose intensity depends on the location of the territory, metropolitan France, unlike several countries, has taken into consideration this risk in the pace of development of its territory. The establishment of seismological stations, the creation of Risk Prevention Plans (PPR) and the Municipal Safety Plan (PCS), are nowadays considered as mandatory tools for seismic risk planning and management.

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Our study included in the framework of End of Studies, treats mainly the question of the optimization of the affectation set up by the city of Nice, by minimizing the distances traveled by the inhabitants and by maximizing Shelters capacity.

At this level of the research we conclude that:

- ***The order of random selection of building in evacuation plan is a Major Key effect on the cost of evacuation plan***
- ***The effectiveness of an evacuation plan requires the support of multiple crisis management actors, effective communication ...Towards a microscopic evacuation***
- ***Hybrid method is required: reconcile structural (combinatorial optimization) and organizational vulnerabilities of crisis management is the key to find optimal evacuation plan.***

References:

UNISDR. *Living with risk. A global review of disaster reduction initiatives*. United Nations International Strategy for Disaster Reduction Secretariat, Geneva, Switzerland (2004)

UNISDR. *Terminology on Disaster Risk Reduction*. United Nations International Strategy for Disaster Reduction Secretariat, Geneva, Switzerland (2009)

EM-DAT. The OFDA/CRED International Disaster Database –www.emdat.be- Université Catolique de Louvain, Belgium (2012)

Jha A., Bloch R. and Lamond J. *Cities and Flooding. A Guide to Integrated Urban Flood Risk Management for the 21st Century*. World Bank and GFDRR, Washington, USA (2011)

Shah M.A.R., Douven W.J.A.M., Werner M. and Leentvaar J. *Flood warning responses of farmer households: a case study in Uria Union in the Brahmaputra flood plain, Bangladesh*. Journal of Flood Risk Management 5 258-269 (2012)

Werner M. *Flood Forecasting and warning & Flood forecasting systems*. UNESCO-IHE, Delft, The Netherlands (undated)

Pearce, L. (2000). *An integrated approach for community hazard, impact, risk and vulnerability analysis : HIRV*. Ph.D. The University of British Columbia.

Renda-Tanali, I. and Mancebo, F., French Emergency Management System: Moving Toward an Integrated Risk Management Policy.

Andres L. and Strappazzon G.,(2007). "Gestion des risques naturels et prise en compte du développement durable : un lien équivoque. Le cas du sud grenoblois", in Gestion des risques et dispositifs d'alerte, Mancebo F. ed., Revue de géographie alpine, n° 95-2, pp. 29-39, Grenoble.

Arnaudiès J.-M. (2005) La Catastrophe de Toulouse, Natures Sciences Sociétés, n° 13, pp. 421-425, Paris.

Barthélemy, F. and Legrand, H. (1999) Rapport au Ministère de l'Environnement et au Secrétariat d'État à l'Industrie relatif à Salsigne (Aude), Mission d'InspectionSpécialisée de l'Environnement, Conseil Général des Ponts et Chaussées. Conseil Général des Mines, Paris. 114 F.

Beck U. (1992). Risk Society: Towards a New Modernit, Sage, London.

Boltanski, L., Chateauraynaud, F., Derouet, J-L., Lemieux, C. and Torny, D. (1996) 'Alertes, affaires et catastrophes. Logique de l'accusation et pragmatique de la vigilance', Actes de la 5e séance du Séminaire du Programme Risques Collectifs et Situations de Crise du CNRS, Grenoble, CNRS.

Callon, M., Lascoumes, P. and Barthe, Y. (2001) Agir dans un monde incertain. Essai sur ladémocratie technique, Paris, Le Seuil.

Champion, M. (1859) Les inondations en France, Seine, Loire, Dalmont et Dunod, Vol. 2.

Chateauraynaud, F. and Torny, D. (1999) Les sombres précurseurs. Une sociologie pragmatique del'alerte et du risque, Paris.

Coanus T., Duchêne F., and Martinais E. (2004) "Risque, territoire et longue durée : vers une "société du risque", Apprivoiser les catastrophes, Les Annales de la recherche urbaine, n° 95, pp. 19-25, Paris.

Cohen de Lara, M. and Dron, D. (1998) Evaluation économique et environnement dans lesdécisions publiques, collection rapports officiels, Paris, Documentation Française.

Dauge, Y. (1999) Rapport sur les politiques publiques de prévention des inondations en Francemétropolitaine et outre-mer, Paris, Sénat.

Feunteun, R., Labarthe, J-P., Lefrou, C., Martin, X., Maziere, B., Tordjeman, R. and Varret, J.(2000) Les crues des 12, 13 et 14 Novembre 1999 dans les départements de l'Aude, del'Hérault, des Pyrénées-Orientales et du Tarn, Rapport du Conseil Général des Ponts et Chaussées et de l'Inspection Générale de l'Environnement, Paris.

Garry, G. (1994) 'Evolution et rôle de la cartorgraphie dns la gestion des zones inondables en France', Mappemonde, Vol. 4, pp.10–16.

Gilbert, C. (2003) Risques Collectifs et Situations de Crise. Apports de la recherche en scienceshumaines et sociales, collection Risques Collectifs et Situations de Crise, L'Harmattan Paris.

Glatron, S. (1995) 'Industries dangereuses et planification: cartographier les risques technologiques majeurs', Mappemonde, Vol. 2.

Godart, O., Henry, E., Lagadec, P. and Michel-Kerjan, E. (2002) Traité des nouveaux risques, Paris, Gallimard.

Godschalk, D.R. (1999) Natural Hazard Mitigation: Recasting Disaster Planning, Washington, DC: Island Press.

Gouriou, V., Quintin, K., Cabon, R. & Cedre, S. L. (2005). Management of operational information in a major oil spill: The Erika and Prestige Experiences, Proceedings of the 2005 International Oil Spill Conference. 4pp.

Hémon, D. and Jougla, E. (2003) Surmortalité liée à la canicule d'août 2003, Estimation de lasurmortalité et principales caractéristiques épidémiologiques, Rapport d'étape au Ministre dela Santé, de la Famille et des Personnes Handicapées, INSERM.

Hubert, P. (2001) Rapport sur la crue et les inondations de la vallée de la Somme de mars à mai2001, rapport au Conseil Général de la Somme, CIG, Ecole des Mines de Paris.

IFEN (1999) (Institut Français de l'Environnement – French Environmental Institute). 1700 communes sont couvertes par un plan de prévention des risques, les données de l'environnement, No.43, pp.1-4. Retrieved from: http://www.ifen.fr/uploads/media/de43.pdf

Jeudy, H.P. (1990) Le désir de catastrophe, Paris, Aubier.

LaFree, G. (undated). Descriptive Analysis of French Terrorism from 1972 to 1997. Project report - French Terrorism 1972-1997 – Les liaisons dangereuses. 4 pp.

Mancebo, F. (2003) Questions d'environnement pour l'aménagement et l'urbanisme, Nantes.

Mancebo, F. (2007) 'Entre sécurité, peurs et catastrophes', Dossier: Le développement durable; une idéologie? Revue des Deux Mondes, Paris, Vols. 10–11, Octobre–Novembre, pp.128–139.

Mancebo, F. and Renda-Tanali, I. (2009) 'Towards an integrated policy of risk management: A critical analysis of Turkey and France', Int. J. Emergency Management, Vol. 6, No. 1, pp.99–115.

Noiville, C. (2003) Du bon gouvernement des risques. Le droit et la question du "risqué acceptable", Paris, PUF.

Quenet, G. (2005) Les tremblements de terre au XVIIe et XVIIIe siècles, la naissance d'un risque,collection Epoques, Paris, Editions Champ Vallon.

PreventionWeb (2009). France Disaster Statistics. Retrieved from http://www.preventionweb.net/english/countries/statistics/?cid=62 on October 22, 2009.

Raffestin, C. (1997) 'Le rôle des sciences et des techniques dans les processus de territorialisation', Revue européenne des sciences sociales, Vol. 35, pp.93–106.

Raffestin, C. (2006) 'Catastrophes naturelles ou catastrophes humaines, journées du réseau international "Alerte en milieu urbain"', Grenoble, March.

Renard, B. (2006) 'Détection et prise en compte d'éventuels impacts du changement climatique sur les extrêmes hydrologiques en France', Thèse de doctorat, Institut national Polytechniquede Grenoble.

Scotti, O., Baumont, D., Quenet, G., & Levret, A. (2004). The French microseismic database SISFRANCE: Objectives, results and perspectives, Annals of Geophysics, Vol. 47, No.2/3.

Shapiro, J. & Bénédicte, S. (2003). The French experience of Counter-terrorism, Survival, Vol. 45, No.1 Spring 2003, pp. 67-98.

Urfalino, P. and Hubert, P. (2000) 'La mise en place d'Agences dans le domaine des risques collectifs', 17 e séance du Séminaire du Programme Risques Collectifs et Situations de Crisedu CNRS, Grenoble, CNRS.

Yengué, J. L., Amalric, M., Andrieu, D., Fournier, M., Serrano, J. Servain, S. & Verdelli, L. (2008). Flood risk consideration: a new paradigm? Urban examples in the middle valley of the Loire River (France), WIT Transactions on Ecology and the Environment, ISSN 1743-3541 (online)

Holling, C. S., (1973), Resilience and Stability of Ecological Systems, Annual Review of Ecology and Systematics, pp. 1-23.

Reggiani, A., De Graaff, T., Nijkamp, P., (2002), Resilience: An Evolutionary Approach to Spatial Economic Systems, Networks and Spatial Economics, 2(2), pp. 211-229.

Haimes, Y. Y., (2009), On the Definition of Resilience in Systems, Risk Analysis, 29(4), 498-501.

Reggiani, A., Nijkamp, P., Lanzi, D. (2015), Transport Resilience and Vulnerability: The Role of Connectivity, Transportation Research Part A: Policy and Practice, 81, pp. 4-15.

Goerigk, M., Hamacher, H., (2014), Optimization Models to Enhance Resilience in Evacuation Planning, Technical University Kaiserslautern, Fachbereich Mathematik.

Li, J., Ozbay, K., (2014), Evacuation Planning with Endogenous Transportation Network Degradations: A Stochastic Cell-Based Model and Solution Procedure, Networks and Spatial Economics, pp. 1-20.

Yazici, M. A., Ozbay, K., (2007), Impact of Probabilistic Road Capacity Constraints on the Spatial Distribution of Hurricane Evacuation Shelter Capacities, Transportation Research Record: Journal of the Transportation Research Board, 2022(1), pp. 55-62.

Yazici, M. A., Ozbay, K., (2010), Evacuation Network Modeling via Dynamic Traffic Assignment with Probabilistic Demand and Capacity Constraints, Transportation Research Record: Journal of the Transportation Research Board, 2196(1), 11-20.

Ben-Tal, A., Do Chung, B., Mandala, S. R., Yao, T., (2011), Robust Optimization for Emergency Logistics Planning: Risk Mitigation in Humanitarian Relief Supply Chains, Transportation Research Part B: Methodological, 45(8), pp. 1177-1189.

Yao, T., Mandala, S. R., Do Chung, B., (2009), Evacuation Transportation Planning under Uncertainty: A Robust Optimization Approach, Networks and Spatial Economics, 9(2), pp. 171-189.

Yazici, M. A., Ozbay, K., (2007), Impact of Probabilistic Road Capacity Constraints on the Spatial Distribution of Hurricane Evacuation Shelter Capacities, Transportation Research Record: Journal of the Transportation Research Board, 2022(1), pp. 55-62.

Xie, C., Lin, D.-Y., Waller, S. T., (2010), A Dynamic Evacuation Network Optimization Problem with Lane Reversal and Crossing Elimination Strategies, Transportation Research Part E: Logistics and Transportation Review, 46(3), pp. 295-316

Al¸cada-Almeida, L., Tralh˜ao, L., Santos, L., Coutinho-Rodrigues, J., (2009), A Multiobjective Approach to Locate Emergency Shelters and Identify Evacuation Routes in Urban Areas, Geographical Analysis, 41(1), pp. 9-29.

Coutinho-Rodrigues, J., Tralh˜ao, L., Al¸cada-Almeida, L., (2012), Solving a Location-Routing Problem with a Multiobjective Approach: The Design of Urban Evacuation Plans, Journal of Transport Geography, 22, pp. 206-218.

Fang, Z., Zong, X., Li, Q., Li, Q., Xiong, S., (2011), Hierarchical Multi-Objective Evacuation Routing in Stadium Using Ant Colony Optimization Approach, Journal of Transport Geography, 19(3), pp. 443-451.

Georgiadou, P. S., Papazoglou, I. A., Kiranoudis, C. T., Markatos, N. C., (2010), Multi-Objective Evolutionary Emergency Response Optimization for Major Accidents, Journal of Hazardous Materials, 178(1), pp. 792-803.

Goerigk, M., Hamacher, H., (2014), Optimization Models to Enhance Resilience in Evacuation Planning, Technical University Kaiserslautern, Fachbereich Mathematik

Saadatseresht, M., Mansourian, A., Taleai, M., (2009), Evacuation Planning Using Multiobjective Evolutionary Optimization Approach, European Journal of Operational Research, 198(1), pp. 305-314.

Stepanov, A., MacGregor Smith, J., (2009), Multi-Objective Evacuation Routing in Transportation Networks, European Journal of Operational Research, 198(2), pp. 435-466.

Tzeng, G. H., Cheng, H. J., Huang, T. D., (2007), Multi-Objective Optimal Planning for Designing Relief Delivery System, Transportation Research Part E: Logistics and Transportation Review, 43(6), pp. 673-686.

Hardy, M, Wunderlich, K, Evacuation Management Operations (Emo)Modelling Assessment: transportation modelling inventory. 2007.Available from: http://www.its.dot.gov/its_publicsafety/emo/emo.pdf. Accessed February 2009.

Esa.un.org. (2018). World Urbanization Prospects - Population Division - United Nations. [online] Available at: https://esa.un.org/unpd/wup/ [Accessed 2 Apr. 2018].

WorldAtlas. (2018). Where is Nice, France?. [online] Available at: https://www.worldatlas.com/eu/fr/u/where-is-nice.html [Accessed 8 Apr. 2018].

Seismo.ethz.ch. (2018). SED | Swiss Seismological Service. [online] Available at: http://www.seismo.ethz.ch/en/home/ [Accessed 8 Apr. 2018].

Sms-tsunami-warning.com. (2018). Richter Scale & Magnitude. [online] Available at: http://www.sms-tsunami-warning.com/pages/richter-scale#.WspfH6K527Q [Accessed 8 Apr. 2018].

Planseisme.fr. (2018). Zonage sismique de la France - Le Plan Séisme. [online] Available at: http://www.planseisme.fr/Zonage-sismique-de-la-France.html [Accessed 8 Apr. 2018].

Emmanuel NERON, Flavien AUDIN, Ismaila NDIAYE, Kaouthar BOUKEBAB et al. Rapport final - Système d'Aide à la Décision Multicritère pour la Logistique de l'Évacuation à Grande Échelle.
Programme de recherche CSOSG 2012. Disponible sur : http://www.agencenationalerecherche.fr/Colloques/WISG2013/presentations/AAP11_DSS_EVAC_LOGISTIQUE.pdf.

Carreño, M. L., Cardona, O. D. y Barbat, A. H. (2005), "Seismic risk evaluation for an urban centre", Proceedings of the International Conference 250th Anniversary of the 1755 Lisbon Earthquake Lisboa,Portugal

Oak Ridge Evacuation Modeling System (OREMS). 2005, Oak Ridge National Laboratory.

Goldblatt, R. and K. Weinisch, Evacuation Planning, Human Factors, and Traffic Engineering: Developing Systems for Training and Effective Response, in TR News. 2005.

CityLabs. [web site] [cited 2007 May 16]; Available from: www.citilabs.com.

Quadstone Paramics. [cited 2007 May 22]; Available from: www.paramics-online.com

Unhabitat.org. (2018). Mobility – UN-Habitat. [online] Available at: https://unhabitat.org/urban-themes/mobility/ [Accessed 4 Feb. 2018].

Hyuan.com. (2018). The P-Median Problem. [online] Available at: http://www.hyuan.com/java/how.html [Accessed 5 May 2018].

Mobility analysis of shelters distribution in the city of Nice

Abstract:

Since seismic risk is an unpredictable natural phenomenon that can cause immense damage as well as loss of life and whose intensity depends on the location of the territory, metropolitan France, unlike several countries, has taken into consideration this risk in the pace of development of its territory. The establishment of seismological stations, the creation of Risk Prevention Plans (PPR) and the Municipal Safety Plan (PCS), are nowadays considered as mandatory tools for seismic risk planning and management.

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Keywords:
Mobility, Modelling, Accessibility, GIS, Disaster management, Algorithms, Scale

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