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ENVIRONMENTAL IMPACTS OF FLOODS IN MALANVILLE

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ABSTRACT

This study aims to determine the impact of the floods on the environment in the township of Malanville. The climatic data (precipitation from 1971 to 2018) of the Kandi station, map data and social-anthropological data were used. The sensitivity matrix made it possible to assess the level of vulnerability of the municipality to floods. Several factors responsible for the floods in the commune of Malanville were identified: the excess rainfall during the period of 1998-2018, the strong irrigation of the municipality (the Sota and the Niger River), the low position of the municipality (slope <2) and human activities in swampy areas. All of its elements are aggravating factors and inevitably cause flooding with each rising water in the most vulnerable areas. The agricultural sector and ecosystems are the most exposed to floods with exposure indices of 73.3% and 86.67% respectively.

KEYWORDS: *Floods, Impacts, Environment, Malanville*

RÉSUMÉ

Cette étude vise à déterminer les impacts des inondations sur l'environnement dans la commune de Malanville. Les données climatiques (précipitation de 1971 à 2018) de la station de Kandi, les données cartographiques et les données sociaux-anthropologiques ont été utilisées. La matrice de sensibilité a permis d'apprécier le niveau de vulnérabilité de la commune aux inondations.

Plusieurs facteurs responsables des inondations dans la commune de Malanville ont été identifiés : la pluviométrie excédentaire au cours de la période 1998-2018, la forte irrigation de la commune (la Sota et le Fleuve Niger), la position dépressionnaire de la commune (pente <2) et les activités humaines dans les zones marécageuses. L'ensemble de ses éléments constituent des facteurs aggravants et causent inéluctablement les inondations à chaque montée des eaux dans les zones les plus vulnérables. Le secteur agricole et les écosystèmes sont les plus exposés aux inondations avec respectivement des indices d'exposition de 73, 3 % et 86, 67 %.

MOT CLÉS: *Inondation, Impacts, Environnement, Malanville*

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INTRODUCTION

Water is the most representative resource for the earth. According to M. L. Bouguerra (2006, p. 45), water is an essential input for households' survival, as well to the development of the ecosystems.

However, the power of excessive or uncontrolled water, or its intrusion in areas formally reserved for another usage, are a menace to the mode of life and the social welfare of people. This means that water is life, but it can also be at the base of great prejudices to most people. (F. S. Eteka, 2008, p. 32). This includes floods. All countries on the earth are concerned with floods, with diverse effects though. Those natural disasters have an important impact on our environment. In 2011, floods represented half of all natural disasters, and have caused 57.1 % of all casualties from natural disasters in the world. (ADSR, 2012, p.7). In Benin, many disastrous events have been recorded, which included the many repetitive cases of floods which have brought negative impacts onto the country, mainly in 2010 when, following a stormy rain and the overflowing of the country's main rivers (the Niger, the Ouémé, the Zou, the Mono and the Couffo), more than 55 townships out of the 77 were affected to diverse degrees. 21 of these townships were severely affected, causing about 78.3 billion cfa damages, over the country's economy and more than 50 billion cfa loss in other sectors, together with sanitary risks (potable water sources contamination, destruction of latrines), spreading of hydric and hydro-fecal diseases (cholera, diarrhea, malaria) (E. Bokonon-Ganta, 2018, p. 10).

Among the 21 severely affected townships, stands Malanville, where flooding has occurred yearly with important impacts on the environment. It is then urgent to apprehend those impacts so as to find appropriate solution to them. This is what explains the choice of undertaking the present research work about the environmental impacts of floods on Malanville Township.

- What factors are responsible for flooding in Malanville?
- What are the impacts of those floods on the environment in Malanville?

PRESENTATION OF THE RESEARCH FIELD

Before 1949, Malanville was name « Tassi », which means « sand » in the Zerma and Dendi languages; the now name means « the Malan city »; Malan was the name of a governor in the ancient Danhomey colony. The Malanville Township is situated to the high North of the Benin Republic, mainly in the Alibori department. The township is situated between11° 18' 45''and 12° 00' 05'' North latitude and between 2° 55' 05'' and 3° 36' 354'' East longitude, extending over 50km North-South, and 60km East - West. Elle s'étend sur 50 km du Nord au sud et sur 60 km de l'Est à l'Ouest.It is limited to the North by the Niger Republic, to the South by the Kandi and Segbana Townships, to the West by the Karimama Township, and to the East by the Federal Republic of Nigeria. It covers an area of 3,016 km², with 8,000 ha of farm lands. Its average altitude is 200m above the sea level, which some 700km straight line away. (F. Ahoudou, 2019, p. 23)

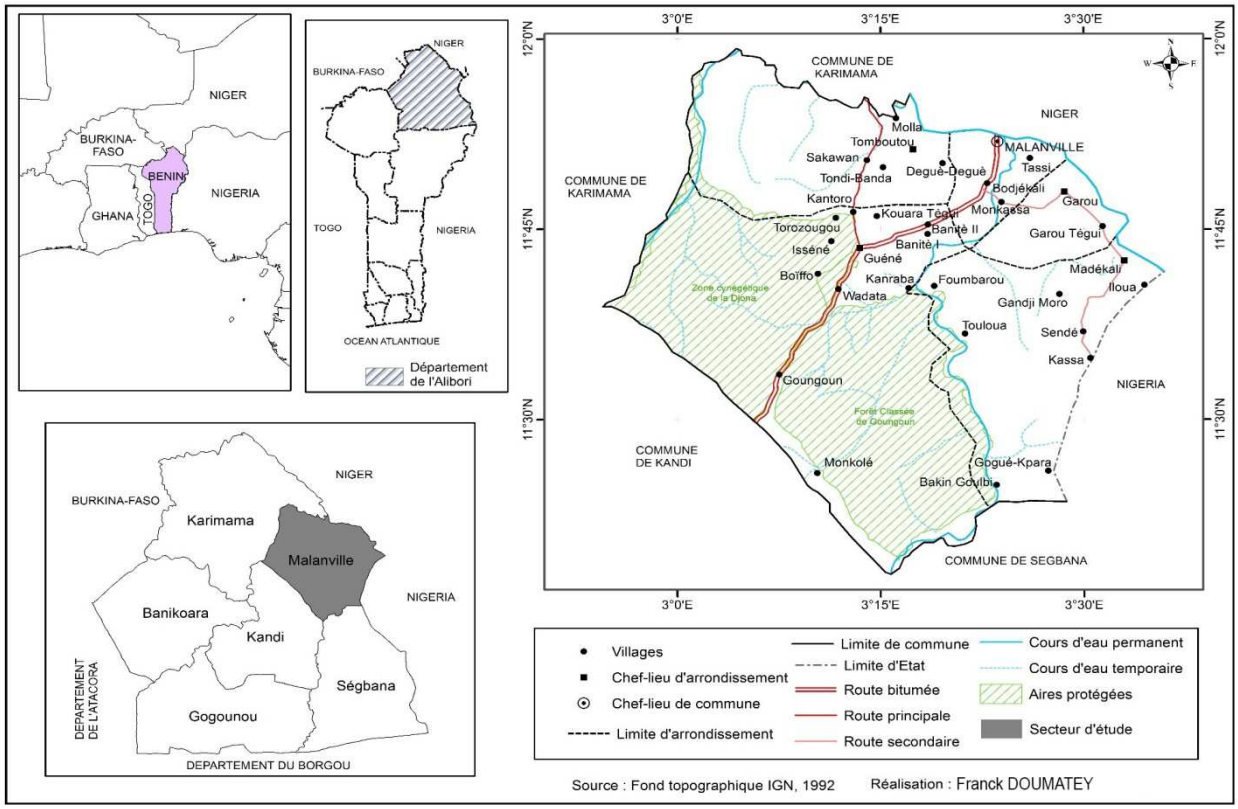


Figure 1: Geographic Situation of Malanville.

DATA AND METHODS

Many types of data have been used in the frame of this study. These are the pluviometry data from 1971 to 2018 of the Kandi water station, the mapping data, and the demographic and socio-anthropologic data. A field investigation has been carried out, basing on the documentary methodology, direct observation on the field using an observation grill, data collection questionnaire taking into account a sampling of 103 participants from the Malanville districts (Garou and Madicali) because of the latter's geographic position with the Sota River, and due to their exposition to flooding phenomena. The Lamb index (1982) has been used to identify the dry or rain deficit years, the wet or rain exceeding years, and the average or normal rain years, over the study period this index is obtained from the following formula:

$$Ip = \frac{(Xi - \bar{X})}{\sigma}$$

With Xi being the rainfall of the year i,$\bar{X}$the inter-annual average rainfall over the target period, andσ, the standard deviation of the series type.

- IfIp< 0, the year is said to be dry or rain deficit
- IfIp = 0, this is an average or normal year.
- IfIp> 0, the year is said to be a humid or rain exceeding year

The sensitivity matrix of key sectors with climatic vulnerabilities has been made to better evaluate the expository degree of the environment to floods.

RESULTS

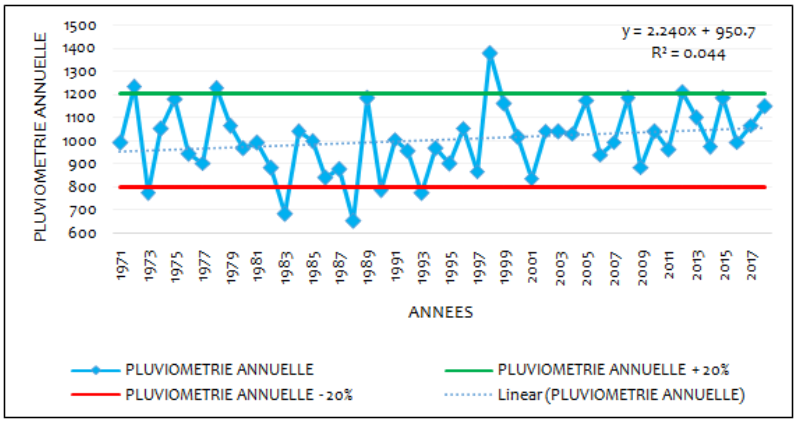
Causes of Floods in the Malanville Township

Among the factors that cause floods in Malanville, there are: the rainfall, the high irrigations in the area, the geographic position of the city, and humans' activities.

Climate Factors

Annual Progress of Rain, From 1971 to 2018

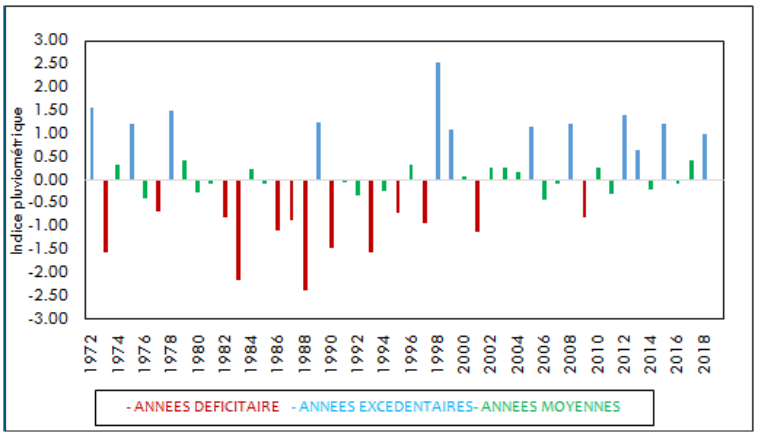
The following table shows the inter-annual variation of rains in Malanville, from 1971 to 2018.



Source: The Kandi Meteo Division, 2019

Figure 2: Inter-Annual Evolution of Rains, From 1971 to 2018.

From the analysis of the above figure (figure 2), it appears that the annual rainfall in the Malanville Township has increased. It is also noted that there are exceptional rainfall years, such as the one of 1998. Evolution of rainfall over the period 1970-2018 shows that there are changes of annual rainfall accumulations. The annual rainfall in Malanville between 1970 and 2018 are marked with a strong inter-annual variability with an average of 969.11mm. Figure 3 shows the rainfall abnormalities in the Malanville Township.



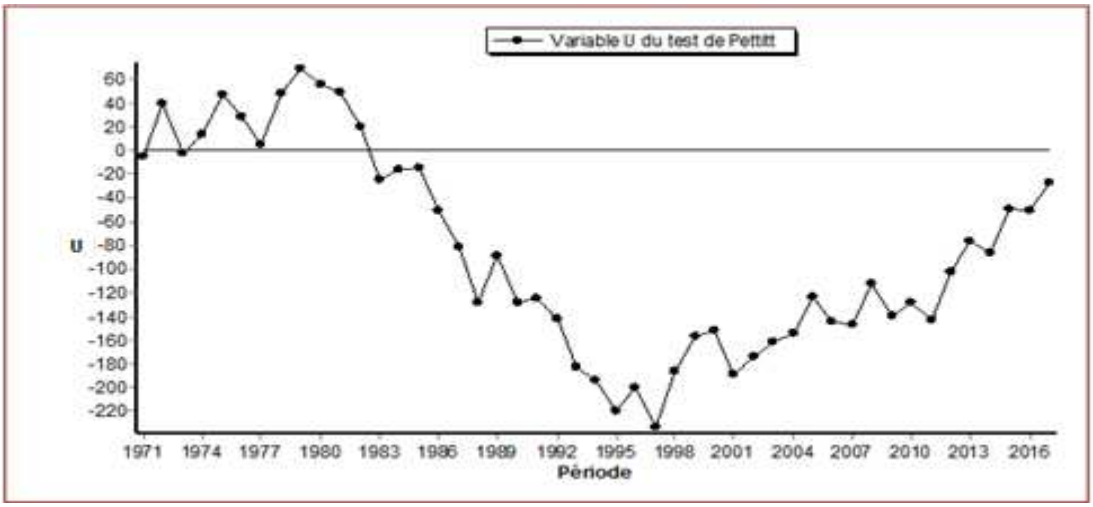
Source: Kandi Meteo Division, 2019

Figure 3: Rainfall Indexes in Malanville.

From the analysis of the above figure, the Township of Malanville has had some successive exceeding, average and deficit years of rain over the period 1971-2018. Over the whole period, there are respectively: 47.92 %, 25 % and 27.08 % of deficit, normal and exceeding rains.

The PettitTest

Figure 4 shows the Pettittest which has allowed determining the breakage over the study series.



Source: Kandi Meteo Division, 2019

Figure 4: Result of the Pettitttest (Variable Studied: Rainfall, Identification: Kandi, Unit: mm, Chronology: 1971-2018).

Evolution of the variable U of the Pettitttest basing on the annual height of rains from 1971 to 2018 in Kandi has revealed the presence of a breakage in the chronological series, up to about 90%. Then, two sub-periods are to be identified: the sub-period 1971-1997 and the sub-period 1997-2018. The following table makes a point about the deficit, the average and the exceeding rainfall year proportions.

Table 1: The Point about the Deficit, The Average and The Exceeding Rainfall Year Proportions

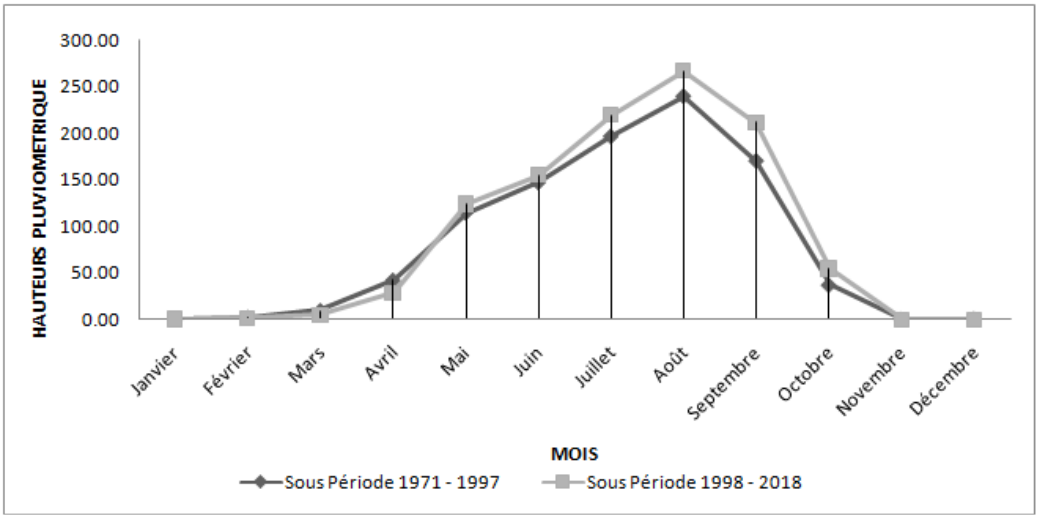
Sub-Periods	Dry Years	Average Years	Humid Years
1971-1997	1973, 1983 ; 1988 ; 1990 ; 1993 ;	1971 ; 1974 ; 1975 ; 1976 ; 1977 ; 1979 ; 1980 ; 1981 ; 1982 ; 1984 ; 1985 ; 1986 ; 1987 ; 1989 ; 1991 ; 1992 ; 1992 ; 1995 ; 1997 ; 1997	1972 ; 1978 ; 2012
1998-2018	-	1999 ; 2000 ; 2001 ; 2002 ; 2003 ; 2004 ; 2005 ; 2006 ; 2007 ; 2008 ; 2009 ; 2010 ; 2011	1998 ; 2014 ; 2015 ; 2016 ; 2017 ; 2018

Source: Kandi Meteo Division, 2019

The analysis of the above table reveals that the second sub-period, 1998-2018,is more humid, with an important increase of the number of exceeding rainy years. This sub-period is then exposed to more flooding than the others. This situation has been confirmed for by 76 % of the questionnaire respondents who have affirmed that flooding has occurred these years more than by the past.

Annual Rainfall of the Two Sub-Periods

The following figure presents the inter-monthly variation of rainfall over the two sub-periods



Source: Kandi Meteo Division, 2019

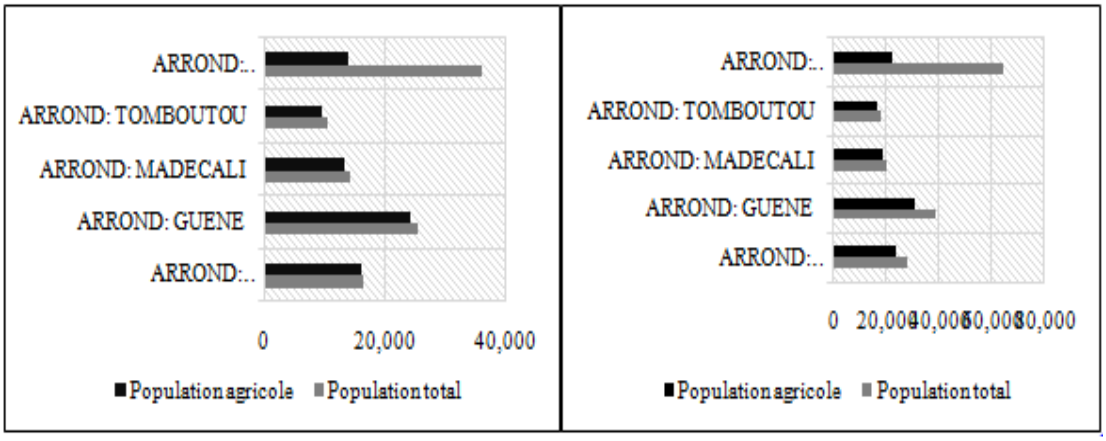
Figure 5: Comparative Evolution of the Rainfall Distribution through the Two Sub-Periods 1971-1997 and 1998-2018.

The progress of average monthly rains over the two sub-periods: 1971-1997 and 1998-2018 shows that at the intra-seasonal scale, the accumulations variation of the rainfall regimes have increased, due to the high rainfalls in the middle of the rainy season for the two sub-periods.

The number of annual rainy days over the study period has reduced considerably between 1971 (73 days) and 2018 (68 days). Since the height of the rain has not fallen over the sub-period 1991-2014, one can conclude that the occurrence of daily rains has been more and more important. This importance of rain has then had as impact the overflowing of river beds, and for extremes cases floods.

Anthropic Factors

The Malanville Township, as the others Townships of Benin, is subjected to demographic growth. In effect, Malanville is among the biggest Townships in term of rice farming in Benin. The districts of Malanville (Madecali and Gourou) have a high population concentration. This situation is due to their being situated on board of the Niger River which is favorable to market gardening activities. (Figure 6).



Source: RGPH 3 and 4, 2002 and 2013

Figure 6: Population in Number, In the Districts of Malanville, In 2002 2013.

From the analysis of figure 6, it appears that the districts of Malanville (Madecali and Garou) have 57 % of the farmer population in the Township. This number has increased from 75,952 in 2002 to 110, 873 in 2013. This growth of the farmer population goes along with their sensitivity to the impacts of flooding.

Picture 1 below shows farms and habitations set up in the bed of the Niger River.

Photos by: Idrissa Y., October 2019

Picture 1: Farms and Habitations Set Up in the Middle Bed of the Tounga (1) and Garou (2) Rivers.

Here, one can see the anarchical settlement of some people in the river way, despite this being forbidden. These people build their houses in the highly floodable areas, usually made with clay; and the houses will then collapse with the rains. Picture 2 shows the level of the water in the less floodable areas in the month of July.

Topographic Factors

The Township of Malanville is set in the Niger valley. It then collects the waters from the two slops: from Bembèrèkè and from the Niger. Figure 7 presents the topography of Malanville Township.

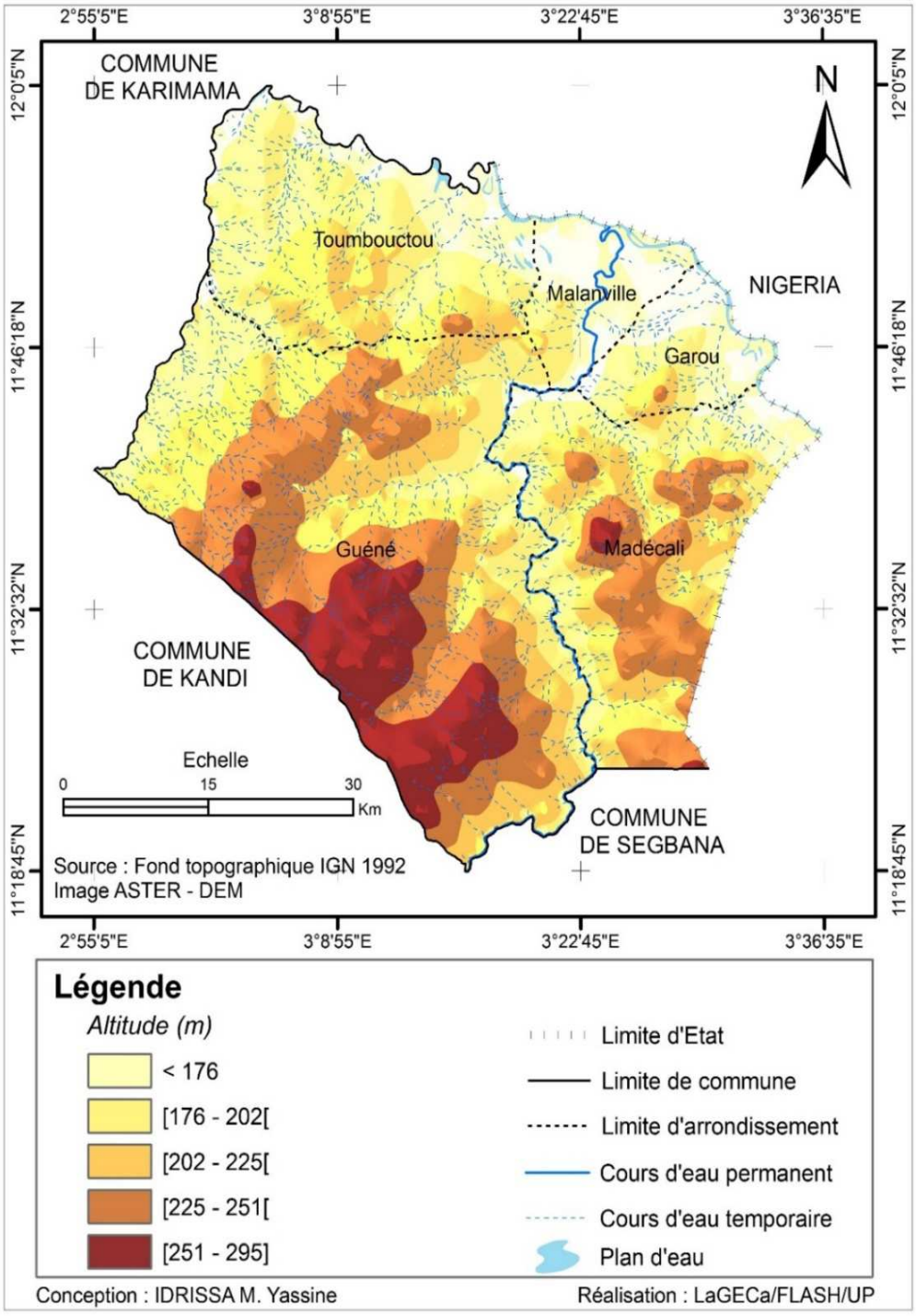


Figure 7: Relief of Malanville Township

From the analysis of the above figure, it appears that the whole Township presents a non-uniform relief, with zones of low altitude crossed by seasonal rivers which are affluent of the Niger River. The Northern part of the Township is characterized by low altitude zones, whereas the South-West is characterized by high altitude zones. At the beginning of the rain seasons, water goes back to its bed and then nourishes the affluent which in turn flood the Township.

Figure 8 presents the slopes in the Township of Malanville.

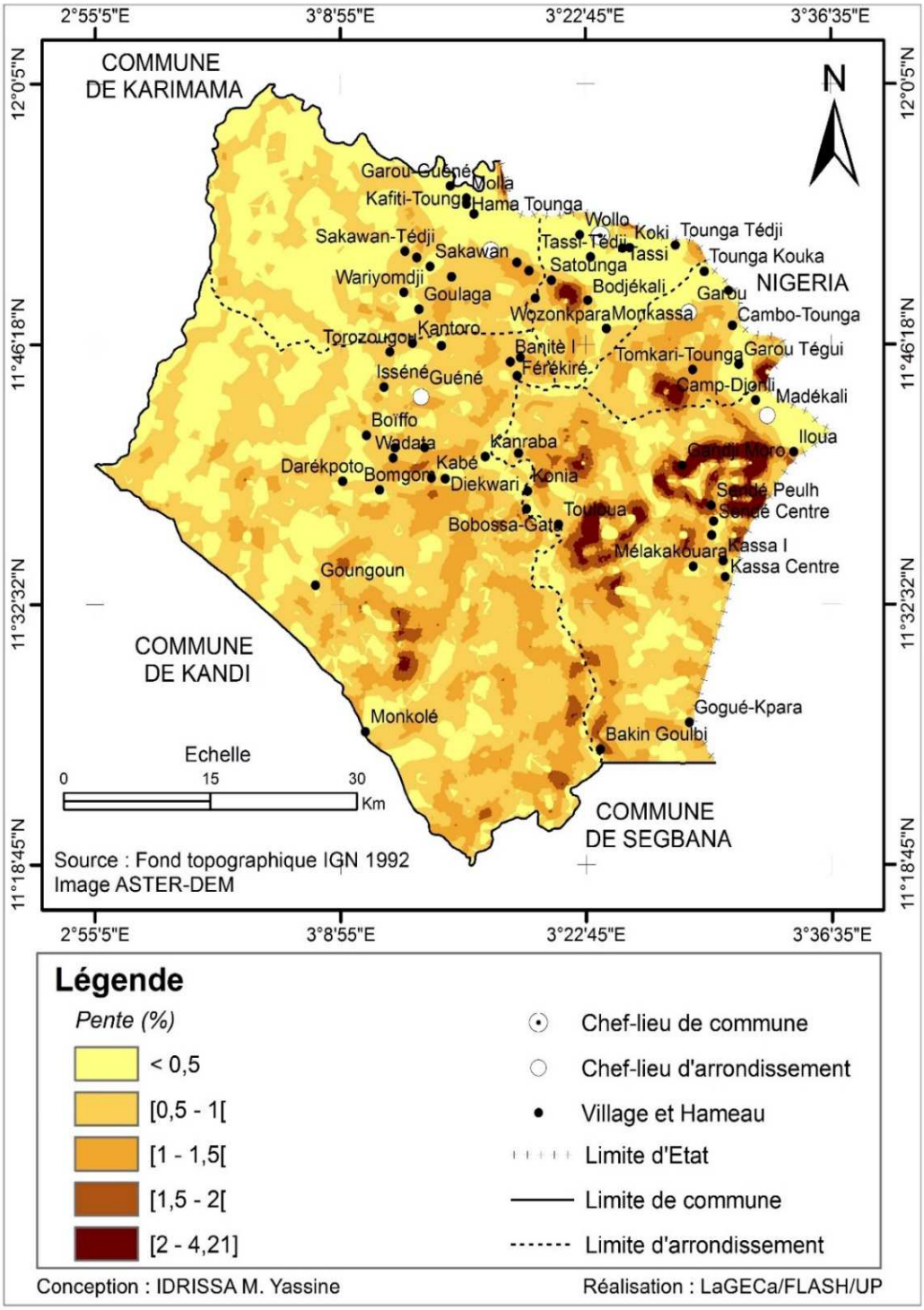
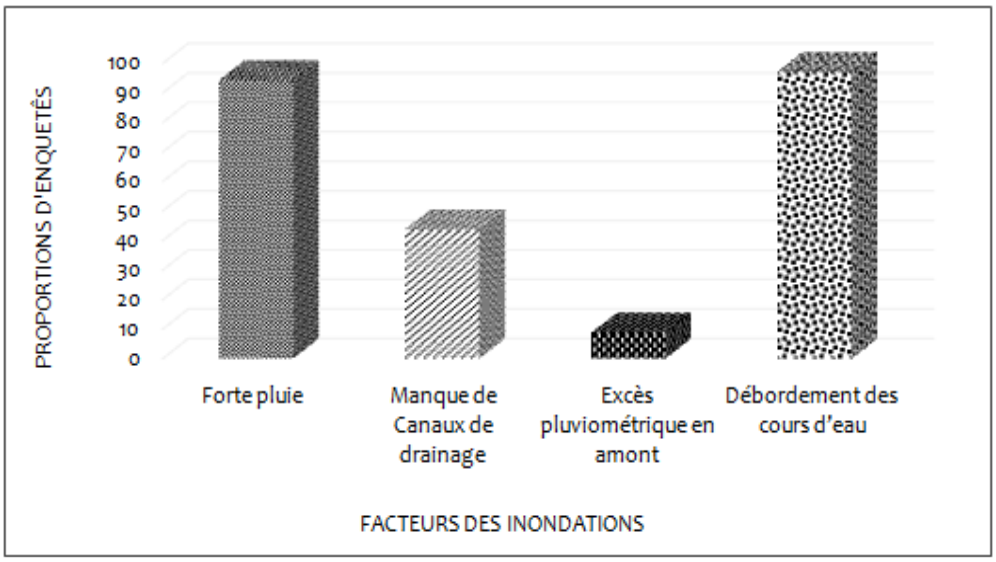


Figure 8: Slopes in the Township of Malanville.

Slopes in the Township of Malanville are insignificant, and they vary from0.5 to 4.21%. This explains the vulnerability of the Township when the Niger River overflows.

Perceptions of the Populations about the Factors that Favor Flooding in Malanville

Figure 9 presents the perceptions of the respondents about the cause of flooding in the Township of Malanville.



Source: Data processing and field investigation, October 2019

Figure 9: Perceptions of the Populations about the Causes of Flooding in Malanville.

From the analysis of this graph, it appears that the populations (94.10 %) perceive an abundance of rains as shown through the rainfall analysis. However, the main factor responsible for flooding is the overflowing of the Niger River, due to abundance of rains, according to100 % of the respondents. Then, it is noted that those populations ignore in their great majority that the water that flood the Township are not solely from the rain that pours over the area.Only8.73 % of the respondents have identified the runoff water as responsible of the flooding in the Township. Also, the respondents reject every responsibility in the damages from the flooding. Indeed, only 16 % of them have acknowledged their share of responsibility in the flooding.

Impacts of the Flooding Over the Environment in the Township of Malanville

Figure 10 presents flooding zones in the Township of Malanville.

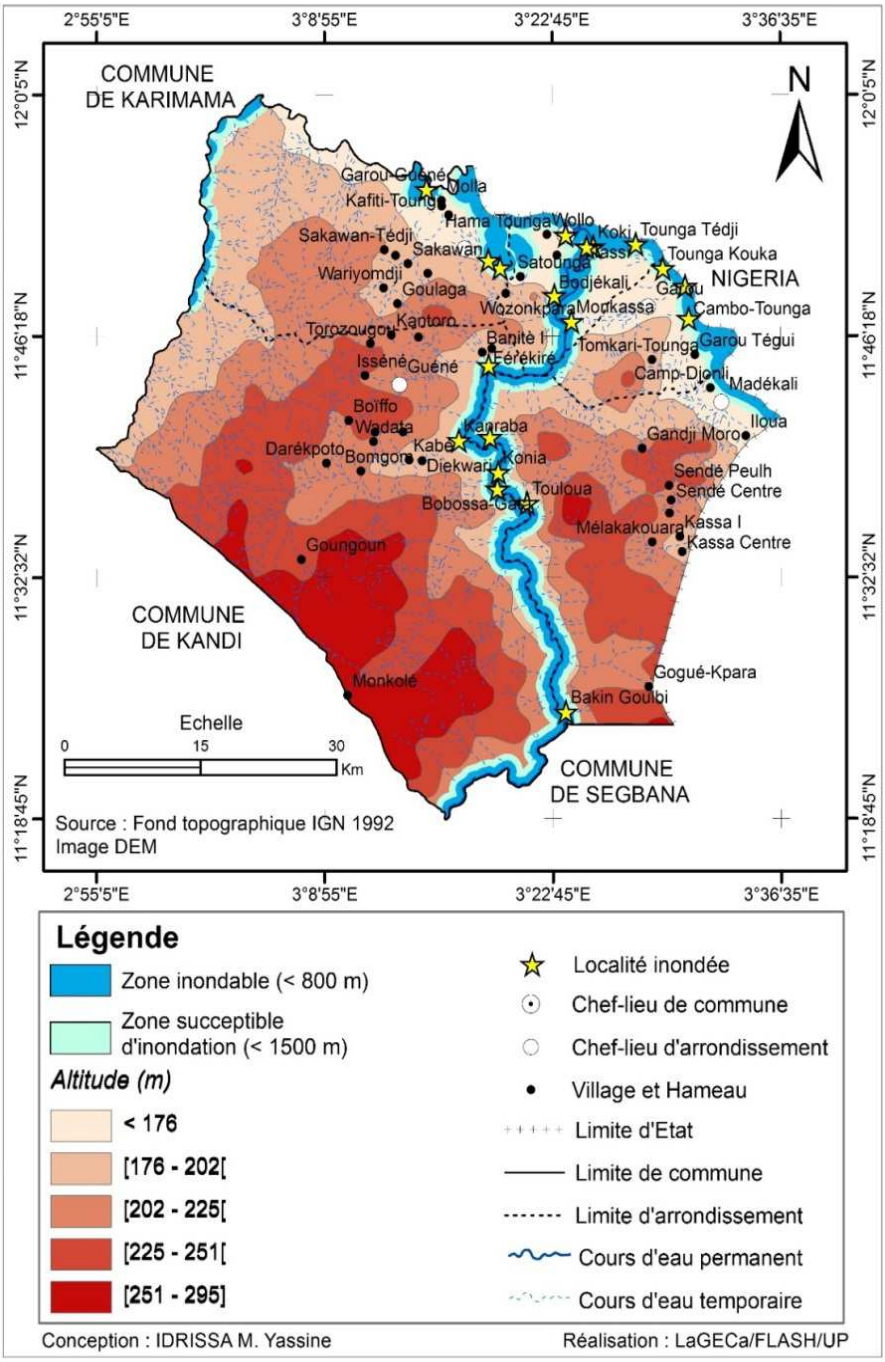


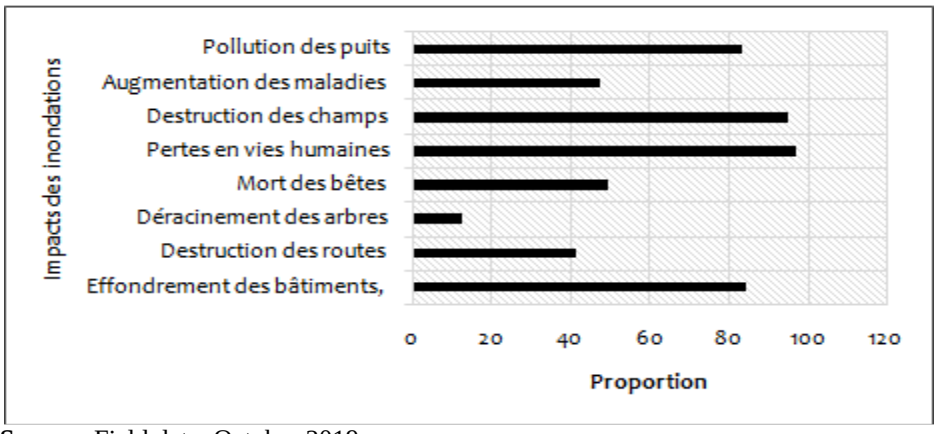
Figure 10: Flooding Zones in Malanville.

From the analysis of the above figure, it is noted that more than eighteen (18) villages a situated at less than 1Km from the minor river bed. Their settlement in these zones exposes them to the least overflow of the water.

The combined effects of the slope, of its orientation and the high concentration of the Niger River affluent in those districts constitute the worsening factors, as they cause flooding at each water overflow.

Vulnerability of the Components of Environment in the Township of Malanville

The Township of Malanville is vulnerable to the evolution of climate parameters (draught and flooding). Figure 11 presents the impacts to which the populations are exposedin case of flooding.



Source: Field data, October 2019

Figure 11: People's Perceptions about the Causes of Flooding in Malanville.

Flooding has huge consequences over the components of the environment.

From human's viewpoint, 100 % of them acknowledge that each year, there are ten (10) deaths and serious casualties cases related to floods. In 2018, there were already two (02) deaths and five (05) wounded in August. Also, animals die either out of drowning, or from garbage intoxications. The evaluation from the National Office of Civil Protection has numbered in 2018, some 937 households affected, including 366 homeless and 678 totally ravaged houses. To this, entire one has to add the more than 8000 ha of flooded farms, which has been confirmed by 95.14 % of the respondents. Picture 2 presents the damages related to flood in 2018, although people there have found it insignificant.

Photo by: Idrissa Y, October 2019

Planche 2: Habitation (1) and Bridge (2) Destroyed at Tassi Zénon and Harù Banda III.

Seventy percent (70 %) of the poor respondents' households lose their habitations and activities during each flooding period. Their average monthly income falls, sometimes up to nothing, for some poor households, due to the bad state of the roads.

Table 2 below presents a summary of the flooding vulnerable local development sectors in the Township of Malanville.

Table 2: Vulnerable Climate Disaster Sectors in the Township of Malanville

	Water	Agriculture	Energy	Commerce	Habitation	Health	Ecosystems
Flooding	X	X	-	X	X	X	X
X=Yes - =No							

Source: M Boko Andal, 2016, PAS-PNA, 2019

Analysis of table 1 shows that all the key sectors are concerned with the flooding, mainly the economic, social and environmental sectors. Then, one should expect changes in the quality and quantity of available water. Inquiries have revealed that a flooding year always has consequences on the following:

- Food security, through a fall in the farming yields (destruction of cultures)
- The health of the populations, through increase of infectious and diarrhea base diseases
- Eco systems of Rivers, through modification of their natural habitation.

Evaluation of the Degree of Vulnerability of Local Development Sectors Facing Climate Hazards

The vulnerability analysis of economic and social sectors shows that agriculture is the most vulnerable sub-sectors to the effect of flooding in the Township of Malanville.

Table 3 below presents the flooding sensitivity matrix of the key sectors. The table has been drawn to better evaluate the exposition degree of those sectors.

Table 3: Flooding Sensitivity Matrix of Key Sectors

Key Development Sectors	Disasters			Ranking	Exposition Indicators
	Draughts	Flooding	Hard Winds		
Water	5	4	1	10/15	66,67
Agriculture	5	5	1	11/15	73,33
Energy	2	1	1	4/15	26,67
Commerce	3	5	4	12/15	80
Habitation	1	5	5	11/15	73,33
Health	5	4	1	10/15	66,67
Ecosystems	5	5	3	13/15	86,67
Impact Indicators	74,28	82,85	45,71		

Source: Adapted from PANA, 2008. Scale: 1:Weak, 2:Very weak, 3:Average, 4:Quite strong, 5:Strong

Analysis of the above table reveals that the development sectors in the Township of Malanville are diversely impacted by the variability and the climate disasters. Comparing the impact degree of the most recurrent disasters in the Township, the ecosystems are the most impacted, with an expository index of 86.67 %, followed by agriculture and habitations (73 %).

DISCUSSION

Identification of flooding factors in Malanville has revealed that the main factors are climate, topographic and anthropic related. Such classification is identical to those of F. Etéka (2008, p. 49) specifying the sub-components of the environment damaged by the flooding in Avotrou, and it has shaped a map of flooding areas in Cotonou. Also, C-R. Assou (2015, p.23) has proposed categorizing the most vulnerable social and environmental sectors. He has mapped the flooding zone, highlighting the level of the Township of Dangbo from the sea zero level.

In the presentation of flooding impacts, the environmental, agricultural, and social sectors are the most impacted by the flooding, which corroborates the results by C-R. Assou (2015, p. 37) who has presented the loss rate in farming, in the Township. Basing on the inquiries, 52 % of the respondents have identified the agricultural sector as more vulnerable to flooding. Anh Tuan Luong (2012, p. 144) has made a distribution of the cost of damages following land occupation, through his thesis research work on the Huong River. D. B Mahutin (2012, p. 15) has shown the social impacts of flooding in Zagnanando. The 2010 flooding there has destroyed habitations, and people were then forced to live under tents.

CONCLUSIONS

The present research work, besides its providing new raw data, has allowed explicifying a large part of the environmental effects of flooding in the districts of Malanville. This study allows to understand that:

- Flooding is sometimes a handicap to development in some districts of Malanville, since it impacts negatively on almost all the constituent elements of the areas.
- The development of the farming sector has led some people, mainly the Garou, Malanville and Madécali populations to settle in the floodable zones.
- The lack of hygiene and the potable water provision problems that are typical to peri-urban areas, favors water and fecal based diseases.

Then, these flooding affect all the key sectors of the Township (agriculture 73 %, potable water 66 % and the ecosystems 86 %). Flooding cause important material damages (destruction of roads, collapse of houses, falling of trees, and many others); human (death of many people) in Malanville, basing on more than 90 % of the respondents.

Many challenges are being taken over in the framework of the management of recent flooding, both on local and national scales. However, there remains a weakness in the process, which needs considering in an emergency: these include the weakness in the crisis management system, due to a deficiency in the coordination system, and the deficit of the capacity reinforcement of the sharing actors in the channel. It is also noted a lack of civic attitude among the populations who, despite the sensitizing and forbidding, always build their houses in the floodable areas.

Globally, and with reference to the past experiences, management of all those critical issues and disasters, and specifically the flooding that have occurred in the Township of Malanville, in the past and in the present, deserve backing up.

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