

Flood Risk in Niamey

Lesson Objectives

- Demonstrate how GIS can be used to assess the flood risk in Niamey, a Sahelian village in western Niger
- Show how maps of flooded and floodable terrain can be used in decision-making

Geographic Information Systems

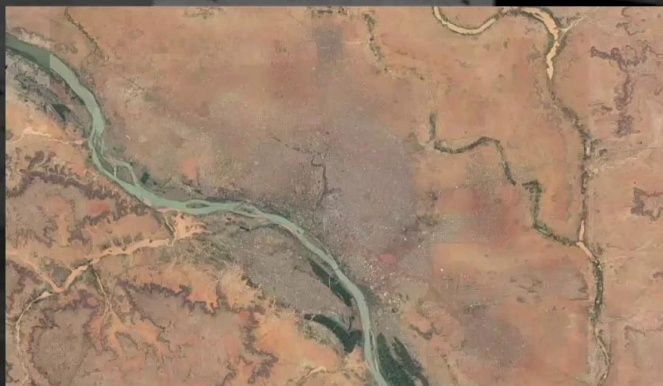
Hello and welcome to this lesson which focuses on flood risk mapping in Niamey, Niger. This lesson, which is a case study, shows how to use the GIS to map the flood plains in order to make decisions on the town planning. Indeed, the recent and recurrent floods of the last 15 years have resurrected in the memory of the inhabitants of Niamey, a Sahelian region, the risks of flooding. Thus, the only logical explanation for the increase in flooding must be sought in the increasing vulnerability of populations to the Niger river overflowings and the runoffs after torrential rains, especially in urban extensions close to the banks of the river. This lesson is based on the analysis of hydrometeorological mechanisms and human occupation. But this study does not allow to address the problem of the floods in Niamey in all its facets. However, it helps to propose to the competent authorities some cartographic tools that can guide them towards a better management of the flooding risk. This lesson aims to illustrate the use of geographic information systems for the spatial assessment of flood risk in Niamey, a Sahelian city of the extreme West of Niger, on one hand, and to exploit the flood plain maps as tools for decision-making on the other hand. What are the main sections of this lesson?

Notes

Summary



Niamey



- Population of 1'300'000 (2011)
- Area of 240 km², and an elevation that ranges between 180 and 250 m
- More developed left bank is composed of 4 districts and is located on a 220m plateau overlooking the river
- The fifth district is located on the right bank on a floodplain with a 200m elevation

Geographic Information Systems

To start with, we must first remember that Niamey is the capital of Niger. The city of Niamey, located in the extreme West of the country, with approximately 1,300,000 inhabitants in 2011, extends over an area of 240 kilometers at altitudes ranging from 180 to 250 meters. It is cut in two by the river Niger, which has shaped the development of the urban and peri-urban fabric. We can distinguish a left bank more developed than the right bank. The left bank which houses four districts is a plateau that overhangs the river at an average height of 220 meters and cut by numerous talwegs, the most important of which is that of Gountou Yéna, in the North-South direction. As for the right bank where the commune 5 is, it is an alluvial plain with an average altitude of 200 meters. The physiographic characteristics of the city of Niamey and the various associated human and economic issues show that floods are mostly directly linked to the strong human growth of the last 30 years. Indeed, the population growth and the development of socio-economic activities have led the city to expand into flood-risk areas. Thus, since the early 1970s, Niamey has been developed on the right bank of the river and the urbanization of this particularly exposed site is currently continuing.

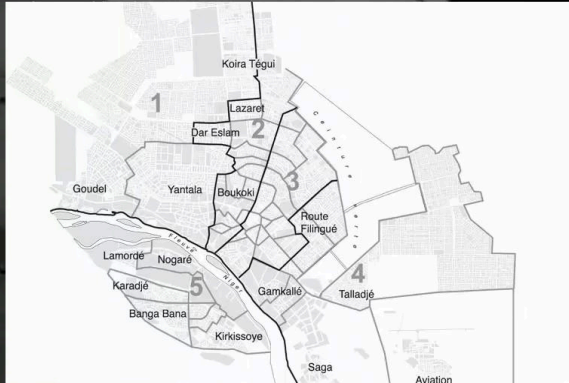
Notes

Summary



2m 08s

Niamey



- Population of 1'300'000 (2011)
- Area of 240 km², and an elevation that ranges between 180 and 250 m
- More developed left bank is composed of 4 districts and is located on a 220m plateau overlooking the river
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Geographic Information Systems

On the left bank, the former districts of Goudel and Saga, which are very vulnerable, are densifying and spreading by new building plots. The spatial assessment of the flooding risk by crossing of the hazard and the vulnerability of the stakes allows to map the areas at risk of flooding in the city of Niamey.

Notes

Summary



3m 46s

The Flood Problem in Niamey



- Riverbank overflow causes important losses and devastation in terms of:
 - People
 - Infrastructures and goods
 - Environment
- Occur with growing frequency – undoubtedly a consequence of climate change
- Protective measures and risk management are being actively discussed

Geographic Information Systems

Floods are natural disasters causing damage to people every year, including the deaths of hundreds of millions of people, damage to the environment and destruction of goods and infrastructure estimated at billions of CFA francs. The frequency of floods has been increasing in the world over the last few years, probably in relation to climate change. This subject is therefore topical, and deserves to be considered for a better management of the flood risk.

Notes

Summary



4m 16s

The Flood Problem in Niamey



2008 flood in Niamey (Ali & Trebossen ,2009)

High frequency of floods in Niamey

- Most recently:
1998, 2002, 2003, 2007, 2008, 2010, 2012 and 2013
- Consequences :
many casualties, population displacement and relocation, infrastructure destruction, etc.

Geographic Information Systems

The floods in the sahelian regions have become increasingly recurrent and Niger is not spared. In recent years, Niger has experienced an excess pluviometry with torrential rains causing unprecedented flooding in practically all parts of the country including Niamey, the capital. The protective dikes in Niamey, about five meters high, on the right bank have been totally submerged during the last flood. These floods cause many deaths, population displacement and rehousing, destruction of habitats and fields.

Notes

Summary



4m 50s

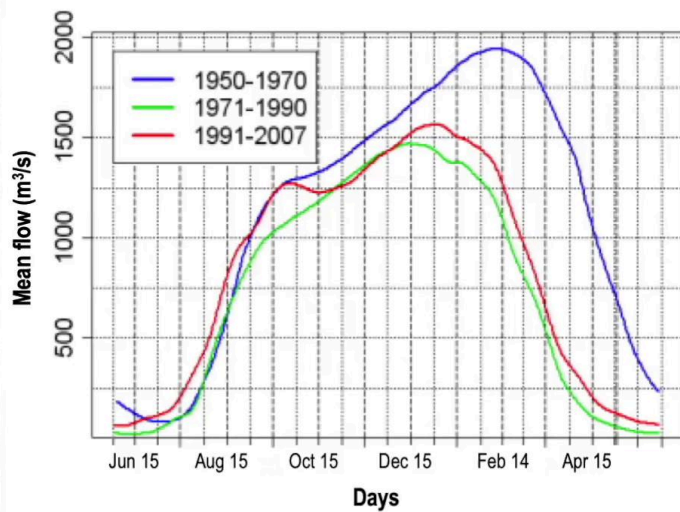
The Flood Problem in Niamey

Causes

Hydrologic regime

- Two seasonal floods
 - ➔ "Malian" flood (December-January) originating in the upper basin
 - ➔ Local flood during the rainy season
- The local flood has become more and more important in recent years

The latter is the cause of frequent floods occurring in rainy seasons



Daily flow rate in Niamey

Geographic Information Systems

The hydrology of the Niger river in Niamey is well known thanks to the Niamey measurement station installed since 1928 and regularly followed since 1944. The hydrological regime has two floods. There is the malian flood which takes place from December to January from the top of the basin and the local flood that occurs during the rainy season. Over the last years, the local flood has become increasingly important as you can see on the graph and it is the cause of frequent floods during the rainy season.

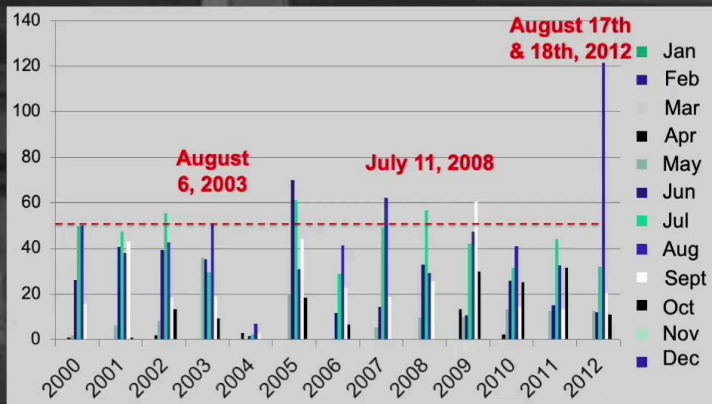
Notes

Summary



5m 31s

The Flood Problem in Niamey



Daily rainfall maxima in Niamey

Causes

Local floods and peak rainfall

- Exceptional rainfall peak in August 2012
- Significant variability between daily maxima from July to August (7 to 121 mm), with peaks of at least 50 mm/d having been recorded almost every year since 2000

Geographic Information Systems

Local floods are most often caused by exceptional pluviometry peaks. In August 2012, the daily peak of 121 millimeters caused 28 deaths, more than 51,000 victims, more than 4,500 houses and more than 250 hectares of fields destroyed. The analysis of the daily pluviometric peaks in Niamey reveals a large amplitude of the maximum daily peak variability for the months of July and August, ranging from 7 to 121 millimeters with peaks at 50 millimeters per day reached or exceeded almost every year since 2000.

Notes

Summary



6m 12s

The Flood Problem in Niamey



Flooding in the Harobanda neighbourhood (right bank) – Flood on August 17-18, 2012 (Amadou, 2012)

Aggravating factors

- Reduced soil permeability and soil degradation through deforestation and urbanization
reduced infiltration and increased overflow
- Expansion of the city limits into the Niger river's floodplains
increased vulnerability
- Chronic failure of river bed maintenance
reduced flow capacity, rising water levels

Geographic Information Systems

What are the aggravating factors of these floods? We will look at the factors that are generated by humans. It is the waterproofing and the soil degradation, particularly in connection with the deforestation and the urbanization, which leads to less infiltration and more runoff. Otherwise important is the spreading of the city of Niamey in the main bed of the, which accentuates the vulnerability of the city, and the chronic failing of the maintenance of waterways which leads to the river bed being blocked with sand should be added.

Notes

Summary



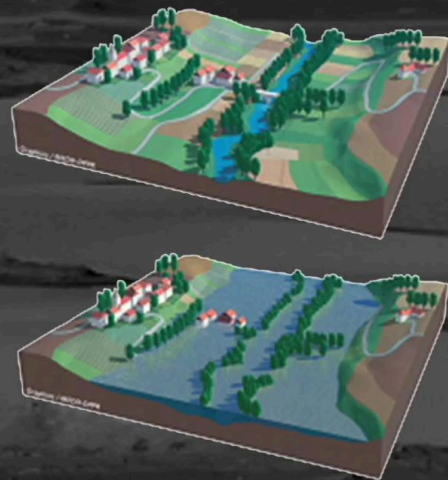
6m 50s

The Flood Problem in Niamey

Flood Control

Management

- Fluvial environment
- Floodable areas
- Dam management and improve flow rate capacity by removing major obstacles from the river bed
- Increase infiltration capacity, reduce overflow



Geographic Information Systems

In the light of the different causes of flooding and of the victims recorded each year, several measures can be envisaged to combat the phenomenon of flooding, in particular management measures on one hand and preventive measures on the other. Regarding the development measures, it is essential to preserve the waterway area and also to avoid to colonize the flood zones.

Notes

Summary



7m 31s

The Flood Problem in Niamey

Flood Control

Management

- Fluvial environment
- Floodable areas
- Dam management and improve flow rate capacity by removing major obstacles from the river bed
- Increase infiltration capacity, reduce overflow



Geographic Information Systems

It is also necessary to develop the banks to construct dikes, to dredge the major bed to improve the flow capacity in the riverbed, to improve the infiltrability of the soils, which will allow to reduce the runoff.

Notes

Summary



8m 00s

The Flood Problem in Niamey

Flood Control

Prevention

- Flood modeling and alert systems
- Territorial management and risk maps



Geographic Information Systems

So, regarding the prevention measures there is the town planning and the danger mapping, the flood modeling and the establishment of warning systems.

Notes

Summary



8m 24s

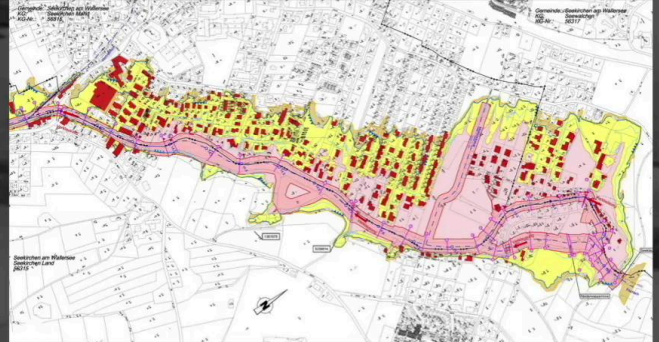
The Flood Problem in Niamey

Flood Control

Prevention

- Flood modeling and alert systems
- Territorial management and risk maps

>> Data collection, flood modeling and mapping flood risk



Geographic Information Systems

These measures show the need to collect data, to modelize the phenomenon and to map the risk of flooding, this mapping is the interest of this work.

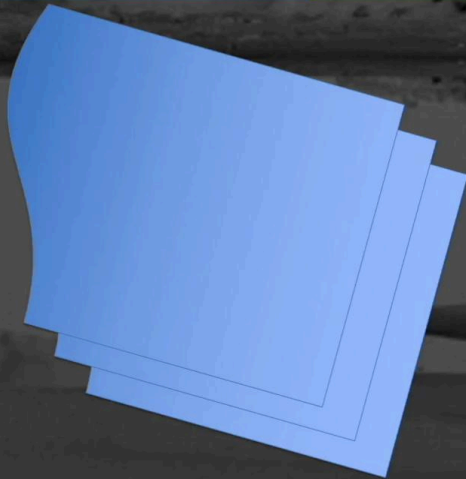
Notes

Summary



8m 40s

Methodology



Data on flood risk factors

- Natural factors
 - Topography: slope, elevation
 - Hydrology, meteorology
 - Geology, hydrogeology, etc
- Anthropogenic factors
 - Land use
 - Built areas

Types of data

- Satellite imagery
- Maps
- Ground data

Geographic Information Systems

What is the methodological approach to adopt? Two types of flood-related factors are distinguished by flood risk study approaches. There are the natural factors controlling the hazard, such as the topography, which provides information on the slope, the altitude, the hydrology, the meteorology, the geology and the hydrogeology. And also the anthropic factors which concern the occupation of the ground and the buildings. Thus, several types of data will be necessary for the spatial analysis of the flood risk. It is the satellite images, maps, ground data, statistical data, and so on.

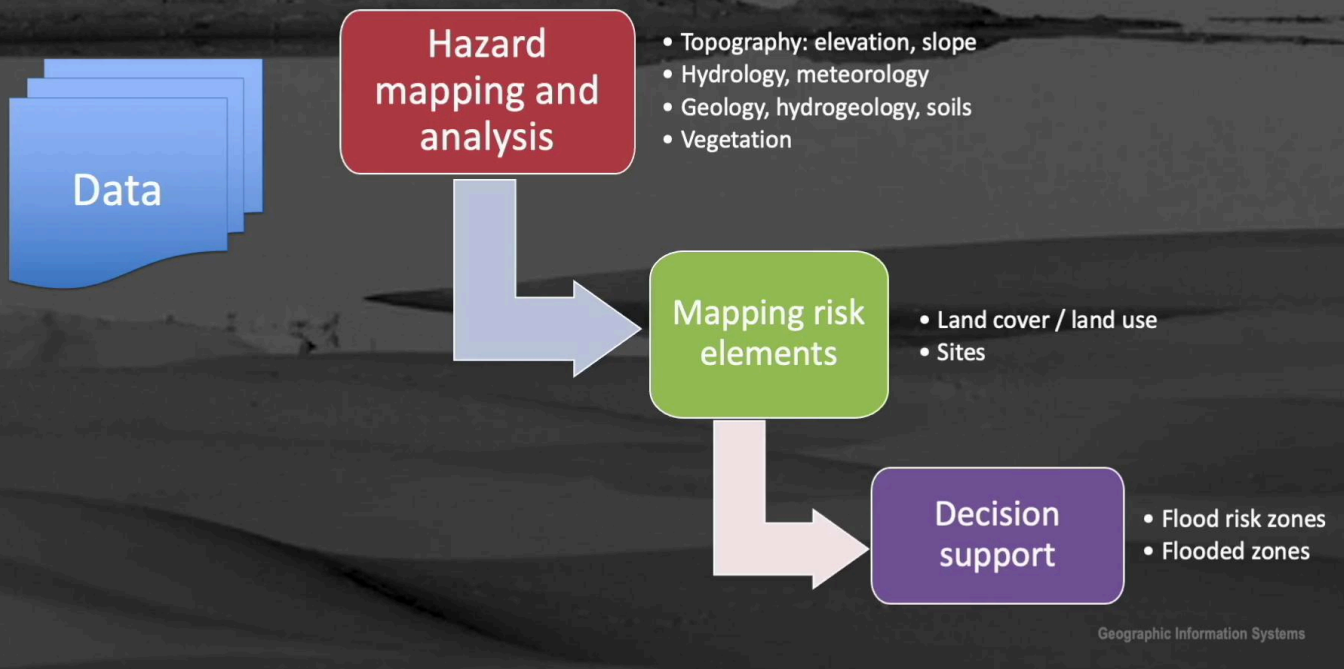
Notes

Summary



9m 03s

Methodology



We need to remember that the notion of risk is perceived as the possible occurrence of a hazard on potentially vulnerable issues. The study of the flood risk is based on two main points: First, the analysis of the hazards concerning the knowledge of natural phenomena causing the damages, their process and their functioning. In this case, it is necessary to analyze the morphological, topographical, geological, pedological and hydraulic characteristics controlling the phenomenon. Secondly, the mapping and assessment of vulnerabilities and major issues. The aim is to integrate data on anthropogenic and socio-economic activities into the flood risk assessment, whilst knowing that the risk of flooding is primarily a social object. These two map, that is to say the hazard map and the stakes map, are combined to determine flood plains. It is a decision-making tool for the town planning.

Notes

Summary



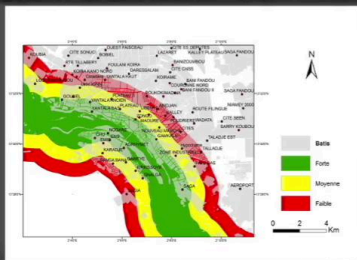
9m 47s

Methodology

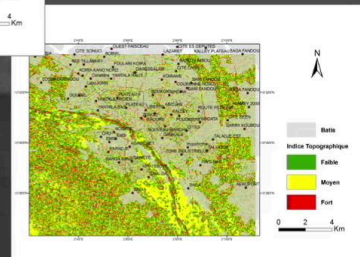
Hazard mapping and analysis

- Hazards linked directly to bank overflow
 - Analysis of Niger river flow rate at Niamey
 - Estimate 100-year flood and its spatial extent
 - Exposure to direct overflow
- Hazards linked to ponding water
 - Creation of DTM
 - Calculation of Beven index
 - Estimation of ponding levels

Geographic Information Systems



Bank overflow hazard



Ponding hazards

The mapping of the flood hazard is based on the analysis of natural factors, including the morphology, the topography, the geology and the pedology, which influence the development and extent of floods, as we have said before. On the basis of the data available in the case of this study, the most relevant hazards defined are the exposure to the Niger river overflowing and the exposure to run off water accumulation following torrential rain.

Notes

Summary

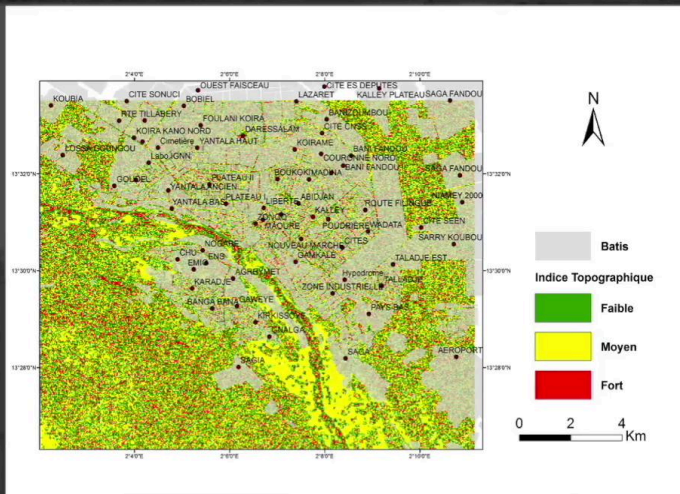


10m 50s

Methodology

Hazard mapping and analysis

- Hazards linked directly to bank overflow
 - Analysis of Niger river flow rate at Niamey
 - Estimate 100-year flood and its spatial extent
 - Exposure to direct overflow
- Hazards linked to ponding water
 - Creation of DTM
 - Calculation of Beven index
 - Estimation of ponding levels



Geographic Information Systems

Thus the hazard to the direct overflow of the river is determined from the analysis of a series of historical data: the flow of the Niger in Niamey allowing to define the once-a-century flood, that is to say a flood that comes back on average every 100 years. The centennial flood is often used as a reference event for the implementation of flood risk prevention plans. The radius of influence of such a flood contributes in determining the exposure to the Niger overflow. In this study, it is a radius of 400 meters that is defined. The linear distance of each unit in relation to the river bed determines its exposure level and is presented by a buffer zone on both sides of the river. The closer the entity is to the course of the river, the greater its exposure to overflow. Regarding the water accumulation hazard, the most representative variable here is the topographic index or the Beven index. It is calculated from the MNT obtained from the data ASTER DEM. This is the natural logarithm of year surface ratio to a point given on the slope. This index provides information on the spatial distribution of the accumulation level of the run off waters of each entity.

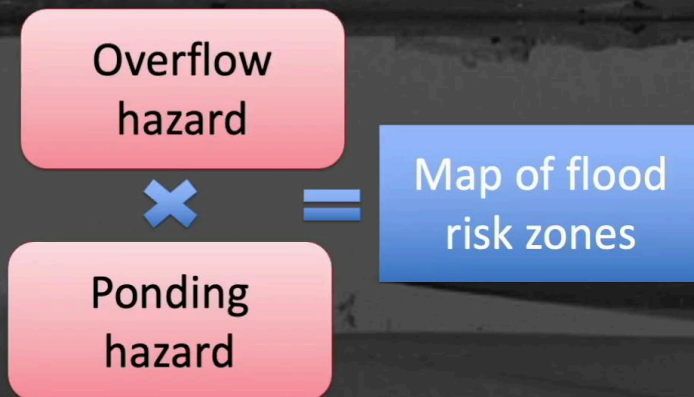
Notes

Summary



11m 21s

Methodology



Mapping flood risk zones

- Analysis and combination of maps
- Reclassification (3 classes: weak, moderate, strong)

Geographic Information Systems

The other factors are considered to be constant and have no remarkable effect on the flooding phenomenon and will not be taken into account in this study. Once the two maps, that is to say the overflow hazard and the accumulation hazard, are determined we will construct the flood plain map. For that, depending on whether the flooding is low, medium or high, we will reclassify the images on the basis of three criteria, and these three criteria are in particular on factors aggravating the flooding, taking into account the topographical, hydrological and hydrogeological elements. The combination of these two hazard maps allows to determine the flood plain map in the city of Niamey.

Notes

Summary



12m 44s

Methodology

Mapping vulnerability

- Land use dynamics
 - 1998 land use (Landsat TM)
 - 2013 land use (Landsat OLI)

Geographic Information Systems

One of the most important elements is the stake map. This map was made by mapping the dynamics of land use between 1998 and 2013 using the Landsat TM images of 1998 and the Landsat OLI images of 2013. The objective here is to show that buildings have evolved over the years, which is therefore of a particular interest for this study where populations have become vulnerable due to the urban growth.

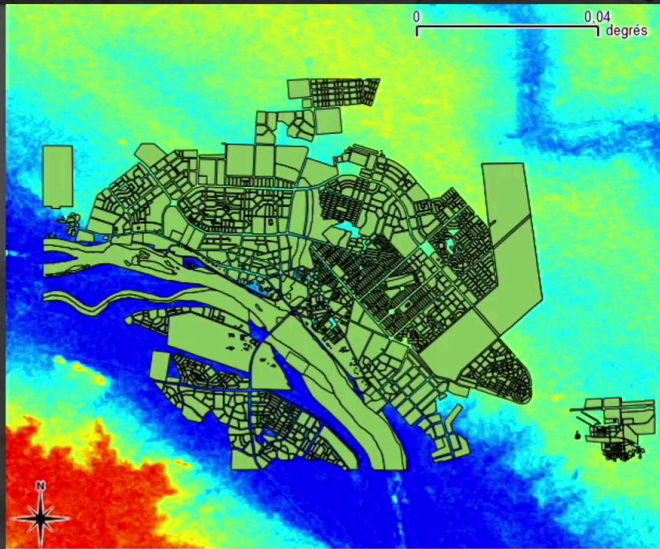
Notes

Summary



13m 29s

Methodology



Mapping vulnerability

- Land use dynamics
 - 1998 land use (Landsat TM)
 - 2013 land use (Landsat OLI)
- Built environment
 - Digitization of buildings
 - Overlayed on the DTM

Geographic Information Systems

The supervised classification of the images, followed by a validation by field missions, allowed to establish a dynamics of land use. Then, we will digitize the buildings to produce the map of the buildings. This map superimposed on the numerical model of altitude shows that part of the city is on the bed of the river Niger, and the stakes, concern the economic, socio-economic activities and how are we going to characterize these activities to determine the stake map? Here, we have not retained a specific criterion regarding the administrative buildings, the public and private companies, and the houses. We considered them to be of the same level of vulnerability. Thus the vulnerability of the building is considered as unique and can allow to map the stakes that we will couple with the hazards later to help us make decisions for the development of the territory.

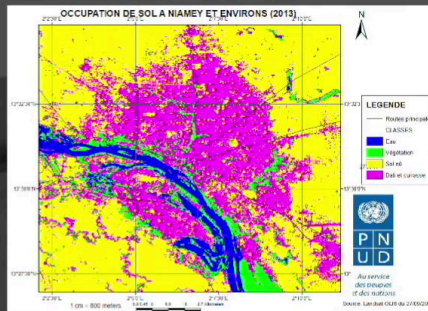
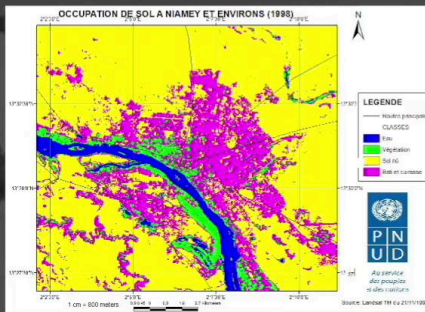
Notes

Summary



14m 01s

Results



The map established from a combination of different factors, the hazard and the vulnerability of the stakes, is an important element which allows to make a decision. And it is the object of this study that allows you to know that spatial analysis can help identifying areas that can be developed, areas that can be protected against floodings. And it is the interest of this work that allows the decision-makers of the city of Niamey to be able to guide the development activities and the future plots for the spreading of the city which continues its growth on the two banks of the Niger river. The analysis of land use maps shows a growth in built-up areas between 1998 and 2013, a growth that is more pronounced on the left bank of the Niger river.

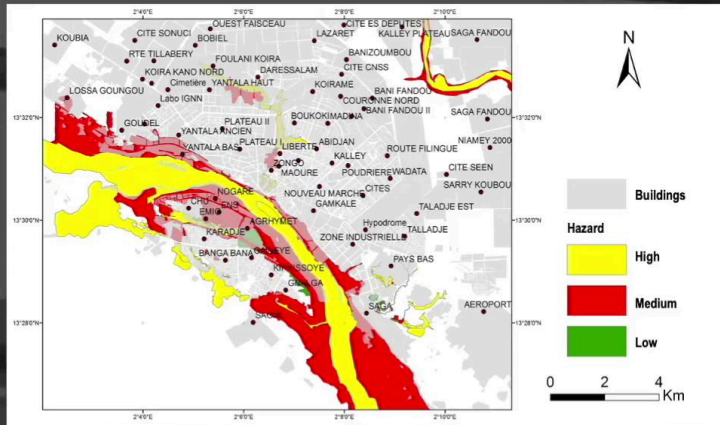
Notes

Summary



15m 19s

Results



We observe that the zones situated on the very edge of the river concentrate a variety of economic activities and certain strategic infrastructures. One of the most important results in this study is the flood risk map. In view of the topography, the hydrography, the climate and the regime of the Niger river, the city of Niamey presents obvious risks of flooding if we look and analyse this map. On the right bank, the districts of Lamordé and Nogaré are the most vulnerable and, to a lesser extent, those of Karadjé and the university. On the left bank, the districts of Goubel and Saga would be the most exposed. At the infrastructure level, on the right bank, the AGRHYMET, the CHU, the INS and even the MIG are in flood plains. What steps should be taken? This map is an example of a decision case. It was established in a very simple way, but it has the advantage of situating the flood plains of Niamey. It can serve as a basis for future plot allocations in the riverside areas of the river whilst avoiding hazardous areas. The climate disruption being a natural phenomenon, the preventive action through flood modeling and the setting up of an alert system seems to be a solution to the flooding problem in Niamey.

Notes

Summary



16m 33s