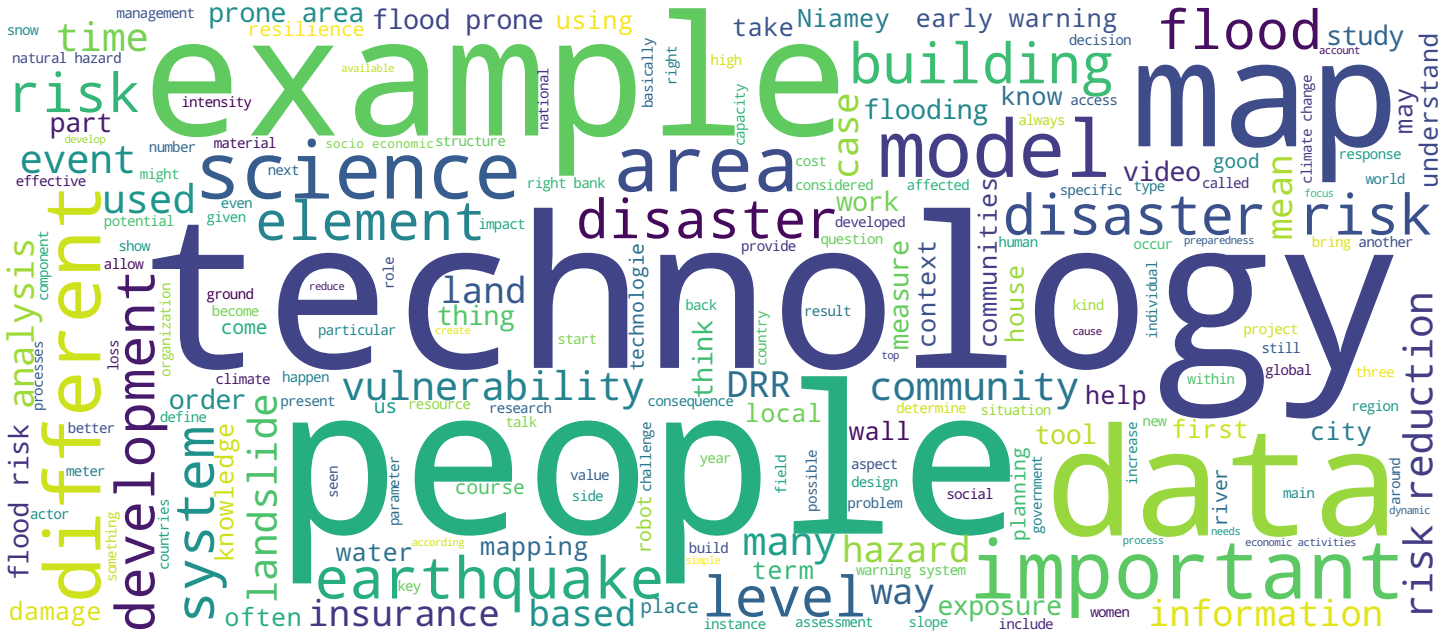
Mapping of flood prone areas in Niamey

A Resilient Future: Science and Technology for Disaster Risk Reduction

Professor Fernand Koffi Kouamé
Centre Universitaire de Recherche et d'Application en Télédétection (CURAT)
Université Félix Houphouet-Boigny d'Abidjan-Cocody



Search MOOC

Video

EPFL

This video was originally recorded for the EPFL MOOC “Introduction aux Systèmes d’Information Géographique – Partie 1” in the EPFL MOOC series “MOOCs Africa”

http://moocs-afrique.epfl.ch/

Mapping of flood prone areas in Niamey A Resilient future: Science and Technology for Disaster Risk Reduction.

Notes

Summary

0m 00s

Outline

- Introduction to the case study
- Methodological approach
- Results
- Main points

A Resilient Future: Science and Technology for Disaster Risk Reduction

Hello, this lesson which is a case study shows how to use GIS to map flood prone areas, in order to make decisions for land-use planning. This lesson is based on the analysis of hydro-meteorological processes and human settlements. But this study does not allow to address in all its facets the problem of flooding in Niamey. However, it helps to provide the competent authorities with mapping tools to guide them towards better flood risk management.

Notes

Summary

0m 08s

The city of Niamey

- 1,300,000 inhabitants (2011)
- Area of 240 km^2, with an elevation ranging from 180 to 250 meters

(1)

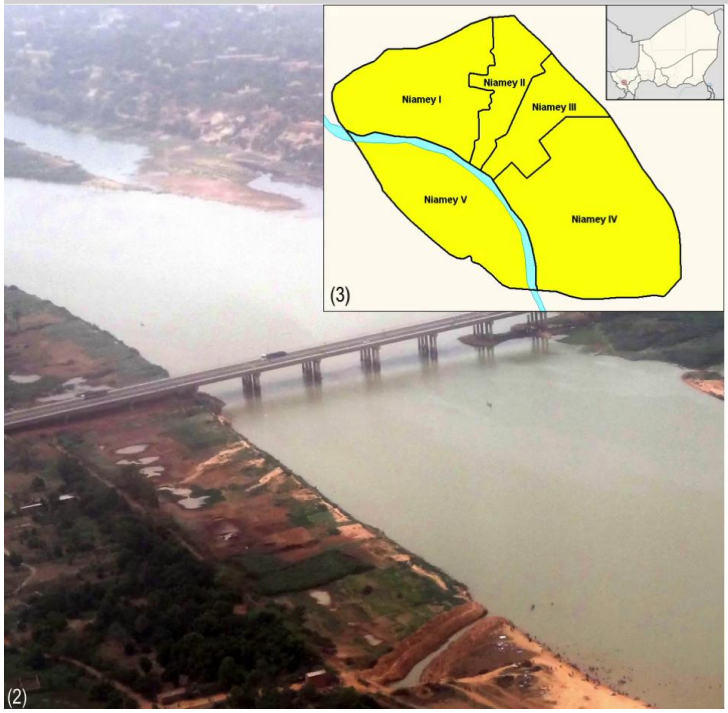
To begin, we must first remember that Niamey is the capital of Niger. Niamey, located in the far west of the country, with about 1.3 million inhabitants in 2011, spreads over an area of 240 km², with an elevation ranging from 180 to 250 meters. It is bisected by the River Niger, which has shaped moreover the development of urban and suburban areas. We distinguish that the left bank is more developed than the right bank.

Notes

Summary

0m 47s

The city of Niamey



- Left bank more developed with four districts on a plateau overlooking the river at an altitude of 220 meters
- District 5 located on the right bank, in an alluvial plain at an altitude of 200 meters

The left bank, which shelters four municipal districts, is a plateau above the river at an average altitude of 220 meters and notched with many talwegs, of which the most important is that of Gountou Yena, with north-south direction. As for the right bank, where the fifth municipal district is located, it is an alluvial plain with an average altitude of 200 meters. Physiographic features of the city of Niamey and various associated human and economic issues show that floods are, for the most part, clearly linked to the strong urban growth over the last thirty years. Indeed, population growth and the development of socio-economic activities led the city to extend in flood prone areas. Thus, since the beginning of the seventies, Niamey has grown on the right bank of the river, and the urbanization of this particularly exposed area is ongoing. On the left bank, the very vulnerable old quarters of Goudel and Saga, densify and extend through the allotment of new plots. The spatial assessment of flood risk by intersecting hazard and vulnerability issues allows mapping of flood risk areas in the city of Niamey.

Notes

Summary

1m 24s

Floods in Niamey

High frequency of flooding in Niamey

- The most recent:
  1998, 2002, 2003, 2007, 2008, 2010, 2012 and 2013
- Consequences: Many casualties, displacement and relocation, destruction of infrastructure, etc.

A Resilient Future: Science and Technology for Disaster Risk Reduction

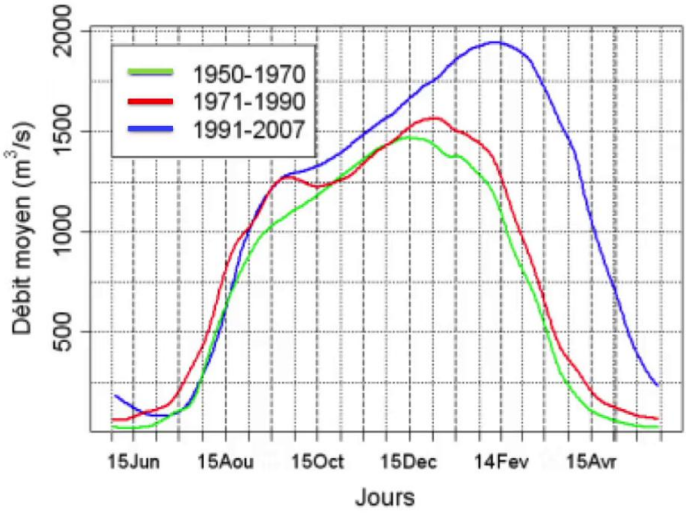
Floodings in the Sahel have become more and more recurrent, and Niger is not on the sidelines. During these last few years, Niger experienced excess rainfall, with heavy rains causing unprecedented flooding, practically in all regions of the country, including the capital Niamey. The protective dikes in Niamey with a height of 5 meters, on the right bank, were completely submerged during the last flood. These floods caused many deaths, population displacements and relocations, destruction of homes and farms.

Notes

Summary

2m 47s

The flooding issue in Niamey



Causes - Hydrological regime

- Two seasonal floods:
  - «Malian» floods (December-January) originating in the upper river basin
  - Local rainy season floods (August-September)
- Local rainy season floods have become increasingly important in recent years with frequent overflow and flooding of the urban area

A Resilient Future: Science and Technology for Disaster Risk Reduction

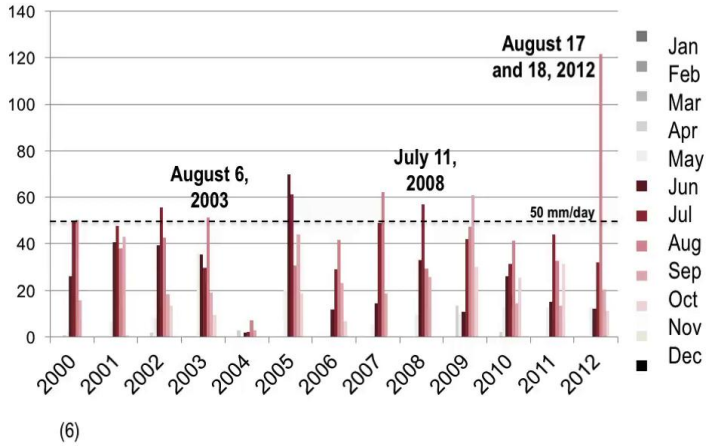
The hydrology of the Niger River in Niamey is well known, thanks to the measuring station in Niamey, installed since 1928 and regularly used since 1944. The hydrological regime has two floods. The "Malian" floods, which take place from December to January, from the top of the basin, and local flooding that occurs during the rainy season. Over the last years, the local flood has become increasingly important, as we see in the image and is the cause of frequent flooding during the rainy season.

Notes

Summary

3m 28s

The flooding issue in Niamey



(6)

Local high waters and rainfall peaks

- Exceptional rainfall peaks in August 2012
- High amplitude of the variability of the maximum daily peaks in July and August (from 7 to 121 mm). 50 mm/d reached or exceeded almost every year since 2000

A Resilient Future: Science and Technology for Disaster Risk Reduction

Local floods are usually caused by the exceptional peaks of rainfall. In August 2012, the daily peak of 121 mm caused 28 deaths, more than 51 000 victims, more than 4 500 damaged homes, and more than 250 hectares of destroyed farms. The analysis of daily rainfall peaks in Niamey reveals a high amplitude in the variability of the maximum daily peaks in July and August from 7 to 121 mm, with peaks of 50 mm per day met or exceeded almost every year since 2000.

Notes

Summary

4m 07s

The flooding issue in Niamey

(7)

Aggravating factors

- Soil sealing/degradation linked to urbanization and deforestation: Less infiltration and more runoff
- Urban sprawl of Niamey in the floodplain of the Niger River: Increased vulnerability
- Chronic lack of riverbed maintenance: Reduced flow capacity, higher water levels

A Resilient Future: Science and Technology for Disaster Risk Reduction

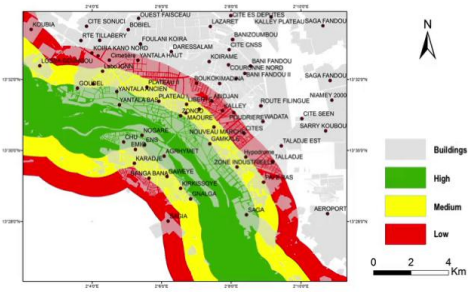
What are the factors aggravating these floods? We will focus on the factors caused by humans. These include soil sealing and soil degradation, particularly in connection with deforestation and urbanization, which results in less infiltration and more runoff. More important is the spread of Niamey city, in the main river bed, which increases the vulnerability of the city. You should also add the maintenance of watercourses, which induces sedimentation.

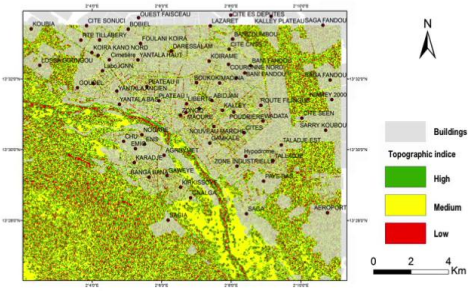
Notes

Summary

4m 45s

Methodology





(9)

Hazard mapping and analysis

- Hazard linked to the direct overflow
  - Niger River flow
  - 100-year flood and its spatial extent
  - Exposure to direct overflow
- Hazard linked to water accumulation
  - DTM
  - Beven's index
  - Ponding levels

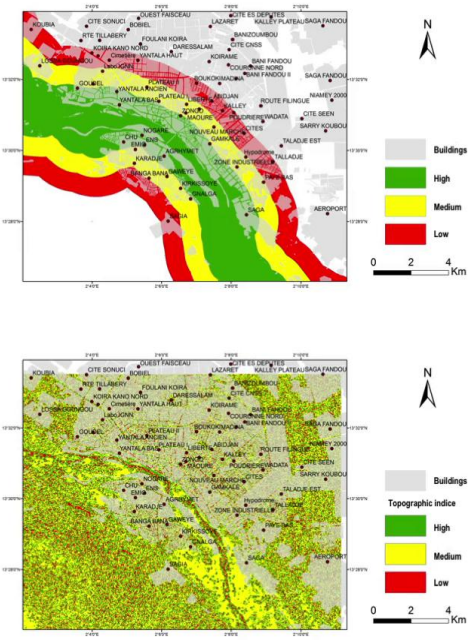
We must remember that the concept of risk is perceived as the possible occurrence of a hazard on potentially vulnerable elements. The study of flood risk is based on two main points. First, analysis of hazards, based on knowledge of natural phenomena causing damage, their processes and operations. In this case, it is important to analyze the morphological, topographical, geological, soil and water features concerning the phenomenon. Second, the mapping and assessment of vulnerabilities of the major elements. This is to integrate data on human and socio-economic activities in the assessment of flood risk, knowing that flood risk is at first a social issue. These two maps, that is to say, the hazard map and the elements at risk map, are combined to determine the flood prone and flooded areas map, that is a decision support tool for land-use planning. Mapping of flood hazard is based on the analysis of natural factors, including morphology, topography, geology, soil science, that influence the development and extent of the flood, as we said earlier. Based on the available data, in the case of this study, the most relevant hazards include defining exposure to overflow of the Niger River and exposure to the accumulation of runoff waters, following a downpour.

Notes

Summary

5m 25s

Methodology



(9)

Hazard mapping and analysis

- Hazard linked to the direct overflow
  - Niger River flow
  - 100-year flood and its spatial extent
  - Exposure to direct overflow
- Hazard linked to water accumulation
  - DTM
  - Beven's index
  - Ponding levels

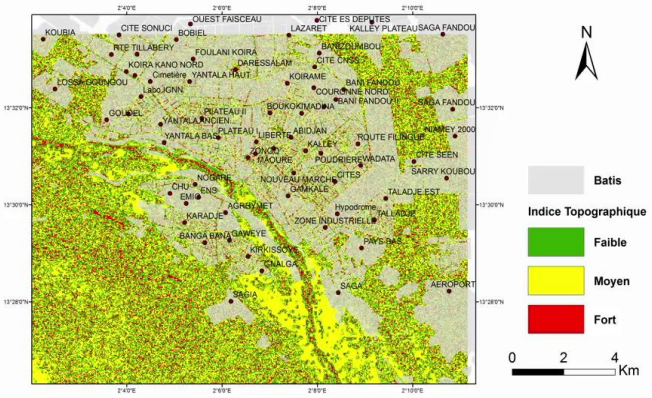
Thus the hazard of direct overflow of the river is determined from the analysis of a series of historical data of the Niger flow in Niamey allowing to define the 100-year flood. That is to say, a flood that comes on average every hundred years. The 100-year flood is often used as the reference event for the implementation of flood risk prevention plans. The radius of influence of such floods helps determine the exposure to overflow of the Niger. In this study, it is defined within 400 meters. The linear distance of each unit relative to the riverbed determines its level of exposure and is presented by a buffer zone on both sides of the river. The closer the entity is to the river route, the stronger its exposure to overflow. Regarding the accumulation of water, the most representative variable here is the topographic index or Beven index. It is calculated from the DTM obtained from the ASTER DEM data. This is the natural logarithm of the ratio of the area at a given point on the slope. This index provides information on the spatial distribution of the accumulation level of runoff water of each entity. Other factors are considered constant and have no notable effects on the flood phenomena.

Notes

Summary

6m 57s

Methodology



Hazard mapping and analysis

- Hazard linked to direct overflow
  - Niger River flow analysis
  - 100-year flood and its spatial extent
  - Exposure to direct overflow
- Hazard linked to ponding water
  - DTM
  - Beven's index
  - Ponding levels

(8)

A Resilient Future: Science and Technology for Disaster Risk Reduction

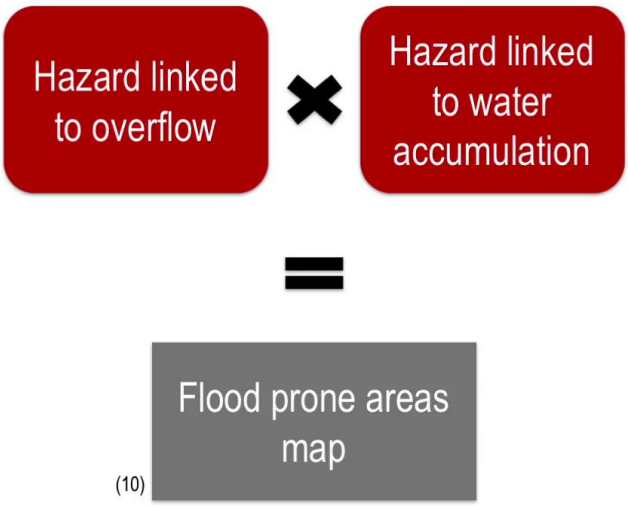
They will not be taken into account in this study.

Notes

Summary

8m 18s

Methodology



Mapping of flood prone areas

- Analysis and combination of maps
- Reclassification (3 classes: low, medium, high)

A Resilient Future: Science and Technology for Disaster Risk Reduction

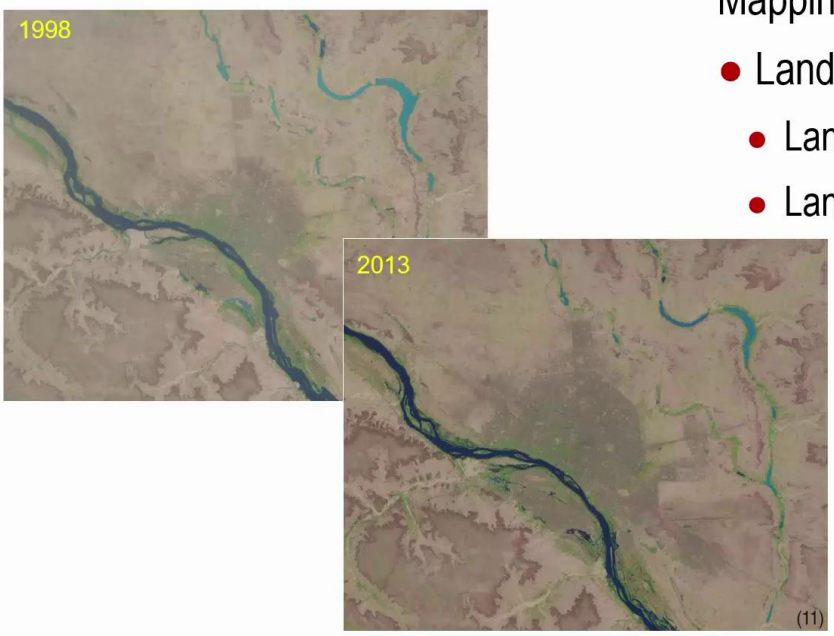
Once the two maps, that is to say the overflow hazard and the accumulation hazard, are determined, we will build the map of flood prone areas. For this, according to the floodability: low, medium or high, we will conduct a reclassification of images, using the three criteria, including the factors aggravating the flood, taking into account the topographic, hydrological and hydrogeological elements. The combination of these two maps, therefore, determines the Niamey flood prone areas.

Notes

Summary

8m 23s

Methodology



Mapping vulnerability

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

A Resilient Future: Science and Technology for Disaster Risk Reduction

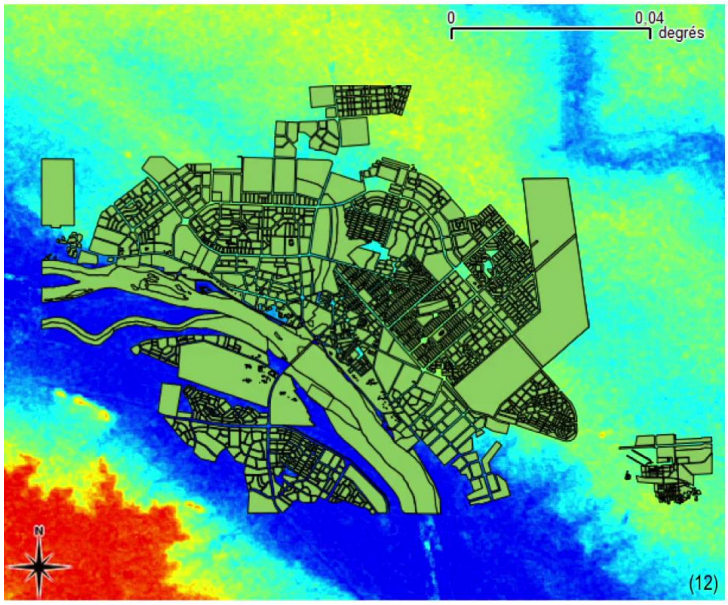
One of the most important elements is the map of elements at risk. This map was produced by mapping the dynamics of land use between 1998 and 2013, using Landsat TM images of 1998 and Landsat OLI images of 2013. The goal here is to show that the settlements have evolved over the years, thus showing a particular interesting aspect of this study, where populations have become vulnerable because of urban growth.

Notes

Summary

9m 06s

Methodology



Elements at risk mapping

- Land use dynamics
  - Land use in 1998 (Landsat TM)
  - Land use in 2013 (Landsat OLI)
- Map of built environment
  - Digitalization of built environment
  - Overlayering on the DTM

A Resilient Future: Science and Technology for Disaster Risk Reduction

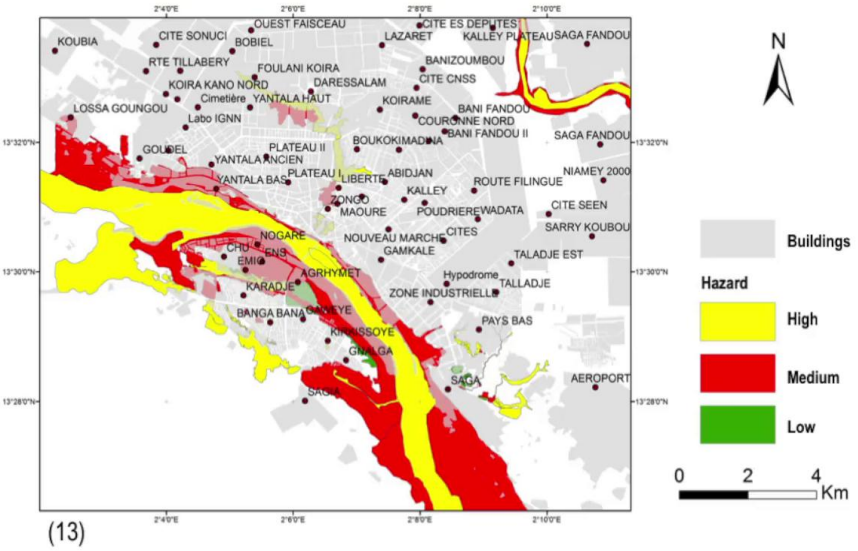
The supervised classification of images, followed by a validation by field missions, made it possible to establish the land use dynamics. Then we digitalised buildings to produce the map of elements at risk. This map, superimposed to the digital elevation model, clearly shows that one part of the city is on the bed of the River Niger. The challenges therefore concern economic and socio-economic activities. How do we characterize these activities to determine the map of elements at risk? Here we have not included a specific criteria for government buildings public and private companies, and homes. We have considered the same level of vulnerability. Even if the vulnerability of the buildings is considered to be the same, we can still map the elements at risk, that will be coupled to the hazards thereafter to help us make decisions about land-use planning.

Notes

Summary

9m 38s

Zones at risk of flooding



(13)

Superposition of flood prone areas map and elements at risk map= “flood risk map”

A Resilient Future: Science and Technology for Disaster Risk Reduction

One of the most important findings of this study, is the flood risk map. Given the topography, hydrography, the climate and the Niger River system, Niamey city is obviously at risk of flooding, in light of the analysis of this map.

Notes

Summary

10m 55s

Main points

- Use of GIS to map the zones that are at risk of flooding in the city of Niamey
- This simple map can be used as a decision support tool

A Resilient Future: Science and Technology for Disaster Risk Reduction

This map is an example of a decision map. It was established in a very simple way, but it has the advantage of locating the flood prone areas of Niamey. It may serve as a basis in future land use/plot allocations in areas along the river, while avoiding the dangerous areas. What can we learn from this case study? We used GIS for mapping flood prone areas in Niamey, Niger. We also observed that there is strong urban growth along the river, over recent years. This has accentuated land and population vulnerability. This document can be made available to policymakers, and this simple map shows the areas vulnerable to flooding, in order to take preventive measures against floods, which is a natural hazard that affects all countries of the world. Even Niger, a Sahelian country, is affected by floods near the main bed of River Niger, and because of uncontrolled urbanization in these areas.

Notes

Summary

11m 14s

Image credits

Image credits in order of appearance (please consult the annex to access the links):

Cover picture: "Fleuve Niger à Niamey" by Jean Rebiffé is licensed under CC BY 2.0

(1) "Niger on the globe (North Africa centered)" by TUBS is licensed under CC BY-SA 3.0

(2) "Pont de l'Amitié Chine-Niger – Niamey from the sky" by Jean Rebiffé is licensed under CC BY 2.0

(3) "Niamey (district map).png" by Дэя-Бояд is licensed under CC BY-SA 3.0

(4) Ali, A. and Trebossen, H. Prévention du risque d'inondation à Niamey par l'approche cartographique. PowerPoint presentation.

(5) Modified from: Ali, A. and Trebossen, H. Prévention du risque d'inondation à Niamey par l'approche cartographique. PowerPoint presentation.

(6) Modified from original video recorded for the EPFL MOOC "Introduction aux Systèmes d'Information Géographique – Partie 1" in the EPFL MOOC series "MOOCs Africa"

(7) "Niamey Flood 2013.JPG" by Nomax12 is licensed under CC BY-SA 4.0

(8) Modified from Fernand Koffi Kouamé, original video recorded for the EPFL MOOC "Introduction aux Systèmes d'Information Géographique – Partie 1" in the EPFL MOOC series "MOOCs Africa"

(9) Fernand Koffi Kouamé, original video recorded for the EPFL MOOC "Introduction aux Systèmes d'Information Géographique – Partie 1" in the EPFL's MOOC series "MOOCs Africa"

Notes

Summary

12m 33s

Image credits

Image credits in order of appearance (please consult the annex to access the links):

(10) Modified from Fernand Koffi Kouamé, original video recorded for the EPFL MOOC “Introduction aux Systèmes d’Information Géographique – Partie 1” in the EPFL MOOC series “MOOCs Africa”

(11) Landsat images, U.S.G.S.’s Earth Resources Observation and Science (EROS) Center /NASA's Land Processes Distributed Active Archive Center (LP DAAC)

(12) Fernand Koffi Kouamé, original video recorded for the EPFL MOOC “Introduction aux Systèmes d’Information Géographique – Partie 1” in the EPFL MOOC series “MOOCs Africa”

(13) Fernand Koffi Kouamé, original video recorded for the EPFL MOOC “Introduction aux Systèmes d’Information Géographique – Partie 1” in the EPFL MOOC series “MOOCs Africa”

Notes

Summary

12m 41s