ÉCOLE POLYTECHNIQUE DE L'UNIVERSITE FRANÇOIS RABELAIS DE TOURS

Spécialité Aménagement et environnement

35 allée Ferdinand de Lesseps

37200 TOURS, FRANCE

Tél. +33 (0)247.361.450

www.polytech.univ-tours.fr

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**Research Master Planning and Sustainability: Urban and Regional Planning**

# Green and blue corridor and vulnerability assessment to flood case of Tours, France and Kinshasa, DR-Congo

**Raïta BALA MAPGHA**

**Professor Vincent ROTGE**

**Professor Karl Matthias WANTZEN**

# Acknowledgment

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# Chapter one: INTRODUCTION

# 1.0. Background of the study

Green infrastructure (GI) provide fundamental advantages to flood mitigation and co-advantages to society and the economy. Evidence demonstrates that interest in green solutions, for example, landscape protection and restoration for upstream floodplains or wetlands, is more cost-effective and gives infrastructure solution (EEA report, 2017). We will study the impact of green and blue corridor on the flood resiliency and ecology restoration in urban areas.

Since the people have started to live in the form of community, settlements have developed along rivers for trade and commerce, agriculture, also for the daily use of water. All over years with the exponential growth of population, our cities have developed rapidly, as large pieces of formerly natural land were developed over time into urban centers and even metropoles and megalopolis. Today most of world major cities are located on the bank of river or river mouth (Aster Image Web Library 2, n.d.).

Our cities were designed based on previous record of flood, and we are more and more destroying wild habitat and losing the biodiversity in urban area, also we are losing the natural sponge areas such as wetland, marshes and open green areas. The consequences are flood, urban heat island effect, loss of biodiversity, different types of pollution, climate change, etc. We are also facing several modifications in temperature, precipitation, etc. The risk of flood in some urban area has increased.

While these urban concerns have been there for very long time , they have now greatly expanded and a new dimension has added after a series of global events such as: The Great Drowning of Men in January 1362, a flood event that affected Ireland, Britain, the Low countries and northern Germany causing around 25,000 causalities (The Guardian, 2011), The Mississippi flood during Spring 1927 when more than 23 000 square miles were swamped, between 250 and 1 000 people died and hundreds of thousands were displaced (Encyclopedia Britannica, 2017) , Paris flood in 2016 that reached 6 meters high (Sudouest, 2016), Crue du Var at Nice in 1994(Meteofrance, 1994), les Alpes-Maritime flood 2015 (Lemonade, 2015) etc. With the effects of climate change, these last years, many neighborhoods of Kinshasa have been affected with flood after every heavy rain. With the event of climate change, urban planners and designers have never been so much under pressure to contribute in making human settlements safer and conserving wild habitat and environment.

In this study for comparing the vulnerability of the city of Tours and Kinshasa we will consider such vulnerability indicators as the population and density, existing flood map, the Digital Elevation Model, public information and awareness. and risk preparedness measure already taken. Then analyze the Green and Blue infrastructures of the two respective cities.

At the end of the study, we will be able to say if the existing vulnerability map will be efficient or not in case of a huge flood, based on the final result we will or not propose another vulnerability map. This study will help us to design a green and blue corridor that will in the domain of flood management and protection of biodiversity in the both cities in the aim of having sustainable cities. Tours and Kinshasa are completely different to one another in term of city architecture, history of the city, climate, history of flood, etc. by assessing vulnerability to flood of both cities with selected parameters we will be able to show that our tools can work in both cities and can be used in different city around the world.

## 1.1. Research question

The research endeavored to answer the overall question: What is the importance of Green and Blue corridor in the city? In particular, has a vulnerability assessment been implemented and a flood mitigation plan has been issued for the physical development of Tours and Kinshasa?
In doing so, the study aims to answer the following questions in relation to the vulnerability assessment of food and the importance of Green and Blue Corridor in Tours and Kinshasa:

- What are the causes of flood in those areas?
- What are the selected indicators for calculating vulnerability to flood in Tours and Kinshasa?
- What is the existing Green and Blue infrastructure in Tours and Kinshasa?
- Which measures can be employed for flood mitigation in those area by mobilizing Green and Blue infrastructure?

## 1.2. Aim and objectives of the study

The aim of the study is to analyze the vulnerability of these areas to flood and how the Green and Blue corridor can be important in the city.

Specific objectives are to: -

- Study the existing conditions with respect to vulnerability of flood disaster.
- Analyze the existing Green and Blue infrastructures and their impacts.
- Calculate the level of vulnerability by establishing parameters and using AutoCAD.
- Recommend strategies for flood disaster preparedness with an emphasis on Green and Blue Infrastructures.

## 1.3. Scope and limitation of the study

### 1.3.1. Scope

- This study will focus on two cities, Tours and Kinshasa.
- The study will cover the physical, social and economic vulnerability.
- The impact of the green and blue infrastructure in the study area.

### 1.3.2. Limitation

- This study will be focus on flood vulnerability assessment only instead of disaster management due to lack of time.
- We will focus also on the importance of green and blue infrastructure for citizens, ecology conservation in the city and flood risk reduction.

## 1.4. Problem statement

This research intends to compare the level of vulnerability of the study areas against the flood risk as forecast/acknowledged through different government policy instruments with a view to recommend appropriate measures and the importance of Green and Blue in urban areas. We will analyze the urban context and recommend strategies to improve the flood mitigation and stressing the importance of Green and Blue infrastructure.

## 1.5. Methodology

Due to the complexity of the issues related to the subject of the thesis and due to the need for an interdisciplinary approach, a broad spectrum of available research methods have been used:

1. Multidisciplinary literature review: this stage consists of the analysis of existing secondary data that included literature review on green and blue infrastructure, grey infrastructure and flood mitigation. These are from published books, research papers, journals and newspapers, projects, articles in magazines, existing government documents.

2. Primary data: I will contact different stakeholders in the field to improve my knowledge in the domain of green and blue corridor and flood mitigation in Tours and Kinshasa. Qualitative and quantitative data will be collected through tools: discussion with expert and stakeholders, observations. Also. we will do the visual survey.

3. Data analysis: for assessing the vulnerability of these two cities, we will use AutoCAD and Google Maps as main tools. Indicators/parameters will be used to establish the vulnerability index such as the existing flood map of the city, land use, population, population distribution, public awareness, accessibility, open spaces, institutional buildings, water supply, existing green and blue infrastructure and grey infrastructures. Based on those indicators/parameters we will establish which city is more vulnerable and why. We will also study the existing green and blue infrastructure map and the impact of this in the city.

4. Recommendations: in this final stage of the work, we will recommend strategies for flood mitigation by stressing on green and blue corridors in the urban area and improve the physical condition of the city for a sustainable and resilient city. And elaborate an improvement plan with Green and Blue Corridor in the respective cities.

# Chapter two: LITERATURE REVIEW

## 2.1. Definition of key terms and concepts

### 2.1.1. Green and blue corridor

In the last decade there has been a significant rise in the quantity of green, or what are now being named as **"**blue-green**"** corridors, being set up in our dense urban areas in order to upgrade and maintain existing habitats by connecting divided and isolated ecosystems (Green Blue Urban, 2017).

Human culture relies upon the benefits given by nature, for example, food, materials, clean water, clean air, climate control, flood management, fertilization and leisure. Be that as it may, huge numbers of these benefits, much of the time referred to as ecosystem services, are utilized as though their supply is relatively boundless and regarded as free products whose true value is not fully appreciated.

Ecosystem-based methodologies are techniques and measures that outfit the versatile powers of nature. They are among the most generally appropriate, economically viable and effective tools to fight against the effects of climate change. Whenever, such methodologies use GI solutions, since they utilize biodiversity and ecosystem services as a feature of a general adjustment strategy to help people to adapt to or mitigate the unfavorable impacts of climate change (European parliament council, n.d.)

Green and blue infrastructure has numerous definitions inside a common understanding of the system. Benedict and McMahon in 2016 page 1, defined green infrastructure as "an interconnected network of green space that conserves natural ecosystem values and functions". Green and blue infrastructure is the green space and water environment fundamental to the quality of our lives and environment. It is alluded to as 'infrastructure' as it is as essential as other sorts of infrastructure, for example, roads, schools and hospitals. It is interpreted as all green space and water that has value for the public and the nature. Blue-Green infrastructure includes; Bio-retention systems, bio retention swales, buffer zone, storage ponds (including lakes and reservoirs), controlled storage areas (example: car parks, leisure areas, minors roads, playgrounds, etc.), permeable paving, rain gardens, stream and river restoration, wetlands, open spaces, street trees, green roofs and green walls.

### 2.1.2. vulnerability assessment

Vulnerability assessment, also known as vulnerability analysis, is a process that is used to evaluate vulnerability to specific hazards, to classify the level of preparedness of an area, a group of people, a species, or infrastructure to an accident, an exterior attack, a disaster that can lead to loss, damage or disruption by the impact of a particular hazard. In addition, vulnerability analysis can forecast the effectiveness of proposed countermeasures and evaluate their actual effectiveness after they are put into use.
Vulnerability is a part of disaster preparedness process in the disaster management cycle.
Disaster preparedness includes many factors such as the area of concern, the type of disaster, the origin of the disaster. On one side, flood is a natural process that contributes to conservation of the ecosystem. On the other side, since the creation of settlement, they are vulnerable to flood and this vulnerability, most of the time, is due to the poor planning or lack of consideration of the environment in city planning. Since centuries cities face flood event, nowadays with the climate change, cities are more and more vulnerable to flood. This is due to river overflow and

sea intrusion. In 1931, the central China faced the most devastating flood of the history with more than 2 million dead (Chris Courtney, 2016). In 1956, many rivers overflowed, it was the case of Rhone River and also *'la Loire'* river when many cities were flooded including Lyon, Blois, Tours and others. In 2010, the Loire River overflow caused a lot of loss and 26 people went missing. (Camille Carlier, 2018).

### 2.1.3. Flood

Flood is defined as water overflowing onto area that is known as dry land. Floods are the most frequent natural hazards and it causes a lot of losses. Around the world, around 1/3 of every single reported casualty and 1/3 of the financial losses caused by natural hazard is attributed to floods. With the climate change we have to expect more floods around the world and specifically in our cities of research. The Loire River has a long history about flood in the *Val de Loire* region, one of the most remarkable flood disaster in Val de Loire region happened in 1856, when 100 000 hectares were flooded, it leads to loss of life, livestock and dykes (M. Dacharry, 1996).

Ecological importance of flood

Contradictory to what we have as perception of flood, it has a positive impact on the ecology. Floods restore the physical structure of river systems, form new habitats, and transport nutrients into the floodplains, which are among the most productive and most diverse ecosystems of the world.
Flood-pulsing systems have a higher productivity than systems with constant water level (e.g., dams) (Karl M. Wantzen, 2017)

Types of floods

There are three main types of floods: storm surges, river floods, and flash floods.

Then there are a number of special cases like groundwater flooding, tsunamis, dam-break floods, glacial lake outburst floods, backwater floods (caused by landslides falling into rivers, ice jams, clogged bridges), debris flows, and rising levels in the sea and lakes

1. Storm surge: it happens because of high water rise due to wind and high waves, this phenomenon occurs in coastal area. One of the effects of storm surge is salination of drinking water.
2. River flooding: it happens because of heavy precipitation that leads to the river overflow. Impacts are loss of infrastructure, material loss, loss of livestock, etc.
3. Flash flood: it is due to several heavy rains that leads to the river over flow.

## 2.2. relation between green and blue corridor and flood

Europe's floodplains once covered wide extends along European rivers, with high environmental importance. Floodplains are hydrologically essential and environmentally productive areas that fill many natural functions. They contain both natural and cultural value that are important for the society. Floodplains are advantageous for animals and plants and helps in water quality, recharge of groundwater, natural flood control, etc. also, floodplain

landscapes are under pressure from human land use, and it is becoming more apparent that floodplains are especially vulnerable to the impacts of climate change and that protecting the existing planned floodplain is highly necessary, with the increasing demand for floodplain ecosystem services (Capon et al., 2013).

However, cleared for farming and changed through urban development and flood control structures, just a part of floodplains remains. Albeit homogeneous spatial information is absent on the expansion and value of Europe's residual floodplains, illustrations shows that their ecological significance is reliant not just on land use in the floodplain area, including its water quality, yet in addition on hydrological and connection between water bodies and floodplains (EEA, 2016a).

Green infrastructure approaches help to fullfil sustainability and resilience goals over a range of outcomes additionally to climate adaptation. The climate adaptation advantages of green infrastructure is typically associated with their ability to moderate the impacts of extreme precipitation or temperature. Benefits embrace better management of storm-water runoff, lowered incidents of combined storm and sewer overflows (CSOs), water capture and conservation, flood mitigation, storm-surge protection, defense against sea-level rise, accommodation of natural hazards (e.g., relocating out of floodplains), and reduced ambient temperatures and urban heat island (UHI) effects (joseph foster et al, 2011).

Flooding is a natural and not unusual process associated with river dynamics.

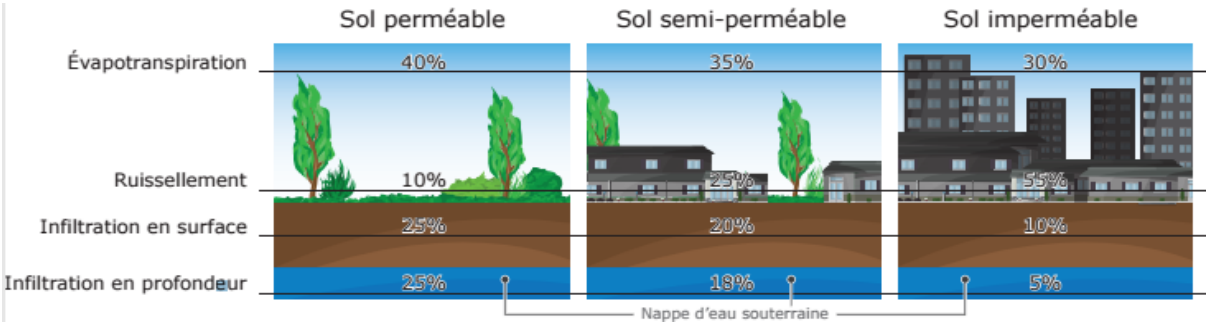



*Figure 1: The impact of ground impermeability on the water cycle*

*Source :* http://www.mrc-beauharnois salaberry.com/sites/default/files/PDF/Amenagement_et_developpement/fiche_impermeabilisation_des_s.pdf

# Chapter three: CASE STUDIES

# 3.0. Introduction

For this study we selected two case study, the first is the master plan of Flint, Michigan, 2013. For elaborating this master plan, they consider 7 environmental features that are: quality of life, youth, civic life, adaptation to change, reshaping the economy, social equity and sustainability.

The second case study is about "*Sponge City Construction: Case Study in Dalian*" (Haixing Dr. Liu, 2017). In this study the authors explained how to estimate the runoff in the aim to reduce flood and the impact of green and blue corridor in flood prevention.

We chose Dalian because it is a tropical city and for assessing the vulnerability to flood they used different parameters that are land use, land coverage, Digital elevation model, transportation and water supply.

We chose the flint master plan because they focus of the green and blue infrastructure to regenerate the city infrastructure, to beautify the city, to boost the economy and to mitigate flood.

# 3.1. Master plan of flint, Michigan, USA, 2013

The city of Flint had a boom in the industrial sector from 19$^{th}$ century to around 1954, which lead to air pollution, destruction of environment, etc. Even after the crisis that push many industries to shut down, today around 50 % of the population has left the city. Now the city is trying to boost again its economy by revitalizing the river front and reviewing the park system by reducing the maintenance cost.

## 3.1.1. The vision covers:

<u>Reshaping the economy</u>

A City's open space impacts significantly more than the customary domain of plants and playgrounds. Parks draw in families also, stimulate "recreational economy" development, for example, new bicycle repair shops, kayak renting shops, and outside suppliers. Parks programming can likewise give job training skills in agriculture, fishing, and gardening, etc.

<u>Quality of life</u>

The aptitude to interact with nature and having a secure environment that helps you to access peacefully the recreational area and raise the quality of life. Adequate green space for walking, playing, and relaxing, increase the happiness, lessen stress, and help to have a healthy and pleasant way of life.

<u>Adaptation to change</u>

Reshaping open space can be a very good tool for bringing positive change. The City's natural frameworks must be protected; be that as it may, their shape and function should be flexible and match with the existing reality and anticipated future needs. These employed methods such as naturalization, riverfront parkland acquisition, or the development of blue and green

infrastructure can improve the beautification of public space while additionally diminishing long-term costs.

Youth

27.3% of Flint's population is below the age of 18, and 8% are age 5 or underneath. Providing secured, good quality and fun spaces for kids to play, has a high importance for children development and can push young adults to invest in their community.

Civil life

As pillars for both little neighborhoods and the large City, parks and open spaces are normal stimulants to civic life. They selves as areas where people interact, sharing values, and identity.

Social equity and sustainability

A secured and clean environment for all inhabitants redresses past environmental injustices and encourage equity in neighborhoods. Parks ought to be accessible to all.

### 3.1.2. Objectives

Objective 1

Developing and planning the city by improving the health quality. Cleaning rivers, lakes and streams, restore the ecosystem in those areas and improve the air quality.

Objective 2

Secure, improve, and value the Flint River and its watershed, alongside other tributary lakes and streams, as profitable group assets.

Objective 3

Create and maintain blue/green infrastructure based on the Flint River system. Create and preserve a "green belt" of land along the Flint River, protect the river from pollution due to urbanism and encourage recreational activity. It also reduce rain water runoff, it reduce flood and reduce the pressure in the sewage infrastructure.

Objective 4

Provide parks, open space, and recreational infrastructure that addresses the issues of the community and is maintenance by the municipality.

Objective 5

Reduce the City’s carbon footprint, improve the air quality, encourage walking and cycling. Promote renewable energy and green technologies necessary to boost the economic growth.

Objective 6

Establish new policies and guidelines for the maintenance of the City’s parks and open spaces for that the urban design must be improved and the city authority have to find partners, volunteers, non-profitable organization for the maintenance of the park and reduce the cost

Objective 7

Motivate the Flint community to promote and use parks and recreational facilities.

### 3.1.3. Recommendations and best practices

Flint riverfront restoration

*Figure 2: This graphic is an excerpt from the Flint Riverfront Restoration Plan (2010) illustrating the green connections that can be made along the Flint River*

Revitalize the river water front

First, they planned to restore the river, inspired by Barcelona green corridor they interconnected different green and blue infrastructure in the city, they created recreational activities like kayaking, and promote last mile connectivity. All of these projects impacted the economy, health, interaction between residents, reduce flood, beautify the city and restore wild habitat.

Classification

For restoring the green and blue corridor, first they classified all different type of water body in the city, they also classified all different type of green space in the city. Than they recorded all vacant space of the city based on their previous usage. They see also the coverage of each different parks based on the national guidelines that said that a neighborhood park of ½ mile must be located in a maximum of 10 minutes walking distance. And a district park must be located in a radius of 30 minutes walking distance.

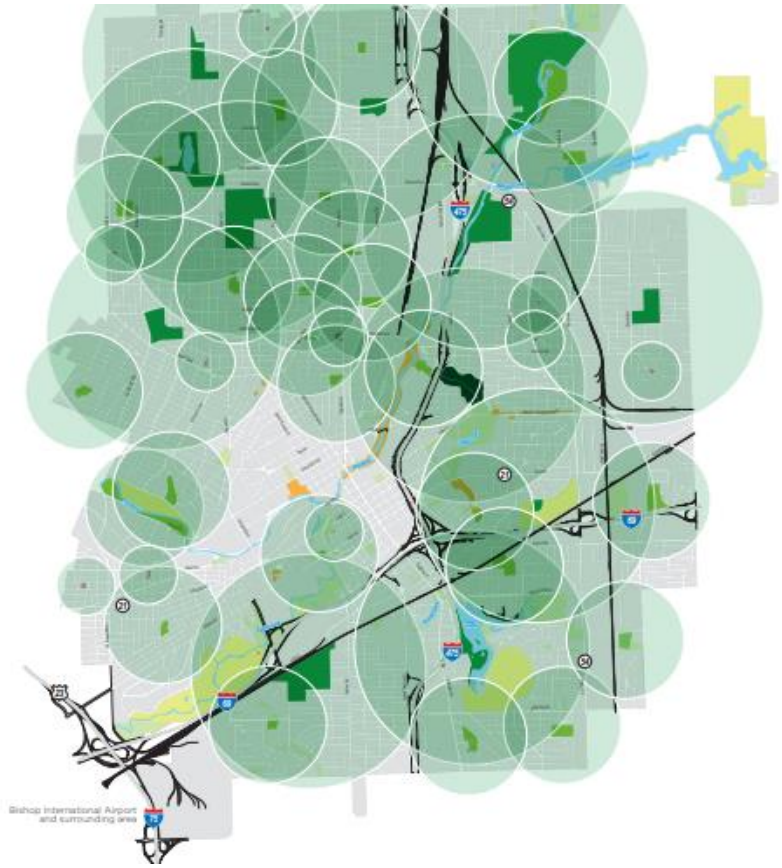


*Figure 3: impact of different green area in the city, flint, Michigan, USA, 2013*

Source: flint master plan 2013,

## 3.2. Sponge city construction: case study of Dalian by Dalian university of Technology, china by Dr. Liu Haixing, 2017

In china, out of 639 cities that have flood control missions, only 236 are feeling the required standards, it means 63% of the cities does not meet to the design standard. Around 137 cities are affected by flood more than three times every year. In the other side, more than 400 cities in China are facing water scarcity and the problem is severe in around 110 cities. The causes are basically due to rapid urbanization, the natural water drainage space is reduced, there is a lot of run off and less infiltration of rain water and there is a less space for groundwater recharge.

### 3.2.1. Flood risk assessment

They try to simulate water risk in Malan reservoir, the risk of urban flooding occurrence is assessed in Dalian through rainfall simulation with the typical 24h rainfall pattern that occurred every 50 year. (6h).

- High-risk zone: water depth 0.25-0.50m flooding duration 30-60min.
- Middle-risk zone: water depth 0.50-1.00m flooding duration >60min.

Low-risk area: water depth >1.00m flooding duration >60min

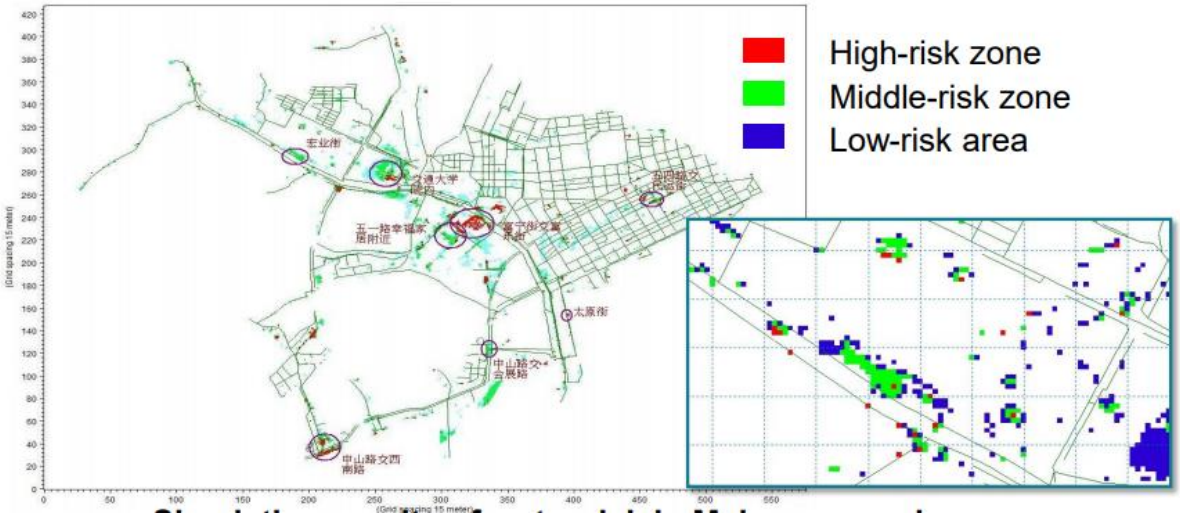



*Figure 4: flood risk map of Dilian, China*

### 3.2.2. Research features

In the city

The main objective was the reduction of water pollution. The main scope was waterscape and the main target was to improve the utilization ratio of rainwater resources.

In the countryside

The main objective was the rainwater harvesting. The main scope was aquaculture and Irrigation and the main target was to reduce the usage of ground water

In the island

The main objective was the rainwater harvesting. The main scope was to harvest water for domestic use and the main target was to improve the utilization ratio of rainwater resources.

### 3.2.3. Modeling

First, they did the evaluation for exploitation potential of rainwater resources

Total rainwater resources $R1 = P \times A \times 10^3$

Theoretical exploitation potential of rainwater resources $R2 = \varphi \times R1$

Practical exploitation potential of rainwater resources $R3 = \alpha \times \beta \times R2$

R2: Total volume of rainwater resources（m3

P: Precipitation yearly (mm

A: Coverage area by land type（km2）

Φ: Runoff coefficient

α: Seasonal delay rate

β: Initially reduced flow coefficient

### 3.2.4. Problems background

Water resource

- Low rate of rainwater utilization
- Lack of water reuse facilities
- Use of reclaimed water is low
- Lack of scientific guidance

Water security

- The drainage system is not sufficient for the changing conditions.
- Old city has lower elevation in Dalian.
- Many prone flooding location

Water environment

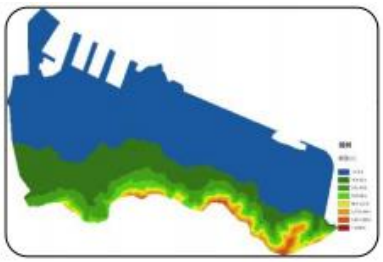
- Water supply is not sufficient for the local use.
- The water quality of surface water is not good.
- Shallow groundwater pollution exists.
- Urban non-point source pollution is serious.
- The initial rainwater runoff management is not good and has high pollution concentration.

Water ecology

- Underground table declined.
- Sea water intrusion.
- Ecological shoreline hardening.
- Ecological water demand.

### 3.2.5. Comparison and analysis

First, they calculated the annual runoff that was 73% of annual rain water, then they applied the digital elevation model on the land use and network and drainage system to see the flood impact in the area.



Digital elevation model

Land use map

Drainage and network map

### 3.2.6. Solutions

After the analysis they concluded that:

- Green roof is better for reducing the pollution of roof runoff.
- Setting the bio-swale on both sides of road is a better measure.
- Permeable pavement is better for increasing the rain infiltration.
- Combine green roof with rain barrels.
- Make full use of roof and underground space

# Chapter four: BACKGROUND OF THE STUDY AREAS

## 4.0. Introduction

In this study we selected two areas, Tours and Kinshasa. Due to time constraint we will focus only in Tours centre in Tours and in Kinshasa we select the *communes* of Kalamu, Ngaba, Lemba, Lemba and Limete. We selected the city of Tours because it is one of the cities in France that is prone to flood and we selected Kinshasa because this last decade it has become the most affected city in DR-Congo to flood due extreme rainfall. We also selected these two cities because we want to study the impact of green and blue infrastructure in the flood mitigation in a tropical and temperate climate and which measure can fit in these two different areas.

## 4.1. Location

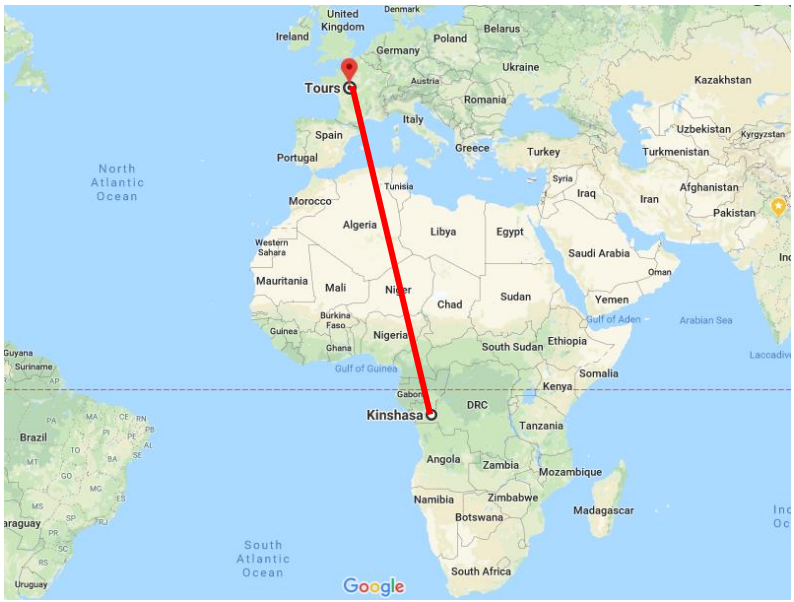



*Figure 5: location of Tours and Kinshasa in the world's map*

Source: Google map

| | |
|---|---|
| The city of Tours is the administrative center of Indre-et-Loire department, it is the largest city in Centre Val de Loire region. The coordinate is 47° 23′ 37″ north, 0° 41′ 21″ east. The city exists since the first century it was a part of the Roman Empire. During the history it was an important point of trade and commerce due to its location between two river Loire and Cher. Today Tours is considered as one of the city with a big historical value in France. We took Tours centre and 1 km after the Loire and Cher river.<br><br>The total study area is 17.44 km$^2$ | Kinshasa is the capital city of the Republic Democratic of Congo (DRC) it has 24 zones. The coordinate of the city is 4° 19′ 54″ sud, 15° 18′ 50″ est. The first occupant were the Teke and Bahumbu tribes. The actual city started there, the city development is more influence by the Congo River, which constitute the boundary in the north and an important commercial point. For our study we select neighborhood in the core of Kinshasa. It is located in the municipality of Kalamu, Lemba, Limete and Ngaba. It is limited in the north and the east by boulevard Lumumba, in the south by Kianza and Bakali Avenue and in the west by Funa River also called Kalamu River.<br><br>The total area is 34. 49 km$^2$ |

## 4.2. Study areas

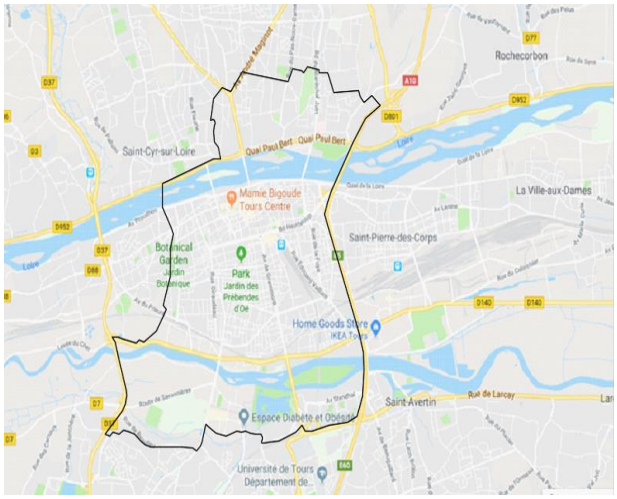



*Figure 6: study area in Tours*

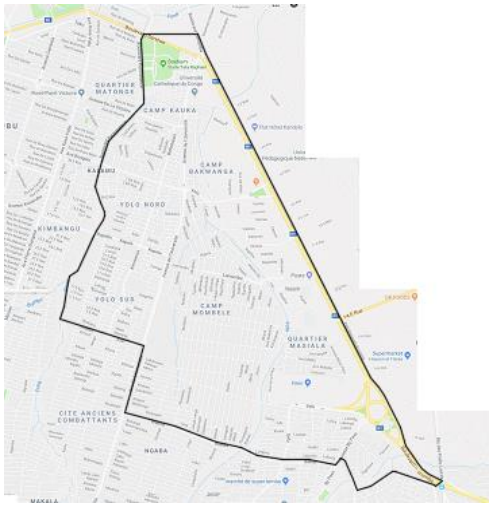



*Figure 7: study area in Kinshasa*

## 4.3. Physical characteristics of cities

| | |
|---|---|
| The study area in Tours is located in a limestone plateau between the Loire and Cher Rivers. Its position gives the area a potential for agriculture activity. The climate is temperate oceanic due to wind from Atlantic Ocean. The average annual rainfall in Tours is 697 mm, November is the wettest month and July the driest. The average temperature is 11.8°C. The most spoken language is French, we also see find others languages such as Portuguese, English. | The study area in Kinshasa are neighborhoods located in a plain and wetland with a sandy soil. The area is crossed by the rivers Funa, Matete, and Yolo. The climate is tropical wet. The average annual rainfall in Kinshasa is 1300 mm. The average temperature is 25.3°C. The official language is French, the most spoken language is Lingala, we also find the three others national language that are Tshiluba, Kikongo and Swahili.<br>The city is developed along the Congo River, all rivers and lakes pour out in there. |

Precipitation

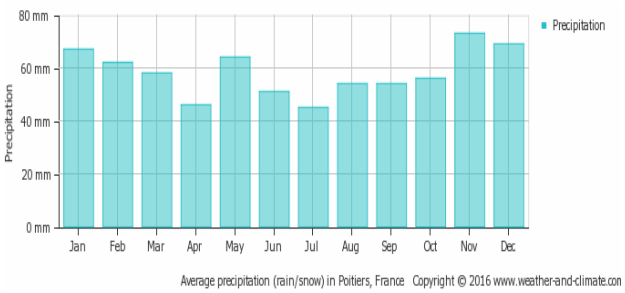



*Figure 8: precipitation in Tours*

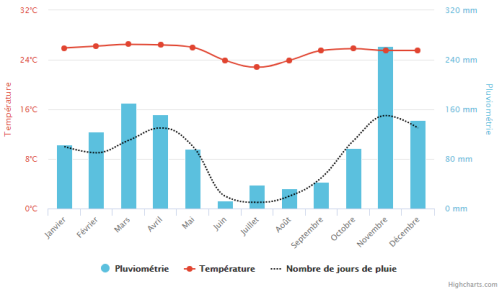
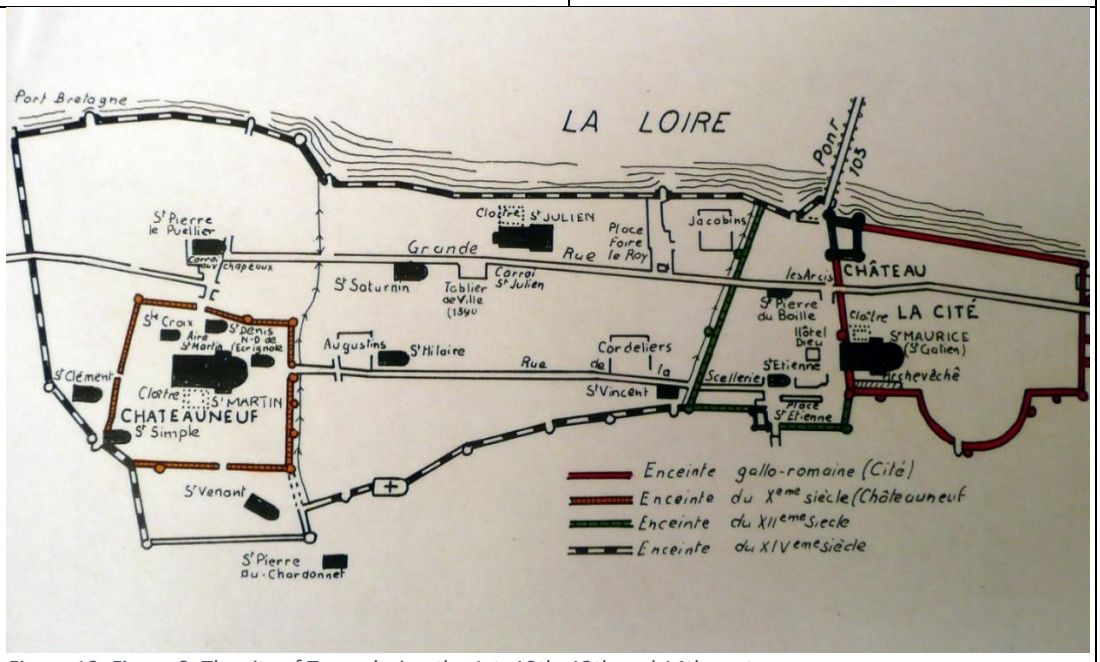


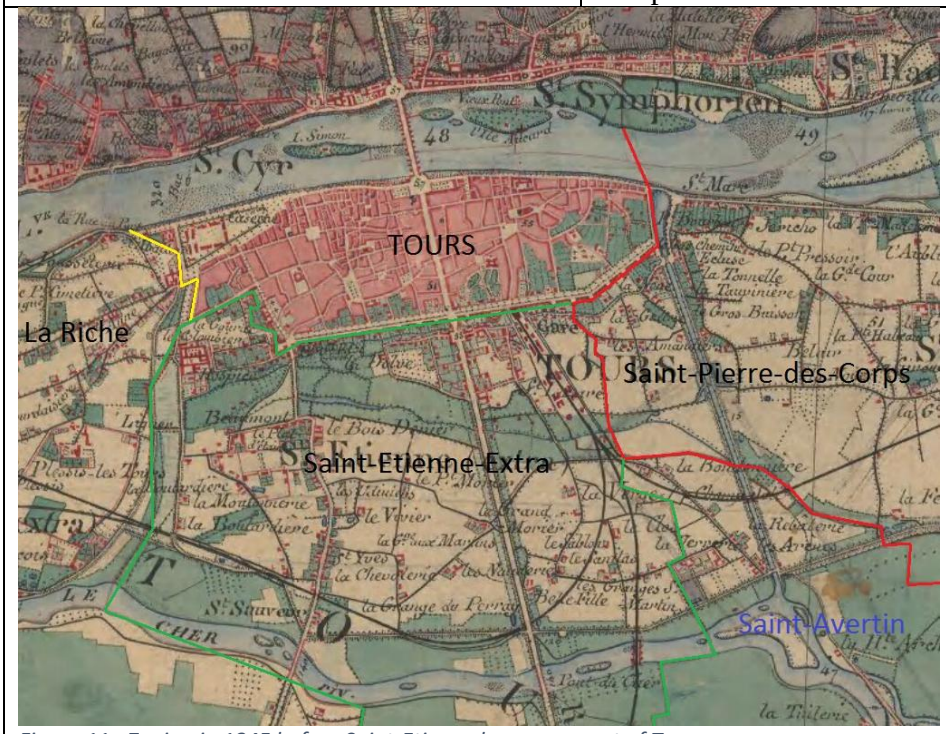

*Figure 9: precipitation in Kinshasa*

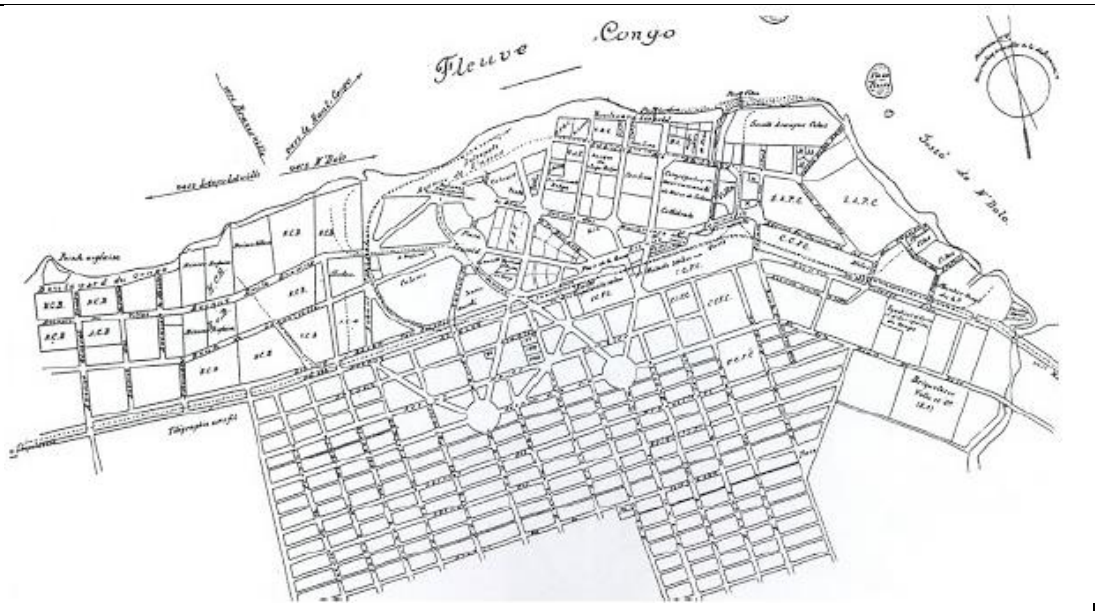
Source: weather-and-climate.com

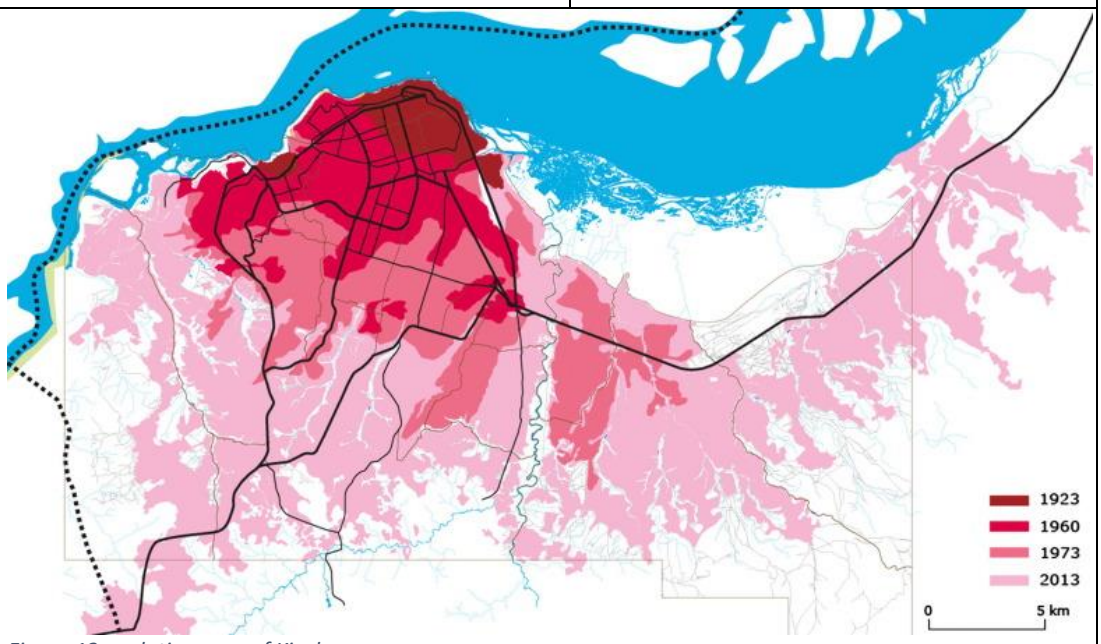
source: planificateur.a-contresens.net/afrique/republique_democratique_du_congo/kinshasa_city/kinshasa/2314302.html

## 4.4. Cities evolution

| Time | Tours | Kinshasa |
|---|---|---|
| 20 AD. | The first occupant of Tours were Turones and Gauls people, they were living 20 kilometers away from Tours, at the actual Ambroise. It was built by the Roman Empire | |
| 370 | A defense wall was constructed | |
| 6th century | The city was divided in two and it was separated by a rampart it was in one side Saint Martin and in the other side the ancient city. | |
| 9th century | A wall was constructed to protect the basilica of St Martin against Vikings attacks. | |
| 10th to 14th century |  <br>*Figure 10: Figure 8: The city of Tours during the 1st, 10th, 12th and 14th century*<br>*Source : http://www.litteratur.fr/wp-content/uploads/2010/06/Tours-plan-vieux-Tours.jpg* | |
| 16th to 17th century | Flood from the Loire this leaded to the construction of the city protection wall. | |
| 18th century | Construction of the rue Royal the actual rue National and Grandmont. And the construction of the town hall. | |
| 19th century | The museum was constructed and the reventilization and modernization of the city. | 1847, First record of the city by Henry M. Stanley.<br>The Congo was a private property of the King Leopold II of Belgium, in |

| | | |
|---|---|---|
| | The medical school and the pharmacy school were constructed and the Decartes high school.<br>The train reached Saint Pierre de Corps. | 1885, during the Berlin conference, the king gives Congo to Belgium.<br>In 1898 the construction of the railway from Matadi to Kinshasa was completed |
| |  <br>*Figure 11: Zoning in 1845 before Saint-Etienne become a part of Tours.*<br>*Source: https://www.37degres-mag.fr/societe/histloire-levolution-de-tours-au-xixe-siecle/* | |
| 1900 to 1930 | During the First World War the city was also affected, factories were transformed to factories of weapon, it was also a home for refugees. In 1917 Americans settled in the city as the first back base.in the end of the war more than 1 800 young people dead at Verdun and at Somme. | For 1900 to 1929 the city was developed around these two poles. In 1922, a decree obliged all companies to build camps for their workers. This is how the first plan city appear on the site of Mampenza and Kikimani. In 1925 the Ndolo airport is opened, in 1929 the capital. In 1929, the Kalima shipyard was created |

| | | |
|---|---|---|
| |  <br>*Figure 12: Kinshasa plan 1919. Source: sosak report* | |
| 1940-1957 | | New municipalities (Kasa Vubu and Ngiri Ngiri) are constructed. In 1945, the country took part in the Second World War, as memorial, streets in the municipality of Kasa-Vubu are named based on the the contries and cities where the Congo army won, we can see Birmanie, Ethiopie, Assossa, Saio, Gambela, etc. |
| 1958 | Out of 14 000 destroyed or damaged homes, 9 000 are rebuilt or repaired. In 1955, a municipal sport palace was inaugurated. | A housing project started, in 10 years, they built 20 000 homes. |
| 1959 | Restauration of the *Vieux-Tours.* | |
| 1960 | | The country get its independence. |
| 1964-1969 | The program of development of the North plateau started, also the zones (communes) of Sainte Radegonde and Saint-Symphorien are annexed to Tours. | In 1968, the city's boundaries were expanded to include new urbanized areas. The number of municipalities has increased from 11 to 24, as they still are today |
| 1970 | The university Francois-Rabelais is created in collaboration with the city of Blois. And the A10 highway is constructed on the old canal. | |
| 1992-1993 | The congress center called Vinci is inaugurated | |
| 1997 | | This year was terrible for the city, with army conflict, many people move to the capital city. |

| | | |
|---|---|---|
| 2007 | | Also the construction of Cité du fleuve, Congo Trade Center, Chinese promotion of future center SCTZ city, etc. Kinshasa is changing its face, and this change is fast. |
| 2013 | swimming pool, lake with aquatic complex, development of the Garaganttua village, construction of swimming pool in Tours Nord, construction of the tram line | |
| |  <br>*Figure 13:evolution map of Kinshasa*<br><br>Source: https://ars.els-cdn.com/content/image/1-s2.0-S002216941630453X-gr1.jpg | |
| Source : | Encyclopédie Universalis, Kinshasa<br>Tours.toile-libre.org | |

## 4.5. Administrative map of Tours and Kinshasa

For this study, we selected the Tours centre and 1km after the Loire and 1km after the Cher, it means we took a part of Tours Nord and a part of Tours Sud. We also delimitate the area based on flood risk map. The total area is 17.40 km$^2$. The area is cross by the Loire and Cher River.

For our study in Kinshasa, we selected neighborhood located in the core of the city, near rivers and have been flooded this last 10 years. For that our neighborhood are Ngaba, Kalamu, Lemba, and Limete. The total area is 34.49 km$^2$. It is crossed by 2 rivers Yolo and Funa (Kalamu).

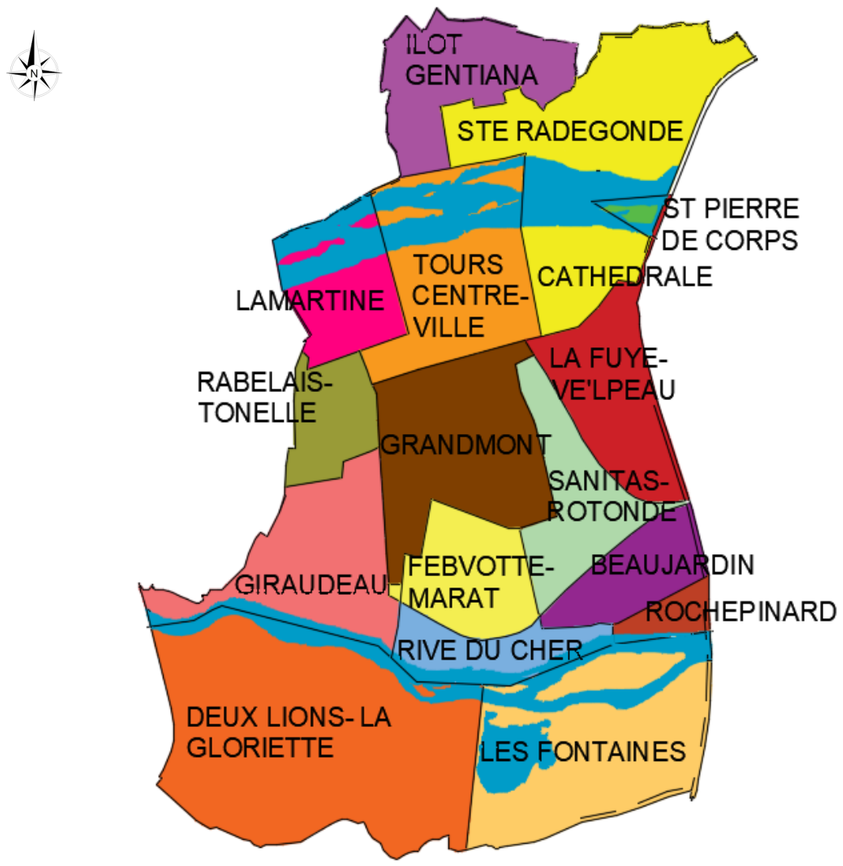



*Figure 14: study area at Tours*

Source: Google map. Drawn by the author
Scale: 1:1000. Area: 17.49 km$^2$
AutoCAD

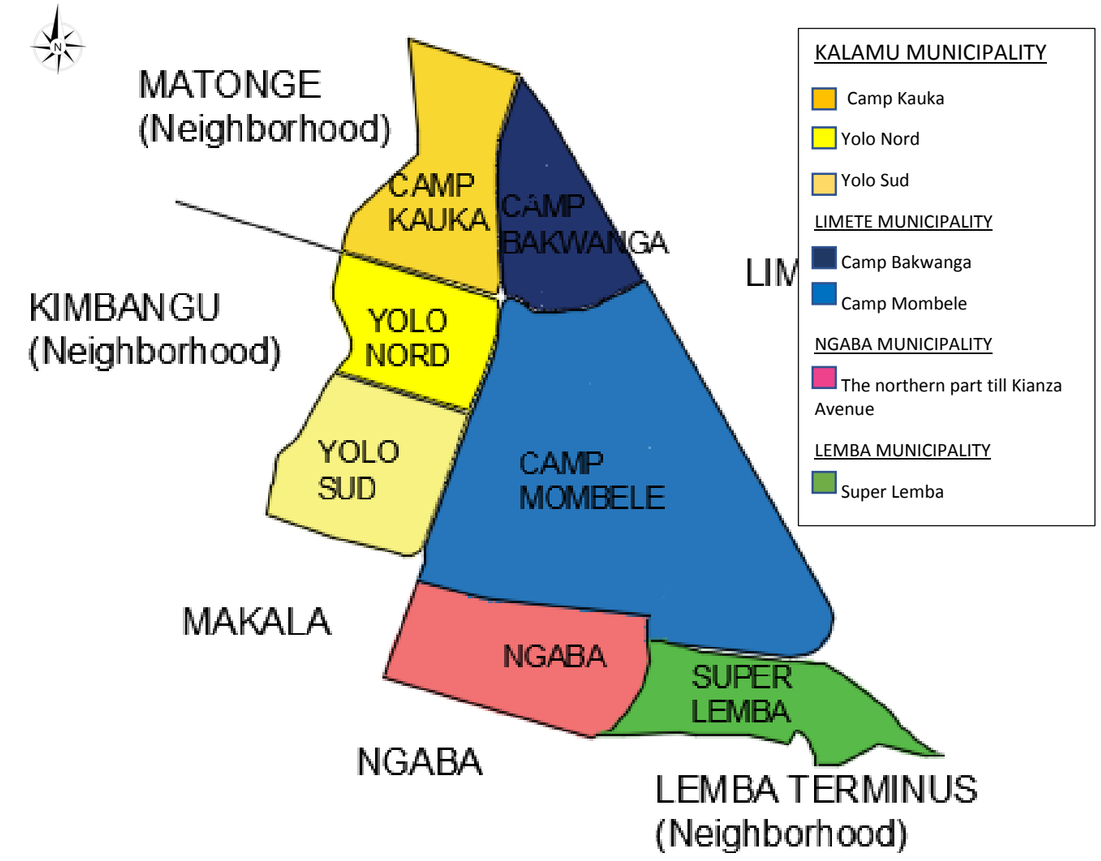



*Figure 15: study area at Kinshasa*

Source: google map. drawn by the author
Scale: 1:1000 Area: 34.49 km$^2$
AutoCAD

## 4.6. Demographic profile

The city of Tours has 136,125 inhabitants with 907 arrivals recorded between 2009 and 2014 (the real estate market in Tours is evolving). Its population has increased by 7.5% in just 5 years. The Department had 268,924 inhabitants in 1801, 335,541 a century later (1901), 559,159 in 2001. Ten years ago (2007): 575,500. In 2017, more than 600,000. We passed this course last year, and it is confirmed this year with 603,924 inhabitants (619,004 if we add the double accounts (*), and we speak then total population), including nearly 90,000 on the Chinon, 51,000 on the Lochois. This is the "legal population" in the 1st January 2017, the date of statistical reference is the 1st January 2014. The Touraine remains a land of welcome, which takes advantage of its centrality to be a "node" road and rail, one hour from Paris by TGV, two hours by the A 10. No demographic decline, no explosion either.

UN estimate 12million in 2015. The most reliable estimates and projections available seem to be those of UN-Habitat's latest report on the state of the world's cities. The median age is 18.6 in Kinshasa. 43% of the population of DR-Congo live in urban area. The median age is 18.6 in Kinshasa. 43% of the population of DR-Congo live in urban area.

Number of inhabitant par municipality:

*Table 1: population in Tours and Kinshasa*

| Tours (census 2014) | | Kinshasa (Census 2004) | |
|---|---|---|---|
| Ballan-Miré | 8 114 | Ndjili | 442 138 |
| Bertthenay | 750 | Kimbanseke | 946 372 |
| Chambray-lès-Tours | 11 351 | Masina | 485 167 |
| Chanceaux-sur-Choisille | 3 566 | Nsele | 140 929 |
| Druye | 1003 | Maluku | 67 450 |
| Fondettes | 10 853 | Kintambo | 106 772 |
| Joué-les-Tours | 38 248 | Lingwala | 94 635 |
| La Membrolle-sur-Choisille | 3 196 | Kinshasa | 164 857 |
| La Riche | 10 653 | Barumbu | 150 319 |

| | | | |
|---|---|---|---|
| Luynes | 5 270 | Gombe | 32 373 |
| Mettray | 2 131 | Ngaliema | 683 135 |
| Notre-Dame-d'Oé | 4 106 | Kalamu | 315 342 |
| Parçay-Meslay | 2 345 | Kasa-Vubu | 157 320 |
| Rochecorbon | 3 278 | Ngiri-Ngiri | 174 843 |
| Saint-Avertin | 15 449 | Bandalungwa | 202 341 |
| Saint-Cyr-sur-Loire | 16 390 | Bumbu | 329 234 |
| Saint-Etienne-de-Chigny | 1 521 | Makala | 253 844 |
| Saint-Pierre-des-Corps | 15 997 | Selembao | 315 342 |
| Savonnières | 3 217 | Mont-Ngafula | 261 004 |
| Tours | 139 507 | Lemba | 349 838 |
| Villandry | 1 112 | Kisenso | 386 131 |
| Saint-Genouph | 1 070 | Limete | 375 726 |
| | | Matete | 268 781 |
| | | Ngaba | 180 650 |
| Total Tour(s)plus | 299 130 | TOTAL KINSHASA | 6 721 958 |

### 4.6.1. Population growth

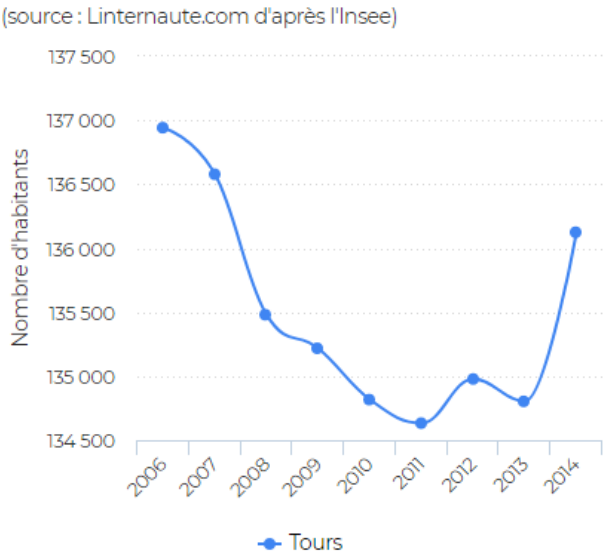



*chart 1: population growth of Tours*

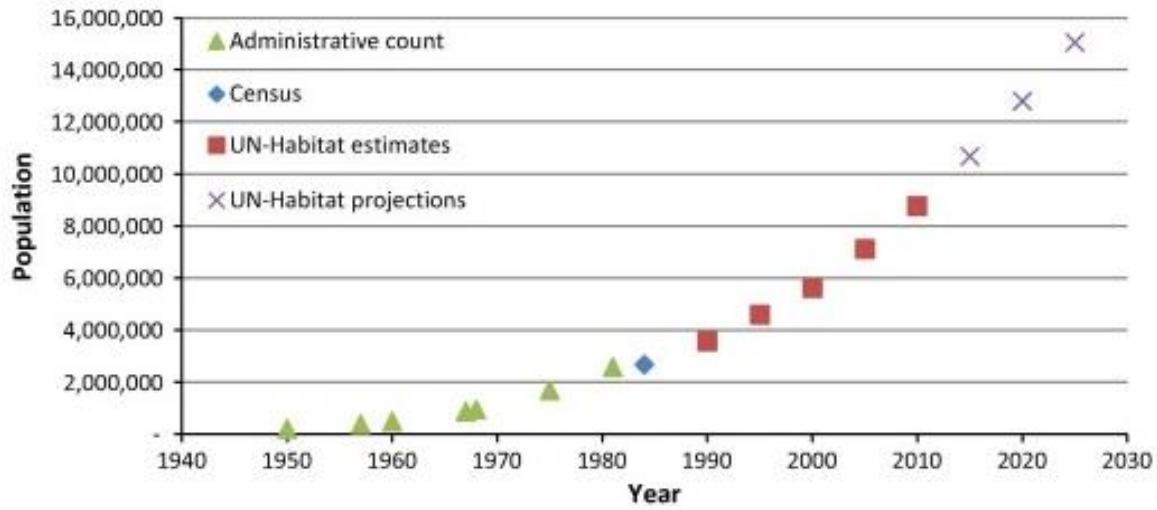



*chart 2: population growth of Kinshasa*

57% of the population in tours area male and 43% are female. In Kinshasa 51% are male and 49% are female.

## 4.6.2. Age pyramid

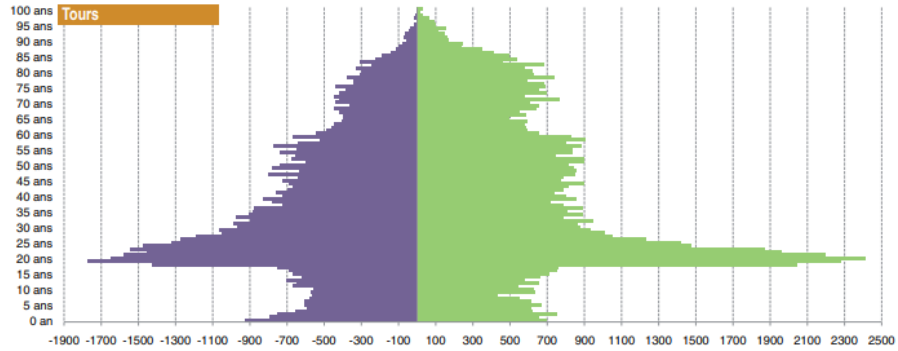



*chart 3: age pyramid of Tours*

Source: http://www.agglo-tours.fr/uploads/Document/b4/WEB_CHEMIN_6149_1309955377.pdf

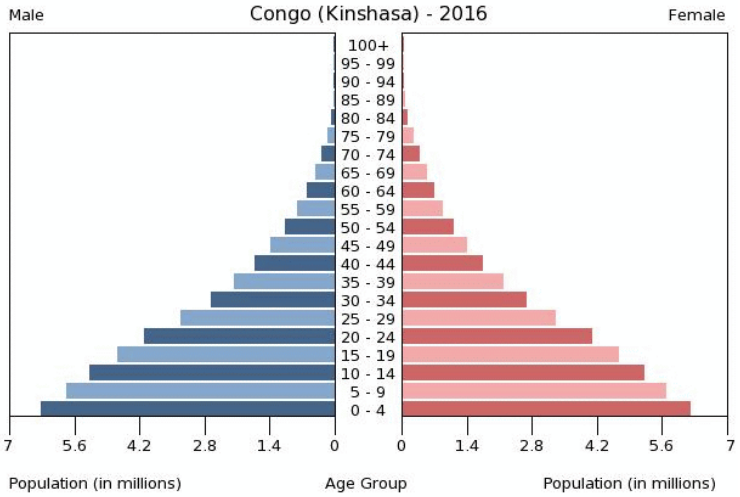



*chart 4: Age pyramid of Kinshasa*

Source: https://www.indexmundi.com/graphs/population-pyramids/democratic-republic-of-the-congo-population-pyramid-2016.gif

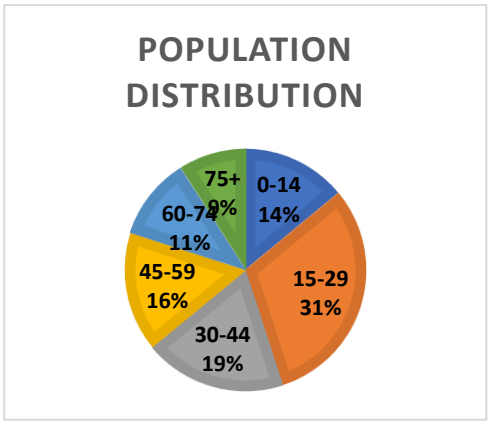



*chart 6: Tours age distribution*

source: http://www.cartesfrance.fr/carte-france-ville/population_37261_Tours.html#ixzz5Hz0j2pck

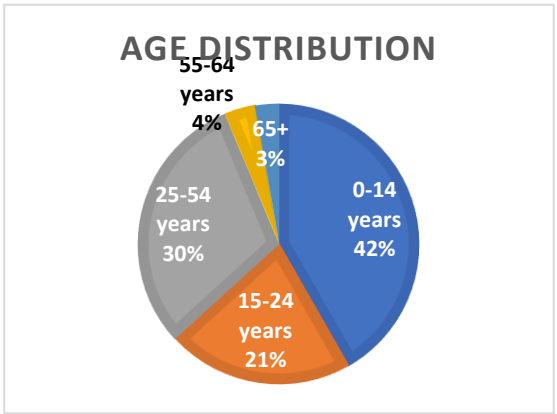



*chart 5: Kinshasa age distribution*

source: index mundu

## 4.7. Timeline of flood in Tours and Kinshasa.

Tours has a long historical background of flood, during the nineteenth century, Tours had four great floods of the Loire in 1836, in 1846 they recorded a loss of 52 houses, in 1856 a castle at la Chappelle-sur-Loire was affected and 1866 which caused many damages. This last reached 50 cm of water on the boulevard Herteuloup.

All this disaster can happen again, also with the climate change the probability is higher. Today, there are 150 000 inhabitants at the flood prone area along the Loire river and around 30% of jobs of the department of Indre-et-Loire.

Kinshasa has flood plain area along all majors' rivers it is one the reason the government forbidden construction on the bank of the river and dedicated these areas to agriculture. With lack of master plan, the city is facing unplanned growth. This last lead to several problem such as more than 600 areas prone to landslide (bibliotheque virtuelle de la R.D.C, n.d.), all those houses located on bank of rivers are prone to flood. This last 10 years, the city is facing flood particularly most of all areas located at the plain due to poor drainage system, lack of maintenance and poor solid waste management the city is flooded when it rains specially during heavy rain season. (Joel Kanya).

*Table 2: flood history in Tours*

| Classées par cote | Échelle | | Classées par cote | Échelle |
|---|---|---|---|---|
| Juin 1856 | 7,58 | | Novembre 1789 | 6,60 |
| Octobre 1846 | 7,17 | | Janvier 1823 | 5,07 |
| Novembre 1789 | 6,60 | | Décembre 1825 | 6,20 |
| Septembre 1866 | 6,58 | | Juin 1835 | 5,47 |
| Décembre 1825 | 6,20 | | Octobre 1846 | 7,17 |
| Octobre 1872 | 5,69 | | Juin 1856 | 7,58 |
| Octobre 1907 | 5,61 | | Septembre 1866 | 6,58 |
| Juin 1835 | 5,47 | | Octobre 1872 | 5,69 |
| Janvier 1823 | 5,07 | | Mai 1885 | 2,52 |
| Janvier 1982 | 3,82 | | Octobre 1907 | 5,61 |
| Décembre 2003 | 3,40 | | Décembre 1981 | 3,34 |
| Décembre 1981 | 3,34 | | Janvier 1982 | 3,82 |
| Mai 1983 | 3,18 | | Mai 1983 | 3,18 |
| Mars 1988 | 2,68 | | Avril 1986 | 2,14 |
| Mai 1885 | 2,52 | | Mars 1988 | 2,68 |
| Mai 2001 | 2,48 | | Mai 1989 | 1,58 |
| Avril 1986 | 2,14 | | Février 1990 | 1,46 |
| Mai 1998 | 2,00 | | Novembre 1992 | 1,76 |
| Janvier 1994 | 1,86 | | Janvier 1994 | 1,86 |
| Février 1999 | 1,84 | | Janvier 1995 | 1,53 |
| Novembre 1992 | 1,76 | | Décembre 1996 | 1,30 |
| Janvier 2000 | 1,70 | | Janvier 1997 | 0,97 |
| Mai 1989 | 1,58 | | Mai 1998 | 2,00 |
| Janvier 1995 | 1,53 | | Février 1999 | 1,84 |
| Février 1990 | 1,46 | | Janvier 2000 | 1,70 |
| Décembre 1996 | 1,30 | | Mai 2001 | 2,48 |
| Janvier 1997 | 0,97 | | Décembre 2003 | 3,40 |

Source : http://www.centre.developpement-durable.gouv.fr/plus-grandes-crues-sur-la-loire-a85.html

## 4.8. Existing situation

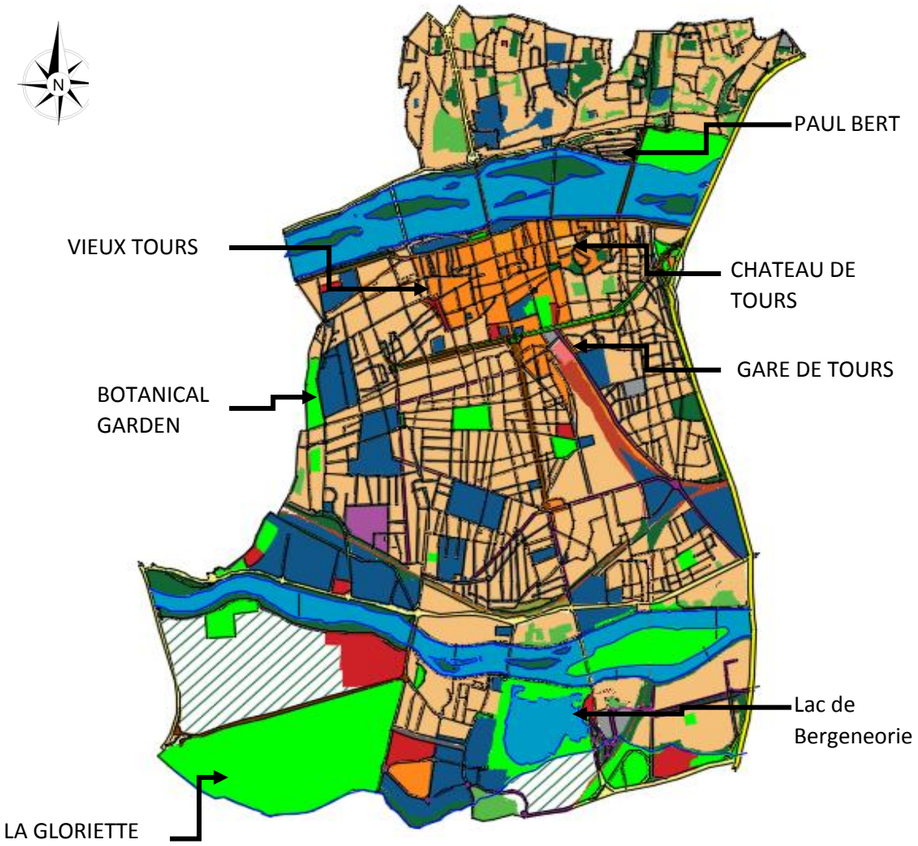



*Figure 16: existing situation in Tours*

Source: Google map. Drawn by the author
Scale: 1:1000. Area: 17.49 km$^2$
AutoCAD

0 20 50 100 200

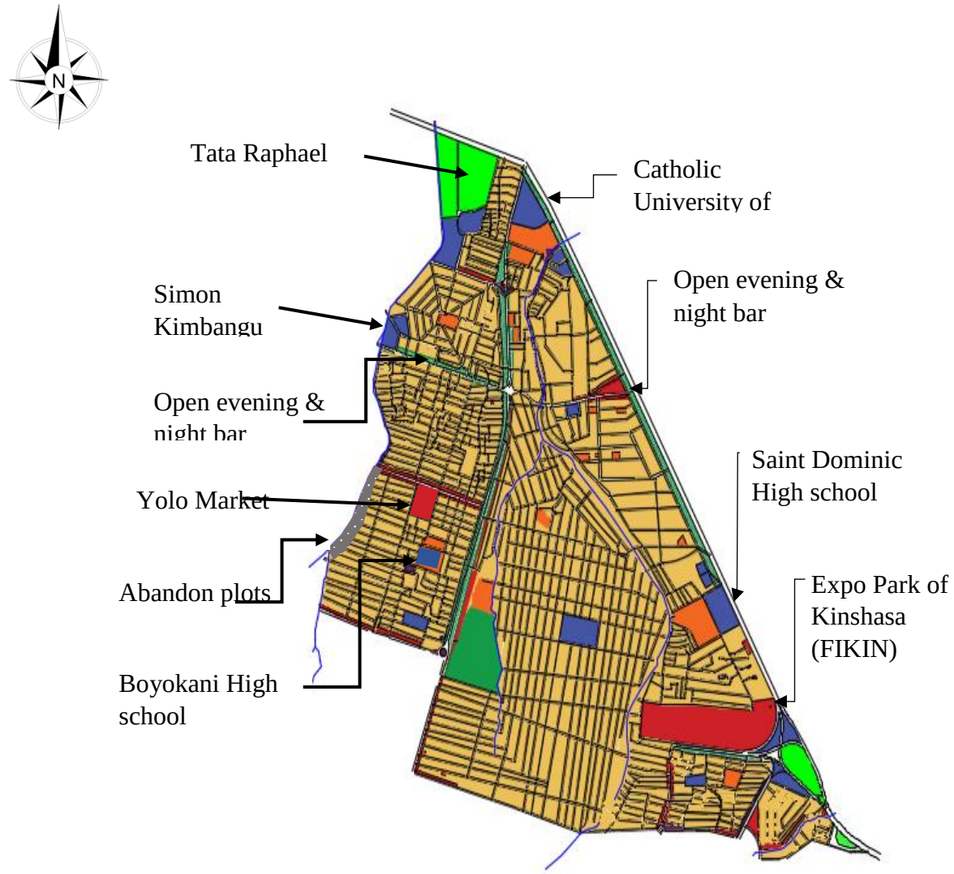



*Figure 17: existing situation in Kinshasa*

Source: google map. Drawn by the author
Scale: 1:1000. Area: 34.49 km$^2$
AutoCAD

0 20 50 100 200

The most remarkable thing when we observe both maps, is shortage of green infrastructure in Kinshasa compare to Tours. The land use in Kinshasa is mainly residential and we find a presence of many institutional buildings there are schools and universities and very few offices. The study area at Tours has schools, universities, offices, many markets and gardens compare to Kinshasa

## 4.9. Administration framework

The major city of Tours since October 2017 is Mr. Christophe Bouchet. The city and state has and 21 neighborhoods. For our study we selected 16 neighborhoods.

The chief minister and major city of Kinshasa since 2006 is Mr. A. Kimbuta Yango. The city and state has 24 municipalities and 310 neighborhoods. For our study we select 7 neighborhoods.

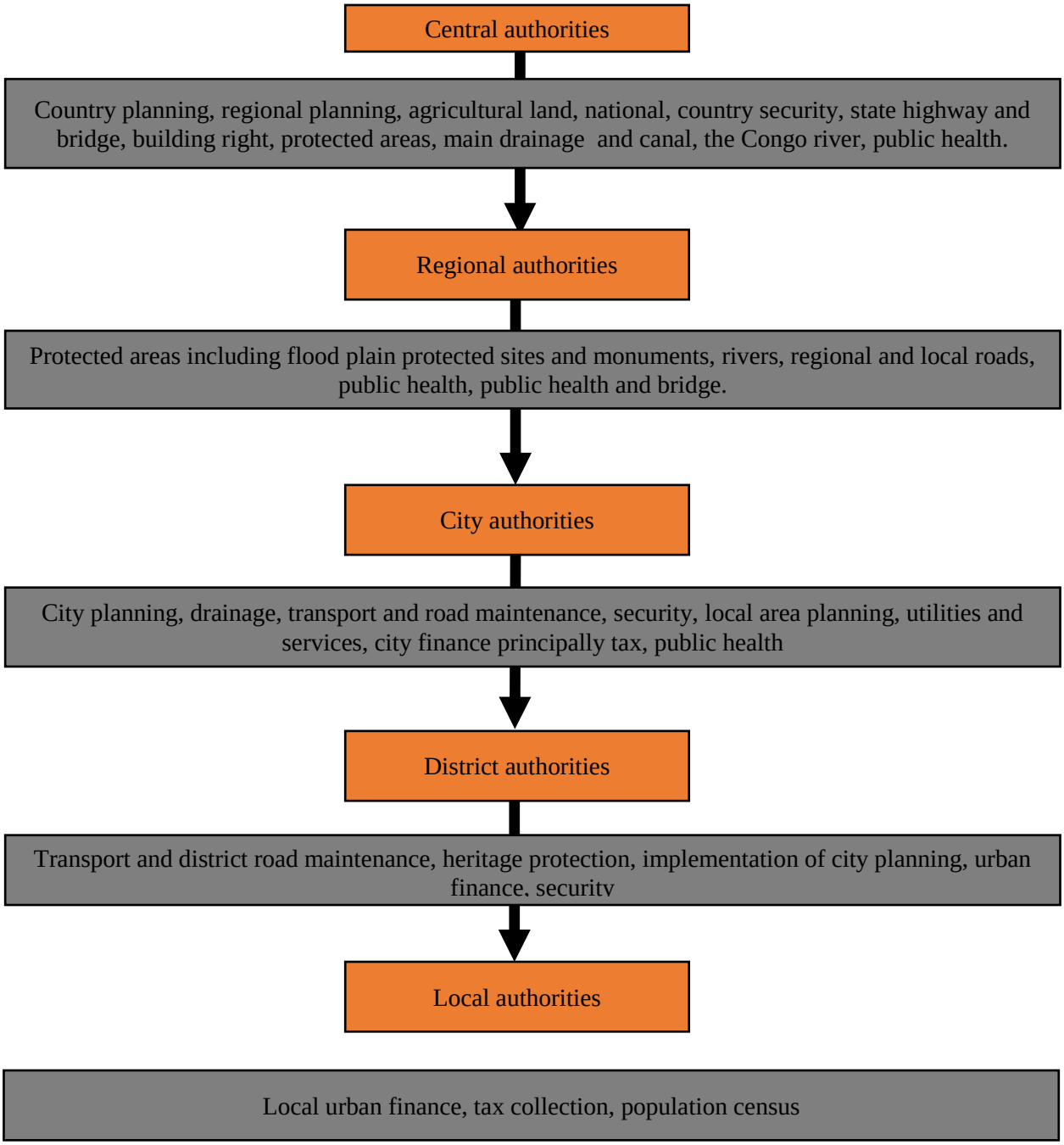



*chart 7: Kinshasa organigram*

Source: Democratic Republic of Congo, 1998

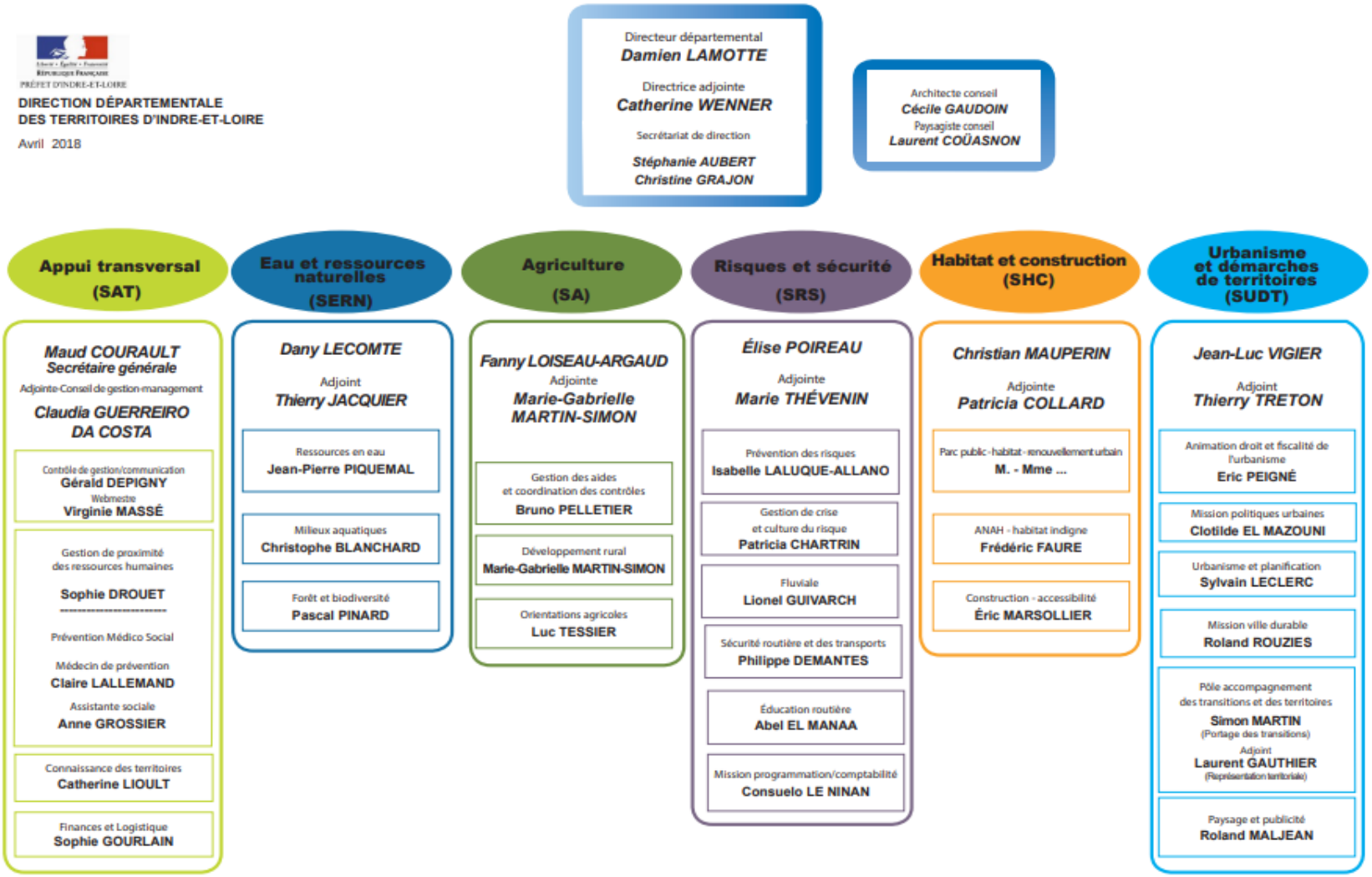



*chart 8: organigram of Tours*

Source : Direction Générale des Territoires d'Indre-Et-Loire, 2017

## 4.10. SWOT analysis

SWOT analysis is an analytical method which is utilized to identify and classify significant internal (Strengths and Weaknesses) and external (Opportunities and Threats) factors faced either in a specific field, for example an organization, or a region, a region, nation, or city. It provides data that is useful in matching the organization's resources and abilities to the competitive environment in which it works and is in this way a critical commitment to the strategic planning process ( JCR European commission, 2005-7).

We analyzed the strength, weakness and opportunity of these two cities for a better understanding.

*Table 3: SWOT analysis*

| SWOT | Tours | Kinshasa |
|---|---|---|
| Strengths | • Flood bring nutrients for aquatic species, shrubs and trees located near the river.<br>• The flood plain is good for agriculture.<br>• Based on the recorded flood events, the city of Tours elaborates flood map and strategies of flood management<br>• Tours has a warning system and evacuation measures. | • Kinshasa has a lot of open space that can be developed.<br>• The flood plain is good for agriculture. |
| weaknesses | • Less permeable area.<br>• Wild habitat destruction due to urbanization.<br>• Water pollution due to utilization of pesticide. | • Lack of flood management in Kinshasa.<br>• The drainage system of Kinshasa wasn't design for the actual quantity of rain fall.<br>• Uncontrolled city growth near rivers in Kinshasa.<br>• Destruction of river's bank in Kinshasa due unplanned growth of the city.<br>• Wild habitat destruction due to urbanization.<br>• Heat land |
| Opportunities | • We can analyze the vulnerability based on the existing document on flood and recorded events for Tours and Kinshasa.<br>• With the existing open space, we can create green corridor in the city.<br>• | • There is a lot pf permeable space in Kinshasa.<br>• We can analyze the vulnerability based on the existing document on flood and recorded events for Tours and Kinshasa.<br>• With the existing open space, we can create green corridor in the city.<br>• We can restore the flood. |

| | | |
|---|---|---|
| threats | • More than 90% of the study area is consider in the risk zone.<br>• The climate change has increased the rainfall quantity due to changes we can't predict exactly what can happened in case of heavy rain.<br>• The urbanization has reduced the percentage of green space in cities. | • In case of heavy rain, the river overflow.<br>• The climate change has increased the rainfall quantity due to changes we can't predict exactly what can happened in case of heavy rain.<br>• The urbanization has reduced the percentage of green space in cities. |

# Chapter five: GREEN AND BLUE CORRIDOR IN KINSHASA AND TOURS

## 5.0. Introduction

Green and blue corridor in a city is define as any green space such park, green belt, gallery forest, flood plain area, reserved forest, green roof, agricultural land and blue corridor are pound, lake, reservoir, river.

## 5.1. Existing green and blue infrastructure in both cities

The northern and the southern part of the Tours are greener than the center part. This is due to the city growth. The center part is where the city started, the southern and the northern part are new expansion of the city. There we find plot with garden, gardening place, and many plots has private garden particularly in the northern part. As park in the study area we have: The Botanical garden, *La Gloiriette* Park, the *Jardin de Prenbenes d'Oe*, S$^{te}$ Radegande Park, *Honore de Balzac* Park and the *Lac de Bergeonerie*

At Kinshasa, there is a leisure park at the *Echangeur,* the green space along rivers are small bushes.

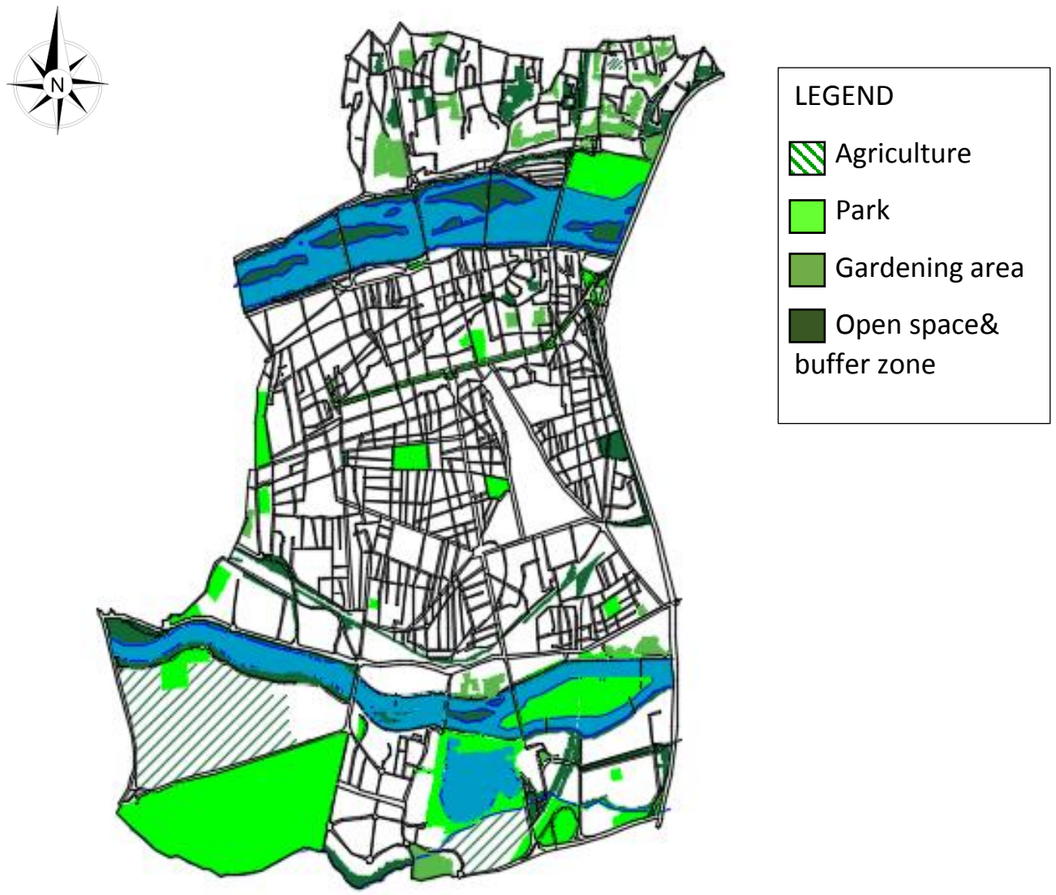



*Figure 19: the existing green and blue infrastructure in Tours*

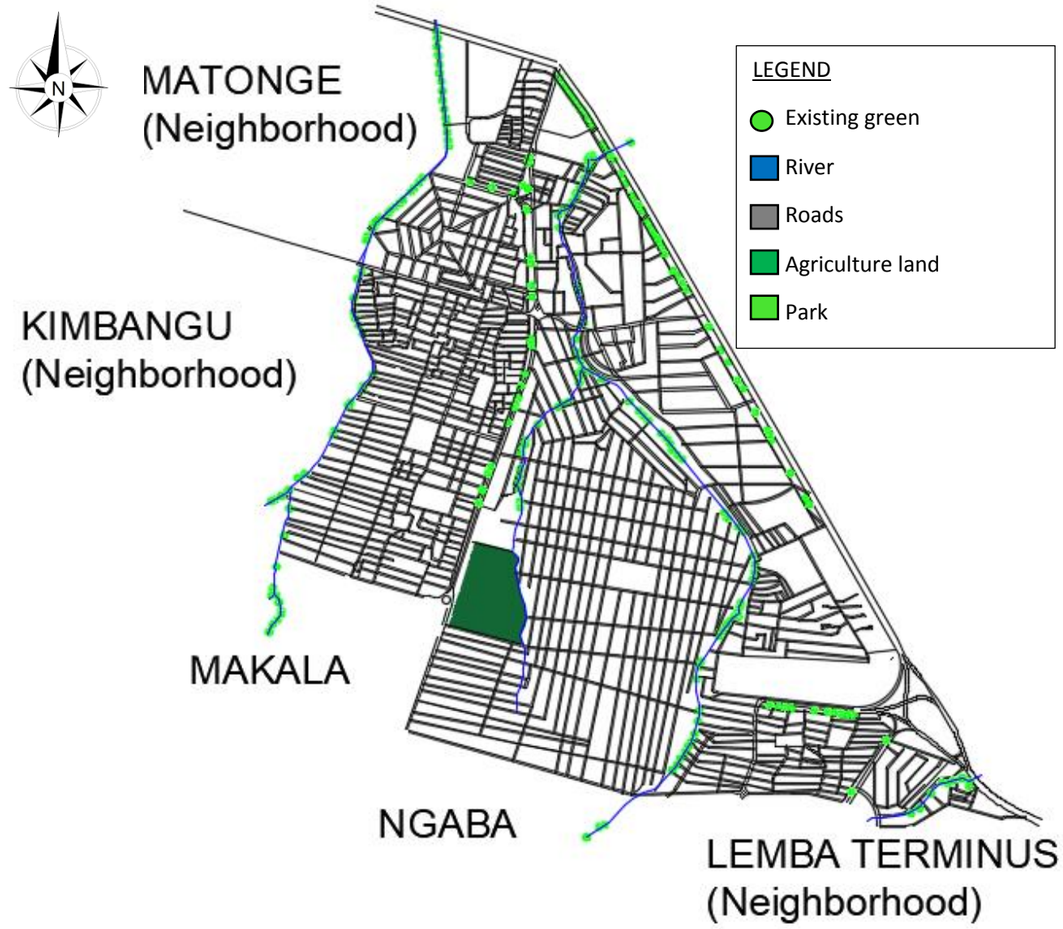



*Figure 20: the existing green and blue infrastructure in Kinshasa*

| | |
|---|---|
| Source: google map. Drawn by the author<br>Scale: 1:1000. Area: 17.44 km$^2$<br>AutoCAD | Source: google map. Drawn by the author<br>Scale: 1:1000. Area: 34.49 km$^2$<br>AutoCAD |

When we compare both cities, we can clearly see that Tours is greener than Kinshasa.

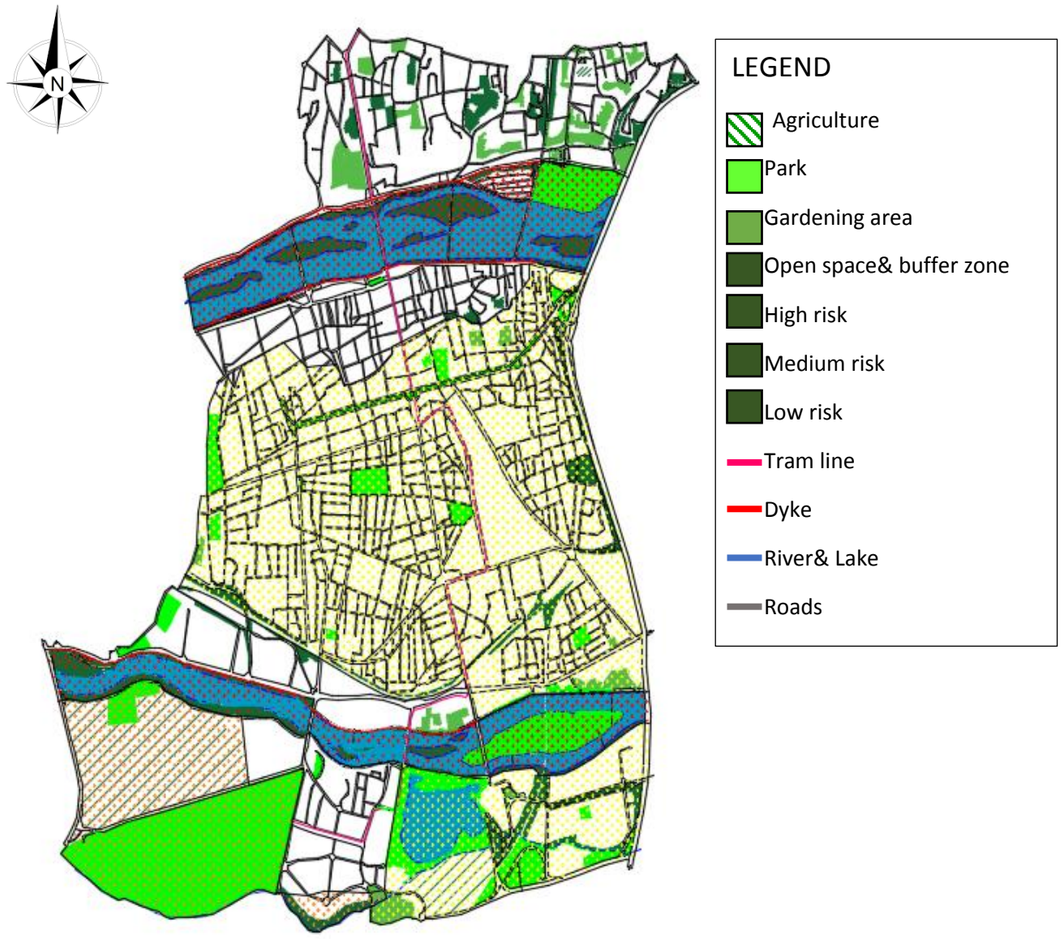



*Figure 22: green and blue infrastructure and flood map*

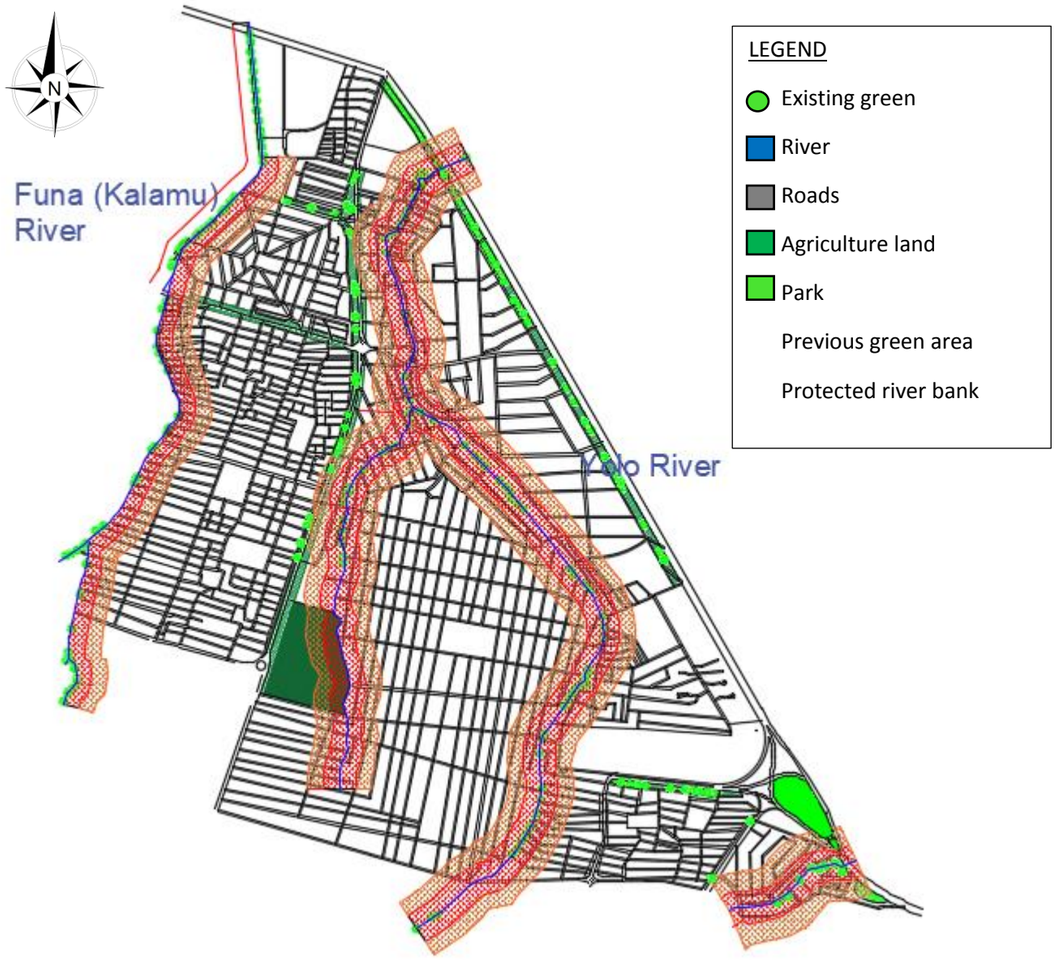



*Figure 23:green and blue infrastructure in the Kinshasa*

| | |
|---|---|
| Source: google map. Drawn by the author<br>Scale: 1:1000. Area: 17.49 km$^2$<br>AutoCAD | Source: google map. Drawn by the author<br>Scale: 1:1000. Area: 34.49 km$^2$<br>AutoCAD |

- The city of Tours has faced flood since century now, to avoid it they built dyke along both rivers. The construction of this last was based on the biggest flood disaster the city has faced. *La Gloriette* Park and the Lac are reservoir in case the Cher River overflow.
- With lack of city planning, people built their houses even in two meters away from the river that result to many damage and losses these two last decades.
- The study area at Tours has 16% of green space and Kinshasa has only 6% of green covers.

## 5.2. Importance of green and blue corridor in the city

### 5.2.1. Value of green and blue spaces

Benefits of green and blue corridor are: natural disaster mitigation, natural cooling to mitigate the urban 'heat island', space for sustainable urban drainage/water storage to absorb excess rainfall, creation of natural areas for recreation, exercise, social meeting, urban gardening and allotments, healthier, happier people, first exposure of urban dwellers to biodiversity, unused land can create green corridors such as disused railway lines, vegetation to reduce the effects of air pollution, store carbon, increase permeability, habitat preservation and sustainable ecosystems, places for species to migrate and adapt to the effects of climate change, fresh water, water treatment.

| Design criteria | Goal |
|---|---|
| community | Creating ecological connectivity |
| stratification | Creating rich layers of vegetables |
| naturalization | Bringing nature to the city |
| biodiversity | Bringing diversity of plant and animal species |
| Regulatory | Maximizing urban comfort |
| Dynamic | Reflecting the evolution of nature and its cycles |
| attractiveness | Creating landscapes that can be perceived and identified |
| Pacification/noise reduction | Bringing peace and quiet to the city |
| complexity | Bring urban social diversity |
| health | Creating therapeutic areas |
| Informative/educational | Generating and interest in nature (conservation) |
| singular | Increase the value of the city's natural and cultural heritage |

*Source: Urban Green-Corridors. Examples and design criteria. Guide published by Barcelona City Council*

### 5.2.3. Value of biodiversity

When we identify our living space we have to consider biodiversity, our well-being, cultural diversity, ecosystem services in the river and river bank and habitat. Once the fauna and flora and the carrying capacity of each species has been defined, these models can be utilized to improve a network habitat management scheme that will include the human well-being and the conservation and protection of species. The beneficial outcomes of dynamic streams on human are complex, including stress reduction (Adams et al, as cited in K.M. Wantzen, 2016-17-18, p 11), good microclimate (Pinto et al, as cited in K.M. Wantzen, 2016-17-18) and reduction of respiratory diseases ( theeuwes et al. as cited K.M. Wantzen 2016-17-18). Diverse waterway have a great aesthetical value (Pfluger et al. as cited K.M. Wantzen, 20016-17-18) and restore the river ecological status (Gosnell and Kelly as cited K.M. Wantzen, 20016-17-18). A river in a pathetic ecological state can cause negative effect for example bas smell, a river in a good state attract more in the entire region (K.M. Wantzen et al, 2016-17-18). "*Recognizing these positive values of healthy rivers for human wellbeing and economic development is an important element of River Culture"* – (K.M. Wantzen, 2016-17-18 as cited in River and Culture).

## 5.3. Accessibility to park

Impact of parks in the neighborhood. We consider a park of 10 acres for 1 000people in the neighborhood that correspond to approximatively ½ mile radius or 10 minutes radius. Bigger parks cover that has sport complex or game like *La Gloriette or Sainte Rodegande park* them we took a 30 minutes radius that correspond to 1 or 2 miles.

*Figure 25: accessibility to parks in the city*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

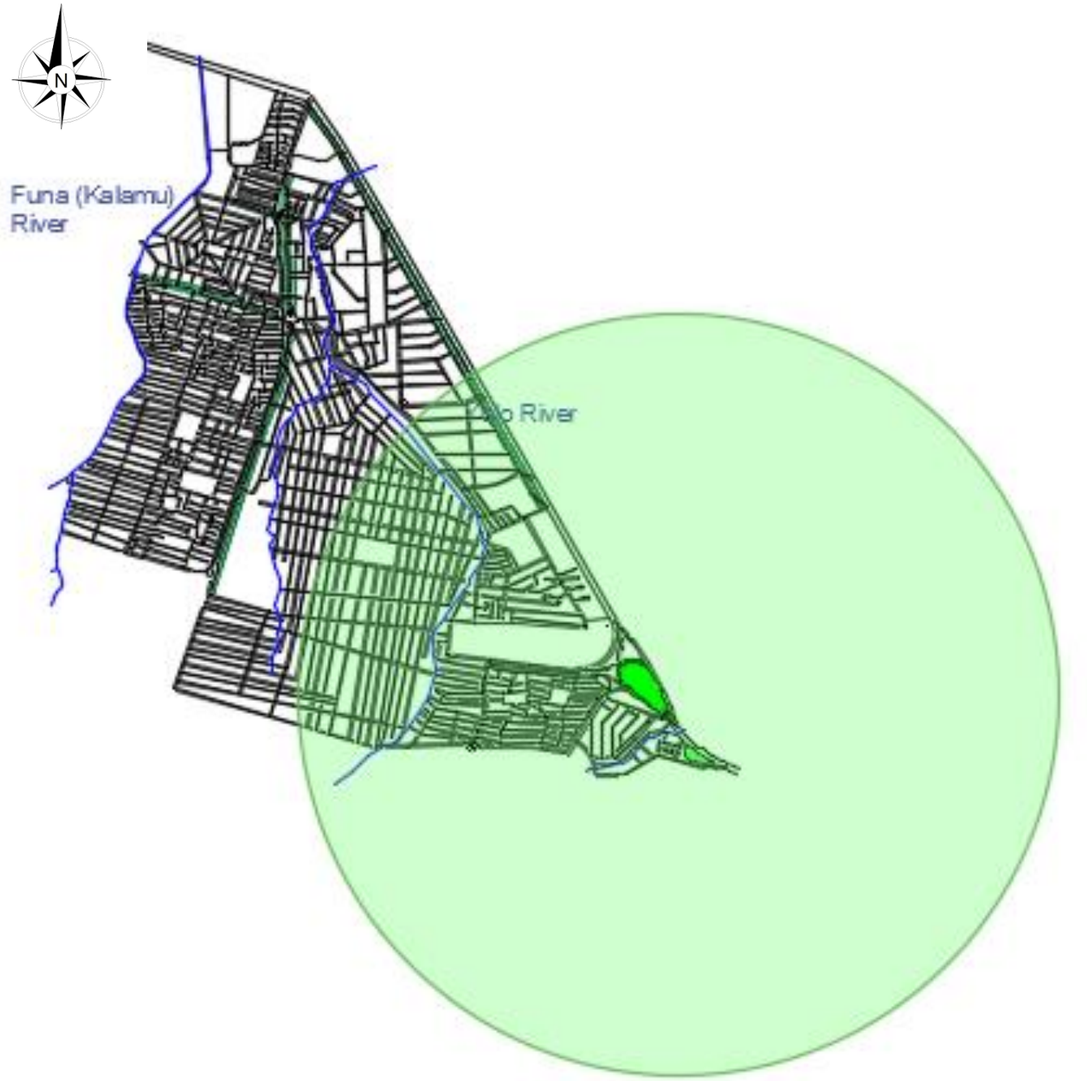



*Figure 26: accessibility toparks in the city*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

All population of Tours has access to a neighbourhood or a district park. In Kinshasa only one third of the population has access to a park.

## 5.4.Impact of green and blue corridor in the flood management

A sponge city alludes to sustainable urban development including flood management, conservation of water, improvement of water quality and protection of environment. Sponge city is a city with a water system which works like a sponge to absorb, store, infiltrate and decontaminate rainwater and discharge it for reuse when required. The idea of sponge city was taken from the low impact development (LID) and green infrastructure in the US and Canada, sustainable drainage systems (SusDrain) in the UK and other European countries, and water sensitive urban design (WSUD) in Australia and New Zealand. It promotes green and blue corridors for managing rainwater. The first goal for China's sponge city construction are: retaining 70–90% of average annual rain water onsite by applying the green infrastructure concept and using LID measures, eliminating water logging and preventing urban flooding, improving urban water quality, mitigating impacts on natural eco-systems, and alleviating urban heat island impacts. The sponge city program will also create investment opportunities in infrastructure upgrading, engineering products and new green technologies (Hui Li and al, 2017)

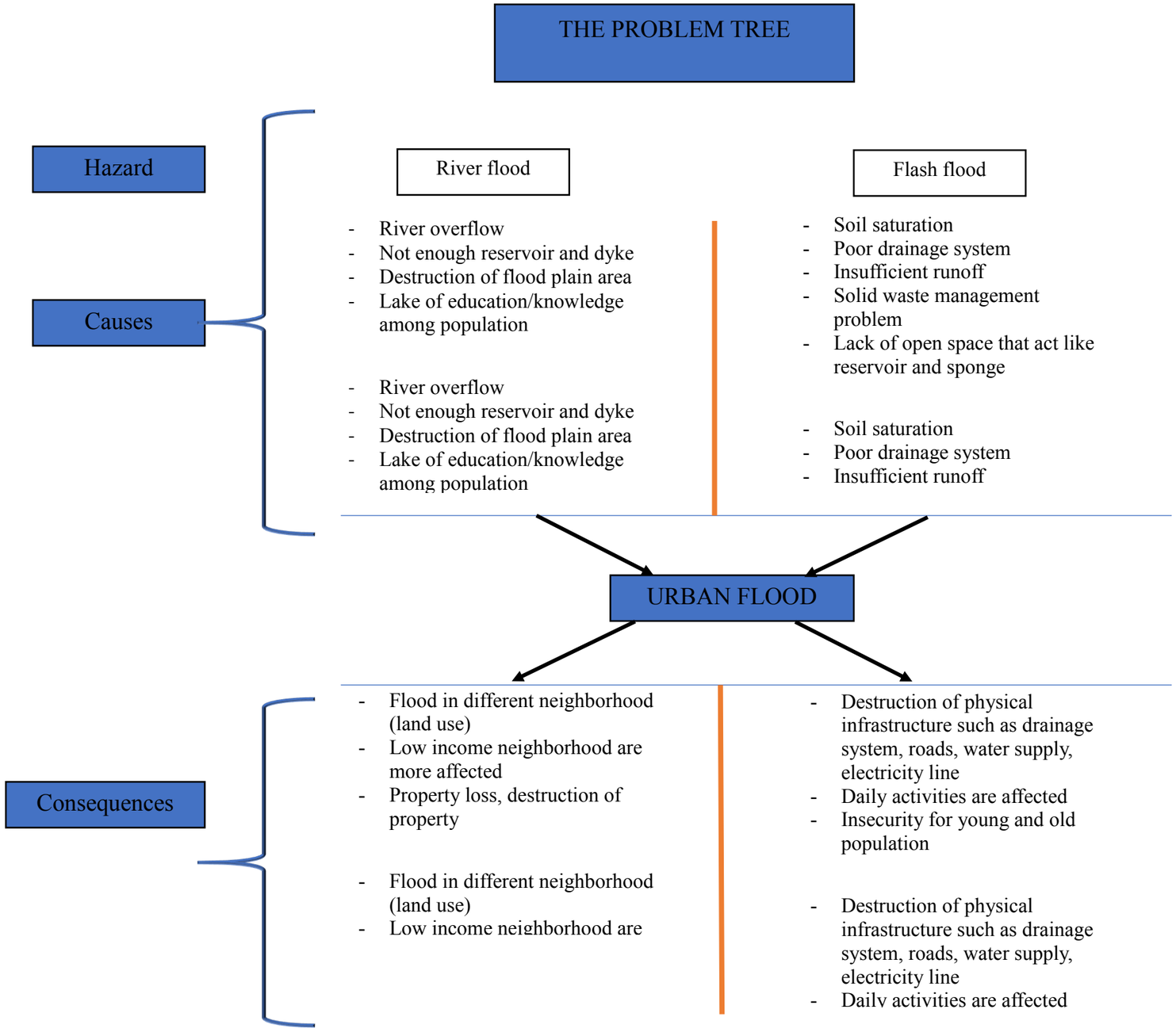
## 5.5.Impact in both cities

With the destruction of green areas, European cities are facing diminution of biodiversity and urban heat island effect (EEA report, 2015).

With the destruction of green corridor in the city due unplanned construction, Kinshasa is facing disaster such as flash flood in the city when it rain, this is first due to heavy rain in short time also insufficient drainages system. Also, solid waste thrown in drainage system and river. River overflow due to heavy rain. These lead to many abandon houses, loss of property value, deterioration of roads, personal loss even dead. Also, plastic waste blocks the river that leads to flood on the bridge even the deterioration of this last. Due to this plastic waste, the development of the gallery forest is affected even the aquatic life. This last decade the city is facing severe heat waves.

## 5.6.The problem tree

The tree problem helps us to analyze the existing problems in the study areas and we propose solution to these problems in the solution tree.



# THE SOLUTION TREE

**Hazard**

| River flood | Flash flood |
|---|---|
| - Restauration of floodplain<br>- Creation of reservoir and sponge area<br>- Instruct people about the importance of green and blue corridor and floodplain | - Create sponge area and reservoir.<br>- Create sufficient runoff<br>- Maintain the drainage system<br>- Do the solid waste management<br>- Instruct people |
| - Restauration of floodplain<br>- Creation of reservoir and sponge area<br>- Instruct people about the importance of green and blue corridor and floodplain | - Create sponge area and reservoir.<br>- Create sufficient runoff<br>- Maintain the drainage system |

**Causes**

**URBAN FLOOD REDUCTION**

**Consequences**

| | |
|---|---|
| - Flood control in the short and long term<br>- Beautification of neighborhood that affect the real estate price<br>- Reduce the heat island effect<br>- Reduce river pollution and restore the ecosystem<br>- Reduce pressure in the sewage infrastructure<br>- Economy saving<br>- Good physical infrastructure<br>- Encourage equity between neighborhood | - Security of people and their goods and helps in children development<br>- Creation of recreational area that affect even positively the real estate price and the life quality<br>- Increase the evaporation<br>- Improve the air quality<br>- Groundwater recharge<br>- Promote walking and cycling as last mile connectivity<br>- Create interaction place |
| - Flood control in the short and long term<br>- Beautification of neighborhood that affect the real estate price<br>- Reduce the heat island effect<br>- Reduce river pollution and restore the ecosystem<br>- Reduce pressure in the sewage infrastructure<br>- Economy saving<br>- Good physical infrastructure<br>- Encourage equity between neighborhood | - Security of people and their goods and helps in children development<br>- Creation of recreational area that affect even positively the real estate price and the life quality<br>- Increase the evaporation<br>- Improve the air quality<br>- Groundwater recharge<br>- Promote walking and cycling as last mile connectivity<br>- Create interaction place |

# Chapter six: VULNERABILITY ASSESSMENT IN KINSHASA AND TOURS

# 6.0. Introduction

For this study we analyze the physical, social and economic vulnerability. Also we took the existing flood map of those cities.

**Physical vulnerability**: may be determined by aspects such as population density levels, remoteness of a settlement, the site, design and materials used for critical infrastructure and for housing (UNISDR).

**Social vulnerability**: refers to the inability of people, organizations and societies to withstand adverse effects to hazards because of attributes inherent in social interactions, institutions and systems of cultural values. It is connected to the level of well-being of people, communities and society. It includes 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, traditions and ideological convictions and overall collective organizational systems (UNISDR).

Economic vulnerability: it refers to the source of income, the supply chain, the industrial sector, informal sector and the livelihood can be affected by the disaster (UNISDR).

To assess vulnerability, we study parameters selected by the UNISDR and the Risk, Hazard and People's vulnerability to Natural Hazards: a Review of Definitions, Concepts and Data (S. Schneiderbauer and al. 2004).

| **Vulnerability** | **UNISDR** | **Risk, Hazard and People's vulnerability to Natural Hazards: a Review of Definitions, Concepts and Data** |
|---|---|---|
| **Physical vulnerability** | - Population density<br>- Level remoteness of settlement<br>- The site<br>- Design and material<br>- Infrastructure<br>- Housing | Neighborhood network<br>- Infrastructure<br>- Accessibility<br>- Presence and quality of civil protection, including early warning / emergency plans / disaster management capacities.<br>- Disaster preparedness<br>- Degree of autonomy / participation in decision making procedures and access to resources<br>- Climate records and their long-term changes |
| **Social vulnerability** | - Population<br>- Literacy level<br>- Security<br>- Basic rights<br>- Good governance<br>- Social equity<br>Positive traditional values | - Age<br>- Income<br>- Health / disability<br>- Education (literacy rate)<br>- Savings<br>- Individual and family related insurance<br>- Access to information |
| **Economic vulnerability** | - Industry<br>- Economic activity | - Subsistence economy in primary sector |

After this analysis we elaborate our parameters.

| Physical vulnerability | Social vulnerability | Economic vulnerability |
|---|---|---|
| Land use | Population | Commercial activity |
| Network | Gender | |
| Built and open | Age group | |
| Topography | Employment rate | |
| Water supply | Literacy rate | |
| Heritage | Population distribution | |
| Housing | Gender | |
| Emergency response facilities & social infrastructure | Age group | |
| The existing flood map | Employment rate | |
| Run off | | |
| Digital Elevation Model (DEM) | | |

## 6.1. Physical vulnerability

### 6.1.1. Land use

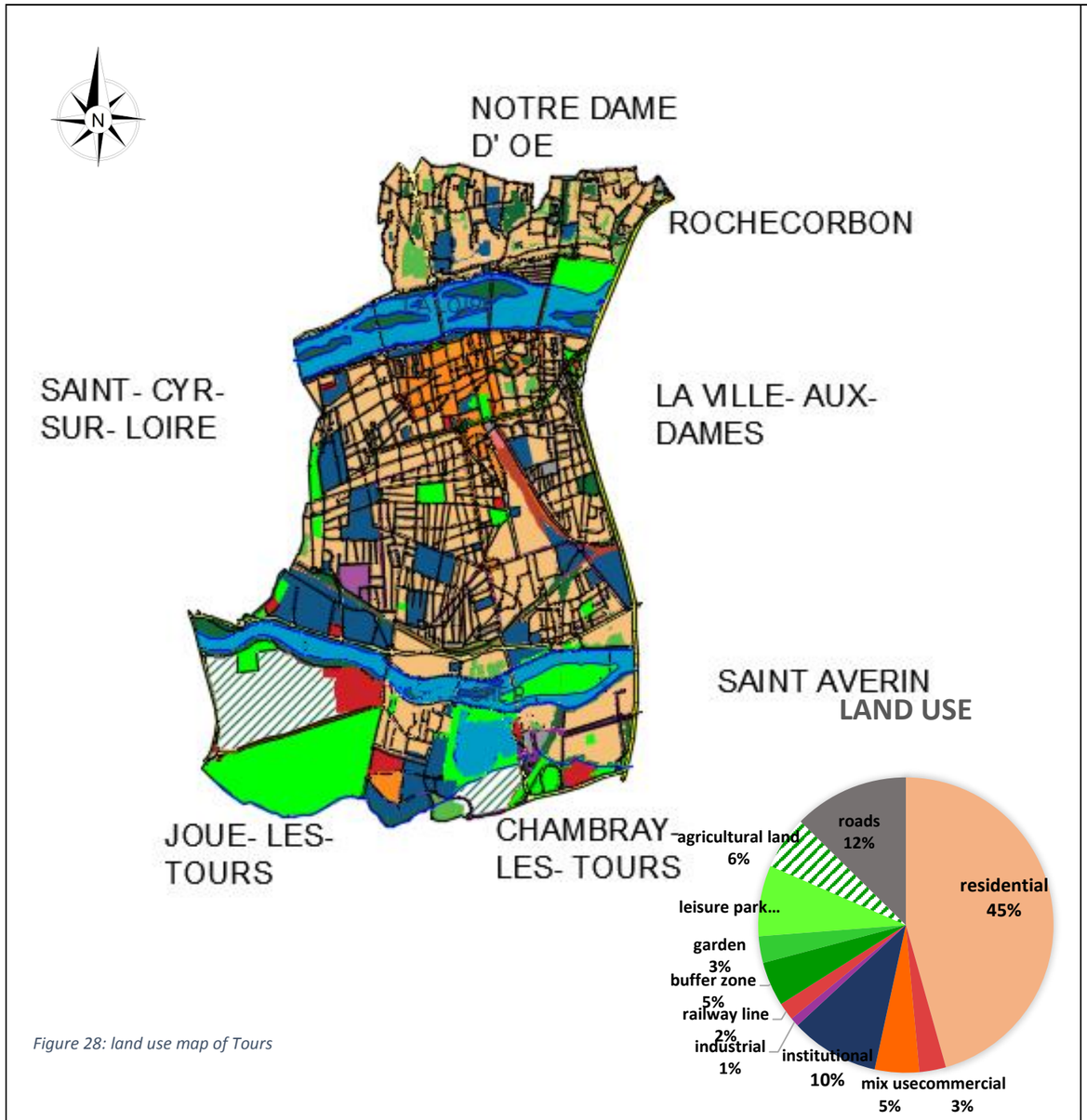
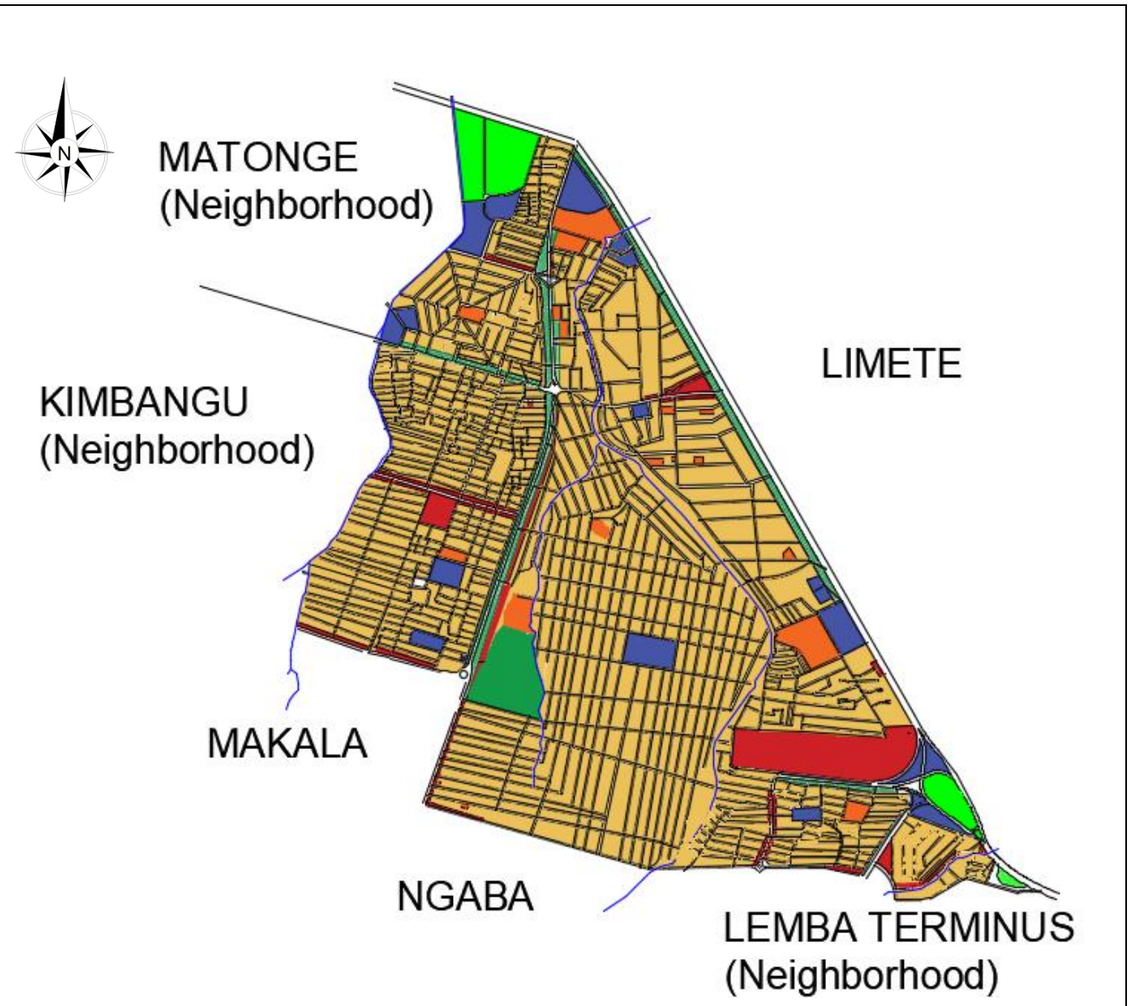



*Figure 28: land use map of Tours*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD




Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

The area is dominated by residential plots, we find also commercial area that include mall. Most of the commerce are located in the mix use area. In the same area we find an important number of shopping shops and we find offices, principally in the *Vieux Tours*. Institutional area is dominated by primary schools, high schools and hospitals. We have also a brownfield. The city has also parks. The area is dominated by residential

plots, we find also commercial area even the one of municipality market.  Along the major roads we find informal market and leisure place. These last are built on the green corridor area of the city except the expo park. The religious area is constituted of churches and nunnery. The institutional area is constituted of two universities and schools. There is only one park that is close to the public, it is used only for specific.

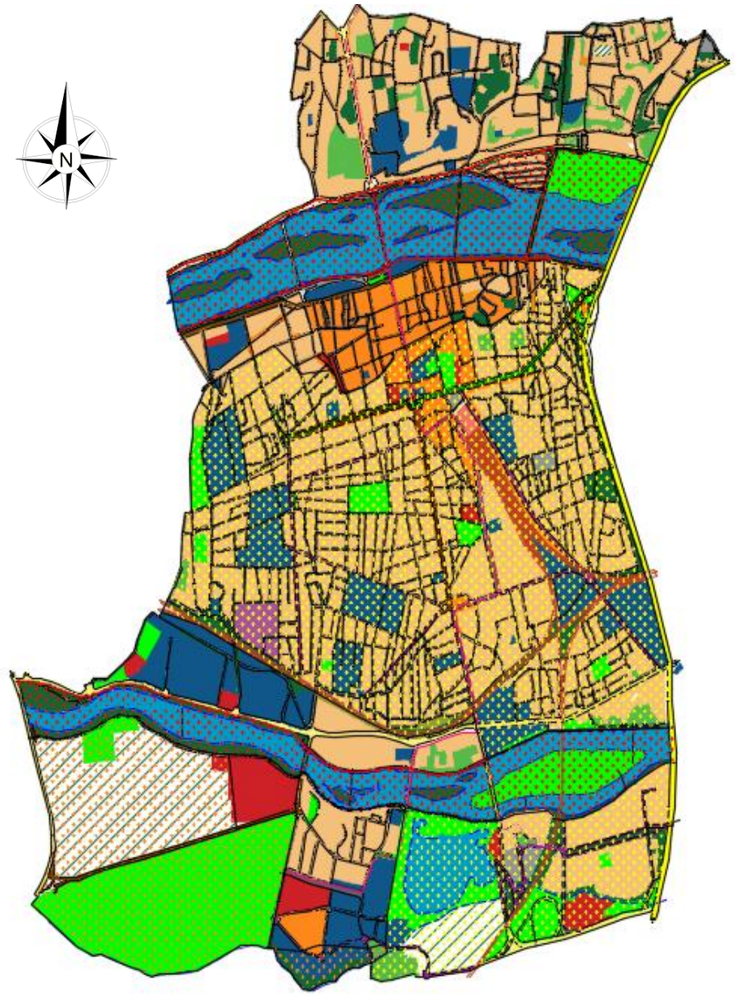


*Figure 32: land use and flood map*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

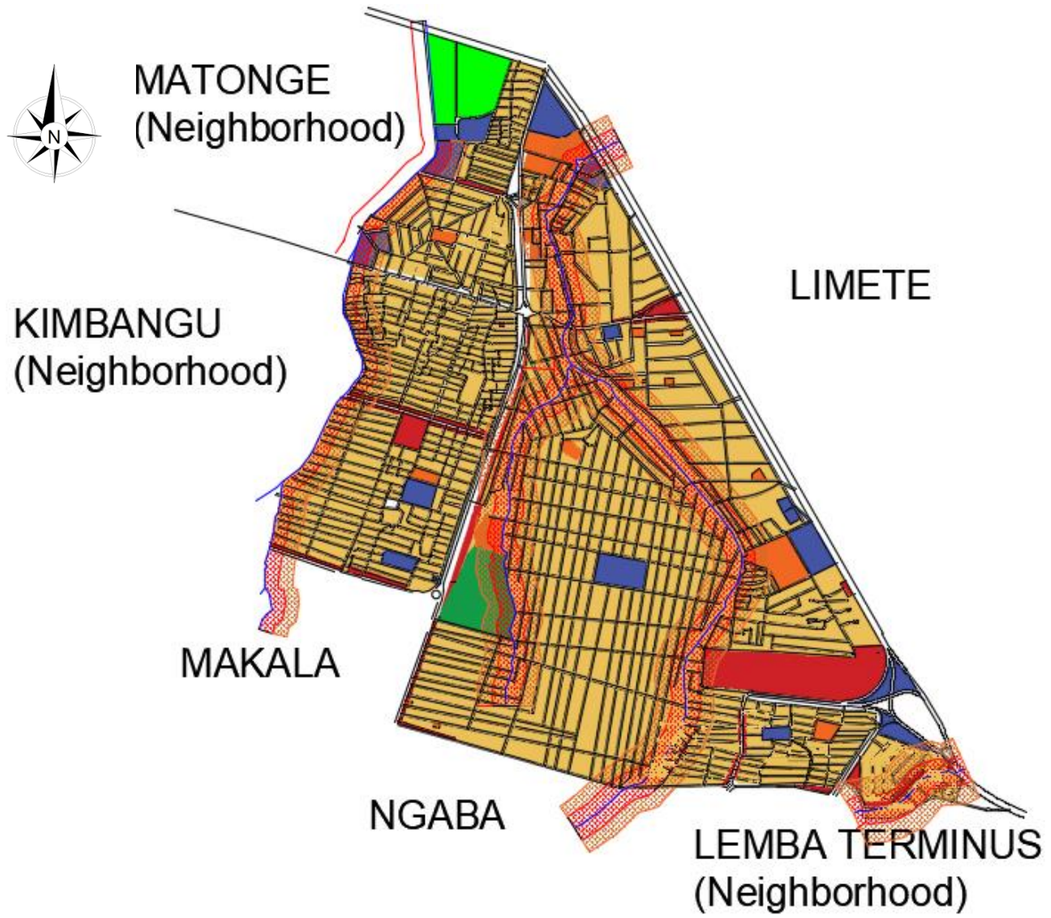



*Figure 33: land use and flood map*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

Based on the existing city vulnerability map, in the study area at Tours, the Paul Bert at and all the islands are located in the high-risk zone. The agricultural land under the Cher River and the agriculture land are in the average risk zone and they are use as reservoir in case of overflow, the major part of the city that is not protected by the dyke is consider as low risk area and the rest of the area are consider as non-vulnerable.

At the other side of the ocean, when we overlap the land use and the risk area, we can clearly see that around 10% of residential area is located in the flood plain area. These residential areas are especially in the unplanned area of the city.

## 6.1.2. Network

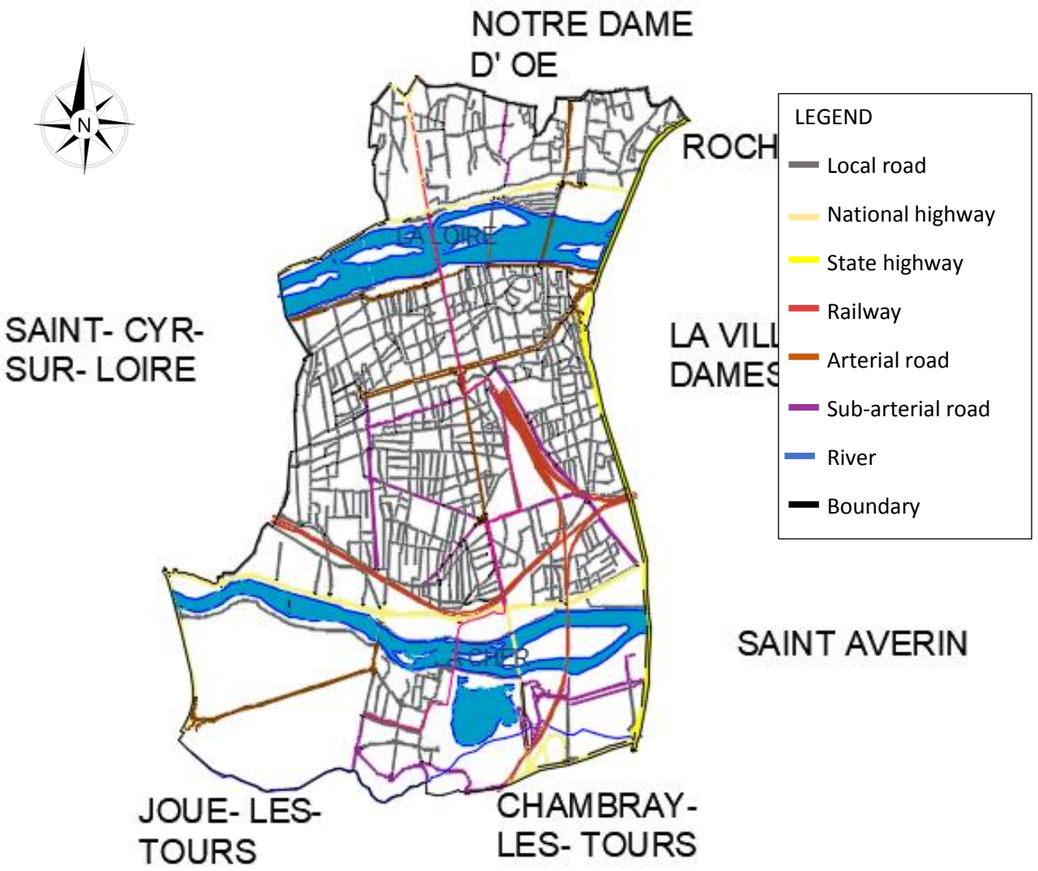



*Figure 35: Tours road hierarchy*

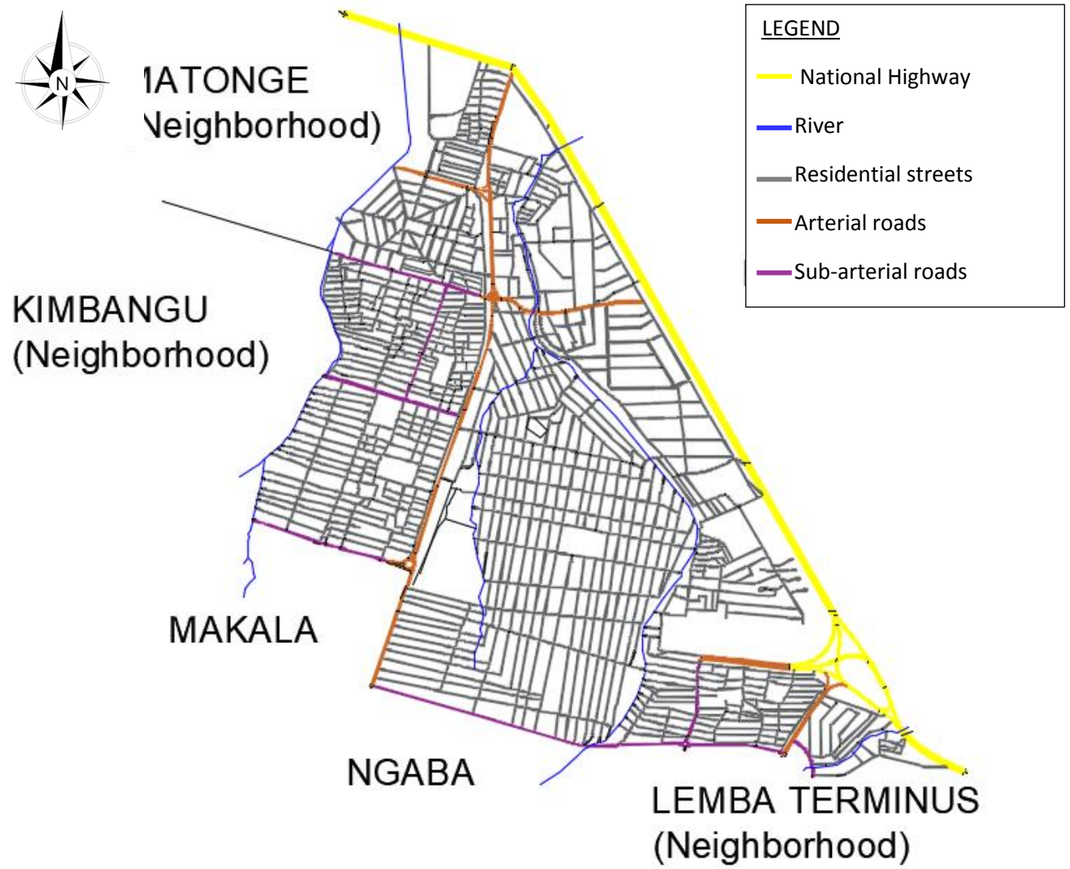



*Figure 36: Kinshasa road hierarchy*

| | |
|---|---|
| Source: google map. Drawn by the author<br>Scale: 1:1000<br>AutoCAD | Source: google map. Drawn by the author<br>Scale: 1:1000<br>AutoCAD |

Both cities have a good road connectivity, they are crossed by the national high ways and have planned roads. The neighborhood road width in Tours has 10.5 meters it includes the walk paths, the parallel parking and the motor way. At Kinshasa the local roads have a width of 5.5 meters it is used as motor way and walk way.

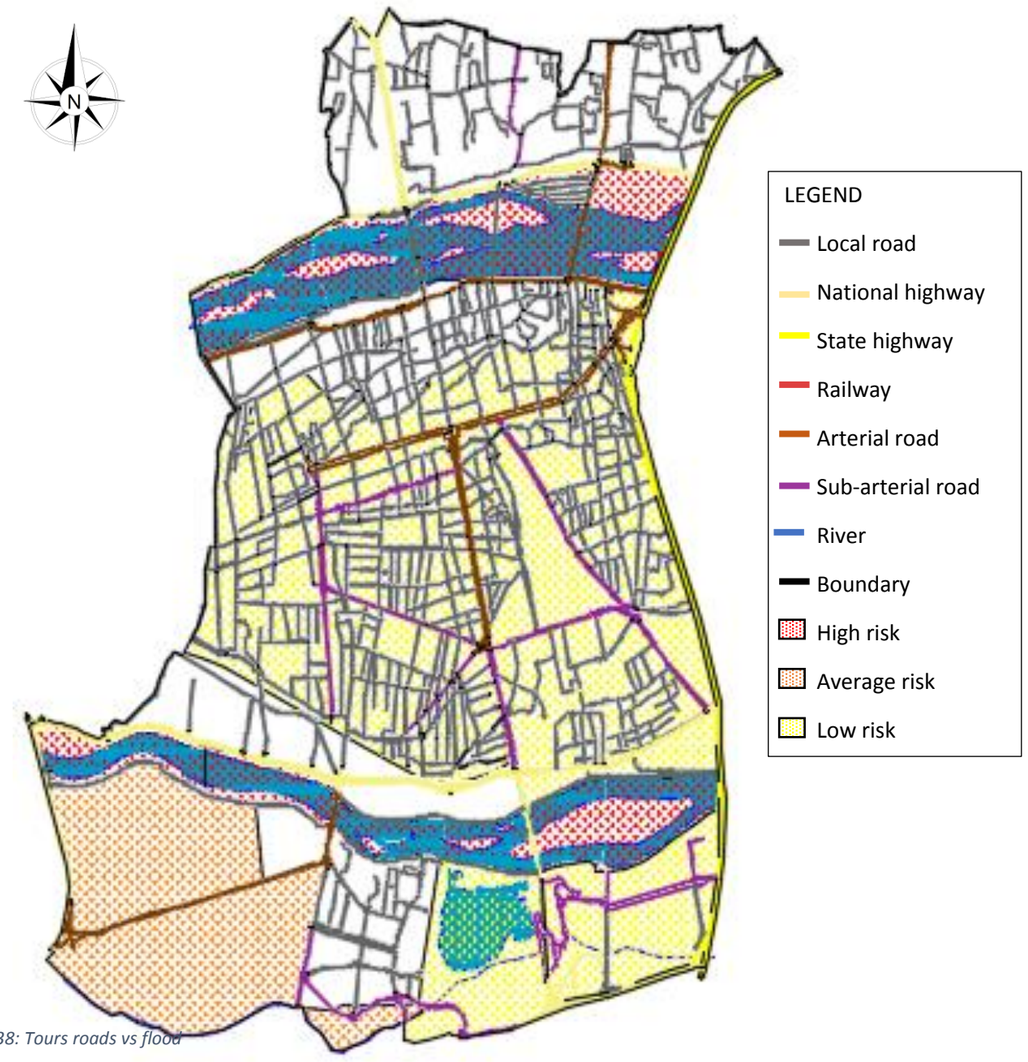



Figure 38: Tours roads vs flood

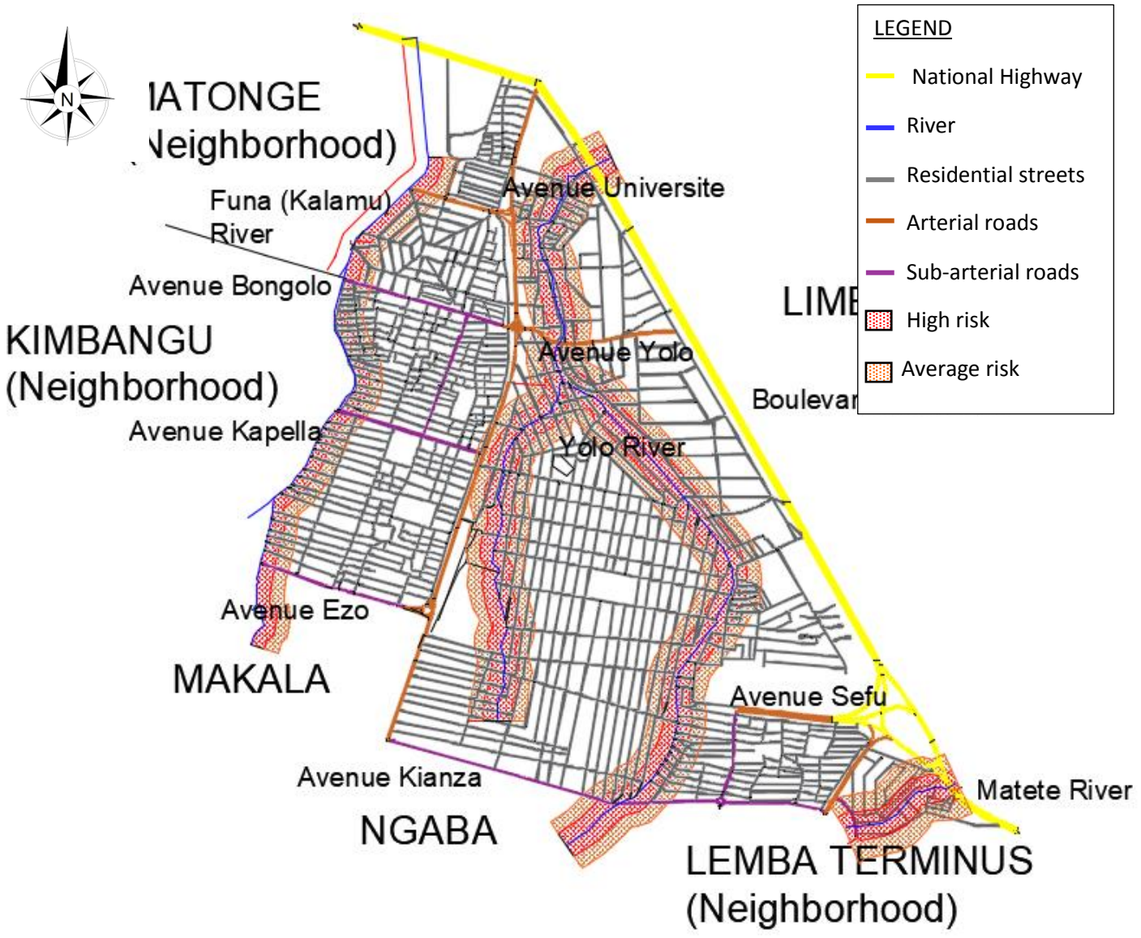



Figure 39: Kinshasa roads vs flood

| | |
|---|---|
| Source: google map. Drawn by the author<br>Scale: 1:1000<br>AutoCAD | Source: google map. Drawn by the author<br>Scale: 1:1000<br>AutoCAD |

In case of huge flood at Tours around 90% of roads will be blocked. At Kinshasa the worst thing is the national highway will be affected by flood. Also, major roads and bridges are not affected by flood. Local roads are affected even in 150 meters avay from the river at some places. Local roads are unpaved, the accessibility even 5 days after the flood in the risk zone and 50 meters away is difficult. That push people to abandon their houses.

6.1.3. Built and open

*Figure 41: Tours road hierarchy*

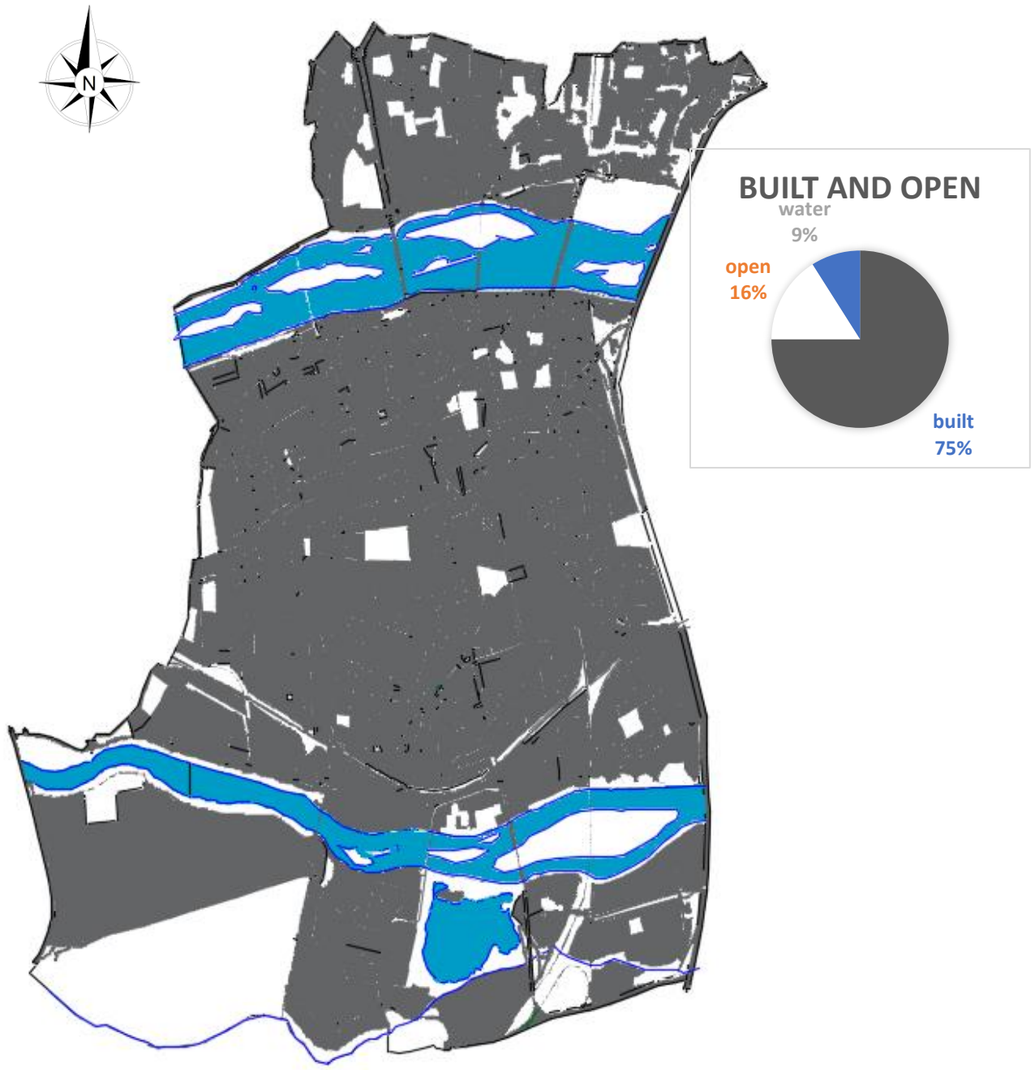



*Figure 42: built and open at Tours*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

0 20 50 100 200

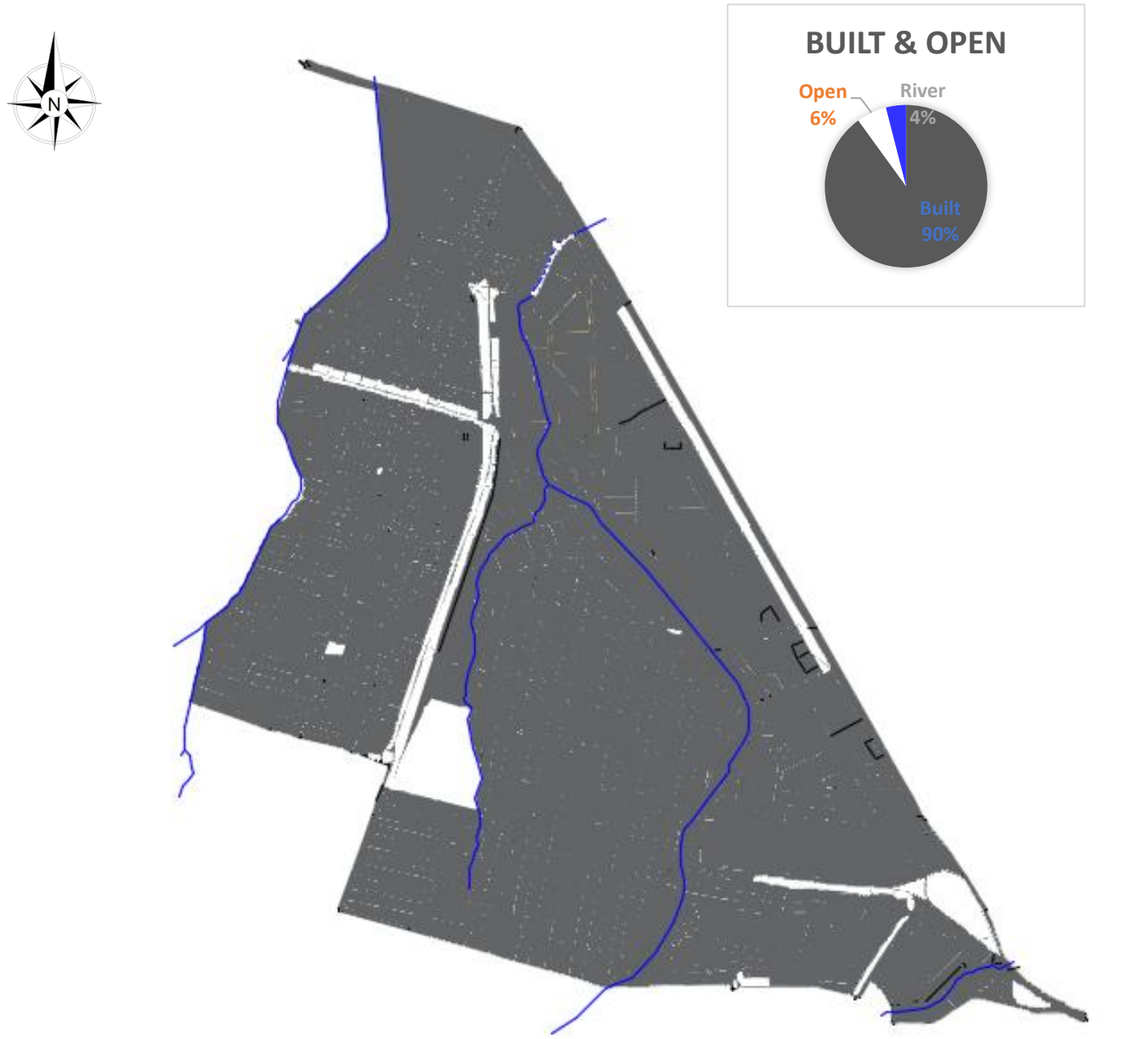



*Figure 43: built and open at Kinshasa*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

0 20 50 100 200

The parks constitute the open space at Tours. At Kinshasa, the informal agriculture land, and the remaining set back constitute the open spaces.

### 6.1.4. Topography

Tours is located in a plain area and is crossed by two rivers. Some part of the city are located in the flood plain area that is the case of the Paul Bert, most the people who live in the flood prone area don't believe that they can be affected by the flood. They soil typology is loam sandy (Geologie et Pedologie)

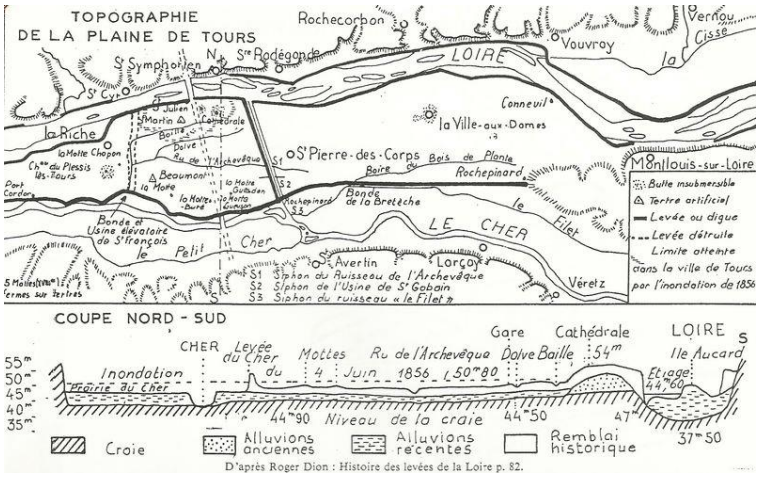



*Figure 45: topography map of Tours*

Source: http://www.aquavit37.fr/2013sdageppri/

As you can see in the graphic below, the study area at Kinshasa is located in a plain area and the soil is sandy. This kind of soil is absorb water quickly and get saturated in short time.

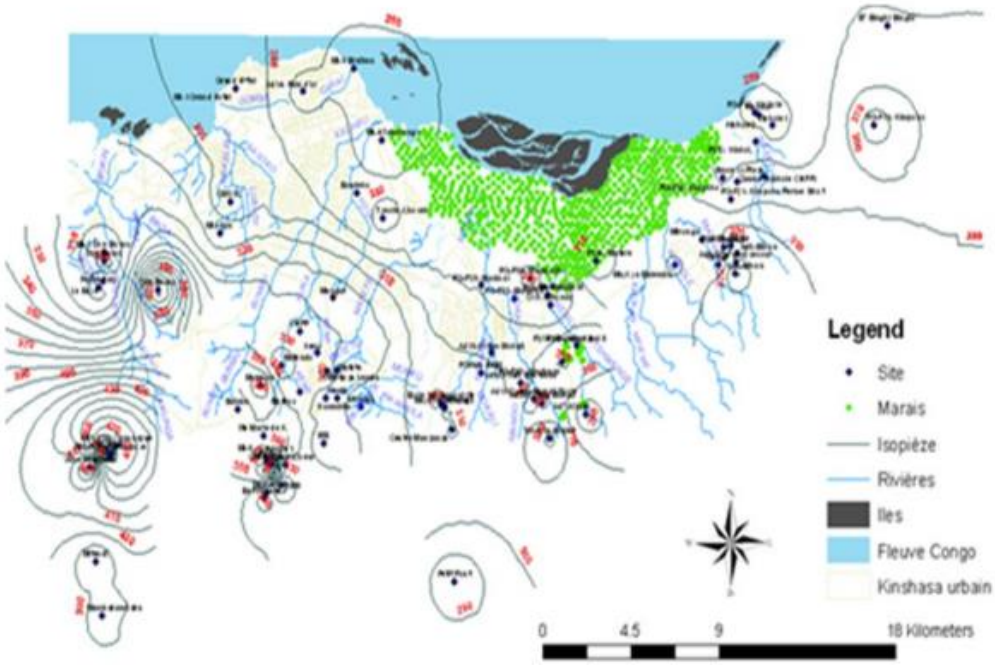



*Figure 46: topography map of Kinshasa*

https://ars.els-cdn.com/content/image/1-s2.0-S002216941630453X-gr1.jpg

## Water supply

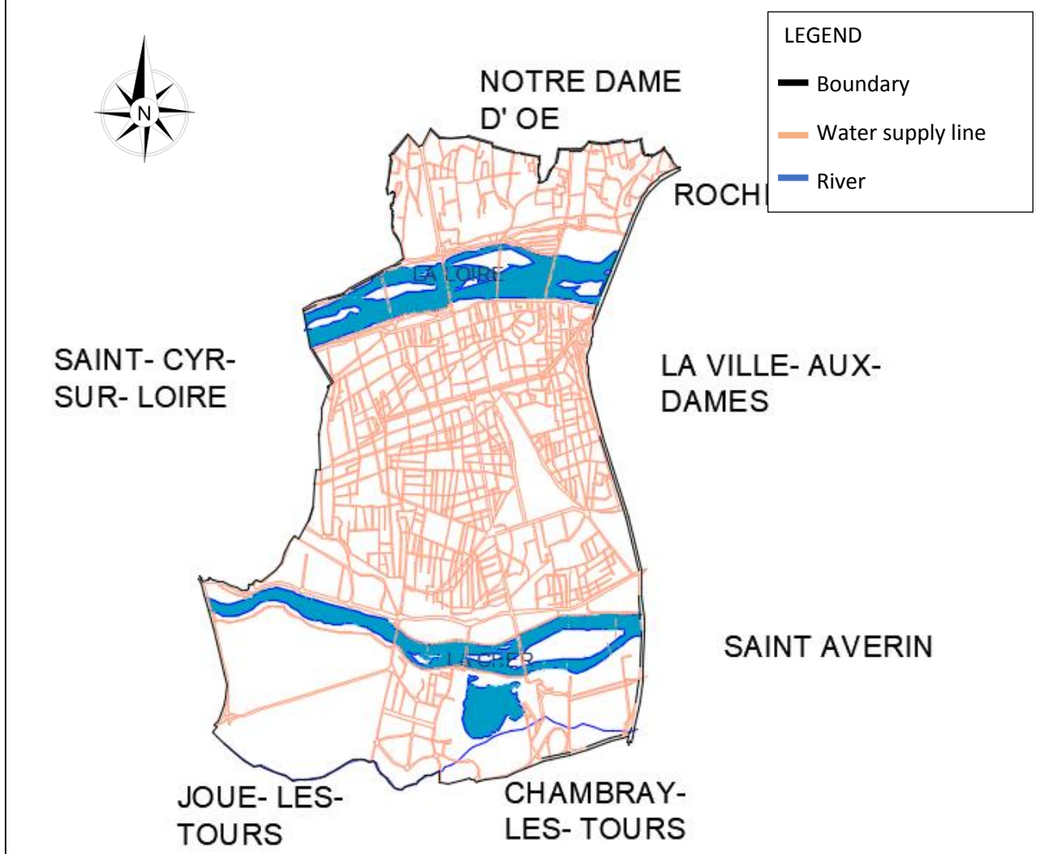



*Figure 47: water supply map*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

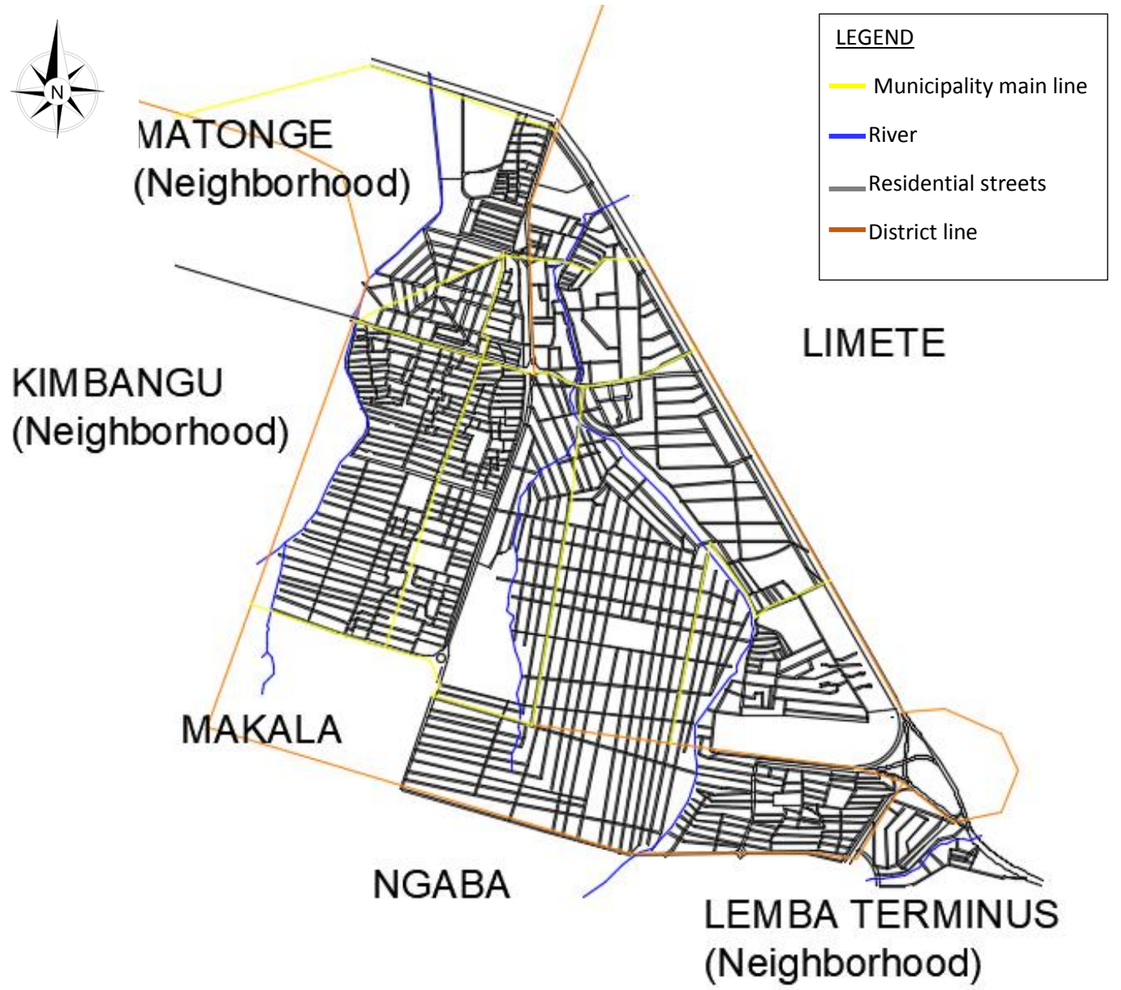



*Figure 48: water supply map*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

In our study are we have municipality water supply line crossing the area and we also have district line.

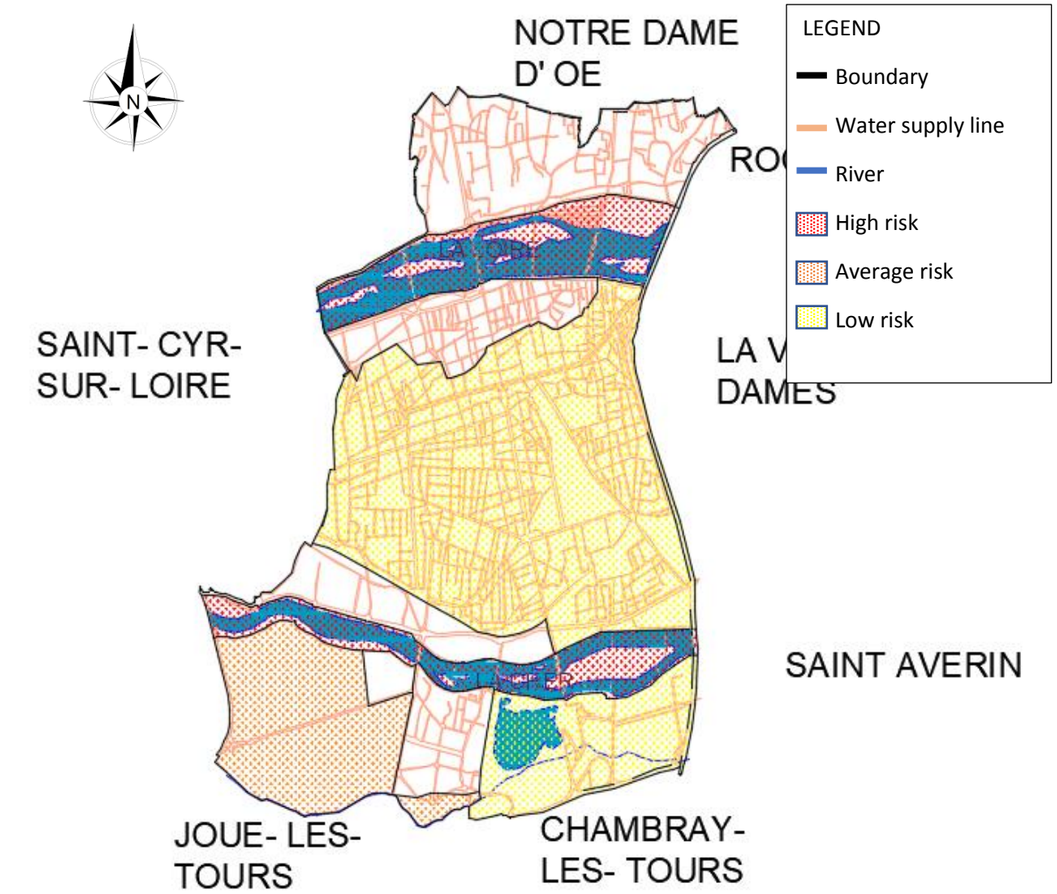



*Figure 50: water supply map vs flood at Tours*

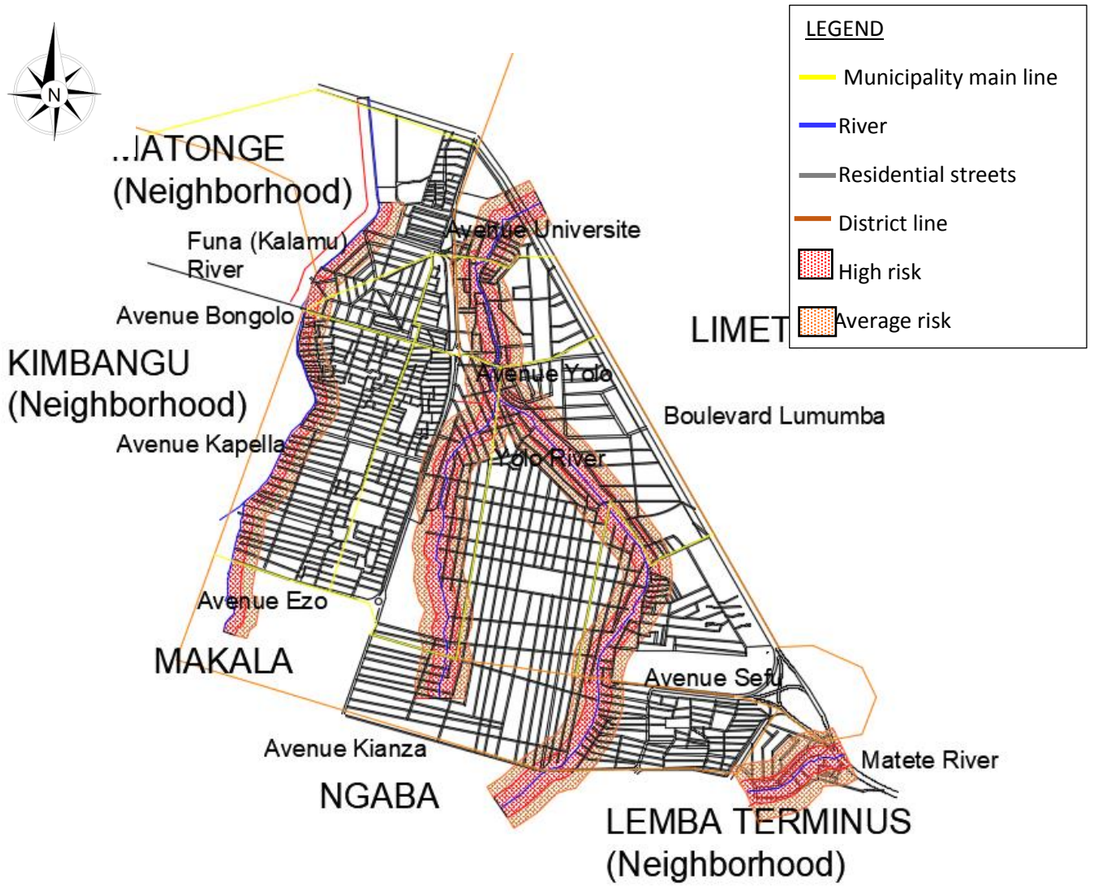



*Figure 51: water supply vs flood at Kinshasa*

| | |
|---|---|
| Source: google map. Drawn by the author<br>Scale: 1:1000<br>AutoCAD | Source: google map. Drawn by the author<br>Scale: 1:1000<br>AutoCAD |

In case of flood there is a risk of flood water intrusion in the water supply line principally located in the Paul Bert. At Kinshasa this last decade the water supply company (REGIDESO) has decided to disconnect areas located in the higher risk zone, one of the reason behind this decision was water intrusion in pipelines.

6.1.5. Heritage

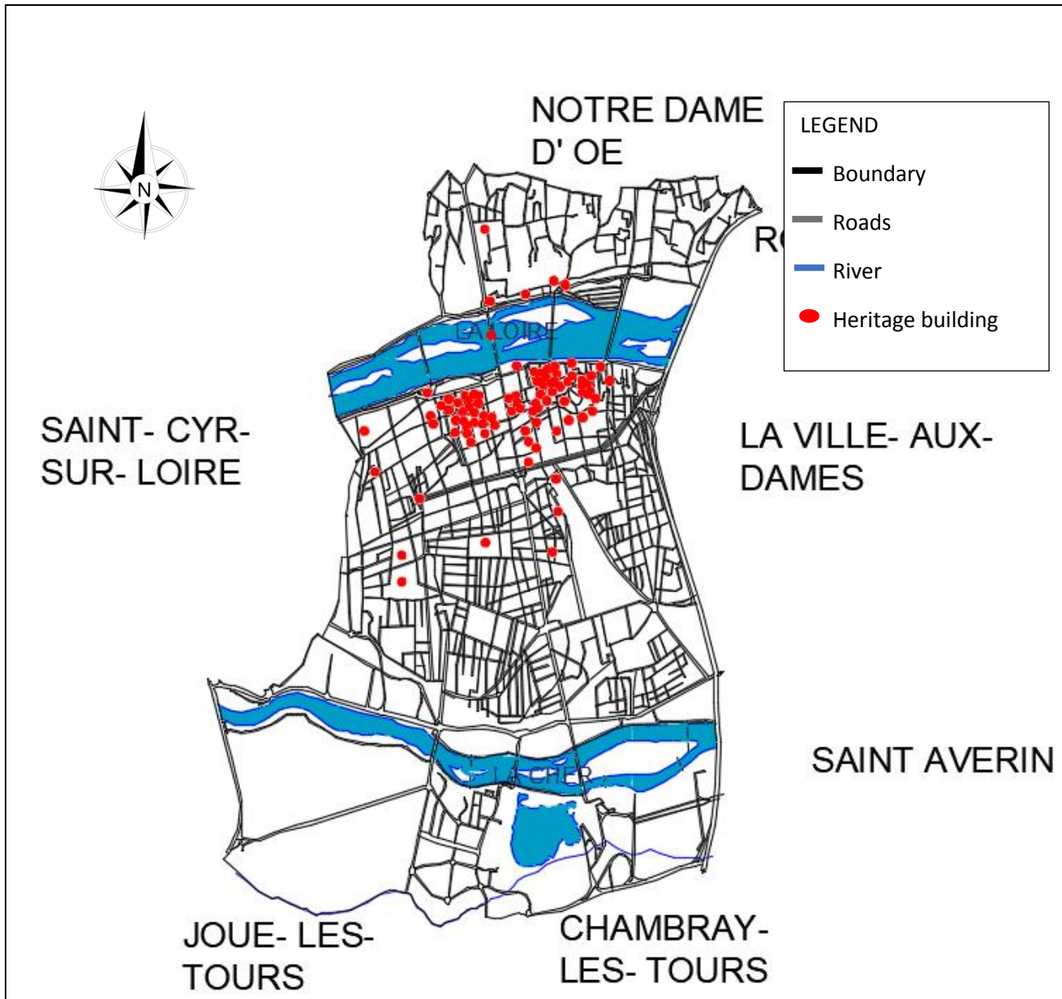



*Figure 53: heritage map at Tours*

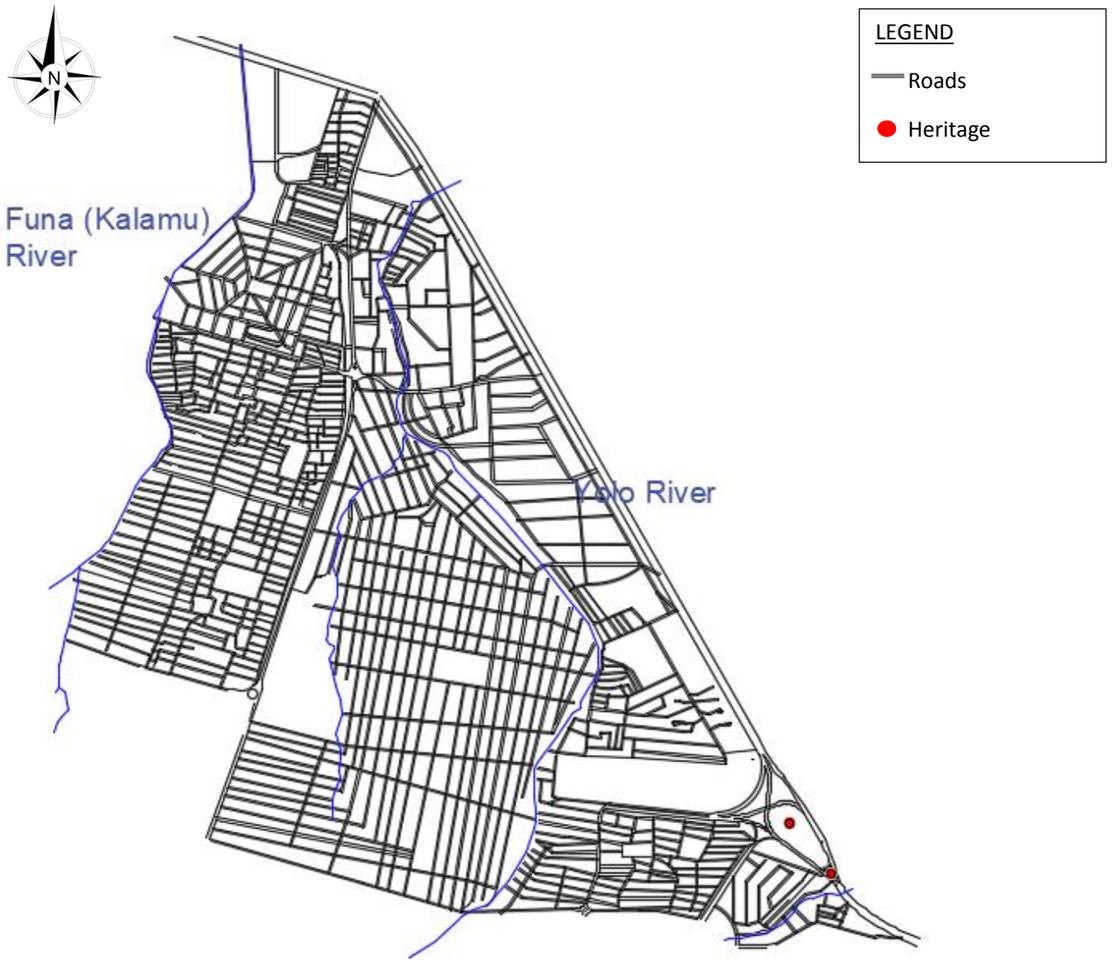



*Figure 54: heritage map at Kinshasa*

| | |
|---|---|
| Source: google map. Drawn by the author<br>Scale: 1:1000<br>AutoCAD | Source: google map. Drawn by the author<br>Scale: 1:1000<br>AutoCAD |

Tours is an old city compare to Kinshasa (refer to the 4.4. evolution of cities). Most of construction consider as heritage are located in the old part of the city because it is where the city started. At the study area in Kinshasa there is only two buildings that are consider as heritage.

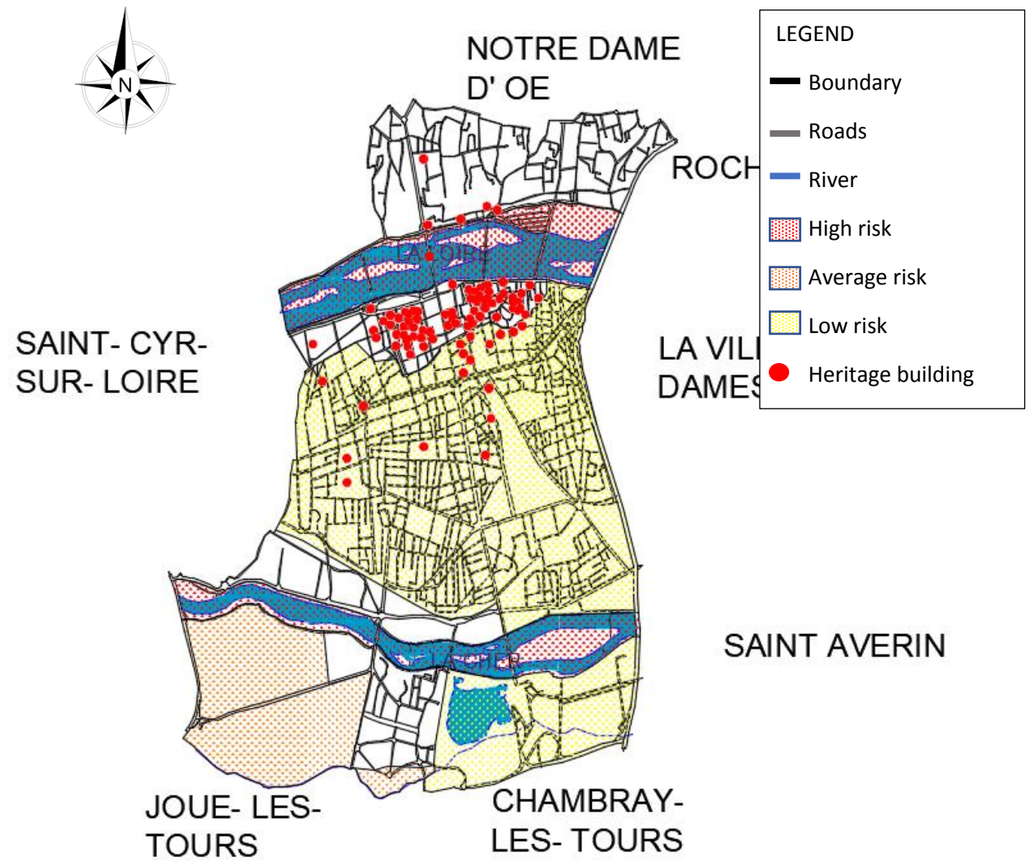



*Figure 56: heritage vs flood at Tours*

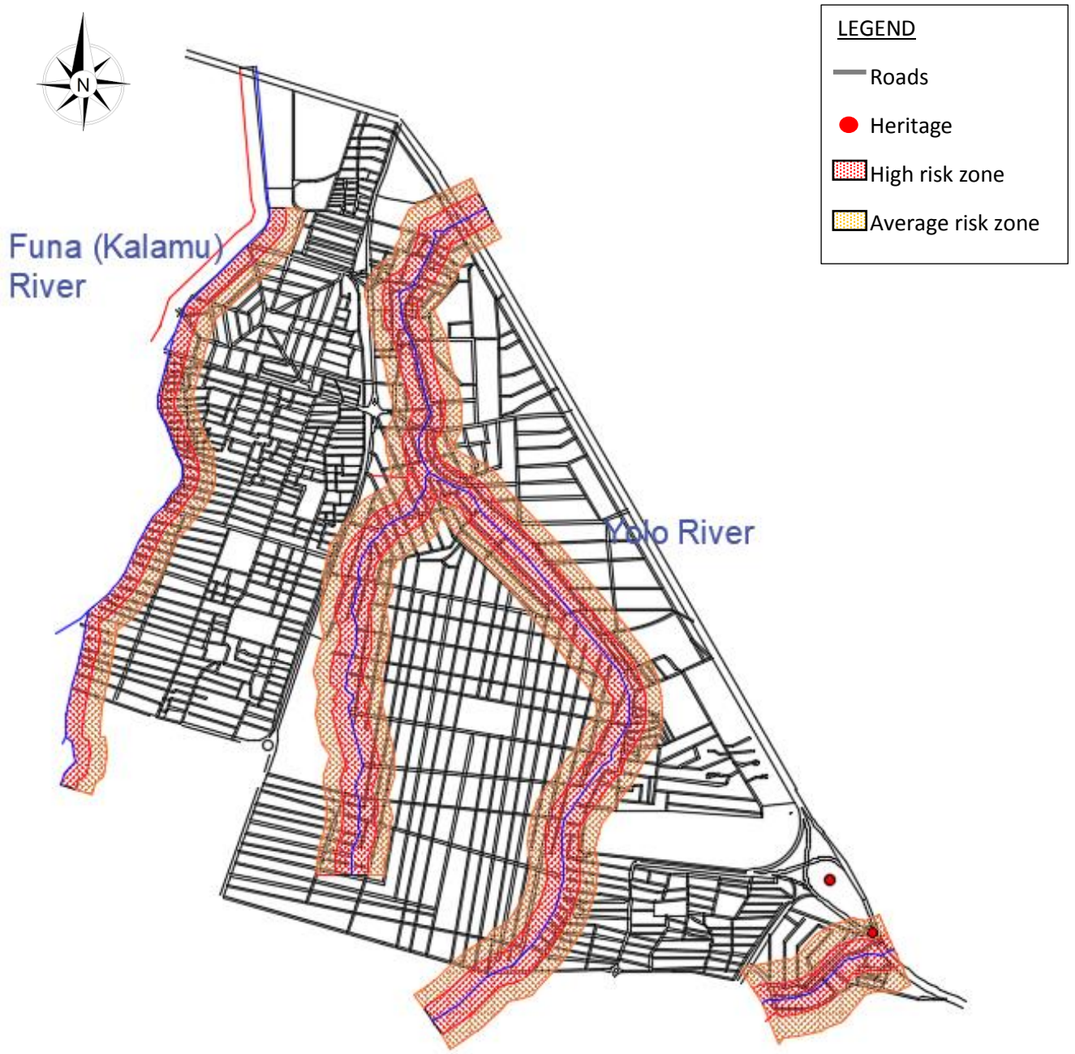



*Figure 57: Heritage vs flood at Kinshasa*

| | |
|---|---|
| Source: google map. Drawn by the author<br>Scale: 1:1000<br>AutoCAD | Source: google map. Drawn by the author<br>Scale: 1:1000<br>AutoCAD |

The major part of heritage buildings at Tours are located in the areas that are protected by the dyke. At Kinshasa all the heritage buildings are not in the flood prone area due the topography.

### 6.1.6. Housing

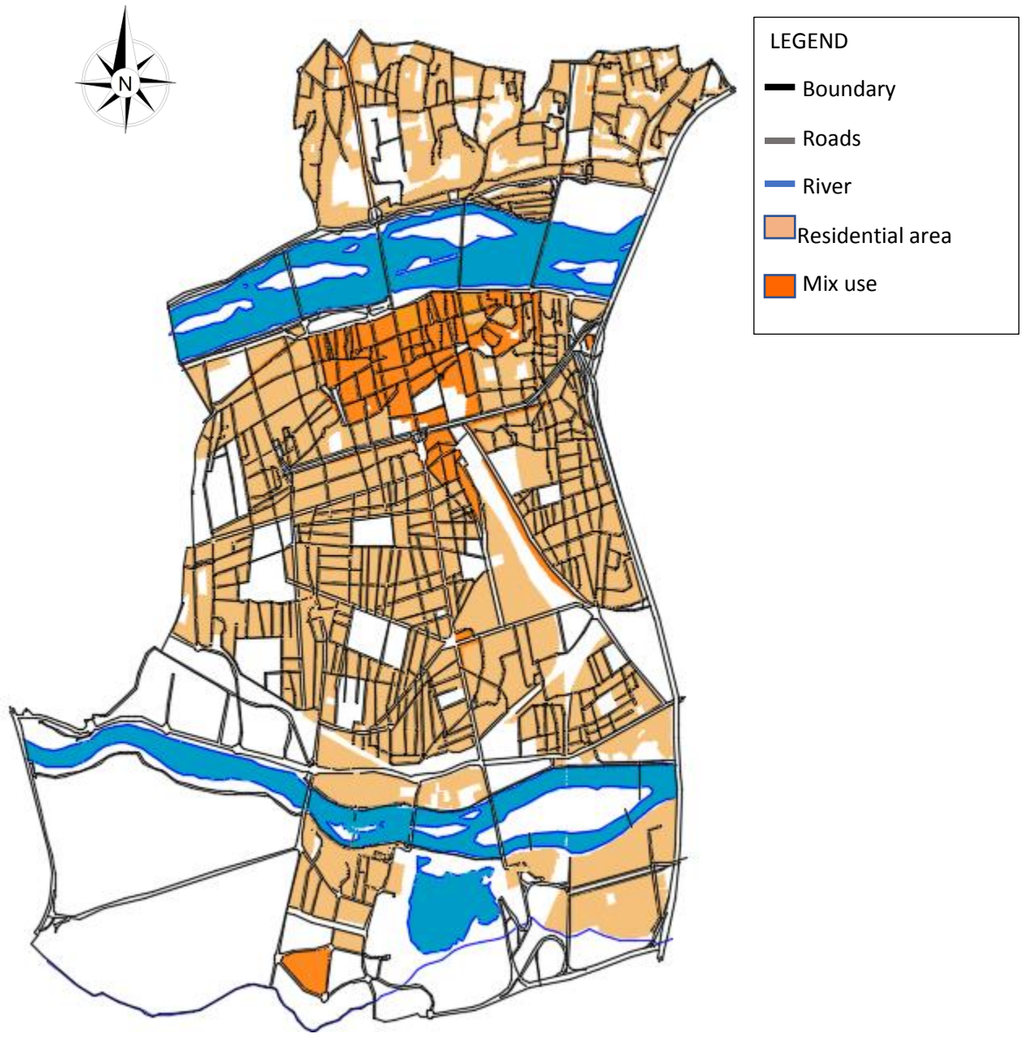



*Figure 59: housing map of Tours*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

0 20 50 100 200

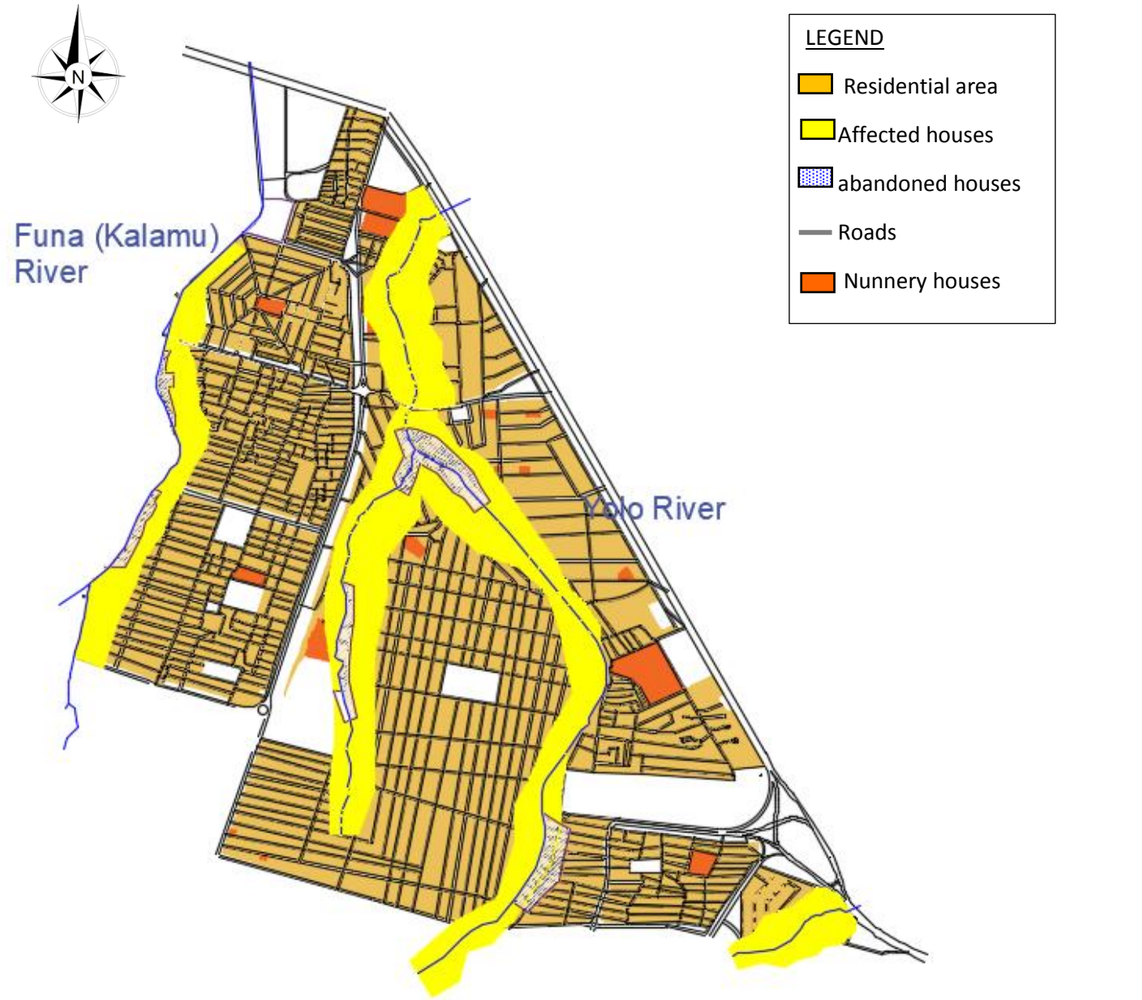



*Figure 60: housing map of Kinshasa*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

0 20 50 100 200

Housing in our study area at Tours is characterized by G+2, G+3 G+4 and above, in the old part of the city we have many building with commerce at the ground or floor and residential above, some others buildings has offices in the residential building. At Kinshasa few buildings are G+1 or G+2 around 97% of are normal houses, it means G+0.

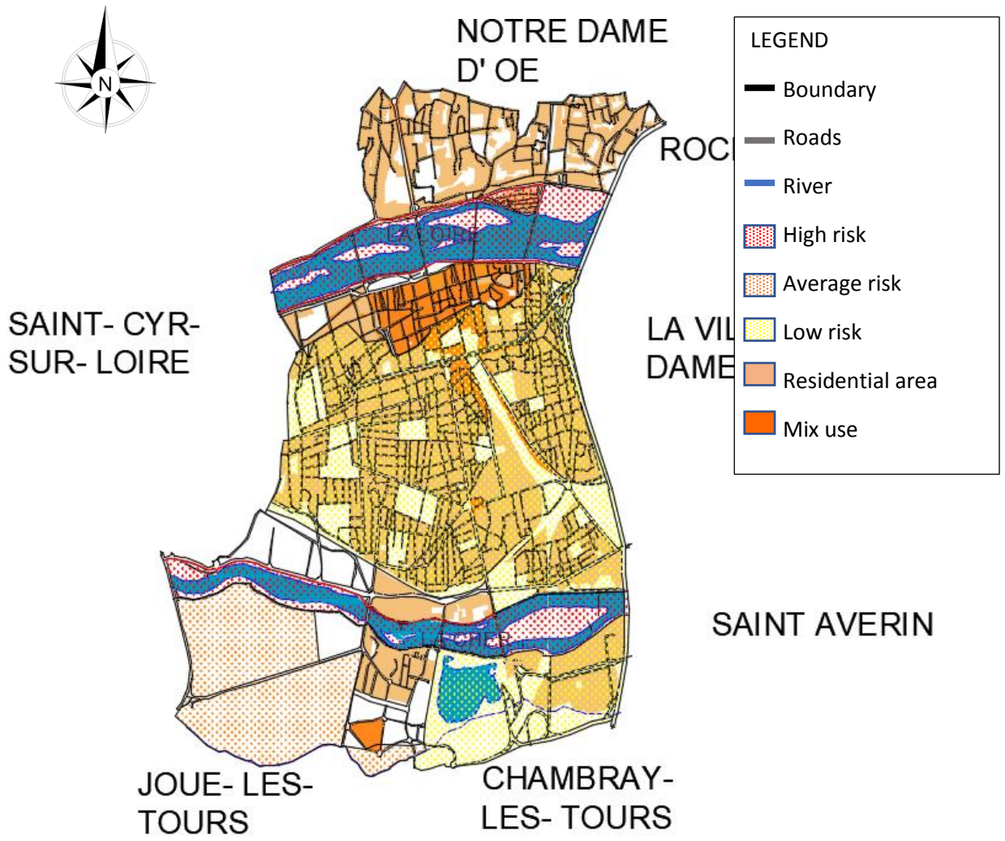



*Figure 62: housing map of Tours vs flood*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

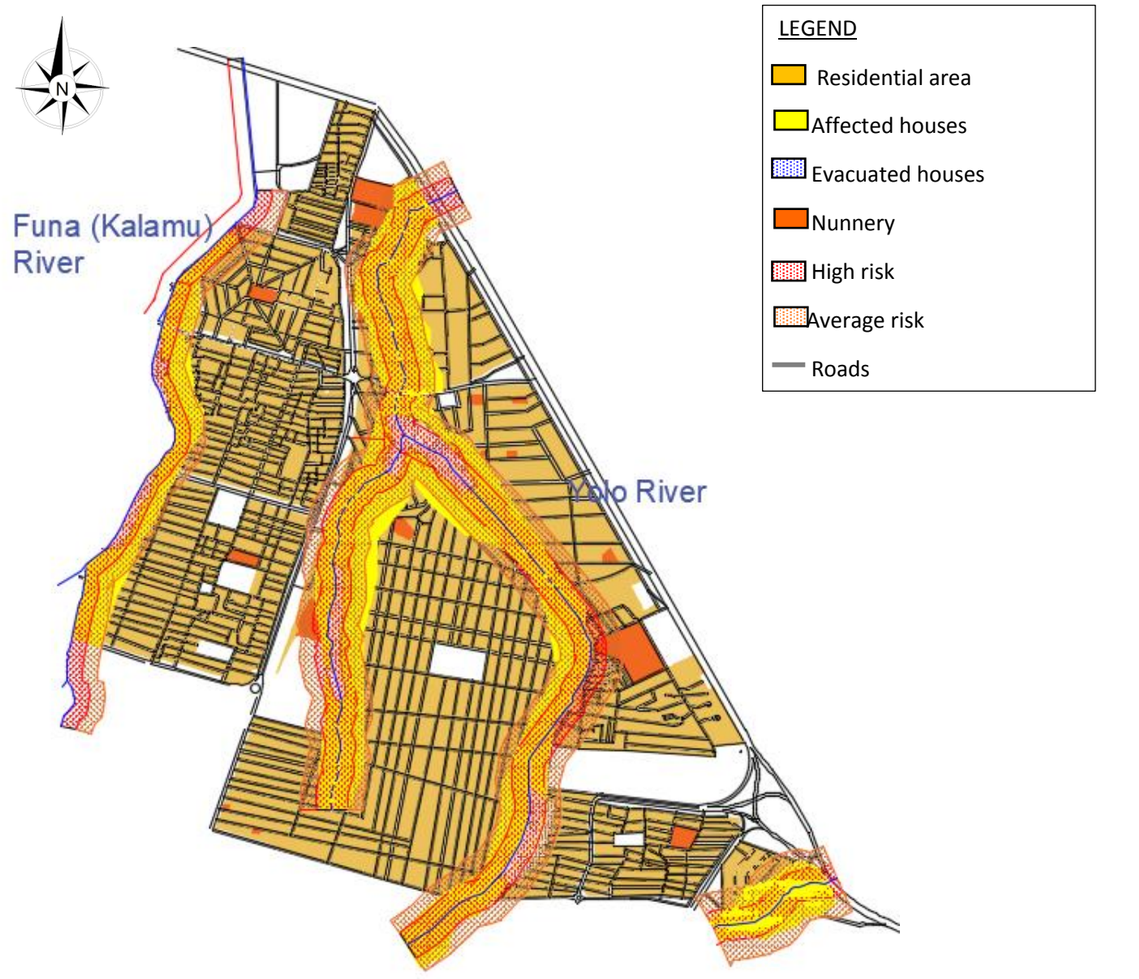



*Figure 63: housing map of Kinshasa vs flood*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

Only resident of Paul Bert are living in a high risk zone. And in case of heavy rain those houses located between *La Gloriette* and *Le Lac* will be in the average flood risk. At Kinshasa, 98% of houses located near the river are affected by the flood. Some area people has abandon their houses because it look like ponds now. The Kimbaguist University is highly affected but they haven't yet plan to move out.

On the Kinshasa's map, it can be clearly seen that all the houses that are affected by the flood are located in the forbidden zone. As most of houses are simple houses, it means when it is flooded people have to evacuate.

6.1.7. Emergency response facilities **&** social infrastructure

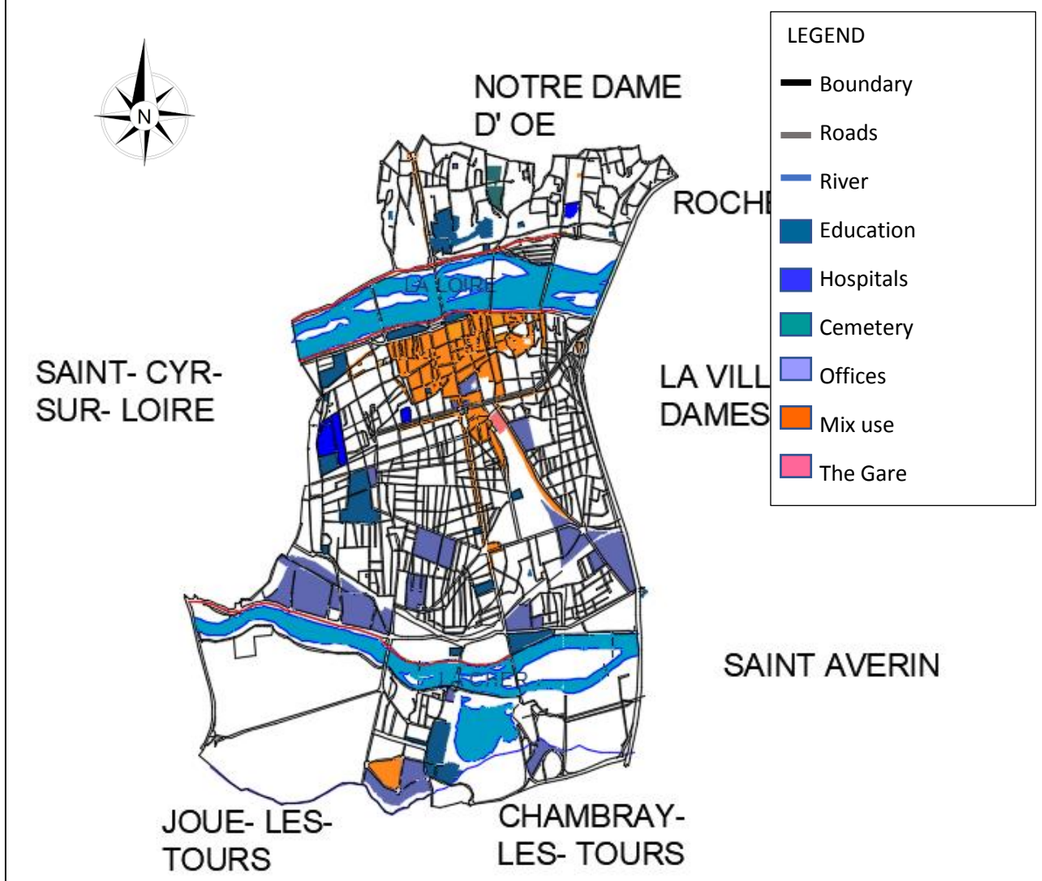



*Figure 65: infrastructure map of Tours*

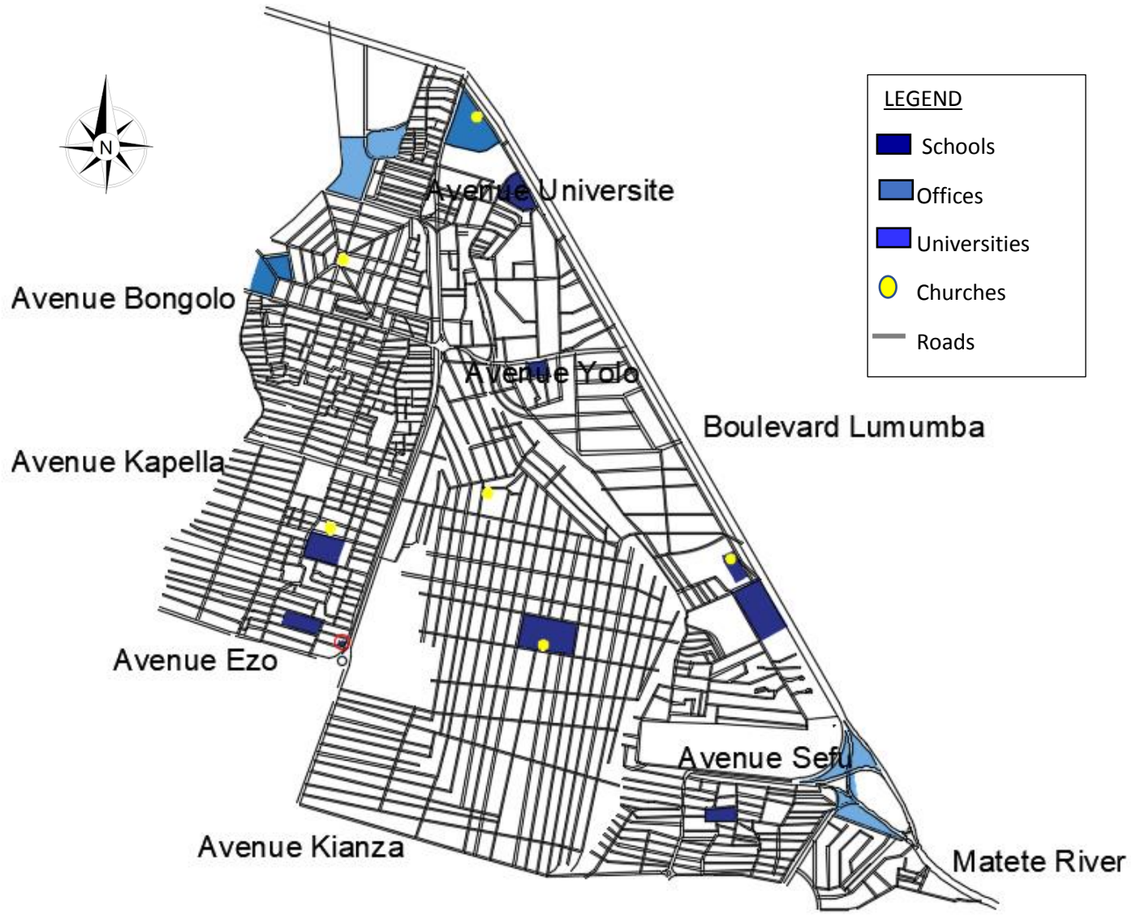



*Figure 66: infrastructure map of Tours*

| | |
|---|---|
| Source: google map. Drawn by the author<br>Scale: 1:1000<br>AutoCAD | Source: google map. Drawn by the author<br>Scale: 1:1000<br>AutoCAD |

The study area at Tours has 3 hospitals, 6 universities campus and many office building, we have also offices in the mix use area. For evacuation in Kinshasa, people move to their neighbors' houses. In case of disaster churches and schools can be used as refuge area.

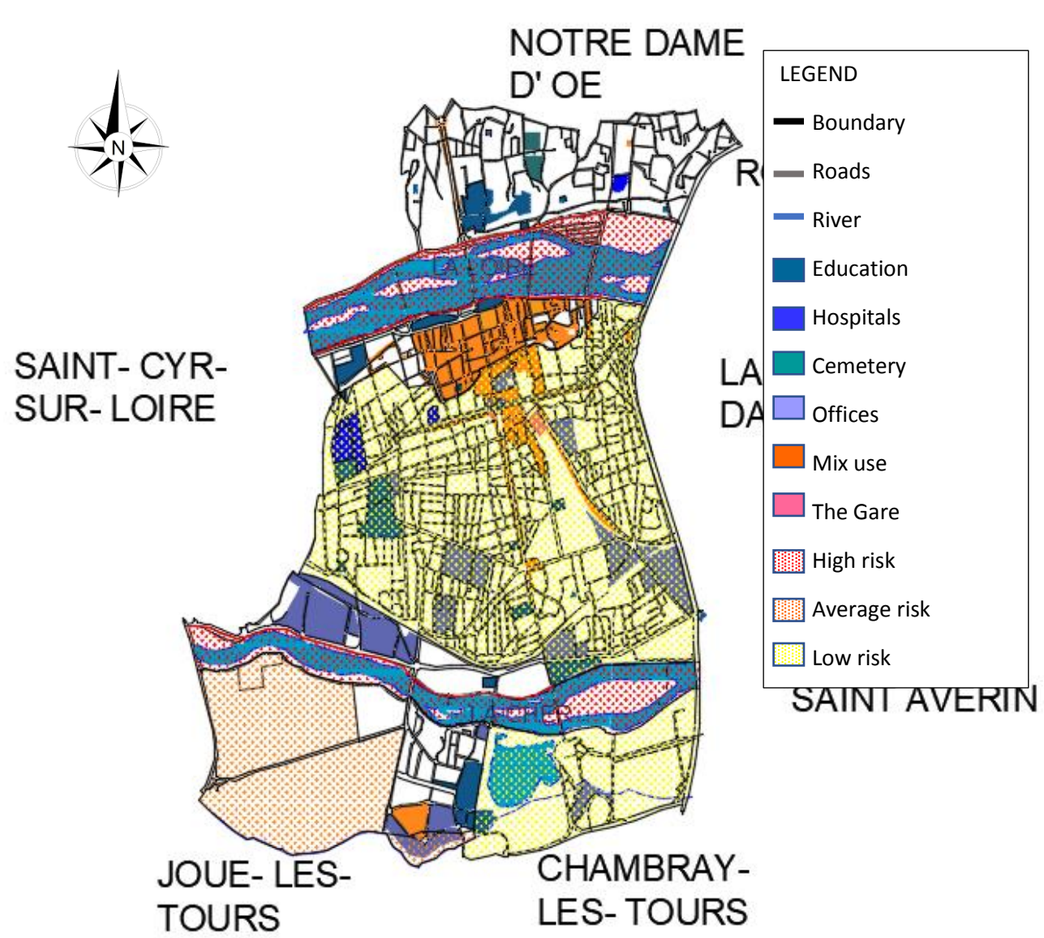



*Figure 68: infrastructure vs flood*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

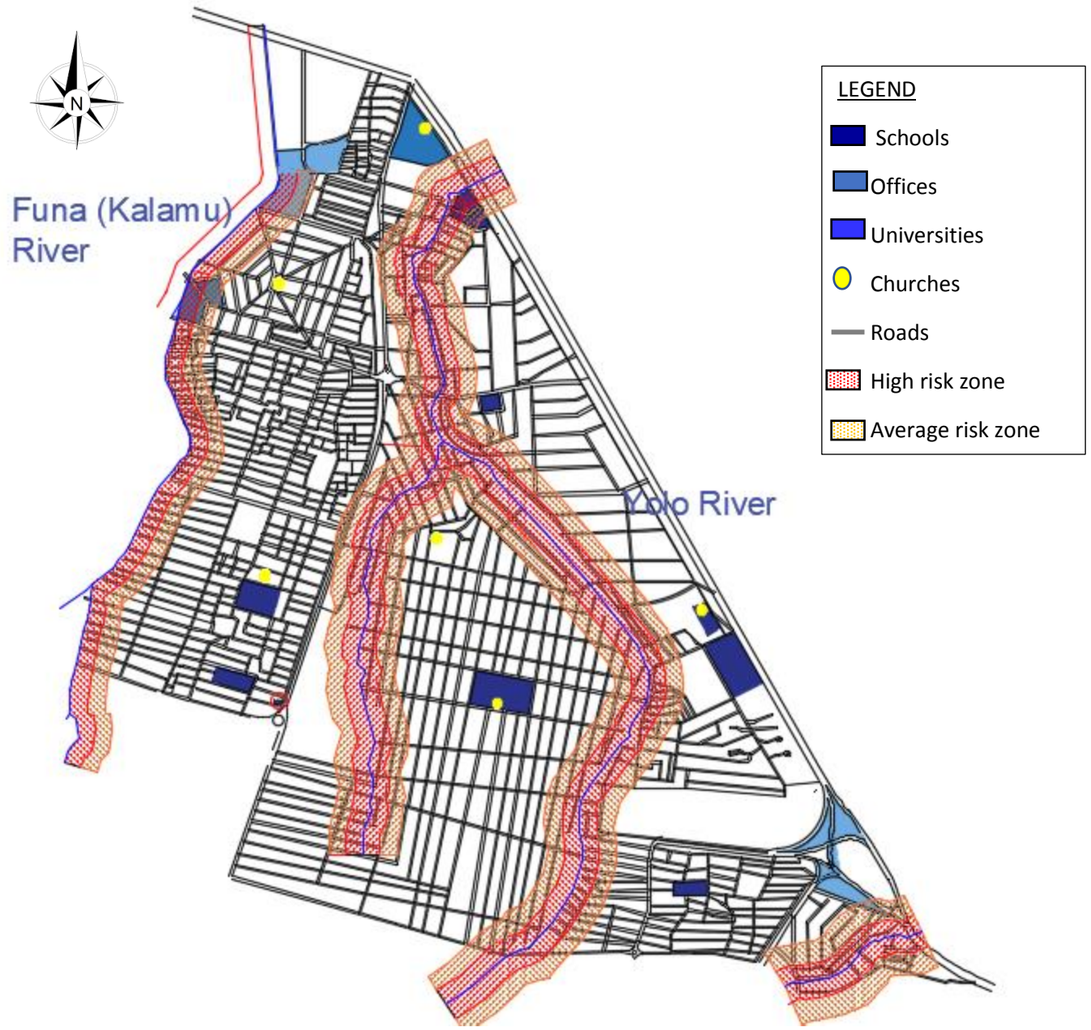



*Figure 69: Infrastructure vs flood*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

At Tours, we can see that some offices in the southern part of the study area are in the average risk zone. Two hospitals are located in the low risk zone. Three campus and a part of the fac 2lions are located in the flood free zone. Most of schools are located in the low risk zone. It means that in case of a huge flood like the one of 1846, authorities will be oblige to relocate people in these 2 hospitals located in the prone area and all of these education buildings could not be used as refuge place because they are in the risk zone.

At Kinshasa, the Kimbaguist University is located at the high risk area. Schools are not in flood plain area. Churches can be used as shelter in case of flood disaster. There is less open space that can be used as sponge or where we can built shelters. The only emergency facility existing in the area is a police station

## 6.1.9. Run off

We calculate the runoff in the study area in Tours and Kinshasa to estimate the quantity of water both city loose yearly. Also an important runoff can cause flash and back flood.

First they did the evaluation for exploitation potential of rainwater resources

Formula

Total rainwater resources $R1 = P \times A \times 10^3$

Theoretical exploitation potential of rainwater resources $R2 = \varphi \times R1$

R2: Total volume of rainwater resources（m3

P: Precipitation yearly (mm)

A: Coverage area by land type（km2）

Φ: Runoff coefficient

**Runoff coefficient**
Soil Group A and B are sandier and Soil Group C and D are more clayey.

| **Land use/ cover** | **Soil Group A** | **Soil Group B** | **Soil Group C** | **Soil Group D** |
|---|---|---|---|---|
| 100% impervious (parking lots, rooftops, paved sidewalks or patios) | 0.98 | 0.98 | 0.98 | 0.98 |
| Open space with grass cover<50% | 0.68 | 0.79 | 0.86 | 0.89 |
| Open space with grass cover 50 % to 75% | 0.49 | 0.69 | 0.79 | 0.84 |
| Open space with grass cover > 75% | 0.39 | 0.61 | 0.74 | 0.80 |
| Woods in fair hydrologic condition | 0.36 | 0.60 | 0.73 | 0.79 |
| Residential lot (1/4 acre) | 0.61 | 0.75 | 0.83 | 0.87 |
| Residential lot (1/2 acre) | 0.54 | 0.70 | 0.80 | 0.85 |
| Residential lot (1 acre) | 0.51 | 0.68 | 0.79 | .84 |
| (table adapted from USDA-NRCS Curve Numbers, 1985) | | | | |

Source: http://riverlink.org/wp-content/uploads/2014/01/CH-1-3CalculatingyourStormwaterRunoff.pdf

Calculation

A. Tours

Total rainwater resources $R1 = P \times A \times 10^3$

$R1 = 697 \text{ mm} \times 17.44 \text{ km}^2 \times 10^3$

$R1 = 960{,}298{,}720 \text{ m}^3$

Theoretical exploitation potential of rainwater resources $R2 = \varphi \times R1$

$R2 = 0.68 \times 12,155,680$

$R2 = 653,003,129.6\ m^3$

$R2 = 172,505,176,942.7$gallons

We can remark that the city has a runoff of 172,505,176,942.7gallons per year.

It means an estimate quantity of 14,375,431,411.9gallons per month

And the estimated monthly runoff is 824, 279, 324 gallons per kilometer square.

B. Kinshasa

Total rainwater resources $R1 = P \times A \times 10^3$

$R1 = 1,400\ mm \times 34.49\ km^2 \times 10^3$

$R1 = 48,286,000\ m^3$

Theoretical exploitation potential of rainwater resources $R2 = \varphi \times R1$

$R2 = 0.68 \times 48,286,000$

$R2 = 32,834,480\ m^3$

$R2 = 8,673,951,969.7$ gallons

We can remark that the city lost 8, 673, 951,969.7 gallons per year.

It means an estimate quantity of 722,829,830.8 gallons per month

And the estimated monthly run off is 20, 957, 663 gallons per kilometer square.

Conclusion

By doing this calculation we understand that our study area in Tours is 17.44 $km^2$ and our study area in Kinshasa is 34.49 $km^2$ it means the study area in Tours is 2 time smaller than Kinshasa. But the runoff in Tours is 20 time higher the runoff in Kinshasa. But Kinshasa has a double amount of rainfall compare to Tours.

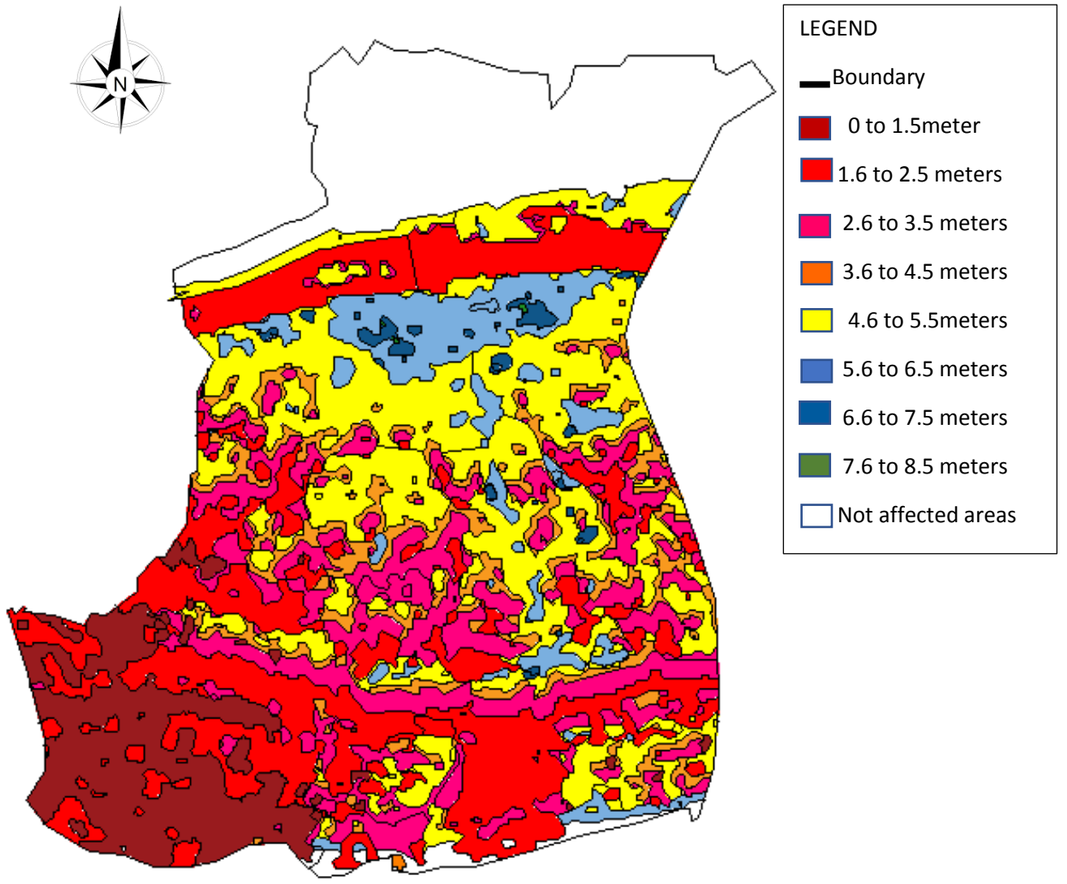
The reason behind this is 97% of local roads in Kinshasa is unpaved but in Tours all roads are paved.

## 6.1.10. Digital Elevation Model (DEM)

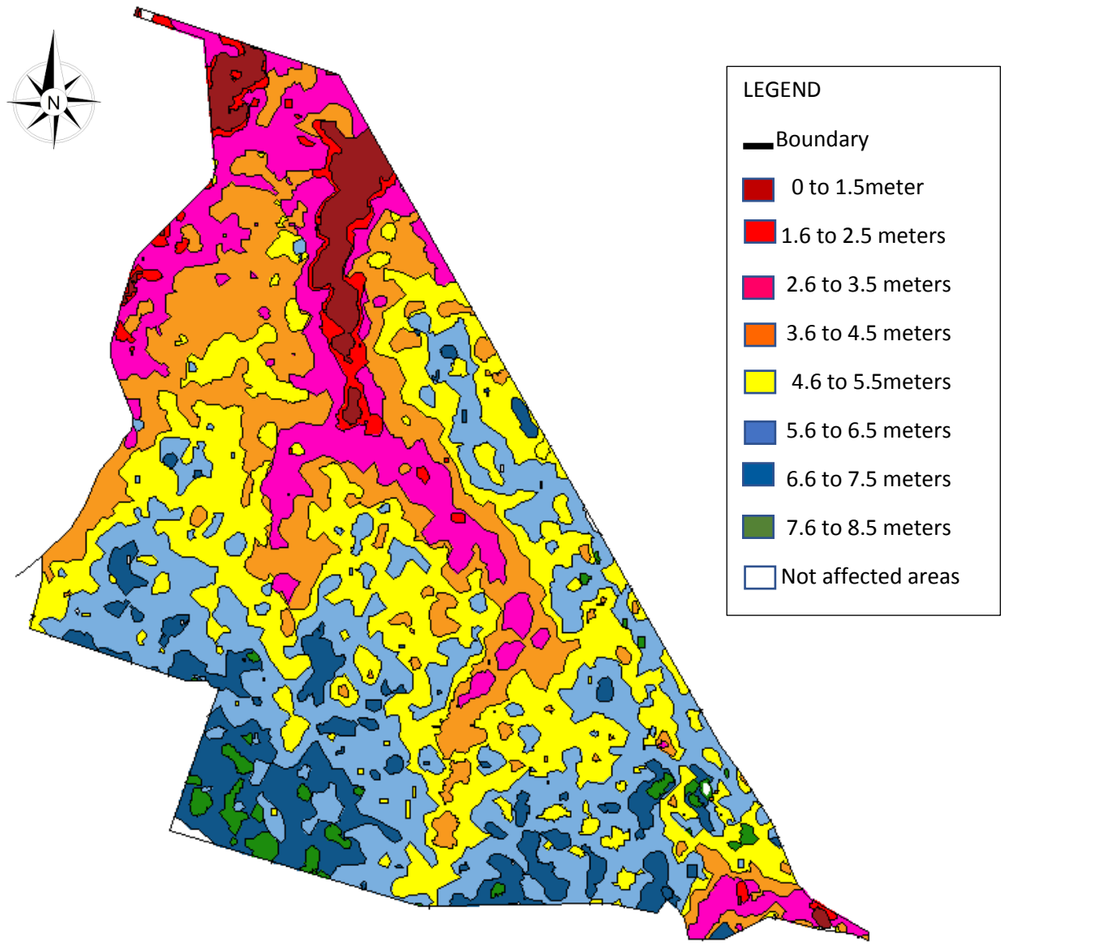
A Digital Elevation Model (DEM) is a particular database that represents the relief of a surface between points of known elevation. By inserting referred to height information from sources, for example, ground survey and photogrammetric data capture, a rectangular digital elevation model grid can be made. GIS software can utilize digital elevation models for 3D surface visualization,

generating contours, and performing view shed visibility analysis (Caliper Mapping and Transportation Glossary).

For making a sustainable flood map and proposal we have to consider the climate change. Therefore, in this study, the DEM is used to simulate flood and design a new flood map based on the given result.



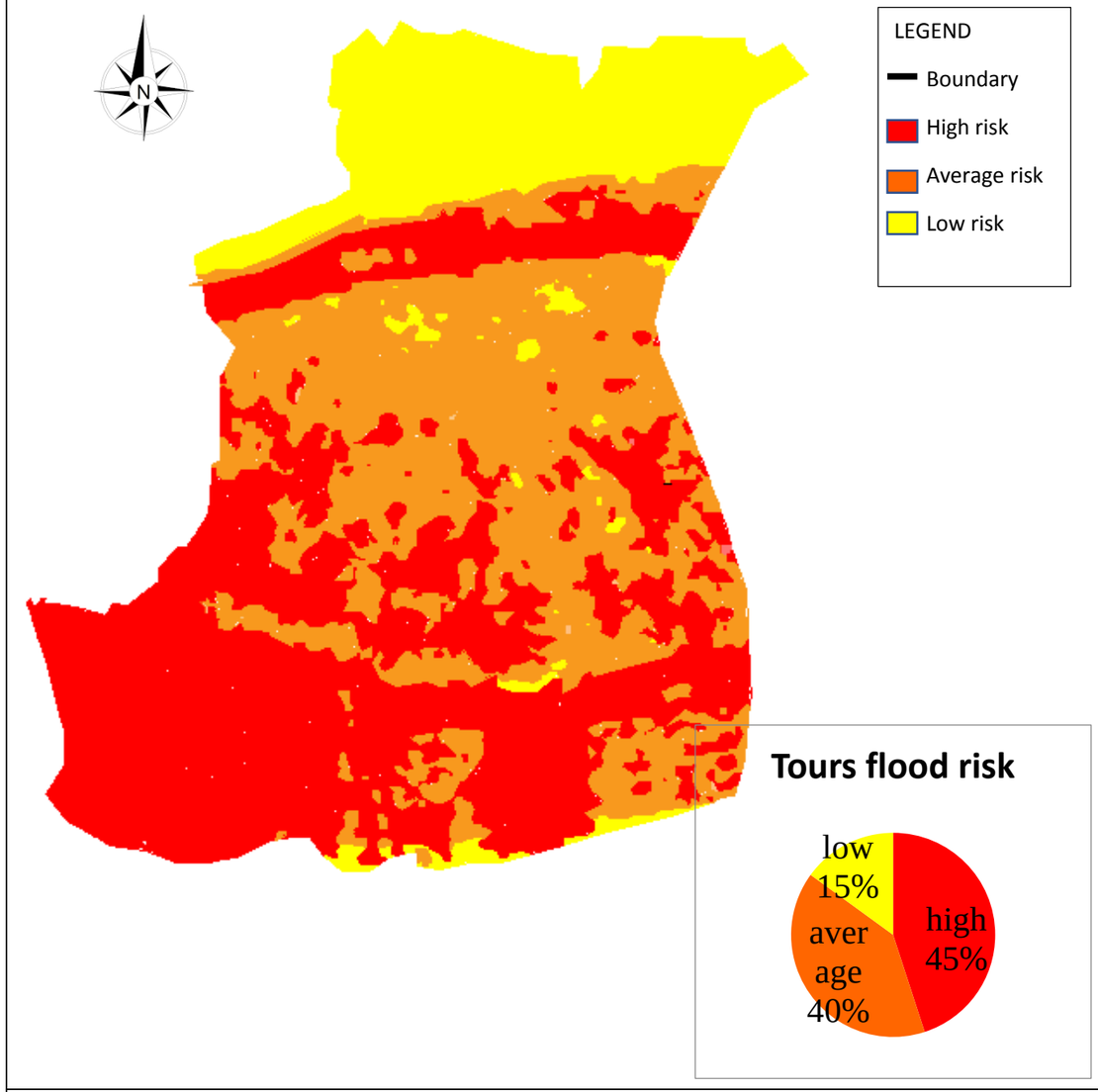

Source: Drawn by the author
Scale: 1:1000
Arc scene and AutoCAD



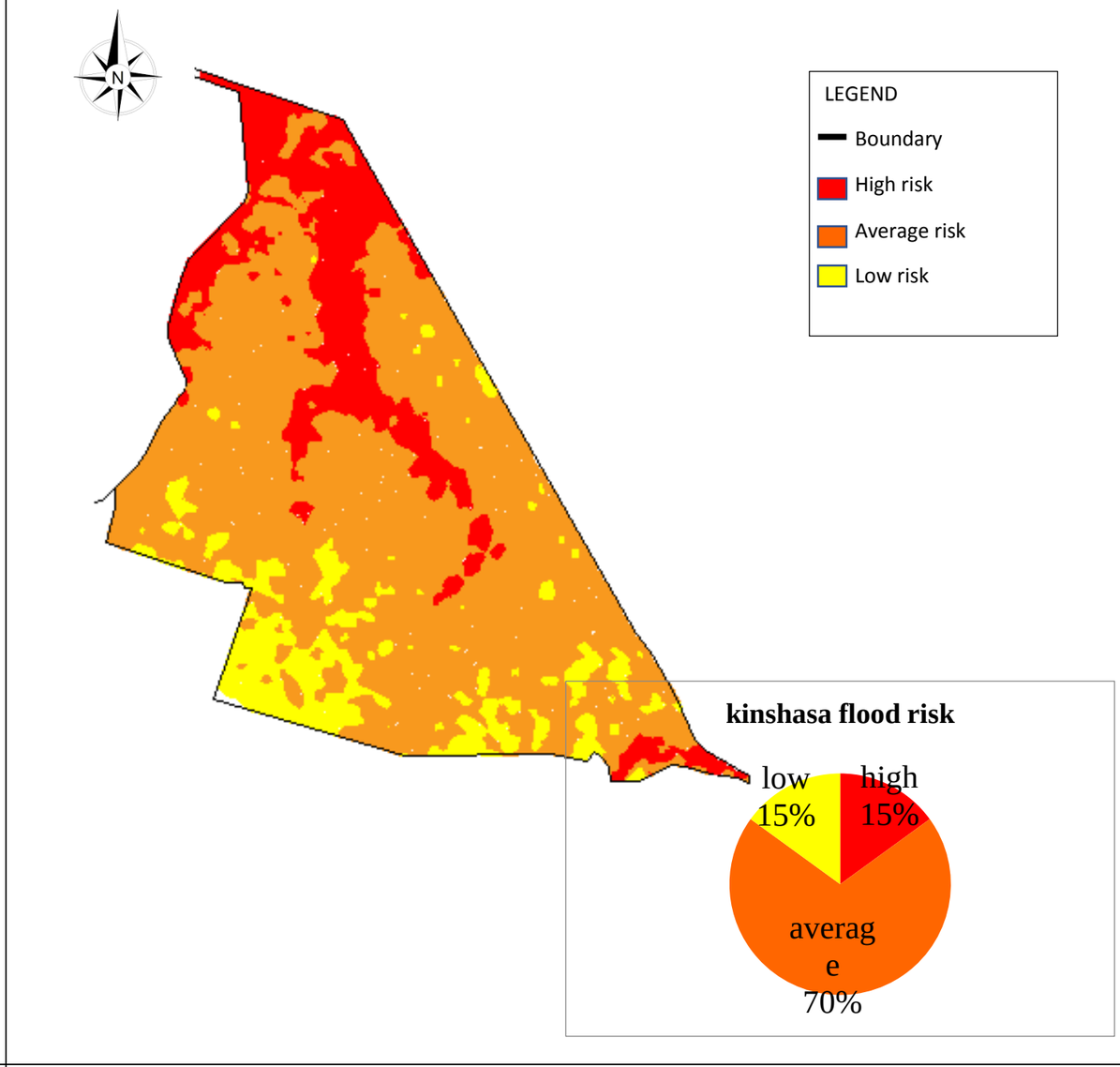

Source: Drawn by the author
Scale: 1:1000
Arc scene and AutoCAD

| Height of water | Impact in Tours | Kinshasa |
|---|---|---|
| 0 to 1.5meter | First, the Cher river will overflow and water will fill *La Gloriette* park and the agricultural land located nearby. | First, the northern part of the study area located near the Yolo river will be affected; the Kalamu river will overflow and will flood the stadium. Small places in the south will be affected by water coming from Matete river. |
| 1.6 to 2.5 meters | At this stage, *La Gloriette* will be completely filled by water. The Bergeonerie lake will start to be filled and some neighborhoods will be filled. It will be the case of Deux lions, Giraudeau and Rive du Cher.<br>At the same time the Loire river will started to level up but the neighborhood around will be protected by the dyke. | When water will level up in all rivers, it won't have a significant impact in the study area. |
| 2.6 to 3.5 meters | When water will reach this level, the Cher river level up that will completely fill Giraudeau and Deux lions' neighborhood. More than 60% of Sanitas-Rotonde, La fuyet- vel'peau, Beaujardin and Febvoyet will be affected. 40% of Rive du Cher neighborhood will be affected. | At this level, all the northern part of the Kalamu municipality will be completely flooded. 40% the middle part of Kalamu neighborhood will be affected. 100 meters along the Yolo river will be flooded. |
| *3.6 to 4.5 meters | When water will reach this height, Grandmont, La Martine and Cathedrale neighborhood will be affected. | When water will reach this height, 50% of the Kalamu and Limete municipalities will be flooded and more than 70% of Matete municipality will be flooded. |
| *4.6 to 5.5 meters | At this level, a major part of the study area will be affected, only *Vieux Tours* and the northern part of the city located on the behind the dyke won't be affected. | At this stage, more than 85%of Kalamu and Limete municipalities will be affected. Around 10% of Lemba municipality will be affected. |
| 5.6 to 6.5 meters | At this stage, more than 80% of the city will be affected, only the northern and some small part of the study area such as area around the cathedral will be preserved because of the soil topography. | At this level, around 97% of Matete, Kalamu and Limete neighborhood will be flooded. Respectively, around 50% and 60% of Ngaba and Lemba neighborhood will be affected. |
| 6.6 to 7.5 meters | Only the cathedral and the northern part will be preserved. | At this stage almost all the study area will be affected except 5% of Ngaba municipality, a very small part of Lemba, Lumumba statue, the Echangeur monument and the garden. |
| 7.6 to 8.5 meters | When water will reach this level, only the northern part will be preserved. | When water will reach this level, only the Echangeur monument and Lumumba statue won't be affected. |
| *the height recorded in 1856. | | |

## City flood map




Source: Drawn by the author
Scale: 1:1000
Arc scene and AutoCAD

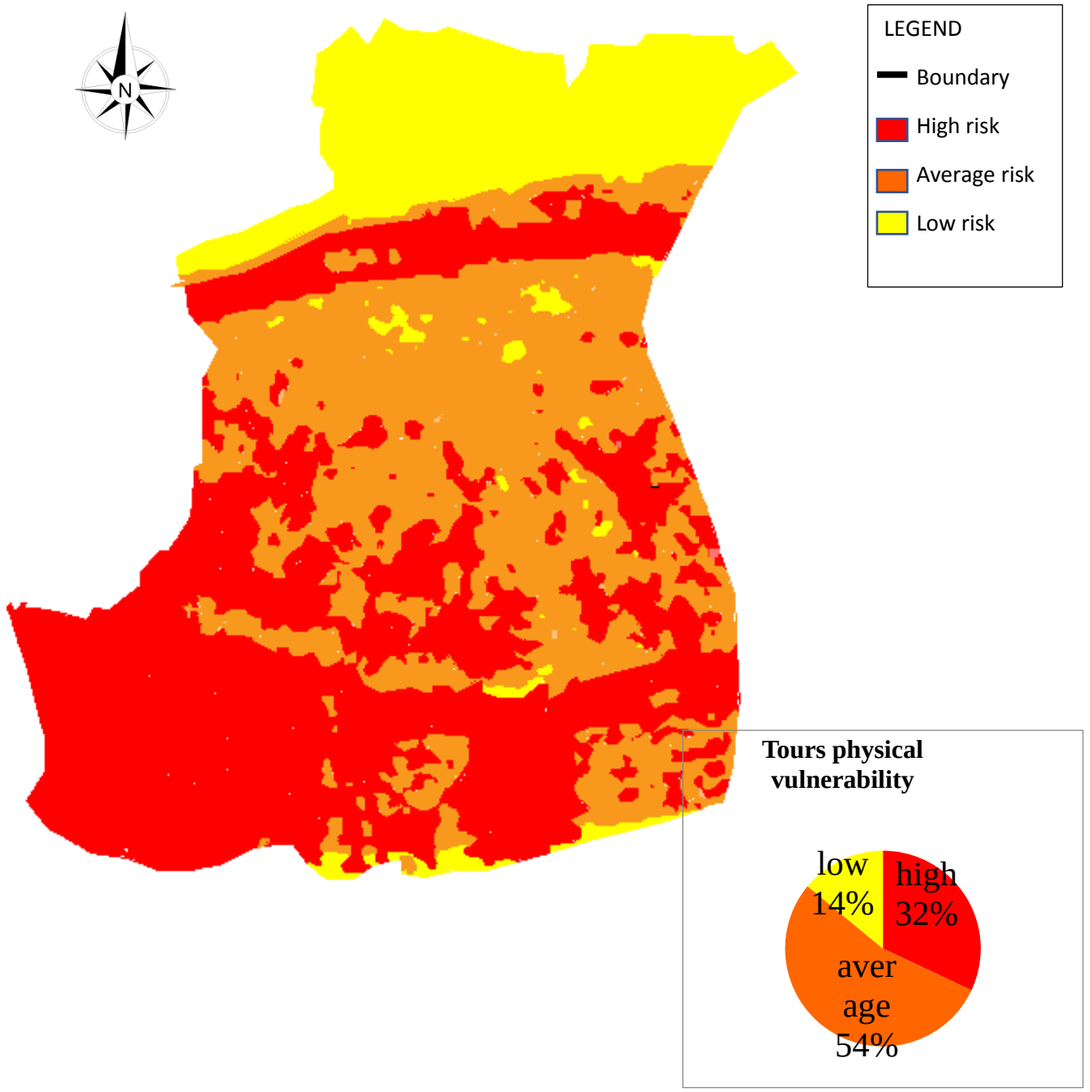



Source: Drawn by the author
Scale: 1:1000
Arc scene and AutoCAD

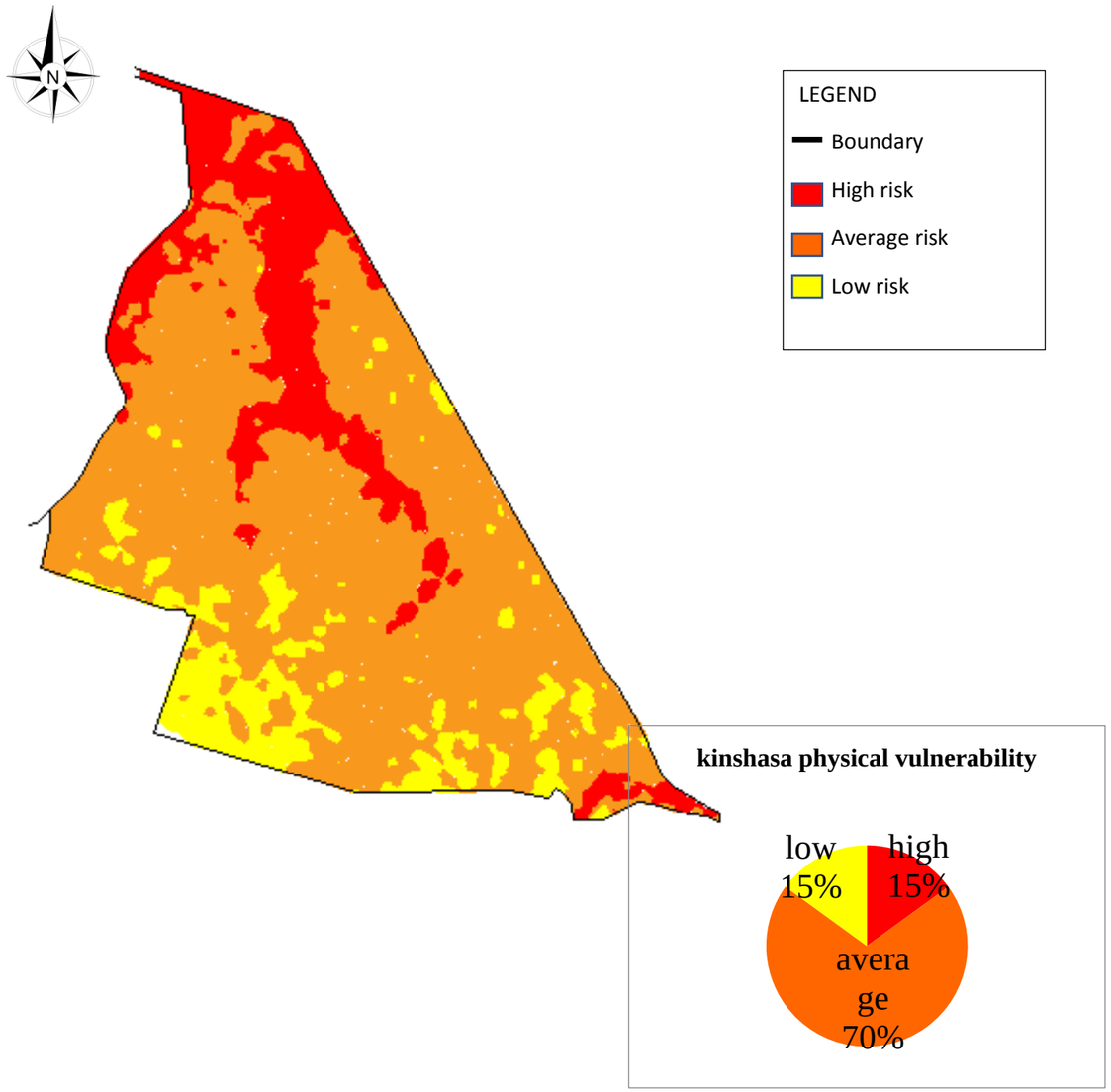
By comparing both cities, 45% of the city of Tours is located in high risk zone and only 15% of Kinshasa is located in high risk zone, 40% of Tours is located in average risk zone against 70% of Kinshasa and 15% of both cities is located in low risk zone.

In conclusion, we can say Tours is more vulnerable to flood compare to Kinshasa.

## Final physical vulnerability map




Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD




Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

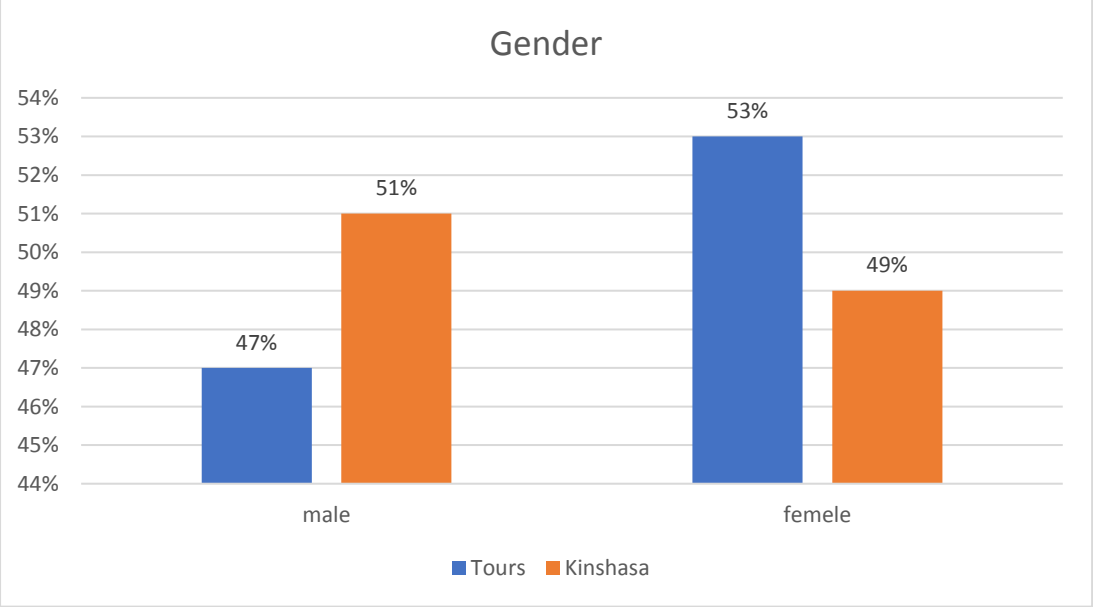
With 32% of physical infrastructure located in high risk zone compare to Kinshasa that has 15%, we can say, the physical vulnerability of the city of Tours is high than Kinshasa

# 1 6.2. Social vulnerability

## 6.2.1. Population

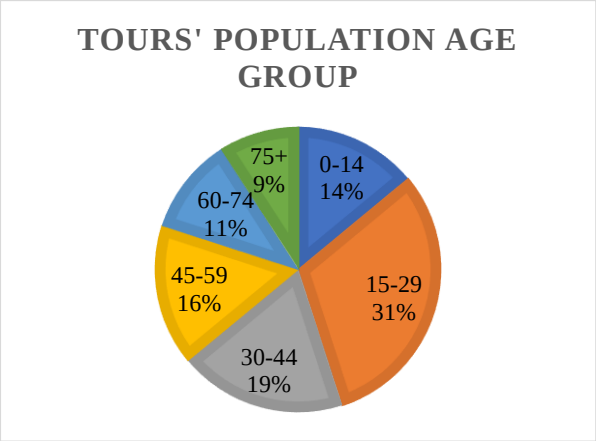
| Neighborhoods | Population (2012) | Population 15+ | Neighborhoods | Population (2004) | Population 18+ |
|---|---|---|---|---|---|
| Ilot Gentiana | 13 432 | 10 586 | Kalamu | 315 342 | 158 304 |
| Ste Radegonde | 7 071 | 5 564 | Lemba | 349 838 | 179 282 |
| Lamartine | 5 104 | 3 880 | Limete | 375 726 | 200 195 |
| Tours centre-ville | 11 804 | 9 302 | Ngaba | 180 650 | 83 249 |
| Cathedrale | 3 074 | 2 846 | | | |
| Rabelais-tonelle | 5 554 | 3 248 | | | |
| Grandmont | 15 189 | 9 197 | | | |
| Fuye vel' peau | 8 940 | 7 230 | | | |
| Sanitas-rotonde | 7 971 | 6 034 | | | |
| Giraudeau | 4 498 | 3 213 | | | |
| Febvotte- marat | 5 681 | 4 484 | | | |
| Beaujardin | 3 965 | 2 791 | | | |
| Rochepinard | 3 859 | 2 959 | | | |
| Rive du cher | 4 235 | 3 292 | | | |
| Deux lions- la gloriette | 2 113 | 1 709 | | | |
| Les fontaines | 7 093 | 5 677 | | | |
| Source : IRIS. Census 20012 | | | Source : Institut National de Statistique. Census 2004 and 2011. | | |

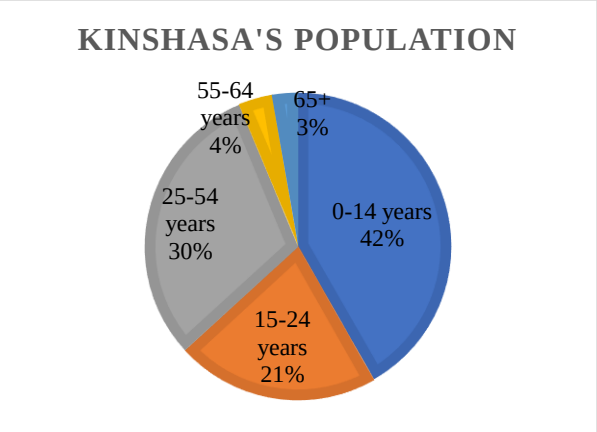
## 6.2.2. Gender




Source: IRIS census 2012 and INS census 2011.

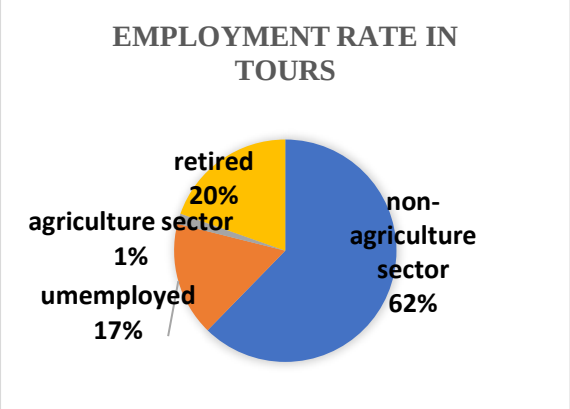
### 6.2.3. Age group



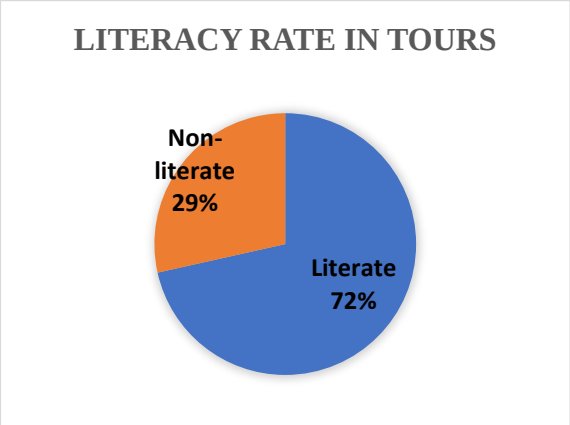

Source: http://www.cartesfrance.fr/carte-france-ville/population_37261_Tours.html#ixzz5Hz0j2pck and indice mundu

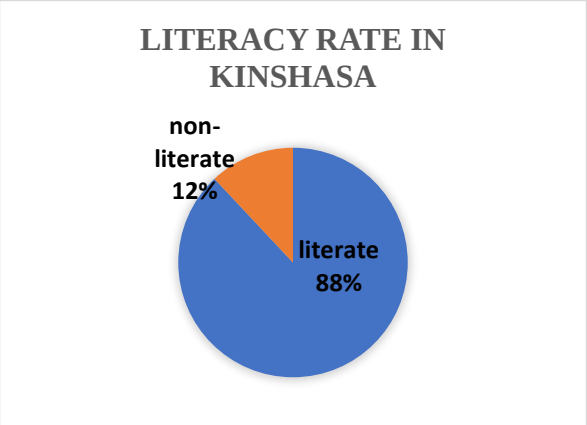
### 6.2.4. Employment rate





### 6.2.5. Literacy rate

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6.2.6. Population distribution

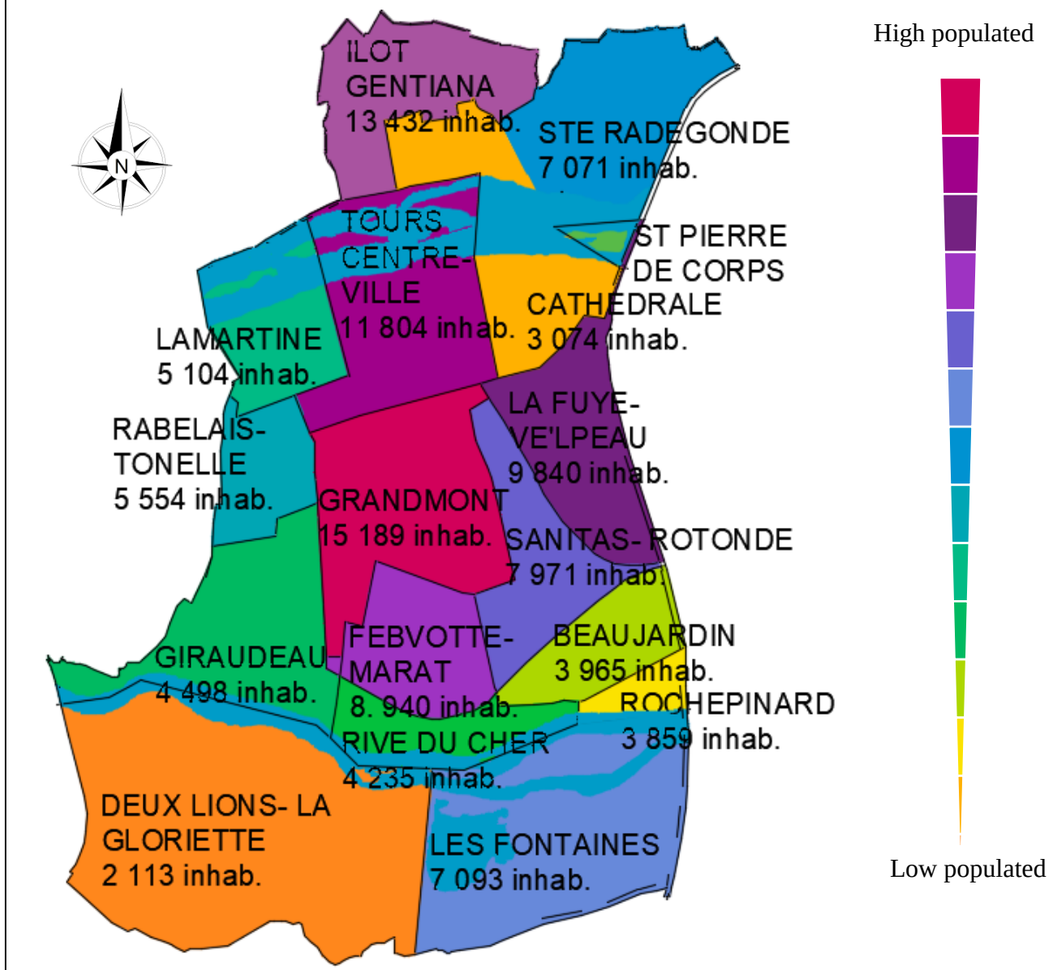
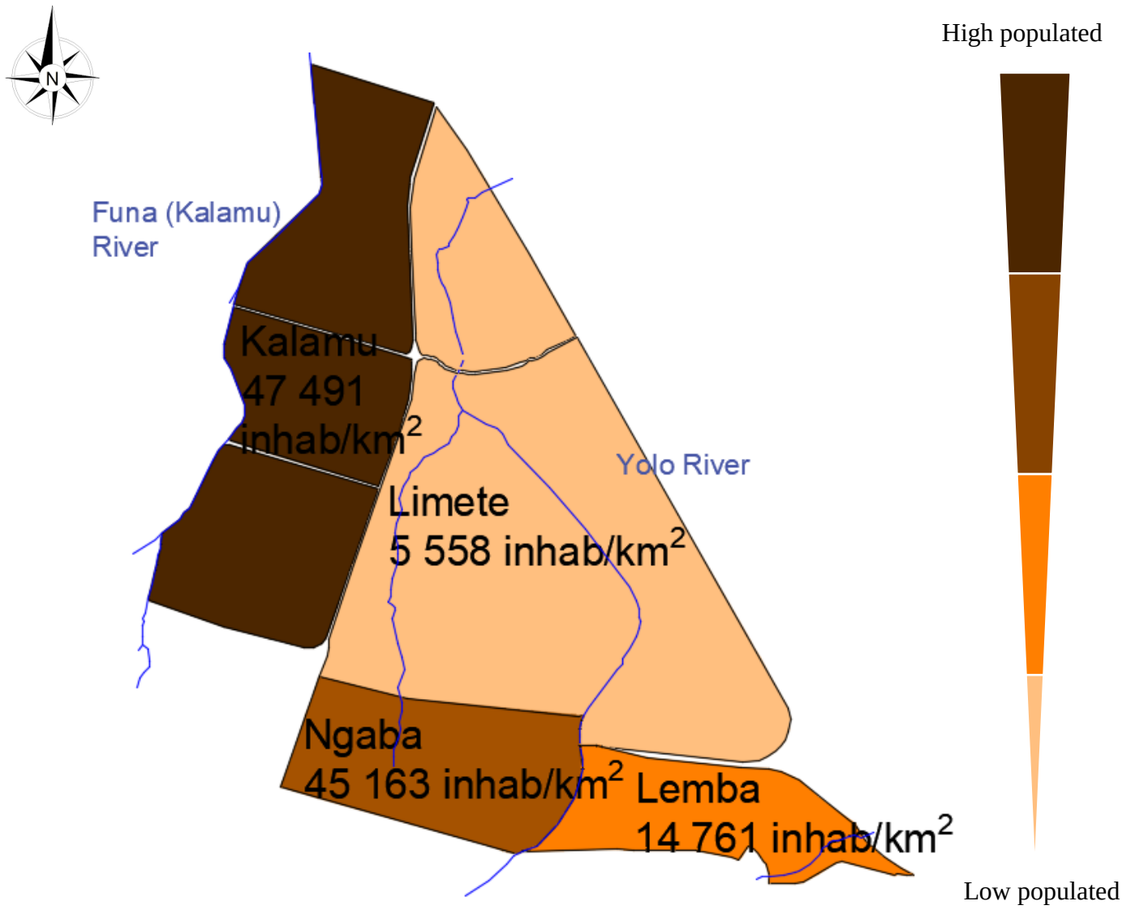



*Figure 74: population distribution in Tours*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD




Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

At Tours, Grandmont has a highest number of habitants and Deux lions- la gloriette has the lowest number of habitant. At Kinshasa, Kalamu has high population and Limete has a low population.

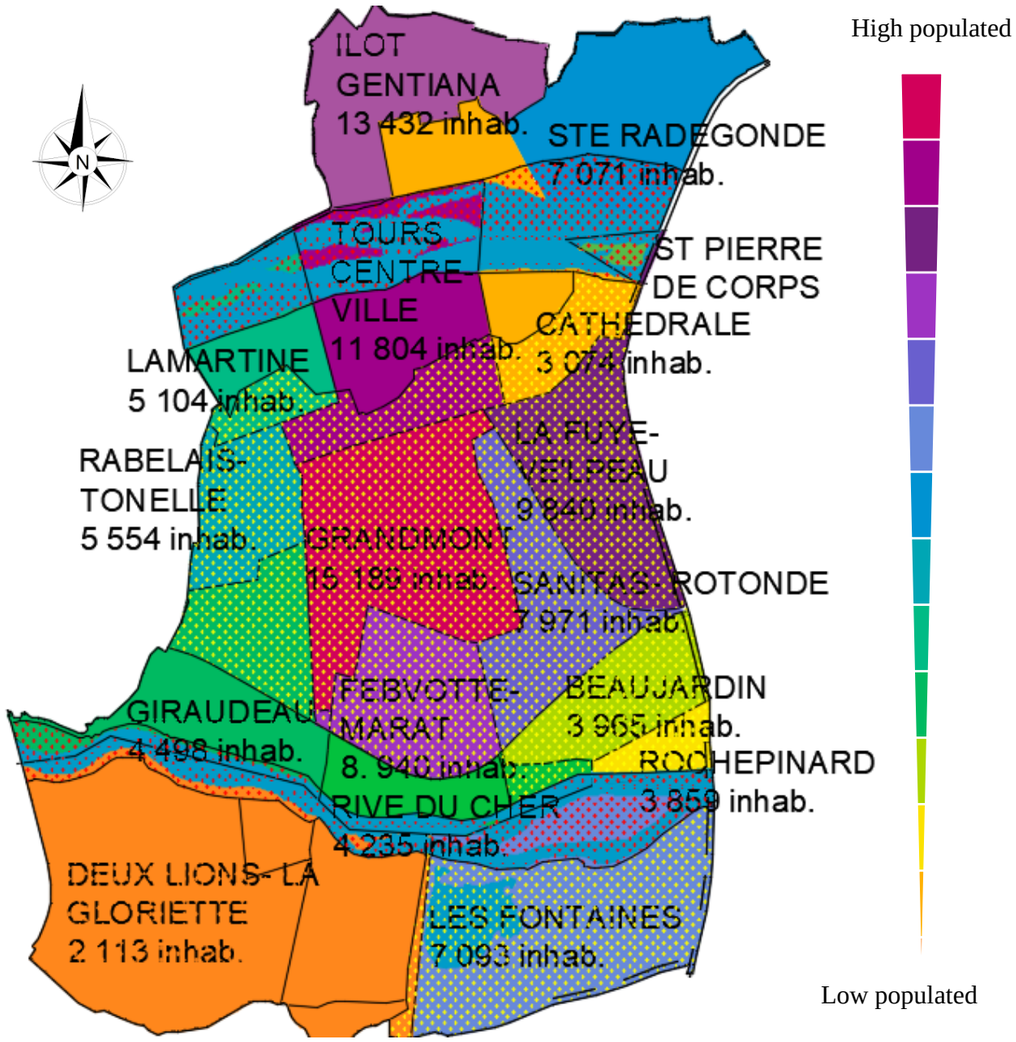
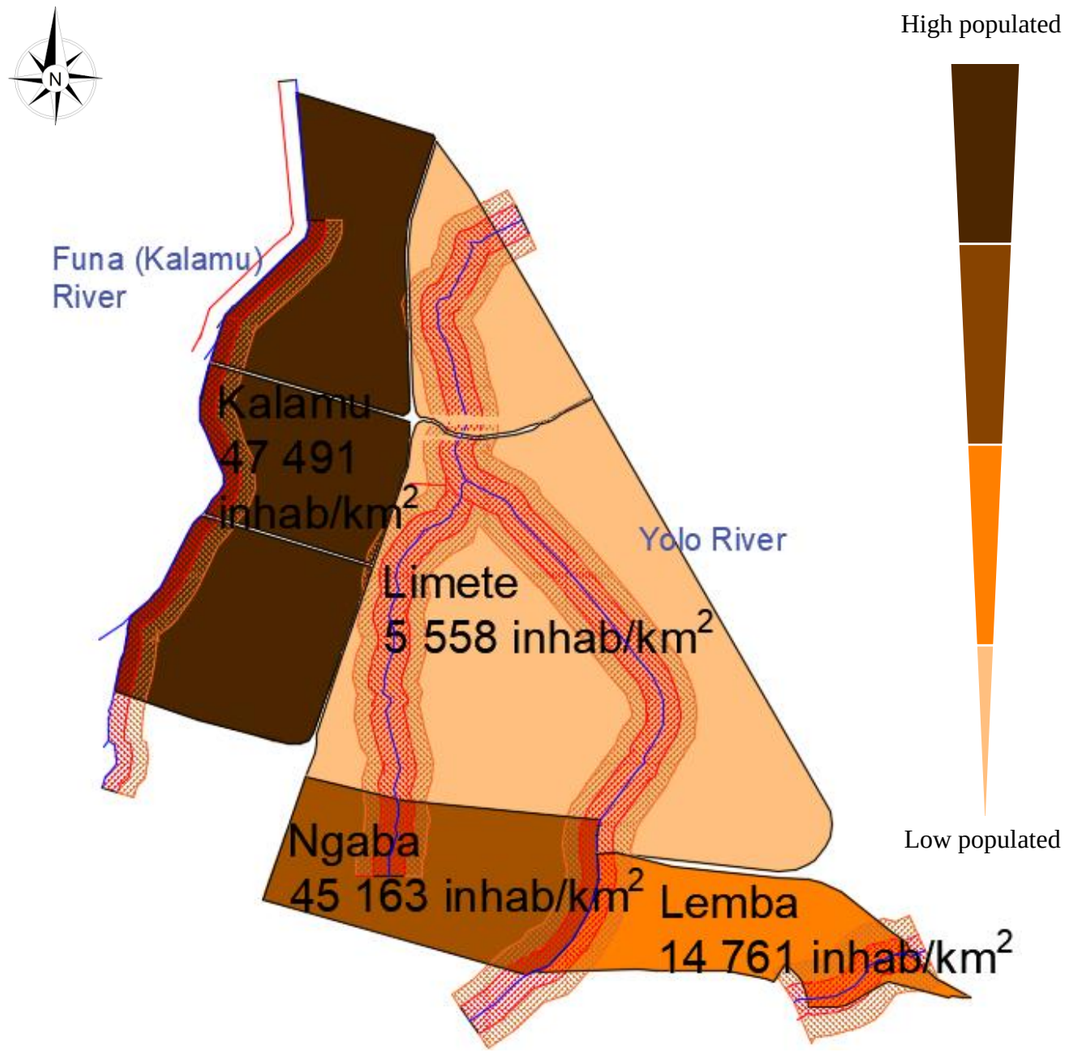


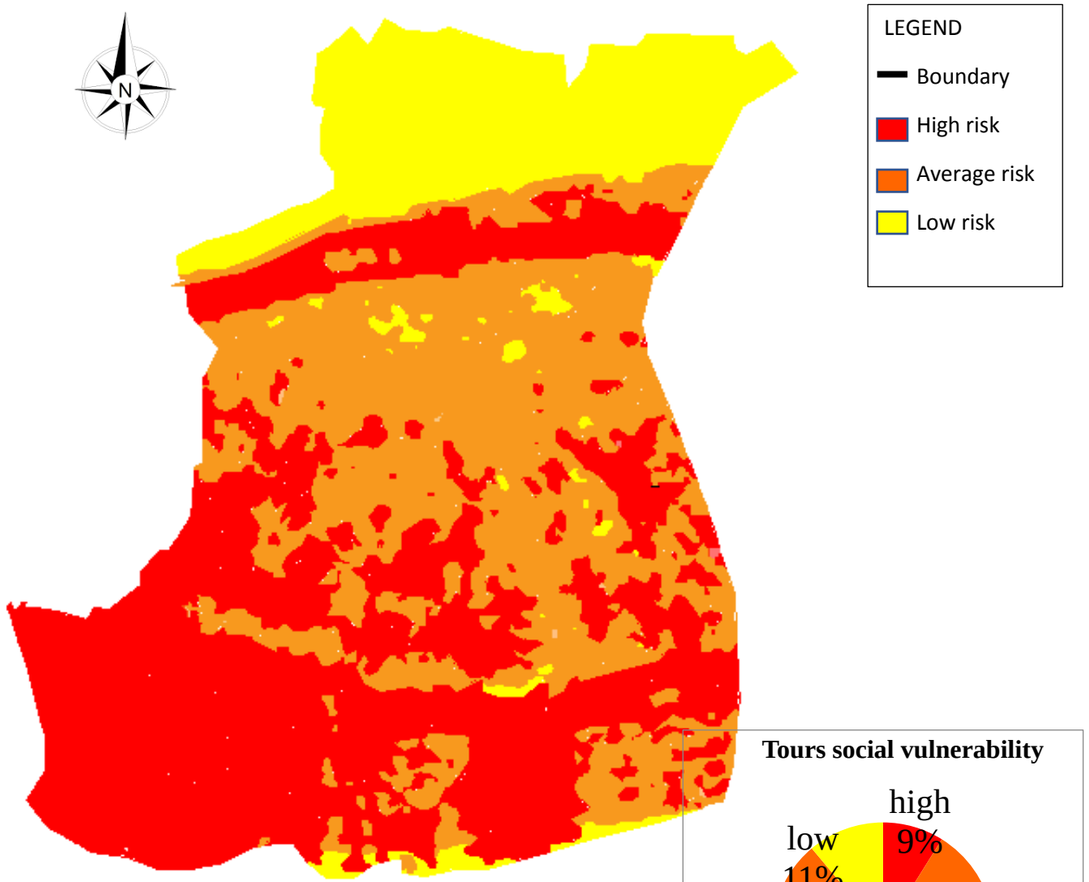

*Figure 77: population distribution vs flood*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

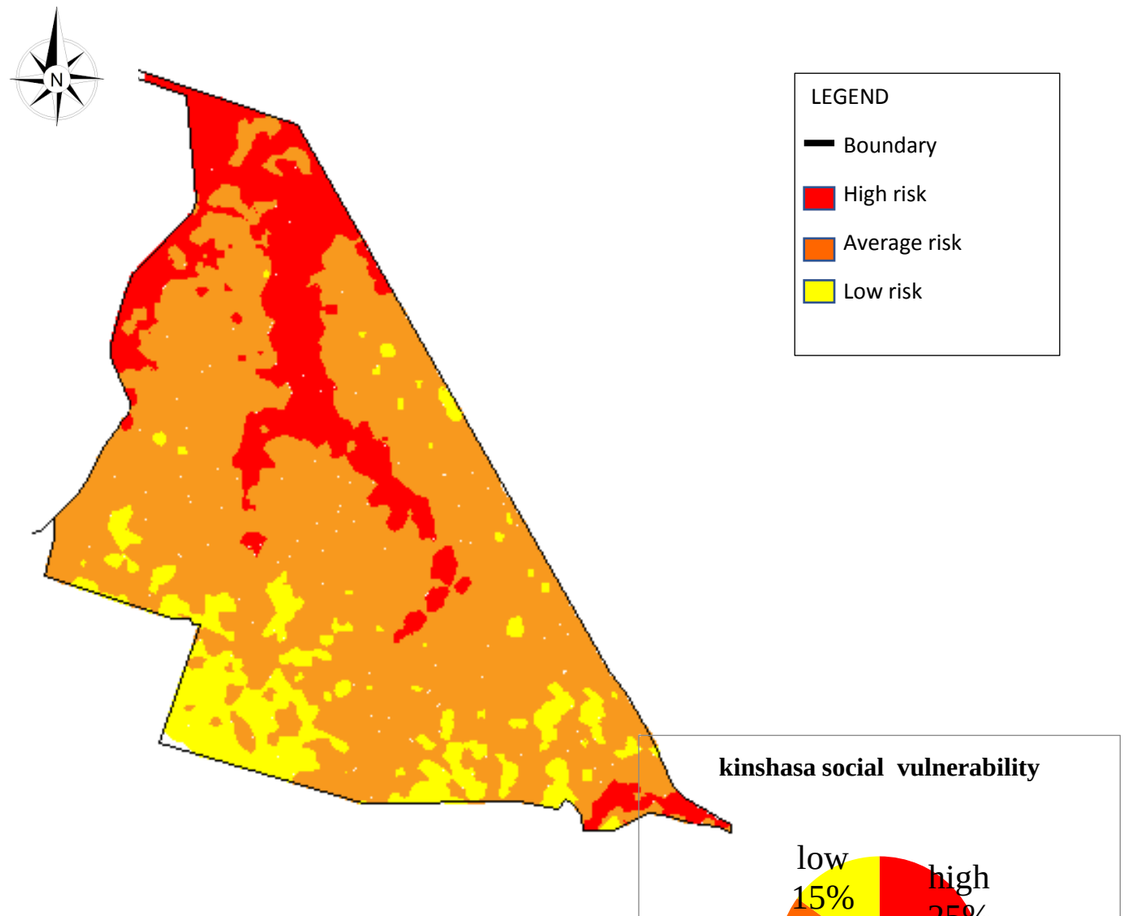



Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

Neighborhoods that have low number of population that has an average risk of flood. The rest of the population is located in the low risk zone. Out of 34.49 $km^{2,}$ 10.28$km^2$ is located in the flood prone area. It around means 30% of the population live in the flood prone area.




Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD




Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

25% of Kinshasa's population is living in the high risk zone but only 9% of Tours population is in this situation. 80% of Tours population is living in average risk zone against 60% of Kinshasa's population and 11% of Tours' population is living in low risk zone against 15% of Kinshasa's population.

## 6.3. Economic vulnerability

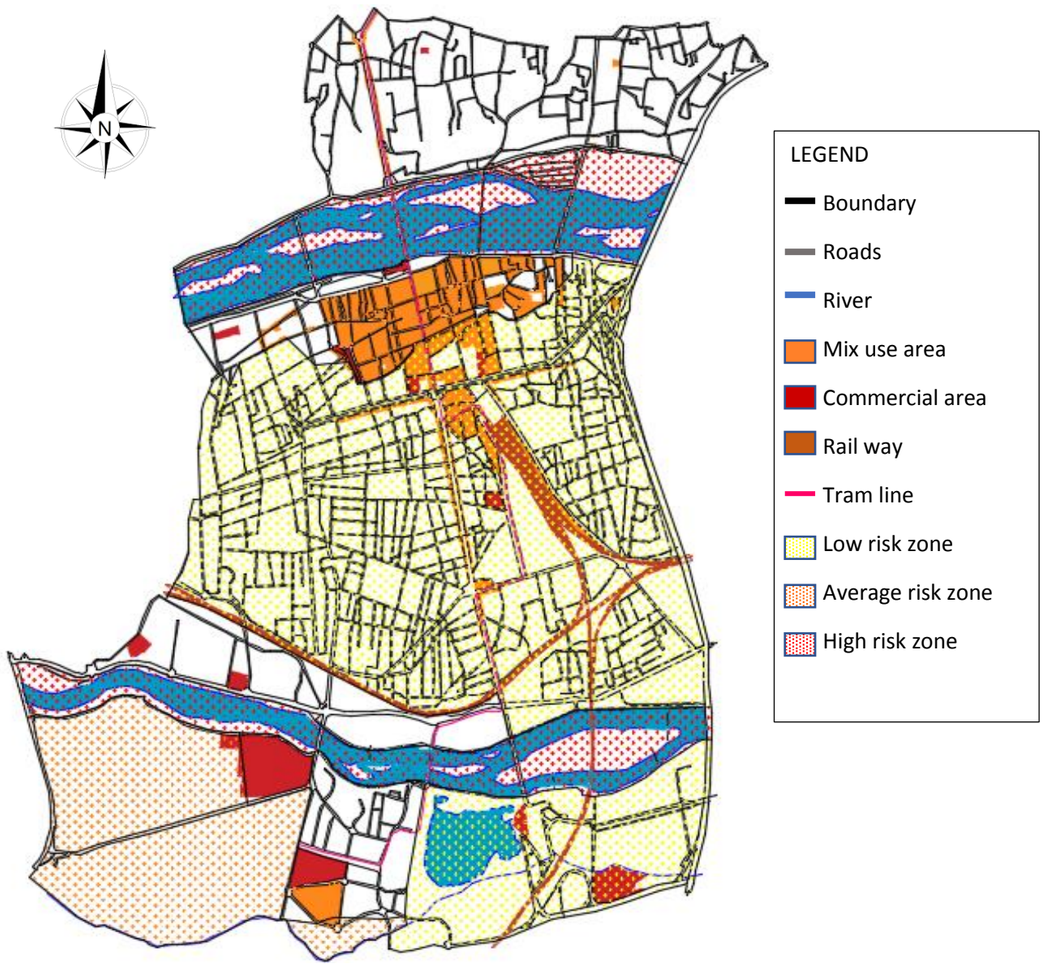



*Figure 81: Commercial area vs flood*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

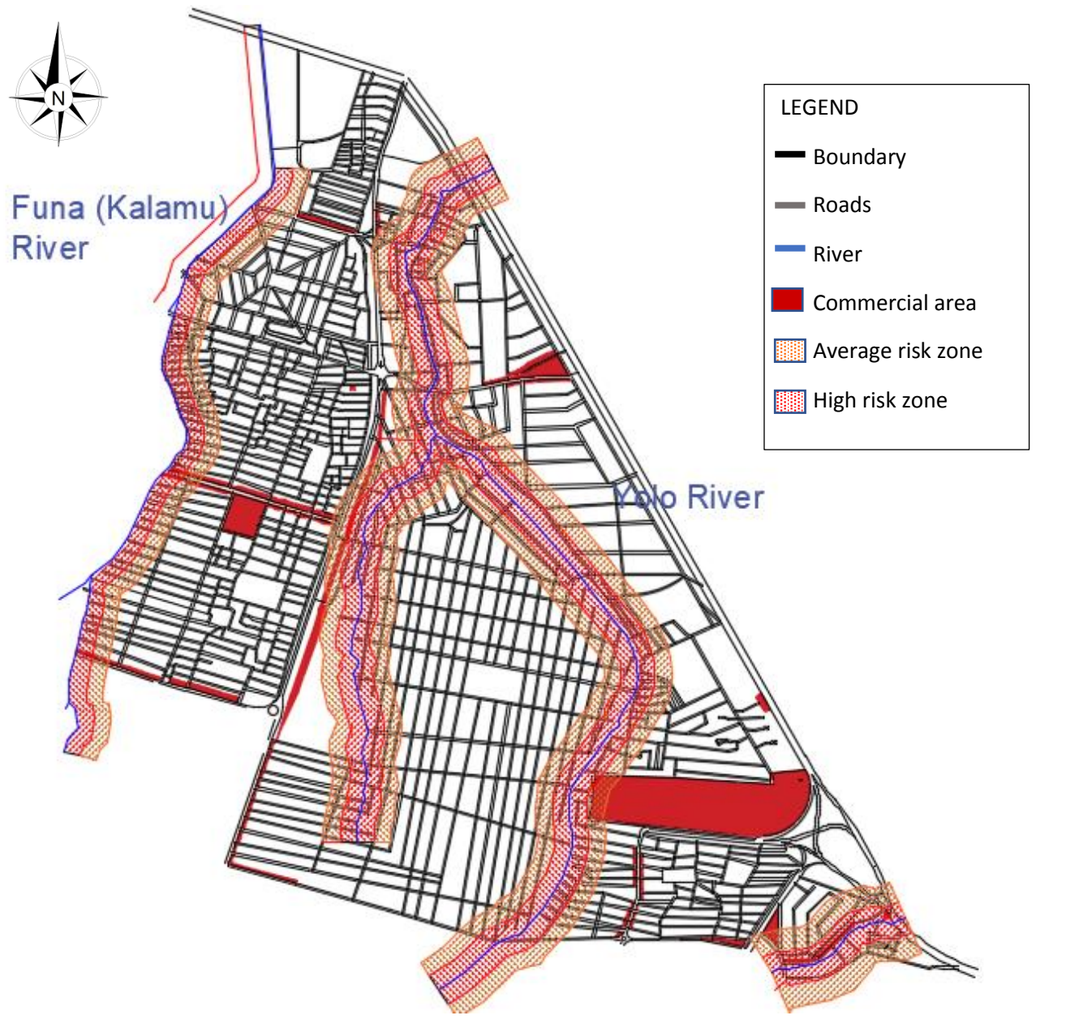
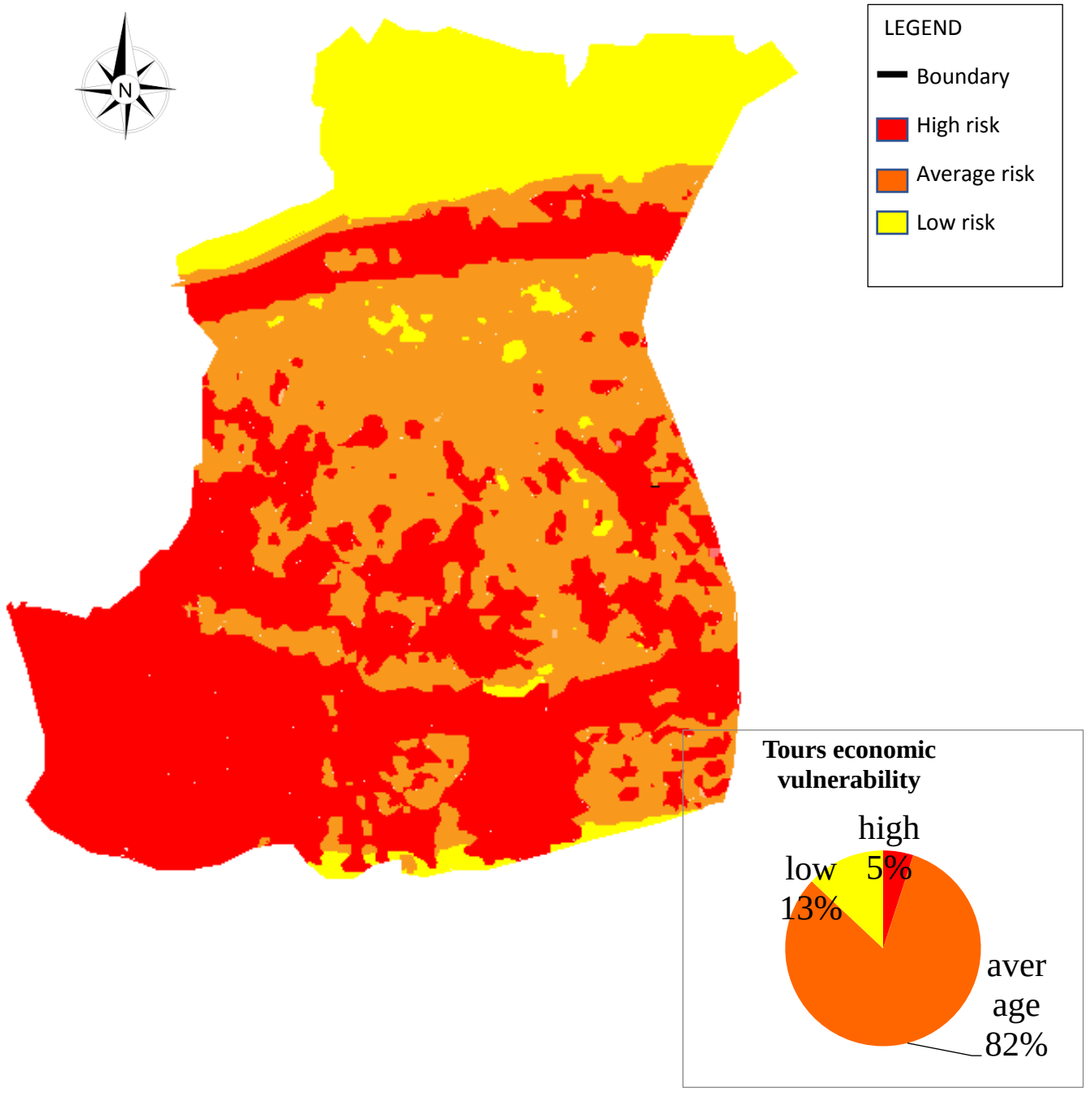


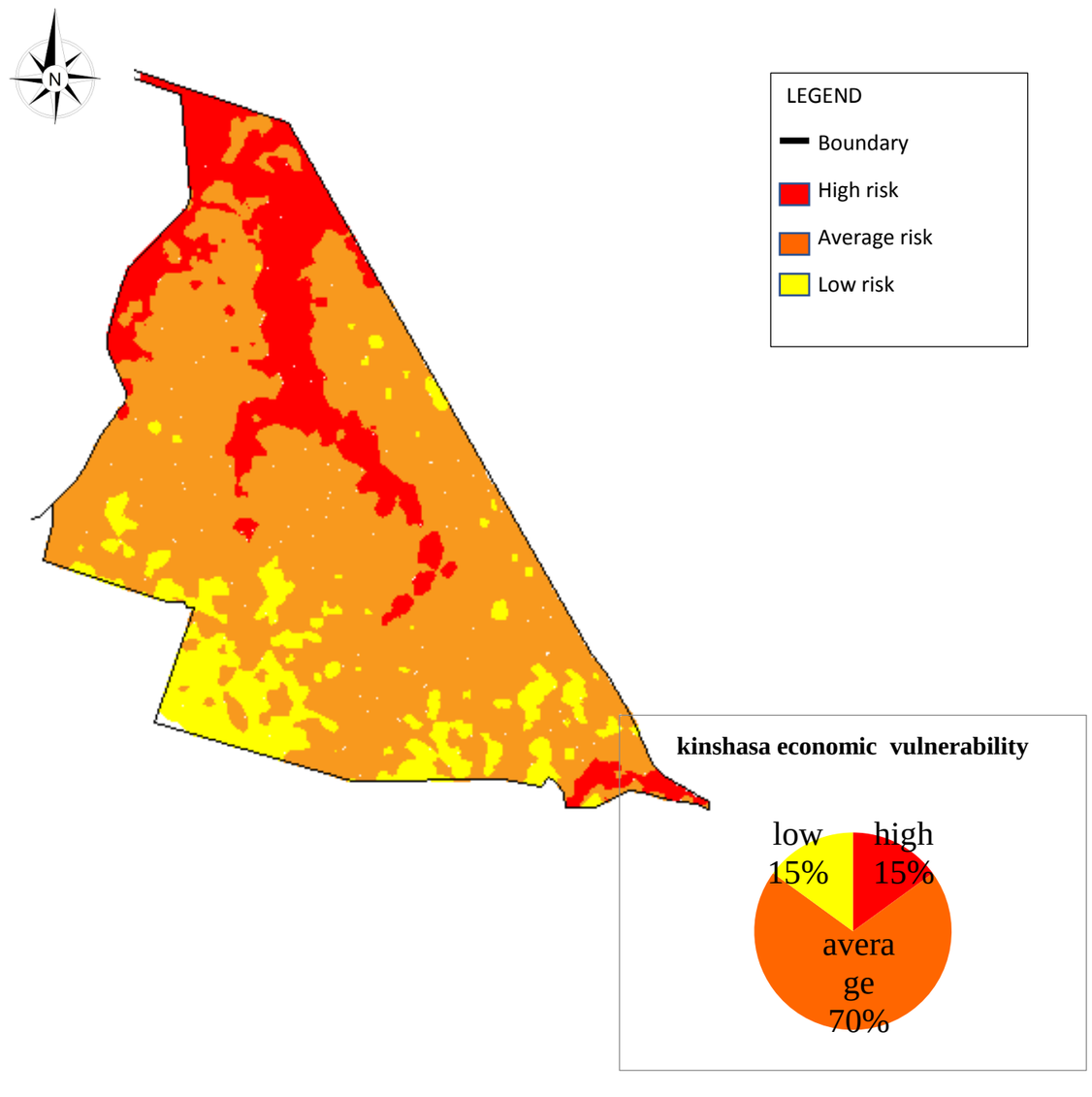

*Figure 82: commercial area vs flood*

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

At Tours, most of commerce based on textile, food even house furniture are located are located in the mix use. We find mall is the less populated area like fac 2lions. When apply the existing flood map, only the Fac 2 lion's mall is located in the average flood prone area. At Kinshasa, markets are not located in the flood prone area




Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

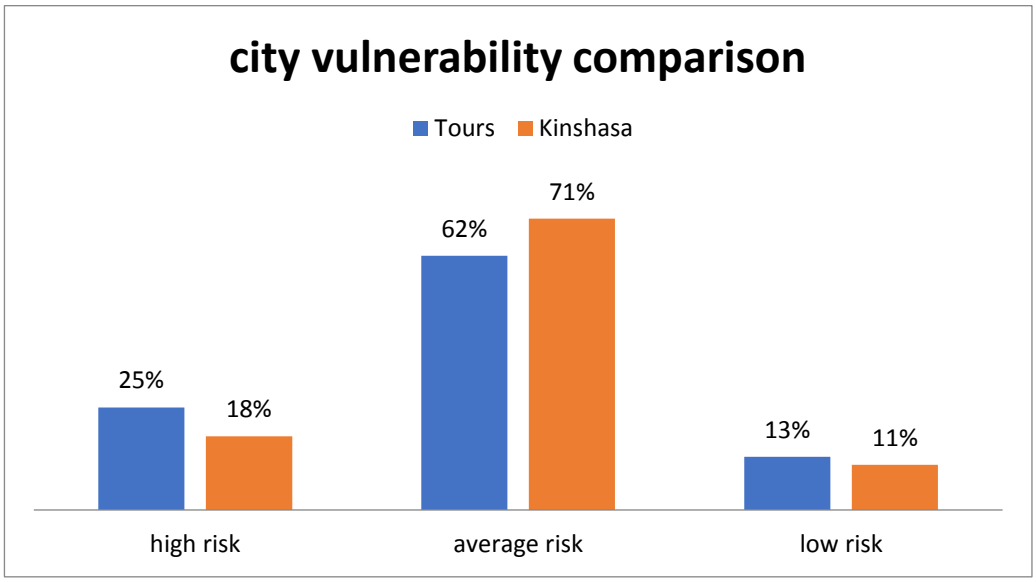



Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

Tours economic area is dominated by shopping complexes, malls, etc. Compare to Tours, in case of flood 15% of commerce will be affected. Economic activities in the study are in Kinshasa is dominated by small shops along main roads the Yolo market that is mainly grocery market and the fair that is seasonal. That means, in case of flood Tours will have an important loss compare to Kinshasa.

## 6.4. Outcome

After all these analysis, we can conclude that physical infrastructure and economic sector of Tours are more vulnerable to flood compare to Kinshasa, in the other side population of Kinshasa are more vulnerable compare to Tours' population.




The northern part of the city of Tours won't be affected because of the topography. The dyke will protect the *vieux Tours* till 5.5 meters flood. Even though, it is difficult to predict the exact impact of flood in Tours because we can't say if the dyke can resist under the pressure of the water rising up. In worst case if the dyke break it will be more disastrous compare to our predicted scenario. Deux Lions and Giraudeau will the most vulnerable neighborhoods in Tours, La Gloriette and Bergeonerie Lake will act as water reservoirs when the Cher River will overflow till 2.5 meters. The water can level up in the Loire river till will reach more than 5.5 meters.

In Kinshasa when flood will occur, 100 meters of each side of rivers will act like reservoir, it could contain water till 3.5 meters high. This last is the highest level recorded in the area. The southern part of the study area in Kinshasa will get affected later because it is located in a plateau.

In case water raise up to 2.5 meters, it will be more disastrous in Tours than Kinshasa in term of economic sector, social sector and physical infrastructure.

# Chapter seven: FRAMEWORK FOR FLOOD DISASTER MANAGMENT IN TOURS AND KINSHASA

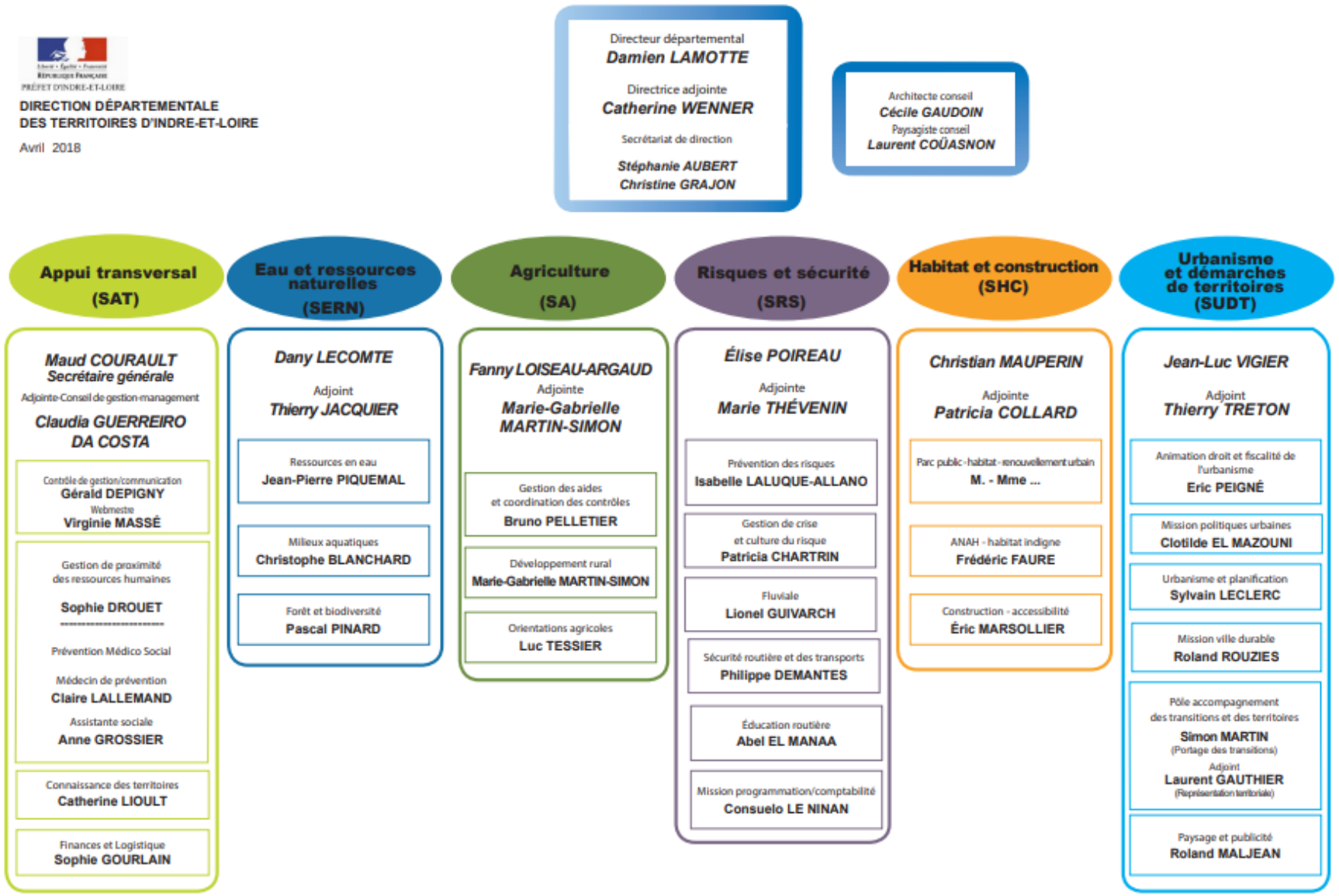
## 7.0. Introduction

Planning framework is a stepwise process for plan making, it outline the roles of different planning institutions involved in the process, and it explains the mechanism of horizontal and vertical coordination between different departments.

## 7.1. Planning framework in Tours

*The Direction departementale des terriritoire d' Indre-Et-Loire* is coordinated by a departmental director who work with a deputy director and an exclusive secretary. They work with an architect and a landscape planner. They coordinate 6 department that are: the transversal support department, the water and natural resource department, the agriculture department, the risk and security department, the habitat and construction department and the urban and territorial planning department.

Source: http://www.indre-et-loire.gouv.fr/content/download/21331/146286/file/organigramme%20DDT%20avril%202018.pdf



## 7.2. Planning framework in Kinshasa

Organisation politico-administrative au regard de l'Ordonnance-loi n° 82/006 du 25 février 1982

All the decisions are taken in the state (province) level, they are voted by the state assembly than the urban council analyze and execute the plan. The territory administration works in the elaboration of specific plan. For rural area, each sector has an executive college, in the groupement (group of villages) who work with all the kings of surrounding villages in the elaboration and execution of plans.

| Entité | Statut | Personnalité juridique | Organe délibérant | Exécutif | Matières locales |
|---|---|---|---|---|---|
| Province | Institution politique régionalisée | Oui | Assemblée provinciale | Gouvernement provincial | Questions d'intérêt provincial |
| Ville | ETD | Oui | Conseil urbain | Collège exécutif urbain | Questions d'intérêt urbain |
| Territoire | ETd | Non | Inexistant | Administrateur du territoire | Pas de matières spécifiques |
| Secteur ou Chefferie | ETD | Oui | Conseil de Secteur ou Chefferie | Collège exécutif de Secteur ou de Chefferie | Questions d'intérêt local |
| Groupement | ETd | Non | inexistant | Chef de groupement | Pas de matières spécifiques |
| Village | ETd | Non | inexistant | Chef de village | Pas de matières spécifiques |
| Quartier | ETd | Non | inexistant | Chef de quartier | Pas de matières spécifiques |

Source : https://journals.openedition.org/pyramides/711#tocto2n1

## 7.3. Policies framework for flood and green and blue corridor and flood management in France and Tours

### 7.3.1. Guidance on the maintenance of landscape connectivity features of major importance for wild flora and fauna

The EU Biodiversity Action Plan for 2010 and Beyond (COM 2006/216) provides specific targets for the Land use planning and nature conservation that aim to improve the integration of related aspects to biodiversity into land-use planning and management practices in the EU.

Land-use planning processes can support the maintenance and creation of landscape features that improve connectivity such as ecological networks and their components. This includes incorporating the creation and management of protected areas, buffer zones, corridors and other connecting structures as integral parts of an area's land-use planning strategy. Also, land use planning and management processes can help to keep a general landscape quality by preventing further landscapes fragmentation for example restricting construction in existing uniform green areas.

Spatial land use approaches, maintaining and enhancing connectivity can also be integrated into a number of different sectoral strategies influencing land-use such as transport.

Spatial plans and associated policies normally indicate the type and boundaries of protected areas and provide guidance on development restrictions that may apply to such areas. Thus they provide policy makers and developers with information that can be used to explicitly identify development opportunities and avoid

potential conflicts. Some spatial plans identify areas that may be protected for connectivity functions for example green corridors in urban areas and may incorporate outputs from ecological network studies. This corridor may be protected by planning restrictions on areas identified as being important for connectivity in ecological networks. The main problem is related to connectivity maintaining and establishing connections between protected areas, it plays an integral role in a number of land-use planning approaches adopted by Member States.

| Type | Class | NWRM Measure |
|---|---|---|
| **Direct modification in ecosystems** | Rivers and connected wetlands | Restoration and maintenance of rivers, basins, ponds, and wetlands; floodplain reconnection and restoration, reconnection of hydraulic annexes, elimination of riverbank protection… |
| | Lakes and connected wetlands | Restoration of lakes |
| | Aquifers | Aquifer restoration |
| **Change & adaptation in land-use & water management practices** | Agriculture | Restoring and maintaining meadows and pastures, buffer strips and shelter belts, soil conservation practices (crop rotation, intercropping, conservation tillage...), green cover, mulching… |
| | Forestry and pastures | Afforestation of headwater areas/mountainous areas/reservoir catchments, targeted planting for "catching" precipitation, land-use conversion for water quality improvements, continuous cover forestry, maintenance of riparian buffers, appropriate design of roads and stream crossing, urban forests… |
| | Urban development | Green Roofs, rainwater harvesting, permeable paving, Sustainable Drainage Systems: swales, soak ways, infiltration trenches, rain gardens, detention basins, retention ponds, urban channel restoration… |
| Source: http://ec.europa.eu/environment/water/adaptation/ecosystemstorage.htm | | |

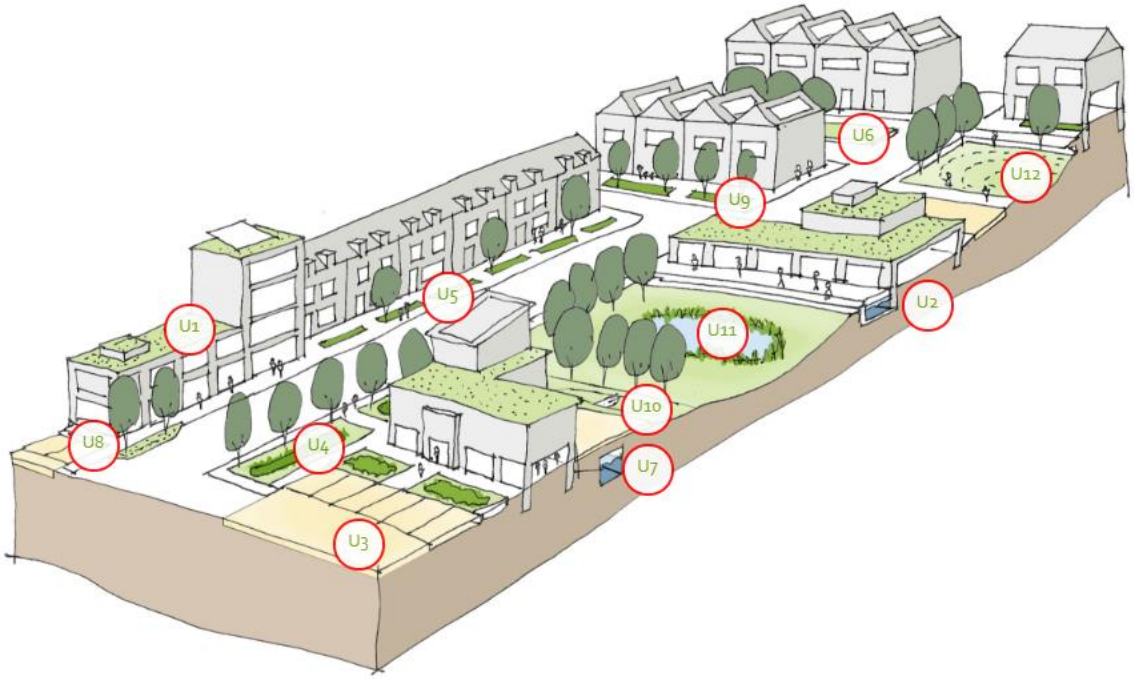
## 7.3.2. Natural water rétention mesures (NWRM)

Source : http://nwrm.eu/measure/overland-flow-areas-peatland-forests

Urban area measure

| | |
|---|---|
| U01 | Green Roofs |
| U02 | Rainwater Harvesting |
| U03 | Permeable surfaces |
| U04 | Swales |
| U05 | Channels and rills |
| U06 | Filter Strips |

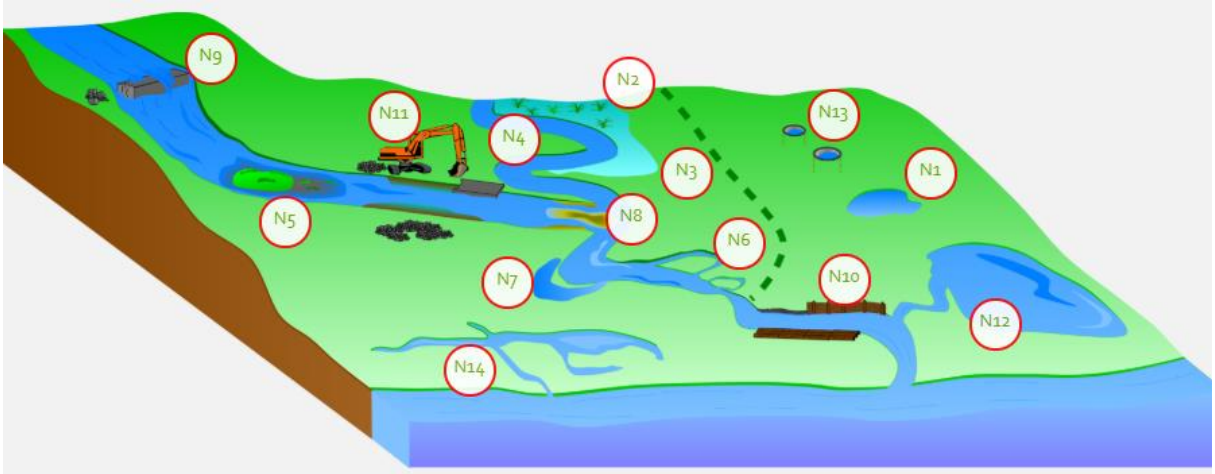
| | |
|---|---|
| U07 | Soak ways |
| U08 | Infiltration Trenches |
| U09 | Rain Gardens |
| U10 | Detention Basins |
| U11 | Retention Ponds |
| U12 | Infiltration basins |




Hydro morphology measure

| | |
|---|---|
| N01 | Basins and ponds |
| N02 | Wetland restoration and management |
| N03 | Floodplain restoration and management |
| N04 | Re-meandering |
| N05 | Stream bed re-naturalization |
| N06 | Restoration and reconnection of seasonal streams |

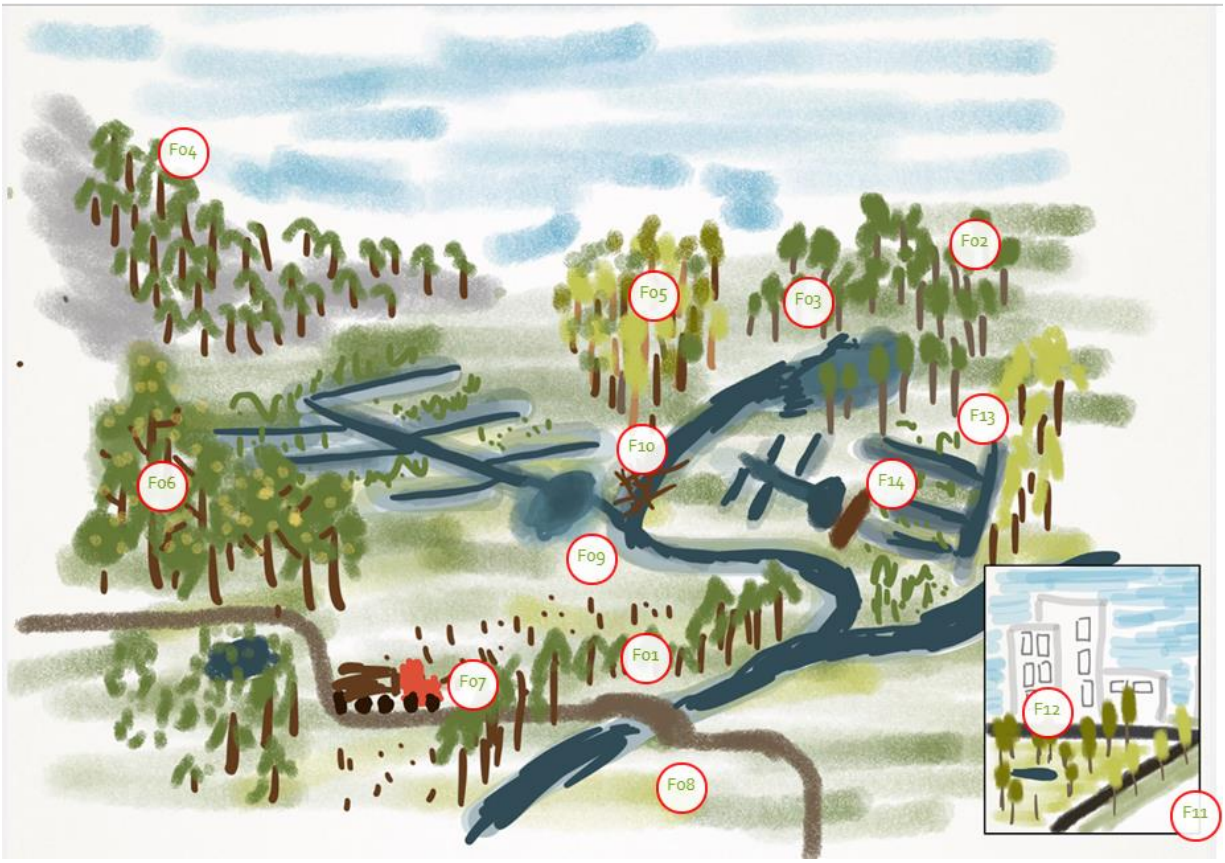
| | |
|---|---|
| N07 | Reconnection of oxbow lakes and similar features |
| N08 | Riverbed material renaturalization |
| N09 | Removal of dams and other longitudinal barriers |
| N10 | Natural bank stabilization |
| N11 | Elimination of riverbank protection |
| N12 | Lake restoration |
| N13 | Restoration of natural infiltration to groundwater |
| N14 | Re-naturalization of polder areas |




Forest measure

| | |
|---|---|
| F01 | Forest riparian buffers |
| F02 | Maintenance of forest cover in headwater areas |
| F03 | Afforestation of reservoir catchments |
| F04 | Targeted planting for 'catching' precipitation |
| F05 | Land use conversion |
| F06 | Continuous cover forestry |
| F07 | 'Water sensitive' driving |

| | |
|---|---|
| F08 | Appropriate design of roads and stream crossings |
| F09 | Sediment capture ponds |
| F10 | Coarse woody debris |
| F11 | Urban forest parks |
| F12 | Trees in Urban areas |
| F13 | Peak flow control structures |
| F14 | Overland flow areas in peatland forests |




## 7.4. Policies framework for flood and green and blue corridor and flood management in in DR-Congo and Kinshasa

### 7.4.1. Law n° 11/009 of 09 July 2011 about fundamental principles relies to the environmental protection.

Section 2: mandatory

Article 3: The Congolese environment is a part of the common heritage of the nation in which the government have a permanent full power. Its management and its protection are the general interest. They are submitted to the respect of the sustainable development principle. The country, the state and the territorial decentralized entity and anybody have the right to participate in the amelioration of its quality.

Article 4: The country guarantees all citizens the right to environmental education. In this framework, the country, the state and the decentralized territorial entity participate, within the limits of their respective competences, in the education, the training and the sensitization of the populations with the problems of environment as well as the environmental research.

Article 5: The Government provides incentives to prevent or reduce environmental damage, to restore or improve the quality of the environment.

These plans are drawn up in consultation with the local population, the users and the associations approved for the protection of the environment. They are the subject of a public inquiry and an environmental and social impact study.

Article 28: The country, the state and the decentralized territorial entity take appropriate measures to prevent land degradation. To this end, they adopt integrated strategies for the conservation and sustainable management of land resources, including soils, vegetation and related hydrological processes.

Article 29: The water resources management concerns groundwater and surface water, both continental and maritime. Their protection, enhancement and use as well as inter-state cooperation for transboundary lakes and rivers are carried out in accordance with ecological balances.

### 7.4.2. PRESIDENCY OF THE REPUBLIC Law No. 15/026 of 31 December 2015 on Water Explanatory Memorandum

CHAPTER 2: CONTINENTAL WATERS

TITLE III: MANAGEMENT OF WATER RESOURCES

Section 3: Inland Water Protection

Paragraph 2: Areas and perimeters of protection

Article 46: Protected areas are established around springs, streams or parts of watercourses, dam reservoirs, lakes, ponds, groundwater catchment area and, in general, bodies of water intended at least partially, for human or animal consumption. These areas are also established to protect groundwater recharge areas. In order to collect drinking water, protected perimeters, as a measure of public health, are obligatory.

Article 47: There are three types of protection perimeter:

a) The immediate protection perimeter;

(b) Close protection perimeter;

c) The remote protection perimeter.

The limits of these perimeters are determined, as the case may be, by provincial decree deliberated by the Council of Ministers or by decision of the executive college of the decentralized territorial entity. They may be modified if new circumstances so require. Article 48: The immediate protection perimeter corresponds to the environment close to the place where the catchment takes place.

Its main function is to prevent the deterioration of the works and to avoid any spillage of pollutants in the immediate vicinity of the catchment.

# Chapter eight: CONCLUSION

# 8.0. Introduction

In this chapter we discuss about the summery of research findings, the conclusion and our recommendations and proposals.

## 8.1. Summary of research findings

The first objective of this study was to study the existing conditions with respect to vulnerability of flood disaster. We did the visual survey in both cities, we did interviews. We list out causes that lead to flood and the history of flood in this area for a better understanding. The major issues in both city was the flood plain modification, a high runoff in Tours due to high percentage of paved spaces, lack of important green infrastructure that can act like sponge in case of flood in Kinshasa. Kinshasa needs a flood plain restoration and sponge area in the city and Tours need more sponge area to reduce the runoff in the city.

The second objective was to analyze the existing Green and Blue infrastructures and their impacts. By doing this study we understand that, both cities has green infrastructure that are not connected. In the case of Kinshasa we have to restore the green and blue infrastructure. In Tours in the Lamartine neighborhood there is a lack of green infrastructure.

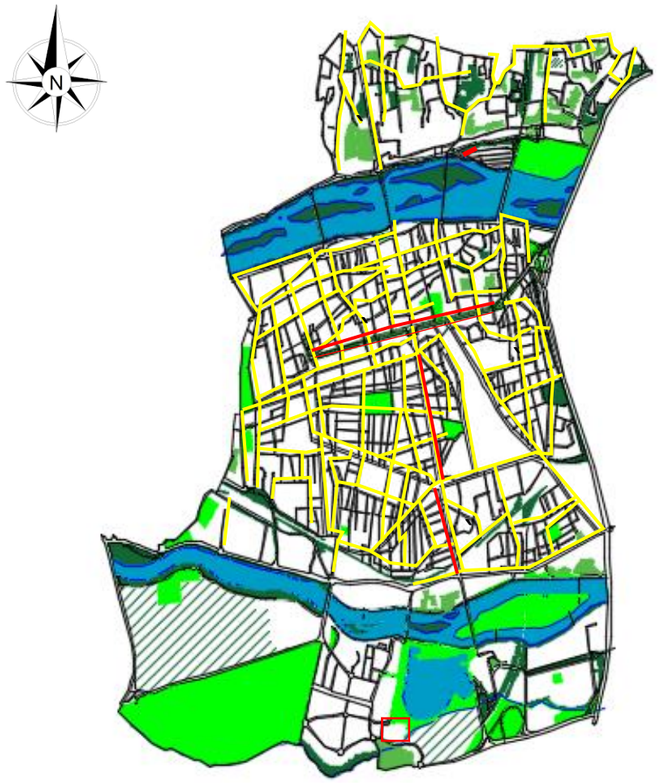
The third objective was to calculate the level of vulnerability by establishing parameters and using tools like AutoCAD and Digital Elevation Model (DEM) data. For this study we assess the physical, social and economic vulnerability. Therefore, we established parameters for vulnerability assessment. For the physical vulnerability we have the land use, accessibility, built and open, heritage, housing, emergency response & social infrastructure and water supply. For the social vulnerability our parameters were population, age group, literacy rate, employment, gender and density. For the economic vulnerability we selected only commercial activity as parameter. We also calculate the runoff and the vulnerability by using the digital elevation model. In the end of the study we conclude that, 30 % of the study area in Kinshasa is vulnerable to flood compare to 90% of Tours. It means that Tours has a high physical vulnerability compare to Kinshasa. Due to high density people living in the flood prone area in Kinshasa are vulnerable compare to Tours. It means that Kinshasa has a high social vulnerability. Also we find that majority of the commercial activity in Tours are located to the flood prone area. It means that Tours has a high economic vulnerability compare to Kinshasa. The city of Tours has to put some restriction in the flood prone area to reduce economic loss in case of flood, Kinshasa has to relocate people who live in the flood plain to reduce social vulnerability. The city of tours ½ smaller than Kinshasa but it has a runoff that is 20 time higher than Kinshasa. The best solution is to apply the sponge city concept in both cities. By using the Digital Elevation Model we realize that even if water raised up at 2 meters in Tours some area that are consider low risk zone can be flooded.

Recommend strategies for flood disaster preparedness with an emphasis on Green and Blue Infrastructures.

## 8.2. Recommendations and proposals

In this study we assess the vulnerability to flood and we analyze the existing green and blue corridor in Tours and Kinshasa. Following the analysis based on selected parameters, the following;

Recommendation for Tours



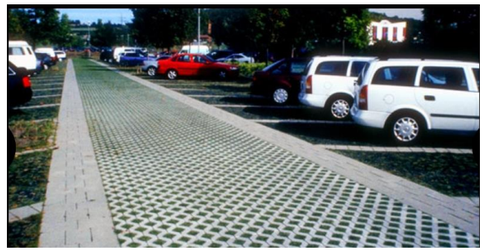

LEGEND

- Agriculture
- Park
- Gardening area
- Open space& buffer zone
- Parking 1
- River
- Green corridor 2

side walking garden at Grandmont street

permeable concreate for the walking side, parking pavement and plot pavement

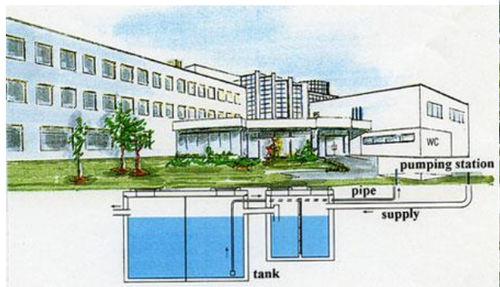

side walking garden along local roads



Green parking and walking side

green roof in commercial building

swales

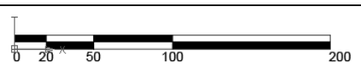


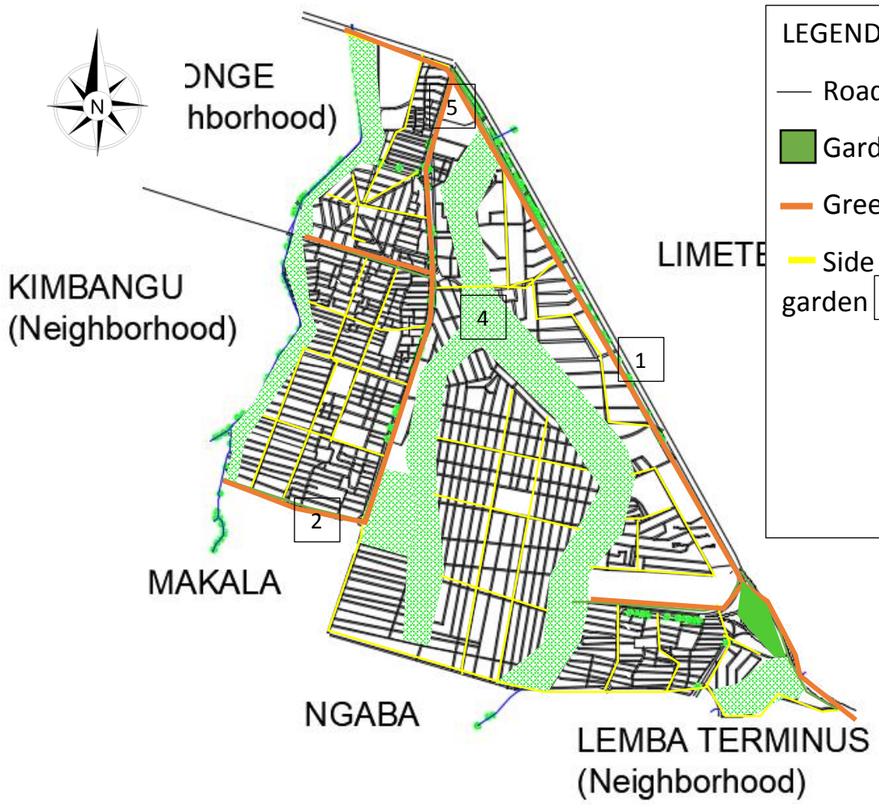

Building rain water harvesting and reuse In institutional building


green parking

- Restrict construction in high risk zone.
- Prohibit storage and housing in basement of buildings located in high risk zone.
- Transform the existing brownfield to park.
- Improve the city's waste treatment plan to reduce pollution.

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD






LEGEND

- Roads
- Gardening area
- Green corridor 1
- Side walking garden 3

Source: google map. Drawn by the author
Scale: 1:1000
AutoCAD

0 20 50 100 200


side walking garden

permeable concreate for the walking side, parking pavement and plot pavement and local road


side walking garden along local roads

Building rain water harvesting and reuse at the house level

swales


park




- Restrict construction in 100 meters each side of rivers.
- Create a waste treatment plant to reduce river pollution.
- Implement public awareness program.
- Implement a zero plastic waste program.
- Implement tourism along the river

| Proposal | |
|---|---|
| Tours | Kinshasa |
| Increase disaster awareness by putting signage. | Household solid waste management |
| Make disaster drill program in schools. Interest a large number of people for the disaster drill program. | Involve the population in the city maintenance |
| Encourage community gardening (jardin partage) | Organize disaster drill program. |
| Encourage household solid waste recycling | |

## 8.3. What both cities learnt from each other

The city of Tours can learn from Kinshasa:

- The level of awareness of the population, in Kinshasa, the population knows the which area can be affected after how much time, they can estimate the lost and prepare themselves accordingly.
- The rain water harvesting in the plot level.

The city of Kinshasa can learn from Tours:

- solid waste management.
- flood plain restoration.
- disaster drill program.
- construction of parks that can act as reservoirs in case of flood event.

## 8.4. End notes

Vulnerability assessment is a function of many factors over and above physical planning. Furthermore, achieving complete safety is neither physically feasible nor economically desirable. All that notwithstanding, this study is of the view that the core to physical planning and development policy has always been, and must continue to be, directed towards narrowing the gap between the ideal and the possible. We cannot totally mitigate a disaster but it is possible to build a safe neighborhood that will be fire free area.

# Appendix

## A national scale flood hazard mapping methodology: The case of Greece – Protection and adaptation policy approaches, 2017

The work introduces a national scale flood hazard assessment methodology, using multi-criteria analysis and artificial neural networks (ANNs) techniques in a GIS environment. The methodology was applied in Greece, the flash floods are frequent in the country and last decades it intensity has increase, causing significant damages in rural and urban area. In therefore the prone area must be identify and will help in the elaboration of the risk map. For the elaboration seven maps (parameters for calculating the flood risk) were combined in a GIS environment. These factor-maps are: the Flow accumulation (F), the Land use (L), the Altitude (A), the Slope (S), the soil Erodibility (E), the Rainfall intensity (R), and the available water Capacity (C). The name to the proposed method is "FLASERC". The flood hazard is classified in 5 categories: Very low, low, moderate, high, and very high. These parameters are combined and processed using the appropriate ANN algorithm tool. For the ANN training process spatial distribution of historical flooded points in Greece within the five different flood hazard parameters of the aforementioned seven maps were combined. In this way, the overall flood hazard map for Greece was determined.

The final results are verified using additional historical flood events that have occurred in Greece over the last 100years. In addition, an overview of flood protection measures and adaptation policy approaches were proposed for agricultural and urban areas located at very high flood hazard areas.

Inference: this article helps us to use the method FLASERC that include these parameters: flood accumulation, land use, altitude, the slope, the soil erodibility, the rainfall intensity and the available water capacity. For the elaboration of the risk map and classification of the level of vulnerability.

## What is a Blue and Green city? Published on blue green cities by KERR WOOD LEIDAL consulting engineers

Benefits of blue and green infrastructure

Floodplain dynamics

Flood peak reduction, sediment trapping and storage

Green Infrastructure

Sustainable Urban Drainage Systems (SUDS), Benefit Profile: relative contribution, Benefit Intensity: spatial/cumulative impact, Benefit Dependency: complimentary impacts

Public Perception and Behavior

Public preference for Blue and Green Infrastructures (GBI), aesthetics and amenity value, not in my backyard, Long term engagement

Cost

To accommodate water and ecology (natural approach), cost reduction of flood damage use blue-green, construction and maintenance cost, change in governance/management.

Benefits (ecosystem services)

Water supply, biodiversity, flood reduction, pollution control, natural hazards, recreational, water quality

Functions

How many functions can the BGI provide?

Water Supply, wastewater, food, energy, transport, health and social

Uncertainty

Confidence and evidence

Scientific uncertainty, socio-political uncertainty/acceptance, decision making uncertainty

Do urban green corridors work? It depends on what we want them to do. What ecological and/or social function can we realistically expect green corridors to perform in cities? What attributes defines them, from a design and performance perspective? By Diogo Borero, Kelly Brenner, Na Xtu and al.

The Barcelona City Council has published a guide for that very purposes, entitled "Urban Green Corridors. It deals with a set of 12 main criteria that need to be taken into account when designing urban green corridors in a city such as Barcelona.

| Design criteria | Goal |
|---|---|
| community | Creating ecological connectivity |
| stratification | Creating rich layers of vegetables |
| naturalization | Bringing nature to the city |
| biodiversity | Bringing diversity of plant and animal species |
| Regulatory | Maximizing urban comfort |
| Dynamic | Reflecting the evolution of nature and its cycles |

(to be continued)

| | |
|---|---|
| attractiveness | Creating landscapes that can be perceived and identified |
| Pacification/noise reduction | Bringing peace and quiet to the city |
| complexity | Bring urban social diversity |
| health | Creating therapeutic areas |
| Informative/educational | Generating and interest in nature (conservation) |
| singular | Increase the value of the city's natural and cultural heritage |

*Source: Urban Green-Corridors. Examples and design criteria. Guide published by Barcelona City Council*

Green corridor along the river is for the respiration of the river, for species, enhance biodiversity, protecting for the erosion and having a rich floodplain area.

# BOOKS

## Preparing for Flood Disaster Mapping and Assessing Hazard in the Ratu Watershed, Nepal, 2007

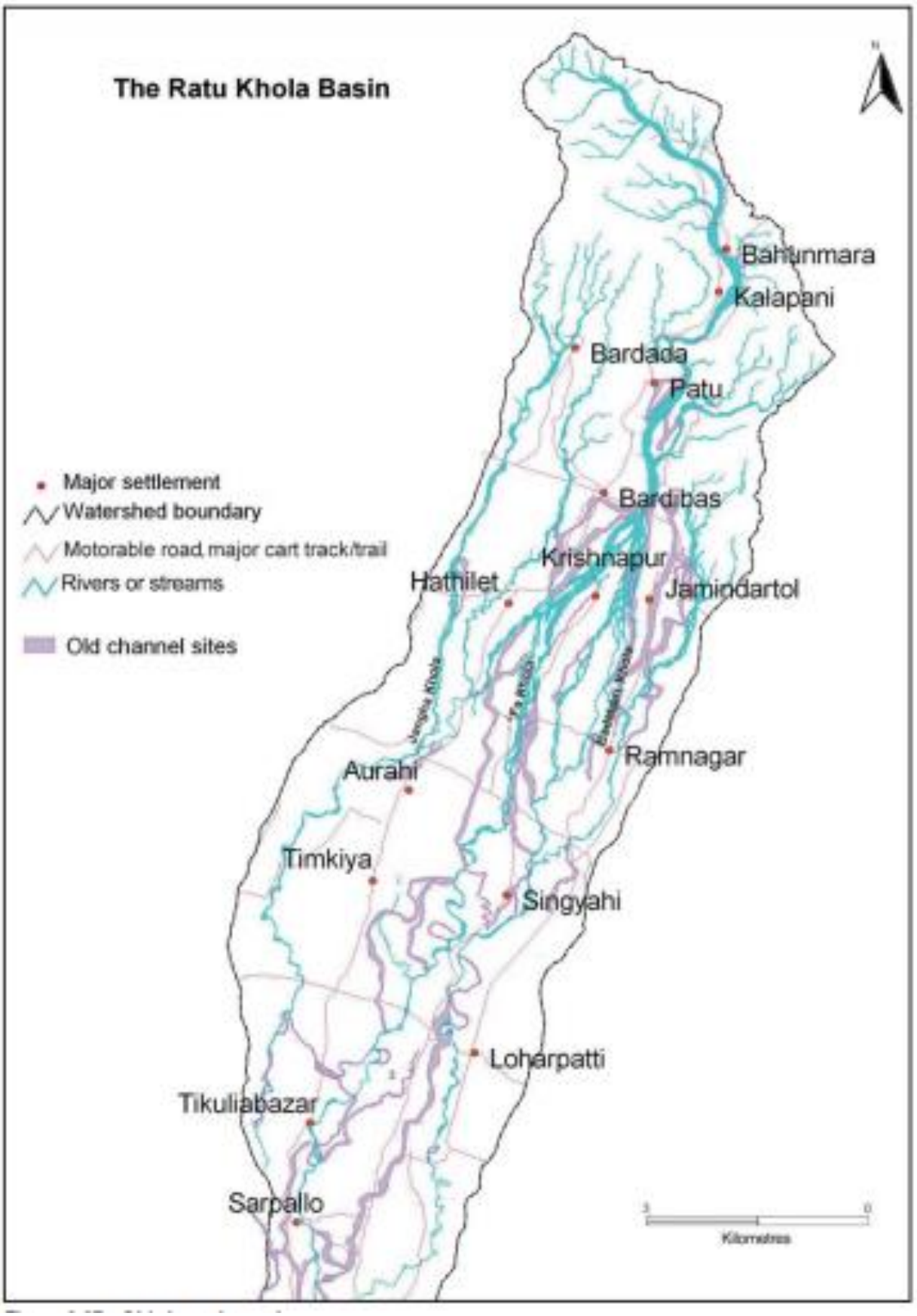
The study covers the physical, socioeconomic and environmental impact. Selected parameters are the topography, annual distribution of rainfall, magnitude and frequency of disasters, previous record of flood, cause of flood and the record damages. Land use, accessibility, population distribution in the area, income distribution, population occupation map, services (hospitals per sq. km and per people, population per bed ratio, travel time to hospitals, literacy rate, infrastructures), population growth, economic growth, income distribution, implemented strategies, policies and programmes on flood, demography, economic activity,

For mapping they used: the study area, the geomorphology map, topographic profile, temperature and precipitation graph, rainfall graph, drainage network, river network in different period, land use, population density map, level of income map,

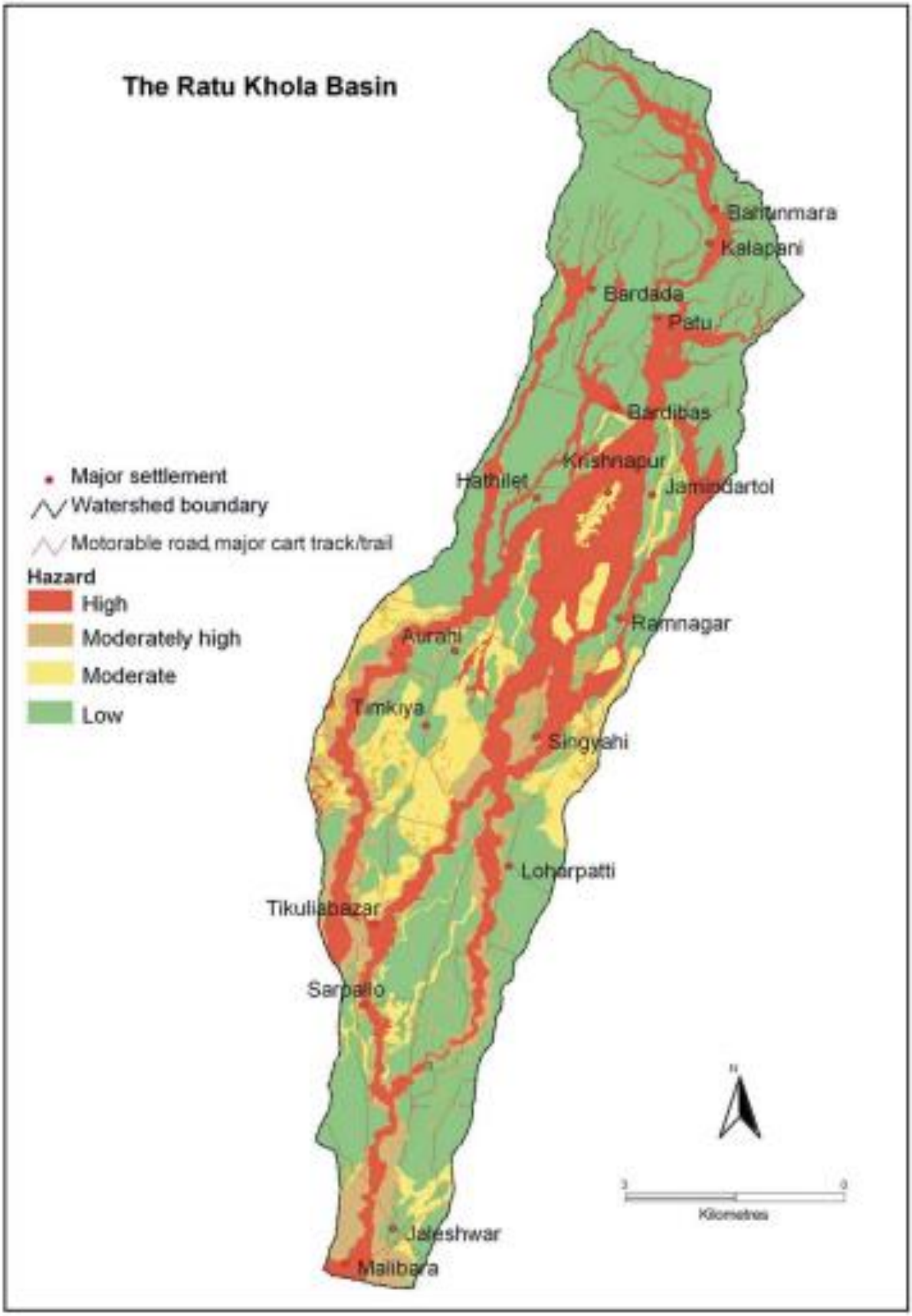
The analytical tools were GIS

Methodology for the elaboration risk map

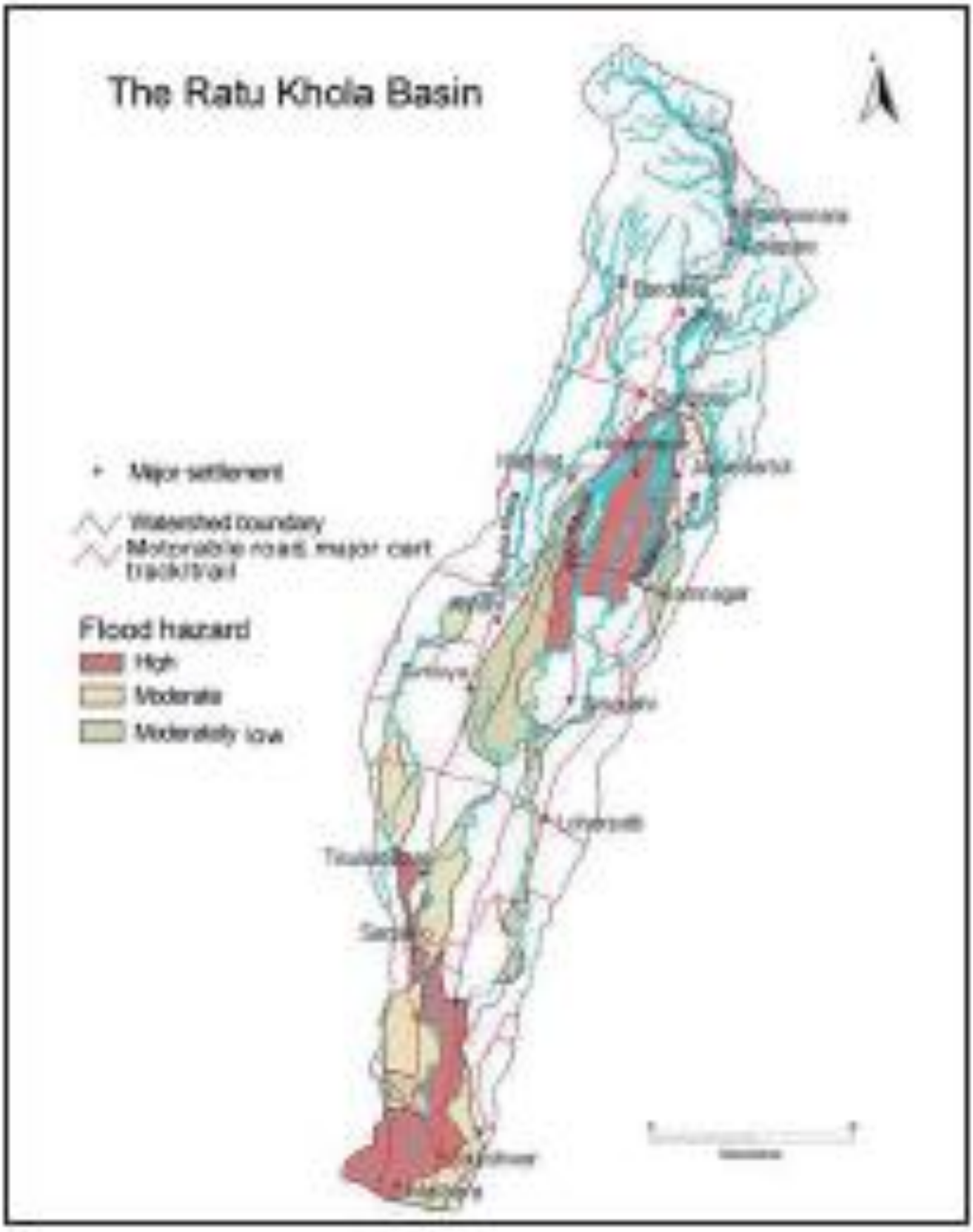
water channel



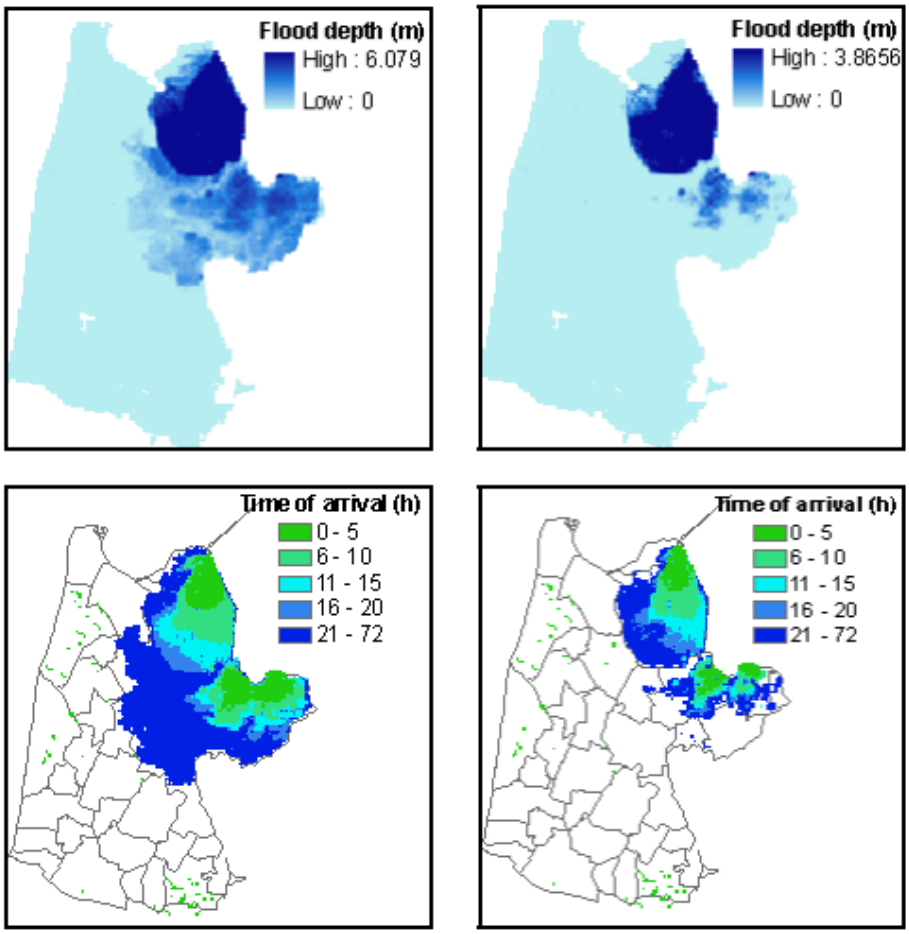

Appendix: E: River channel map



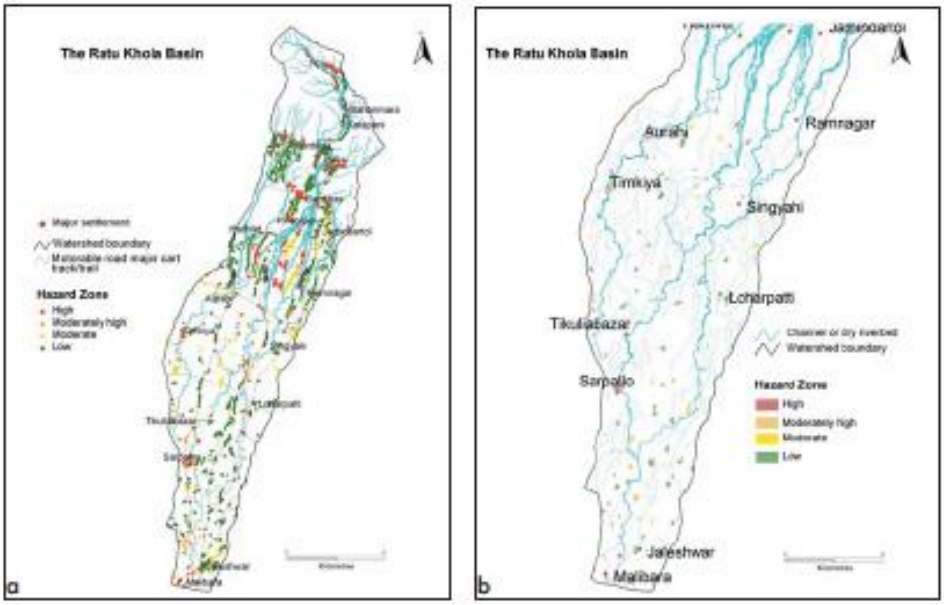

Appendix F: Flood hazard map



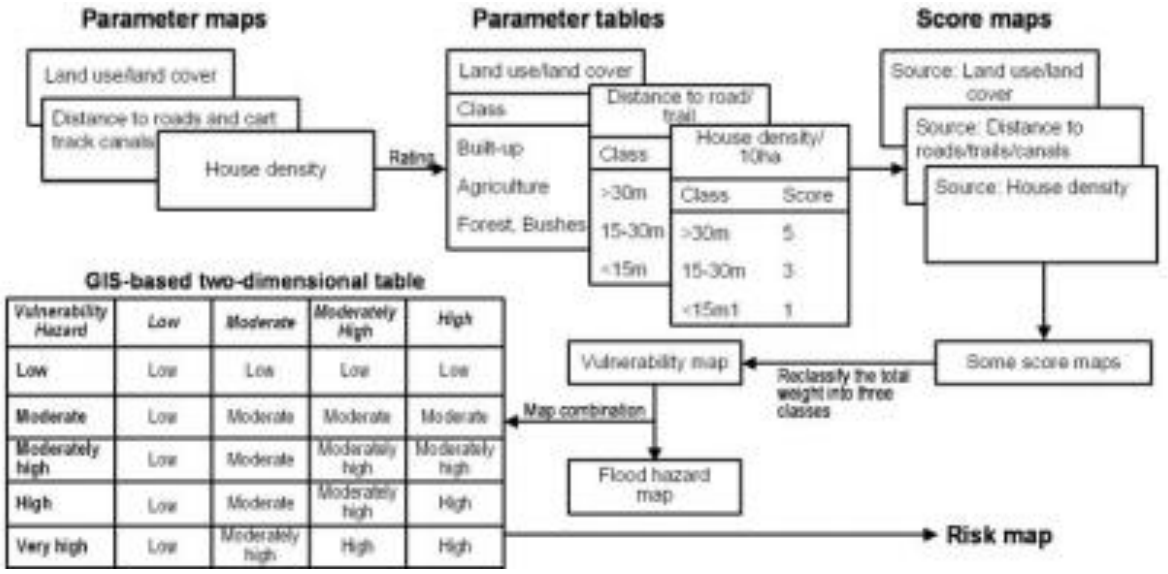

Appendix G: Flood simulation maps




Appendix H: Vulnerability and risk map




Vulnerability map (a) risk map (b)




Vulnerability and mapping scheme

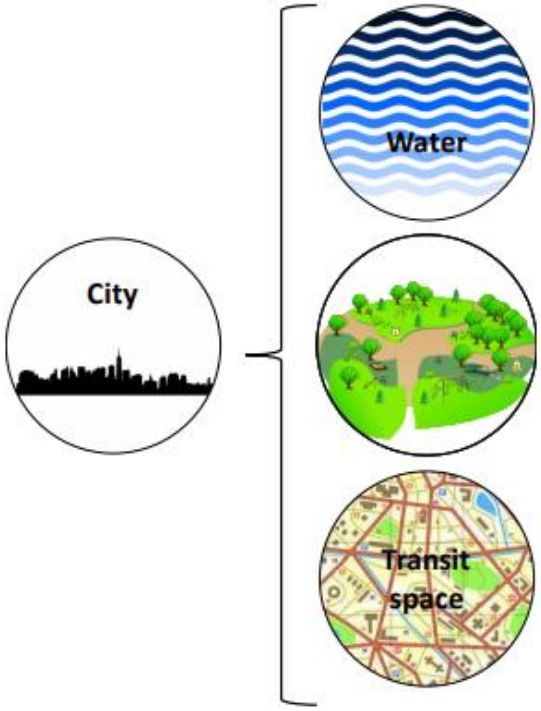
## Designing blue and green infrastructure to support healthy urban living by Danielle Van DINTHER, Ernie WEIJERS and al.

In this research authors wanted to show importance of green and blue infrastructure in quality of health of the city.

An example of urban measure to impact urban health.


Source: http://www.dutchwatersector.com/news-events/news/5312-landscape-architecture-west-8-designs-master-plan-with-ecological-water-system-for-guangzhou-china.html

A city itself can provide basic health conditions for its habitant, these condition include clean air, low noise pollution. It can also provide incentives for healthy living like swimming opportunities, green space as garden, meeting place or can be an urban farming place. The incentive use depends on the lifestyle of or individual behaviour to improve personal health.




Infrastructure that consist the city are water/blue infrastructure, green spaces/green infrastructure and physical infrastructure/grey infrastructure.

<u>Impact of blue and green infrastructure on healthy urban living</u>

a. Water regulation

Impact of green infrastructure on water regulation.

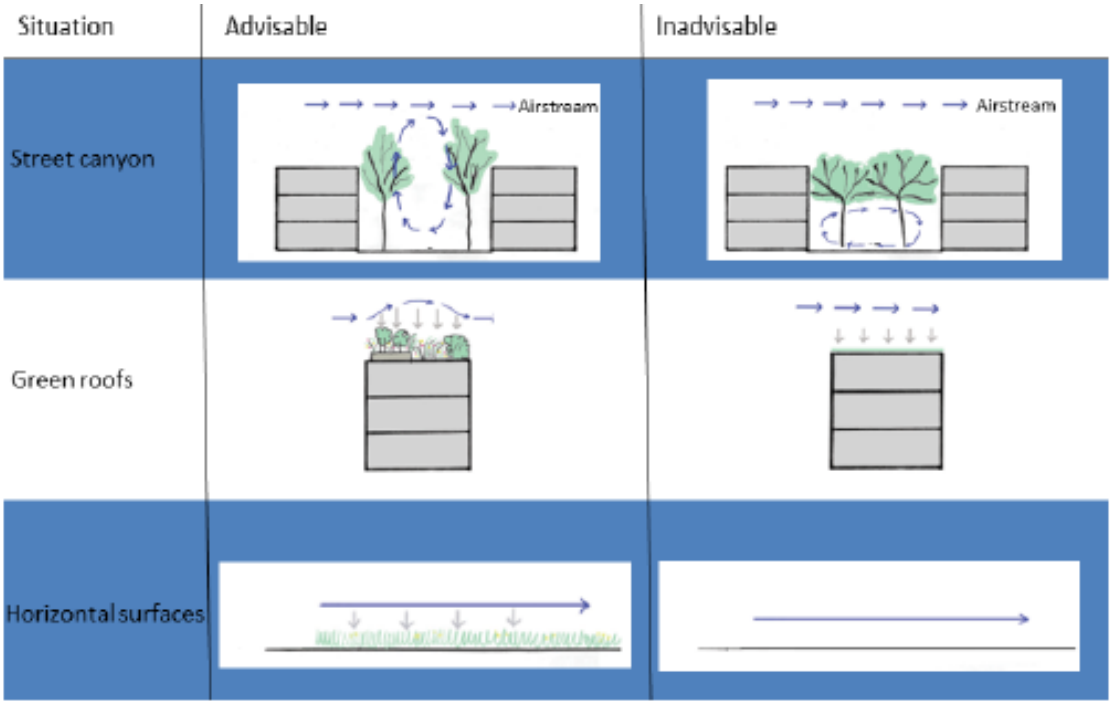
Ground water storage, runoff of water in the urban area, natural storm water drainage system and prevent flood, filtrate water, evaporation.

b. Air temperature regulation

It reduces urban heat island effect and heat stress by acting like a cooler, reducing solar radiation and providing shadow. It is effective by planting trees along streets, making street gardens, parks.

c. Air quality regulation

Increase in deposition of pollutants, altering the wind flow, emitting biogenic volatile compound and pollen, low emission of $CO_2$ due to shading.




Source: vries et al 2015

d. Noise reduction

Trees place in buffer zone act as natural sound barrier especially for traffic, reduce wind speed

e. Mental health

The contact of human and environment reduce the level of stress, which leads to the reduction of healthcare cost and increase productivity of people, it can also have a therapeutic effect on human

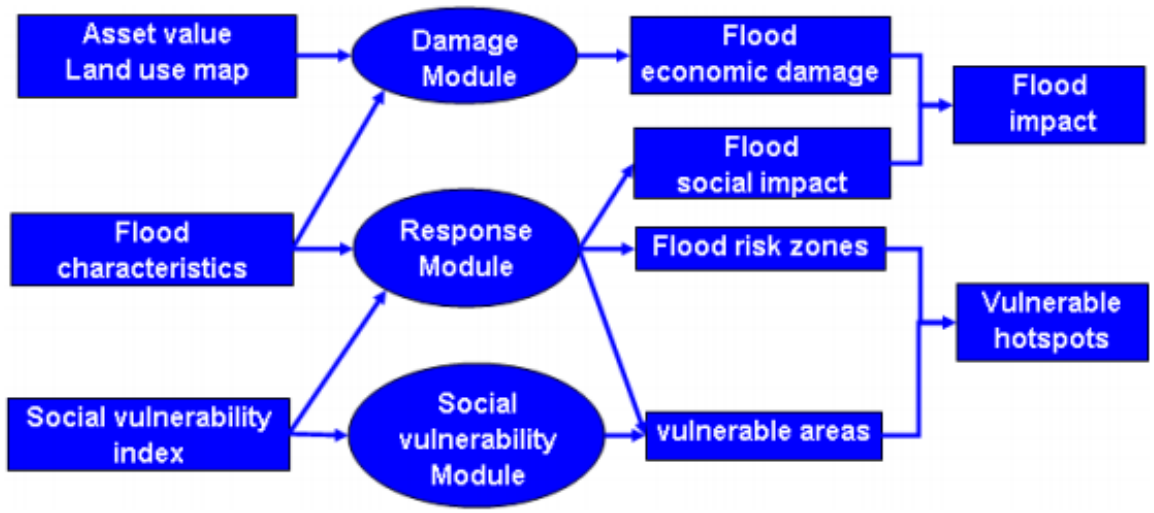
f. Impact on social interaction and physical exercise

Green spaces like garden occasion social interaction, it pushes people to use sustainable transport mode that are cycling and walking for the last mile connectivity, it also stimulate physical activity for children and adult and have a positive effect on families.

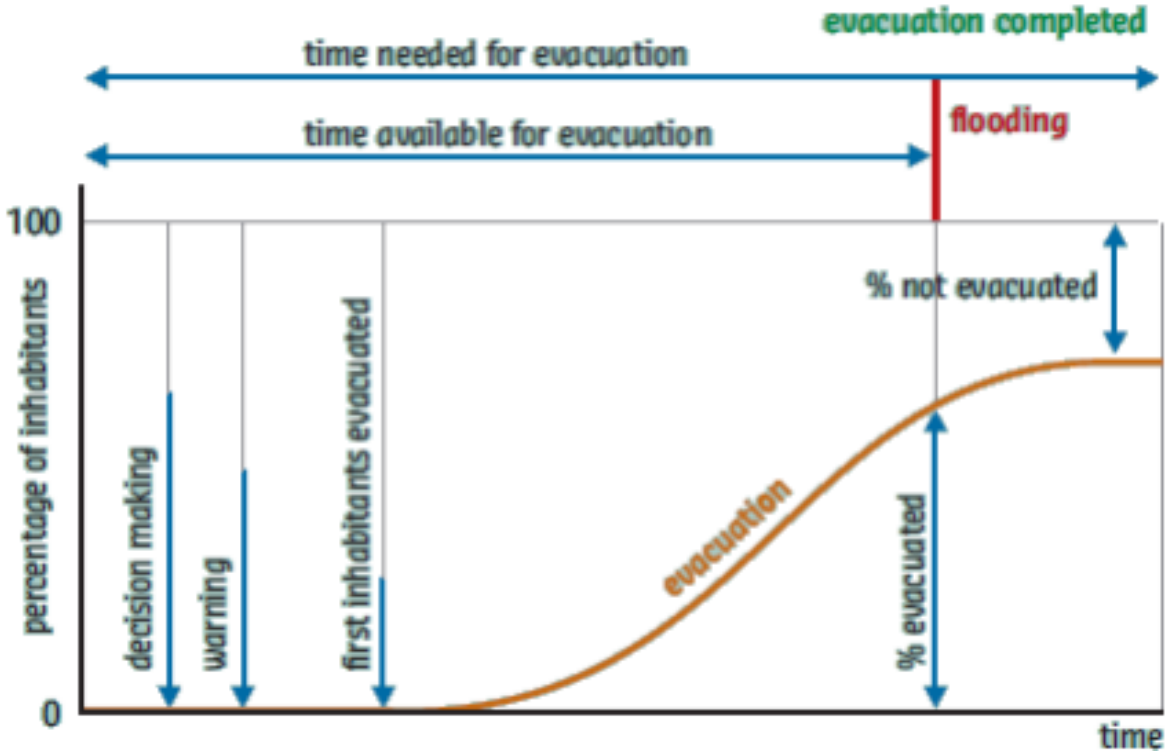
# THESIS PROJECT

## A function-oriented methodology of flood vulnerability assessment by Zhen Fang, 2009

This study was focus only on the social vulnerability index, for elaborating the vulnerability index the author uses these parameters: physically-vulnerable people, female, people without cars, financially vulnerable group, ethnics' minorities. They used the FVI model.



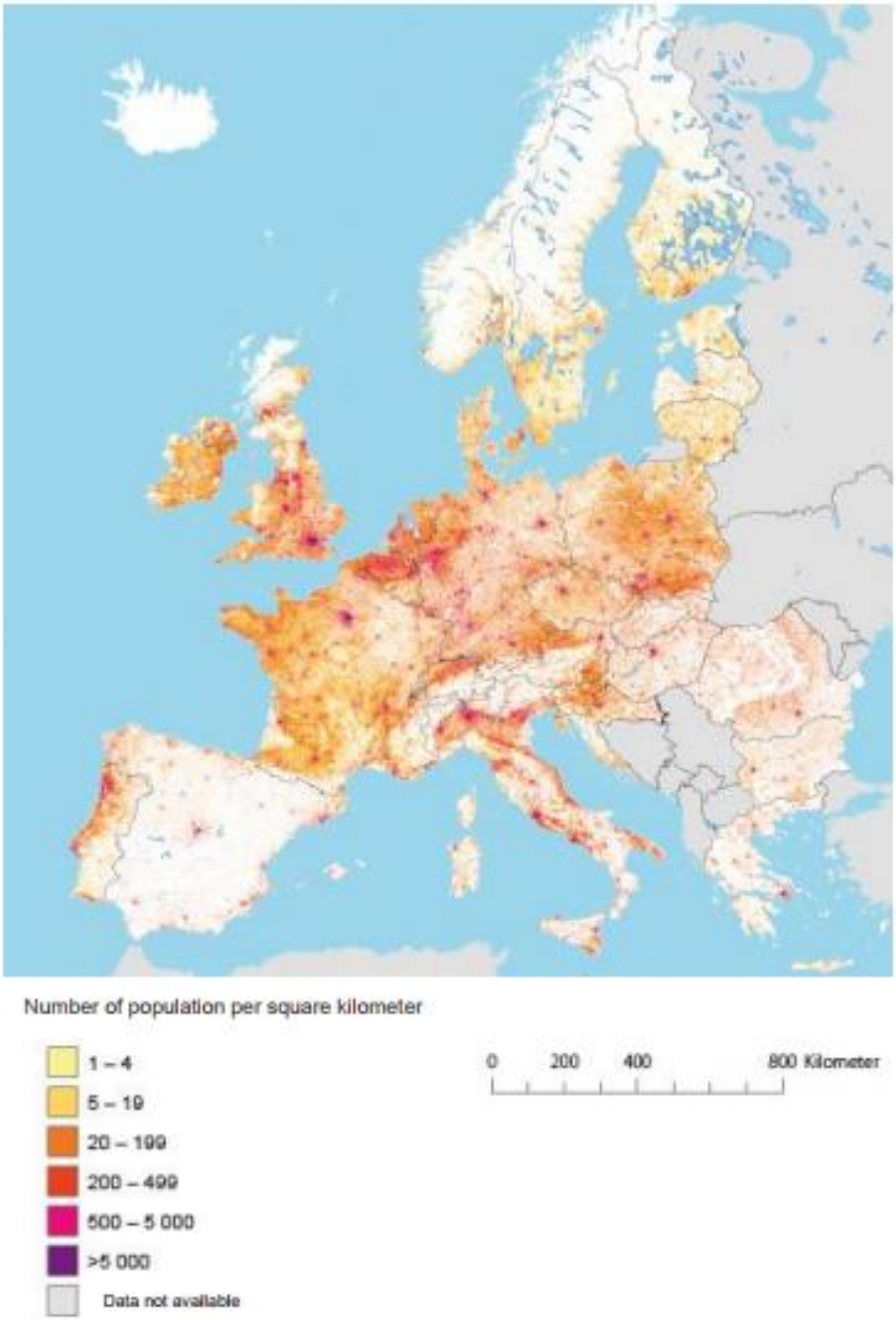

Fvi model




Response module

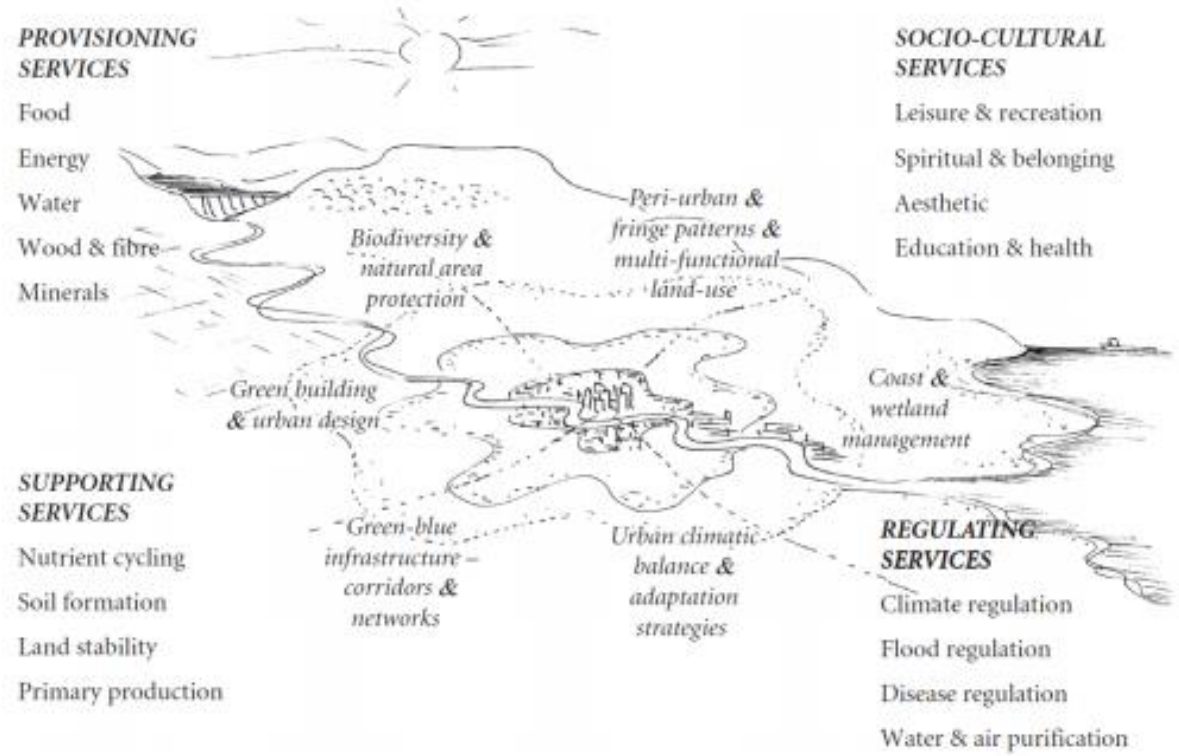
Design to Promote Urban Ecosystem Services Examples of solutions with green - blue infrastructure in public spaces by Xing YIN 2017

The aim of the study was to design solutions that can be used as inspiration and guidance to promote urban ecosystem services through green-blue infrastructures in built environments at different scales.




Source: population density. Source from SCB, 2014a

The map above shows the population density and the level of urbanization, it means that with the city growth, the country is losing its urban space. With climate change and all problems our cities already faced there is an urgent need to promote green and blue spaces in urban area and increase the accessibility and availability of nature in built environment.




Urban ecosystem services. Four main types of ecosystem services with urban and peri-urban responses, sources: MA, 2015; Douglas & Ravetz, 2013.

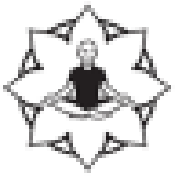
Urban ecosystem services from TEEB, 2011; Traff, 2015

| Ecosystem service | Icon | Description |
|---|---|---|
| Provisioning services: Ecosystem services which describe the material or energy outputs from ecosystems. | | |
| Cultivable land |  | Ecosystems provide the conditions for growing food such as cultivable land, urban horticulture and urban farming. |
| Natural resources |  | Timber and other wood, wild animals and wild plants, medical resources, forest biofuel which are directly derived from wild and cultivated plant species. |
| Fresh water |  | Inland bodies of water, groundwater, groundwater and surface water for household, industrial and agricultural. Vegetation and forests influence the quantity of water available locally. |
| Regulating services: The services that ecosystems provide by regulating the quality of air and soil or providing flood and disease control, etc. | | |
| Water regulation |  | The influence of ecosystems on water flows, flood and aquifer recharge. |
| Waste-water treatment |  | Ecosystems such as wetlands filter effluents. Through the biological activity of microorganisms in the soil, most waste is broken down. Thereby pathogens (disease causing microbes) are eliminated, and the level of nutrients and pollution is reduced. |
| Microclimate regulation |  | Trees and green space lower the temperature in cities whilst forests influence rainfall and water availability both locally and regionally. |

(To be continued)

| | | |
|---|---|---|
| Carbon sequestration and storage |  | The ability of ecosystems to absorb or store greenhouse gases from the atmosphere |
| Air quality regulation |  | The ability of ecosystems to change air quality by removing pollutants from the atmosphere. |
| Pollination |  | Insects and wind pollinate plants which is essential for the development of fruits, vegetables and seeds. Animal pollination is an ecosystem service mainly provided by insects but also by some birds and bats. |
| Biological control |  | Incidence of pests and diseases in crops and livestock that ecosystems can control. |
| Erosion prevention and maintenance of soil fertility |  | Soil erosion is a key factor in the process of land degradation, desertification and hydroelectric capacity. Vegetation cover provides a vital regulating service by preventing soil erosion. Soil fertility is essential for plant growth and agriculture and well-functioning ecosystems supply soil with nutrients required to support plant growth. |
| Supporting services: These services underpin almost all other services. Ecosystems provide living spaces for plants or animals: they also maintain a diversity of plants and animals. | | |
| Habitats for species |  | An area with natural or semi-natural characteristics are important for the populations of species. It also have a protective effect on the ecological communities to recovery from disruptions. |
| Maintenance of genetic diversity |  | Genetic diversity (the variety of genes between, and within, species populations) distinguishes different breeds or races from each other, providing the basis for locally well-adapted cultivars and a gene pool for developing commercial crops and livestock. Some habitats have an exceptionally high number of species which makes them more genetically diverse than others and are known as "biodiversity hotspots:. |
| Cultural services: These include the non-material benefits people obtain from contact with ecosystems. They include aesthetic, spiritual and psychological benefits. | | |
| Recreation and mental & physical health |  | The pleasure as well as mental and physical health that humankind gets from natural or artificial ecosystems. |

(To be continued)

| | | |
|---|---|---|
| Tourism |  | Ecosystems as a function for the travelling visitors. |
| Cultural values |  | The ability of ecosystems to contribute to the spiritual, religious, aesthetic or other values to humankind. |

Main principles of green-blue infrastructure planning (Modified from Li 2008; Pauleit et al., 2013)

| Principles | Planning and management of urban green-blue infrastructure need to: |
|---|---|
| Multi-functionality | ✓ Consider a broad suite of ecosystem services: abiotic, biotic, and cultural.<br>✓ Consider combining different functions/uses whenever possible: multiple function of single greenspace, interconnected green structure, and integrated structures.<br>✓ Prioritize among functions/uses and set up clear goals through comprehensive analysis and stakeholder involvement.<br>✓ Conduct monitoring to learn which functions are operating as expected, in a learn-by-doing adaptive manner.<br>✓ Improve awareness of the multifunction of green-blue infrastructure through communication and public participation/education. |
| Connectivity | ✓ Consider physical and functional connections between green spaces at different scales and from different perspectives: e.g. recreation, biodiversity, urban climate, storm water management, etc.<br>✓ Base green-blue infrastructure planning on thorough analysis of the urban green space and water resource and their functions |
| Integration | ✓ Consider integrating and coordinating urban green-blue infrastructure with other urban (infra) structures in terms of physical and functional relations (e.g. built-up structure, infrastructure, water system).<br>✓ Create beneficial relationships through communication and negotiation between different professions, administrations, and other actors. |
| Communicative and social inclusive process. | ✓ Attempt to meet the needs and interests of all stakeholders.<br>✓ Involve stakeholders in decision-making through coordination, cooperation between different professions, sectors at different levels, between public sector and private sector, and public participation. |

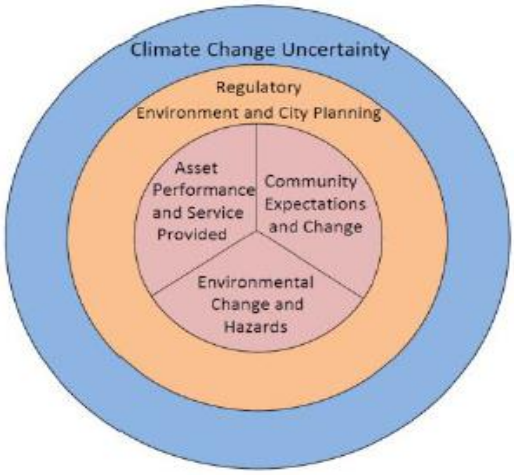
(To be continued)

| | |
|---|---|
| Long-term strategy | ✓ Adopt the sustainable development concept, considering long-term benefits instead of short-term economic gains.<br>✓ Consider multiple uses, interactive structures, and balance between different stakeholders' interests, which will help achieve a long-term goal.<br>✓ Allow adaptation through ongoing learning and discussion between different actors. |

# PROJECT

## Blue and Green cities: Scientific uncertainty and lack of confidence as barriers to wide adoption of Blue-Green infrastructure a case of Oregon, Portland

In this research, authors work on Green and Blue infrastructure and grey infrastructures (drainage, pipe, tank, treatment plant), on the flood risk management. It helps the community on resiliency, it affected infrastructure performance and service provision.
Green and Blue infrastructures and grey infrastructure are interdependent for an efficient flood risk.

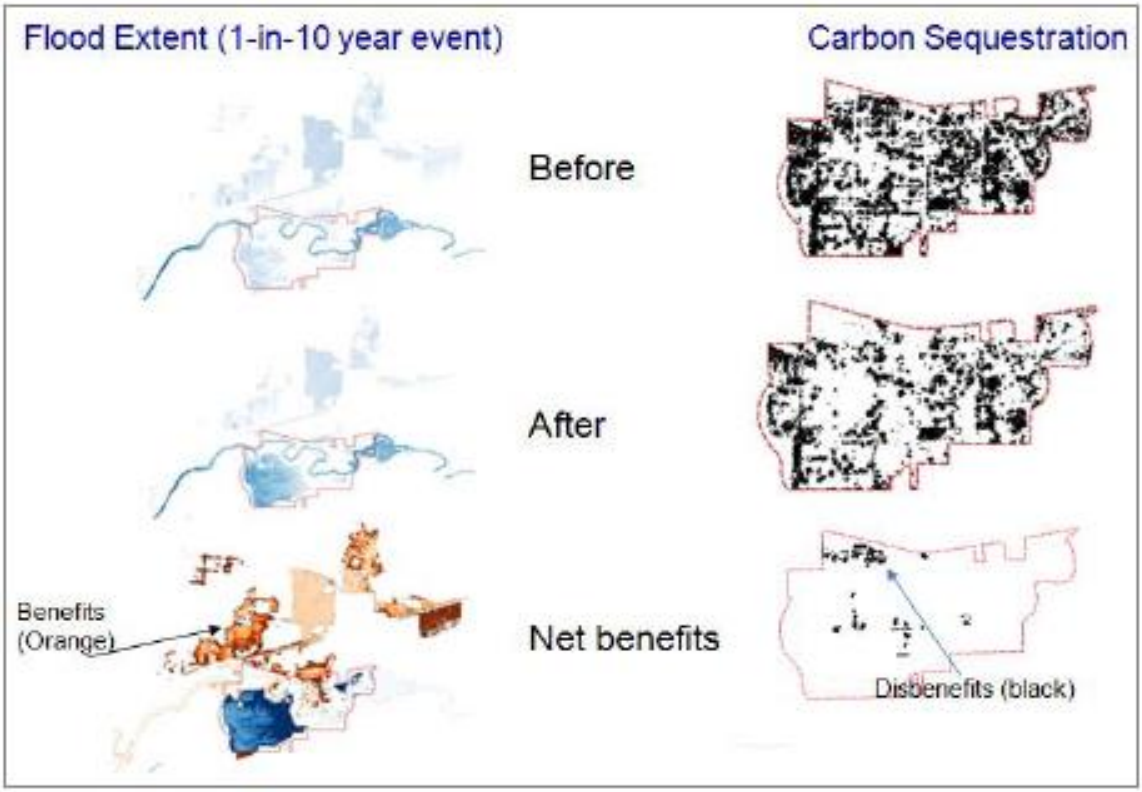



Factors that affect the adoption of Green and Blue infrastructure

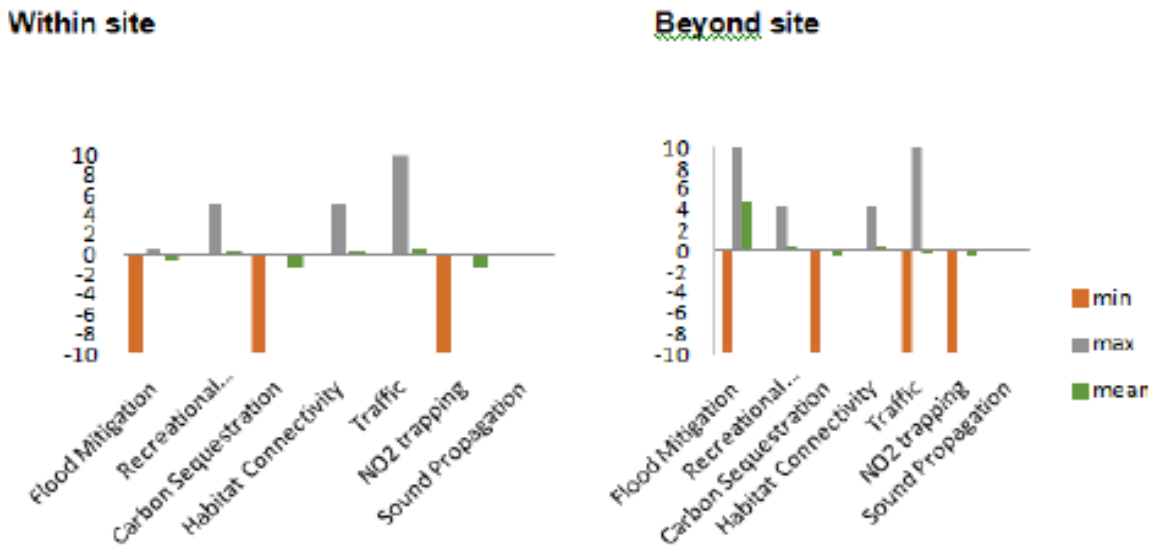
## Green Infrastructure Evaluation Benefit Intensity, Benefit Profile and Benefit Dependencies a case of Oregon, Portland

In this project one of the actions taken was the restauration of the flood plain area.

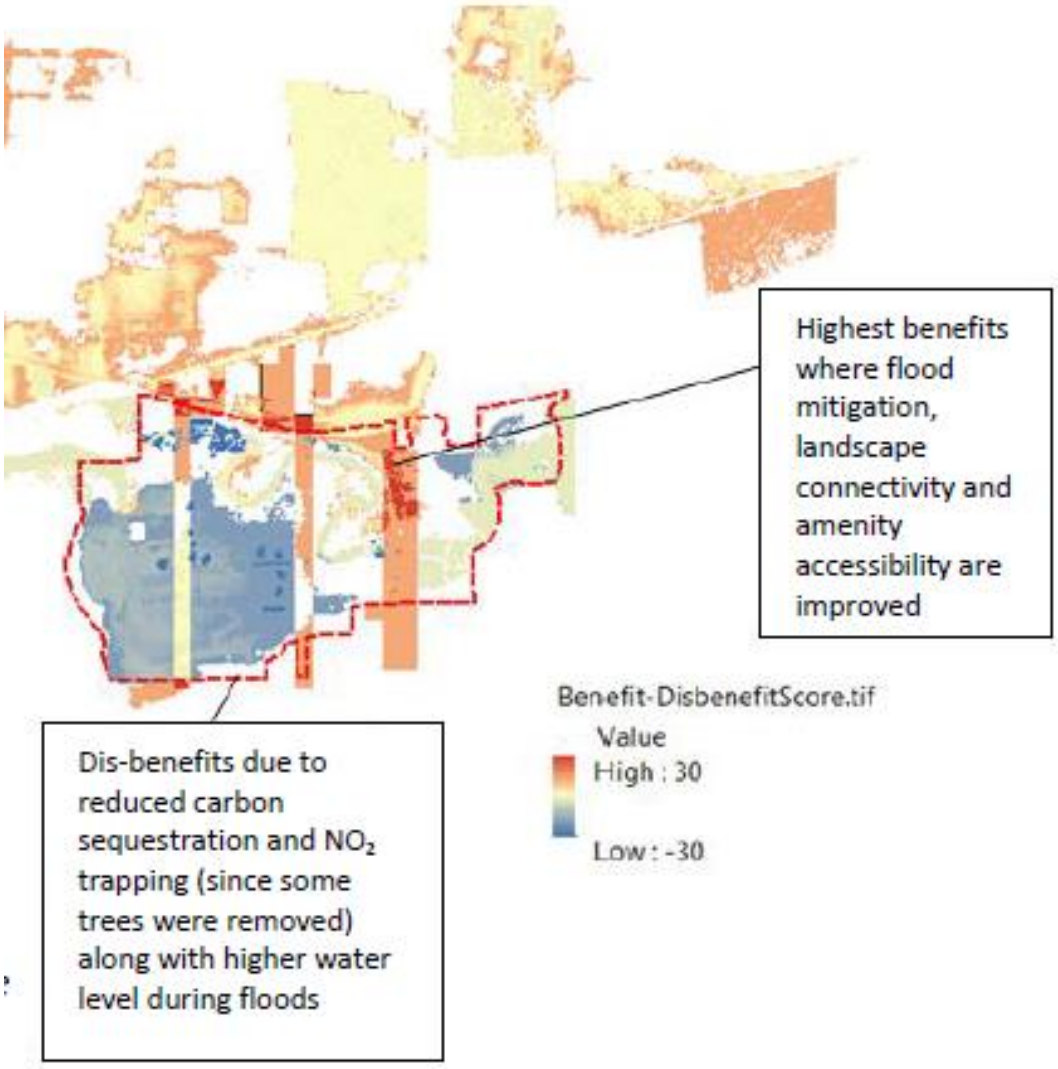

A green infrastructure project in East Lents, Portland, Oregon




Distribution of flood mitigation and carbon sequestration benefits




Benefit profile comparing normalized benefit within and beyond the site




Green and Blue Space Adaptation in Urban Areas and Eco Towns (GRaBS), 2010

Climate change will make cities hotter and drier in summer, and wetter in winter. Effects will be more dramatic in these cities that already suffer from Urban Heat Island effect and poor drainage system [Climate Change Adaptation 'by Design' guide (originated from a partnership with University of Manchester in the ASCCUE project)]
Risk and vulnerability assessment tool used are: google map, flood risk map/climate change, partner socio-economic and demographic data, hyper linked information and local updates.
Value of green and blue spaces

- Natural cooling to mitigate the urban 'heat island'
- Space for sustainable urban drainage/water storage to absorb excess rainfall
- Creation of natural areas for recreation, exercise, social meeting
- Urban gardening and allotments
- Healthier, happier people!
- First exposure of urban dwellers to biodiversity
- Unused land can create green corridors such as disused railway lines
- Vegetation to reduce the effects of air pollution, store carbon, increase permeability
- Habitat preservation and sustainable ecosystems
- Places for species to migrate and adapt to the effects of climate change
- Healthier, happier people!

Value of biodiversity

- Trees and plants in cities have a cooling effect through CO2 absorption and shading
- **Green routes** through unused land (railtracks) reduce pollution, increase exercise
- More natural vegetation, more flood and drought resilience
- Natural planned and planted flood areas for play and recreation
- Improved air quality
-

Proposal for improvement of Green and Blue spaces

Blue-Green cities, Prof. Colin Throne, School of Geography, University of Nottingham

The aim of the project was to mitigate flood disaster by including grey and blue-green infrastructure. For this project, tools used were: CityCAT and GIS.
The project will affect the flooding from rivers, surface water or the sea; coastal erosion; overheating; storm damage; poor air quality.

The strength of the project are:

By increasing the resiliency it will have an economic benefit and social benefit and will reduce the expenditure on recovering and responds, it will increase the awareness and it will lead to a sustainable environment

The challenges are:

To link health and well-being with built environment, the availability of data for making projections of disaster in urban areas.

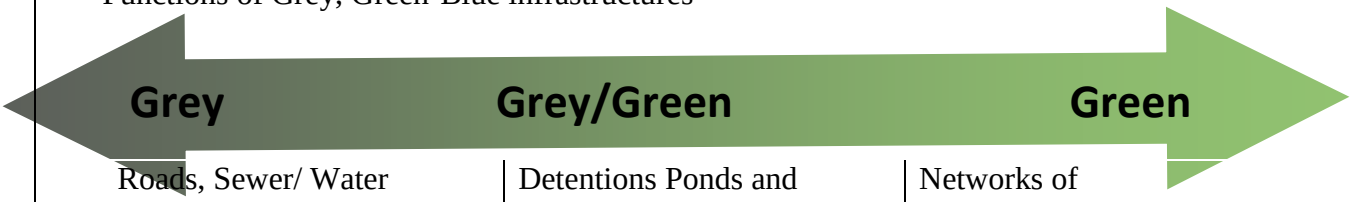
Opportunities is:

To inform stakeholders with up-to-date and useful scientific information, to include local agencies (urban planning department, emergency response, housing, social and health agencies), central government, utilities companies, neighbourhood communities, consultancies/businesses, building designers, schools, universities and researchers.

## Blues-Green Cities by Holland water challenge a case of Indonesia

Today, already half of the world's population lives in urban areas. Continuing population growth and urbanization are projected to add another 2.5 billion people to cities around the world by 2050, 60% of population in Asia live in urban area. The impact of urbanisation are to: 1) create opportunities for people to improve their lives, find jobs, earn money, get education, trade goods, have access to water and power, get health care, etc. 2) provide solutions on problems and challenges that are to provide all these people with transport, housing, food, energy, water, sanitation, education, etc.

Functions of Grey, Green-Blue infrastructures




| Grey | Grey/Green | Green |
|---|---|---|
| Roads, Sewer/ Water Pipelines<br><br>Centralized treatment<br>Collect and channel runoff<br>High impact | Detentions Ponds and Holding Tanks<br><br>Slow release into sewer system<br>Volume pick rate reduction | Networks of wetlands/Floodplain Restauration<br>Allow infiltration<br>Evaporation<br>Transpiration<br>Enhanced water quality<br>Reduced erosion/sediment<br>Restauration<br>Minimal impact |

Examples of blue-green infrastructure are permeable paving, rain gardens, constructed wetlands, parks and gardens, planted drainage assets (green roofs, green walls), bio retention systems, controlled water storage areas (e.g. car parks, recreational areas), etc.

The key functions of Blue-Green infrastructure components include water use/reuse, water treatment, detention and infiltration, transport, evapotranspiration, local amenity provision and generation of viable habitats for local ecosystems.

The resulting benefits are many, such as better management of storm water, conservation of water resources (increasing the resilience to drought), water pollution control, public well-being (recreational water use, parks and recreation grounds), support climate change adaptation and mitigation, healthier soils and reduction in soil erosion, avoided impacts of flood events, etc.

The Challenge: Blue-Green Cities in Indonesia

Indonesia is no exception to the global urbanisation trend: the percentage of people living in urban areas has increased from just 31% in 1990 to 53% in 2014 and projected to increase to 71% by 2050. In absolute terms that's almost 135 million people living in cities in 2014 and 228 million in 2015. There are 11 cities with more than 1 million people, 27 cities with more than 500,000 people and 83 cities with more than 100,000 people.

Indonesian cities face many of the same challenges of other growing cities around the world as they struggle to absorb the large inflow of people, provide the necessary infrastructure and services and divide benefits equally among citizens.

## Blue and Green Corridors - A comparison of Two Cities by Institute Urban Ecology Project of Biology and Applied Ecology by Allison Tischler, Adrienne Paquette and Colton Claborn

The two cities chosen for comparison of their influence in restoring natural corridors are Freiburg, Germany and Toronto, Canada. In their own respects, each city has many differences and similarities, yet both have found it a concern to improve upon its ecological footprint.

The benefits of Green and Blue corridors can be seen in many sectors in urban planning. Those benefit are:
Climate change, biodiversity conservation, reduced energy consumption, quality of life improvement, economic contribution and natural disaster mitigation.

Climate change
Each city has to adapt itself to the climate change, of which natural corridors form a small but critical part.
Biodiversity conservation
Human activities has strongly affect the aquatic life and vegetation that leads to the reduction of narrative species in some areas. By planting narrative plant species, restoring rivers and green area, we can bring back local species.
Reduce energy consumption
The local government develop a method that consist of take to account the topography of the city (slop) for the location of the treatment plant. The gravity reduces the energy used for pumping rain water to the treatment plant.
Quality of life improvement

Green and blue corridors find their source in local ponds, rivers, and parks. Those are leisure areas for citizens encouraging walking and cycling, and providing better living conditions that promote health for both mind and body.

Economic contribution

Green and blue corridors add aesthetics values to the city, prevent flood, make an eco-friendly neighbourhood and promote last mile connectivity the leads to the reduction of transportation costs.

Natural disaster mitigation

Due to climate change and global warming, extreme weather is increasing causing damage and loses. Permeable pavement is also highly recommended.

## CONCLUSION

In this study, literature review and case studies are basically used to define some statements, to elaborate indicators for assessing the vulnerability such as flood map of the city, land use, population, population distribution, public awareness, accessibility, open spaces, institutional buildings, etc. in order to understand to understand the importance of green and blue corridor in the mitigation process of flood in urban area. Theoretical and practical research indicate that they are important for:

- Floodplain dynamics: Flood peak reduction, sediment trapping and storage.
- Green Infrastructure: Sustainable Urban Drainage Systems (SUDS).
- Public Perception and Behavior: aesthetics and amenity value.
- Cost reduction: flood damage, construction and maintenance cost, change in governance/management, favorite the reduction transportation cost.
- Benefits (ecosystem services): water supply, biodiversity, flood reduction, pollution control, natural hazards, recreational, water quality.
- Health and social.
- Water regulation: Ground water storage, runoff of water in the urban area, natural storm water drainage system, filtrate water, evaporation.
- Temperature and air quality regulation.
- Noise reduction.
- Mental and physical health: it has a therapeutic effect on human, increase social interaction and physical exercise.
- Transportation: it promote cycling and walking for the last mile connectivity.
- Climate change: natural corridors form a small but critical part.

## TIME SCALE

| | January | February | March | April | May | June | July | August |
|---|---|---|---|---|---|---|---|---|
| Background study | | | | | | | | |
| Literature review | | | | | | | | |
| Methodology | | | | | | | | |
| Research proposal elaboration | | | | | | | | |
| Tools and indicators/parameters | | | | | | | | |
| Data collection | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Data analysis | | | | | | | | |
| Submission of the 1st draft | | | | | | | | |
| Discussion and conclusion | | | | | | | | |
| Further drafts | | | | | | | | |
| Final meeting | | | | | | | | |
| Final draft | | | | | | | | |

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