ISSN 2522-9400 **European Modern Studies Journal** *Vol 6 No 4*
available at journal-ems.com

Gonzagueville and Jean-Folly, Two Neighbourhoods in the Commune of Port-Bouët, Very Vulnerable to Flooding

DAKOURI Guissa Desmos Francis [1]*, BROU Kamenan Marcel [2], OUATTARA Drissa [3], KOULE Kouamé Bernard [4]
[1]Maître de Conférences, Institut de Géographie Tropicale, Université Félix Houphouët-Boigny, Côte d'Ivoire
[2]Maître-Assistant, Institut de Géographie Tropicale, Université Félix Houphouët-Boigny, Côte d'Ivoire
[3]Maître-Assistant, Institut de Géographie Tropicale, Université Félix Houphouët-Boigny, Côte d'Ivoire
[4]Doctorant, Institut de Géographie Tropicale, Université Félix Houphouët-Boigny, Côte d'Ivoire

Abstract. For a decade, the municipalities of the city of the district of Abidjan have been increasingly affected by natural hazards with considerable damage. One of the most dreadful is the floods that haunt the population every year during the rain season. The objective of this study is to highlight the determinants of the vulnerability of the inhabitants of the districts of Gonzagueville and Jean-Folly in the municipality of Port-Bouët. The methodological framework used to achieve this objective combines bibliographic research, field observation and interviews. The results obtained indicate that the vulnerability of the Gonzagueville and Jean-Folly populations is linked to morpho-structural conditions and anthropogenic factors. In other words, the results of this study highlight the vulnerability of the municipality through its relief of high plateaus which expose the population to flooding. They also indicate that the anarchic occupation of space and the behaviour of the populations are at the root of the floods which strike the commune.

Keywords: vulnerability, factor, flood, Gonzagueville, Jean-Folly, Port-Bouët

Introduction

The risk of flooding to which humanity is exposed is a major concern for all social strata, especially as climate change on a global scale is worrying. Floods are the category of natural disasters whose impact has grown most alarmingly. Indeed, it is estimated that between 1980 and 2004 an average of more than 500 million people were affected by floods each year worldwide, 400 million of them in Asia. They cause more than 25,000 deaths per year. The forecasts are still alarming. They indicate that by 2050, some 2.5 billion people will be vulnerable to catastrophic floods due to factors such as population growth in flood-prone areas, climate change, sea level rise and deforestation (Collin, 2004).

In developing countries, urbanisation results in a significant increase in the population of large cities and is often anarchic (Carry et al., 1996). Urban growth is very rapid in these countries, with the occupation of sites that are not suitable for housing (Thouret & D'ercole, 1996). Among the risks that threaten the populations, those due to meteorological phenomena, in particular floods, are the most recurrent. They affect a greater number of people, especially in urban areas. Urban localities are the most exposed. Many large cities are subject to natural processes known as hazards, and suffer disasters more or less regularly (Veyret & Chocat, 2005).

In Côte d'Ivoire, the city of Abidjan, because of its triple administrative, political and economic status, has a high concentration of human, material and economic issues. This has

* Corresponding Author

resulted in an uncontrolled spatial expansion that has led to the emergence of numerous precarious neighbourhoods. These neighbourhoods generally occupy areas that are partially or totally unbuildable, such as valley bottoms, basins and coastal plains that are prone to flooding (Alla, 2013). The urban planning efforts carried out with the help of the various construction companies, is faced with the thorny problem of the distortion between the occupation and development of space and the demographic boom. This exposes these Ivorian cities to recurrent floods, the most notable of which were those of June 2005, May 2007, May 2008 and June 2010 to 2017 (Alla, 2013; Brou, 2007). The frequency of these floods has led (Bailly, 1996; Kassy, 2004) to assert that flooding is one of the most repeated natural risks on the planet. In urban areas, this is due to constructions that do not fit well with the urban planning regulations in force and obstacles to the circulation of water (Descroix, 2013).

In addition to these anthropogenic factors, natural factors are recorded among the causes of flooding, through topographical contexts (Noiville, 2003).

The cases of Gonzagueville and Jean-Folly, two neighbouring districts of the Port-Bouët commune, are no different. Moreover, the current level of development of these urban areas means that many inhabitants of these neighbourhoods live in areas where they are more or less directly threatened by the flood hazard. The objective of this study is to highlight the endogenous and exogenous factors of flooding in Gonzagueville and Jean-Folly. In order to do so, a good knowledge of the different components of the physical, technical and human environment of these areas is essential. Since the natural risk arises from the encounter between the physical framework of a space which makes it susceptible to the occurrence of one or more hazards and anthropic elements which are of interest to man (Alla, 2008). This requires a detailed description of the physical elements (rainfall, relief, geology and soil). Also, a good perception of the interactions between the technical (stormwater infrastructure equipment), anthropic (population, buildings, activities) and physical components is essential.

Method and Material

Synthetic Aspect of the Study Area

Neighbourhoods of the commune of Port-Bouët in the District of Abidjan, Gonzagueville and Jean-Folly extend along the coastline. The district owes its settlement to the opening of the wharf in the commune and even more to the creation of the first port in Côte d'Ivoire in 1950. With the port came the multiplication of factories and warehouses. Port-Bouët then became the main employment area of Abidjan with its vast industrial and port zones. These sites concentrate important economic activities: fishing, industry, tourism and trade. This urban sprawl is in itself a risk generator as it results in the city being built in areas where the risks are greater.

The origin of the settlement of Gonzagueville and Jean-Folly is linked to the demographic and spatial expansion of the city of Abidjan. Workers bought land in Gonzagueville and Jean-Folly close to their workplaces, but also located on the coast, and built their houses. At that time, it was with the permission of the Abidjan municipal authorities and respect for the public maritime domain, as Abidjan was still only a medium-sized town. For at least 50 years, the coastline has been retreating. The erosion of the coastline, the advance of the sea and the growing demography have brought the population closer to the sea. This geographical location exposes the districts of Gonzagueville and Jean-Folly in particular to extreme phenomena.

The sensitivity of the coastline to sea level rise is all the greater as Gonzagueville and Jean-Folly, a coastal district, is currently very exposed.

Gonzagueville and Jean-Folly, our study area (Figure 1), are part of the narrow coastal basin of Côte d'Ivoire covering 2.5% of the territory located in the south on the Atlantic

coast. The various activities practised destabilise the coastline and contribute to coastal degradation and erosion.

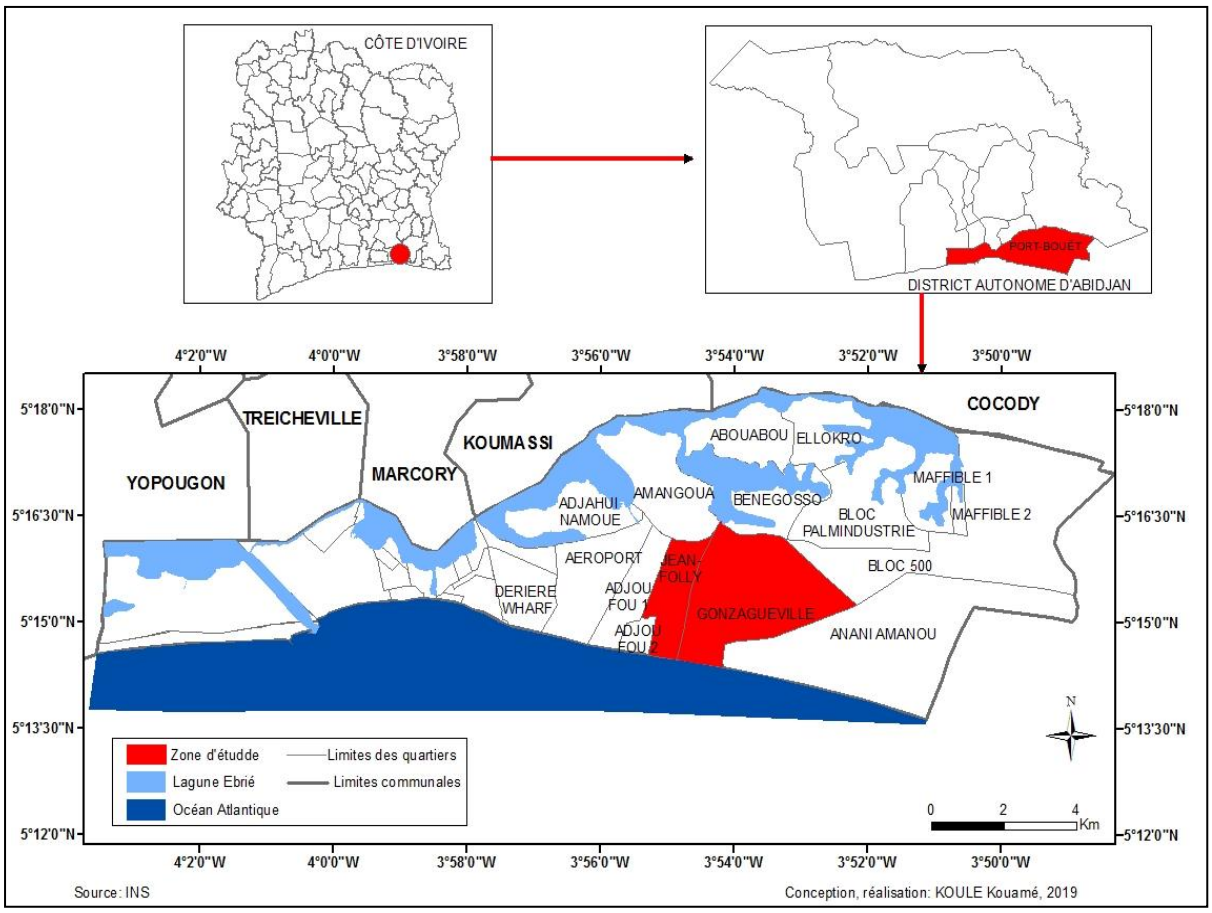

Figure 1: Presentation by Gonzagueville and Jean-Folly

Data Collection Equipment and Tools

Both computer and conventional equipment were used for data collection and processing. The hardware consisted of a computer model notebook 15 from HP, a smartphone model hot 4 from Infinix and software such as Sphinx version 4.5, Google Pro from Google and the OSMtracker application. The computer was useful for the preparation of our questionnaire with the sphinx software. It was also useful for digitising the buildings of Gonzagueville and Jean-Folly using Google earth Pro software. The installation of the OSMtracker application installed on the phone allowed us to record the position of points of interest in our study area.

Other equipment was used. These included a 2m measuring rod to measure water levels, a tape measure to measure water marks on walls and a 15m rope to measure the depth of the water table at wells dug by local people in the dry season. Arcgis software version 10.2.2 was used for the cartographic processing of our data. The cross-referencing of the different layers of information relating to natural factors was done using Arcgis version 10.2.

The Geographic Information System (GIS) approach was used to identify flood-prone areas. This approach allows the extraction of relevant synthetic information from a set of geographical data. It makes the analysis of risks and disasters more accurate by locating the threatening phenomena (hazards) and the consequences they may have on the stakes (populations, buildings, activities, structures, etc.).

Field Survey

These are observations made in the field in May-June 2021. These were conducted with the aim of knowing clearly the events that lead to the occurrence of floods. In addition, a questionnaire was administered to the heads of households in order to gather information on the factors responsible for the occurrence of floods.

The progression of the questionnaire follows the logic of the usual path of thought and discussion of the layman: starting from relatively simple information, i.e. that which forms the fabric of their life, of their concerns (age, nationality, level of education, marital status, professional status, religion practised, etc.) to then arrive at the issue, the dialogue being well underway, to questions involving less familiar concepts such as: natural risk, vulnerability, flooding, etc.

The sampling was based on the principle of information saturation of Pires (1997), i.e. the threshold at which the answers provided by the respondents no longer vary, is reached. Thus, 81 people were interviewed according to a reasoned choice, i.e. they were selected on the basis of criteria deemed relevant, namely being the head of the household and having lived in the neighbourhood for at least five years.

Results and Analysis

Factors Triggering Flooding in the Gonzagueville and Jean-Folly Districts

Topography favourable to flooding

The area covered by this study is the neighbourhoods located in the south of the Port-Bouët commune. The analysis of the geographical context of this area shows that there are risks of flooding. Topographically, the relief is a coastal plain with almost no slope and low altitudes ranging from 2 to 10 metres (Figure 2), making it difficult for rainwater to run off.

This low altitude results in the location of the water table close to the surface, as confirmed by the surveys carried out in 2017 and 2018 at the Gonzagueville site. These show that the depth of the water table decreases with altitude. For example, the water table is between 1.5 and 1.95 metres deep in areas at an altitude of 2 metres. The depth of the water table varies between 2.60 and 3.5 metres for areas with an altitude of 4 metres and between 4.75 and 5.50 metres for areas with an altitude of 6 metres. The depth of the water table in the 8-metre altitude zones varies between 6.90 and 7.50 metres and in the 10-metre altitude zones, between 8.60 and 9.45 metres.

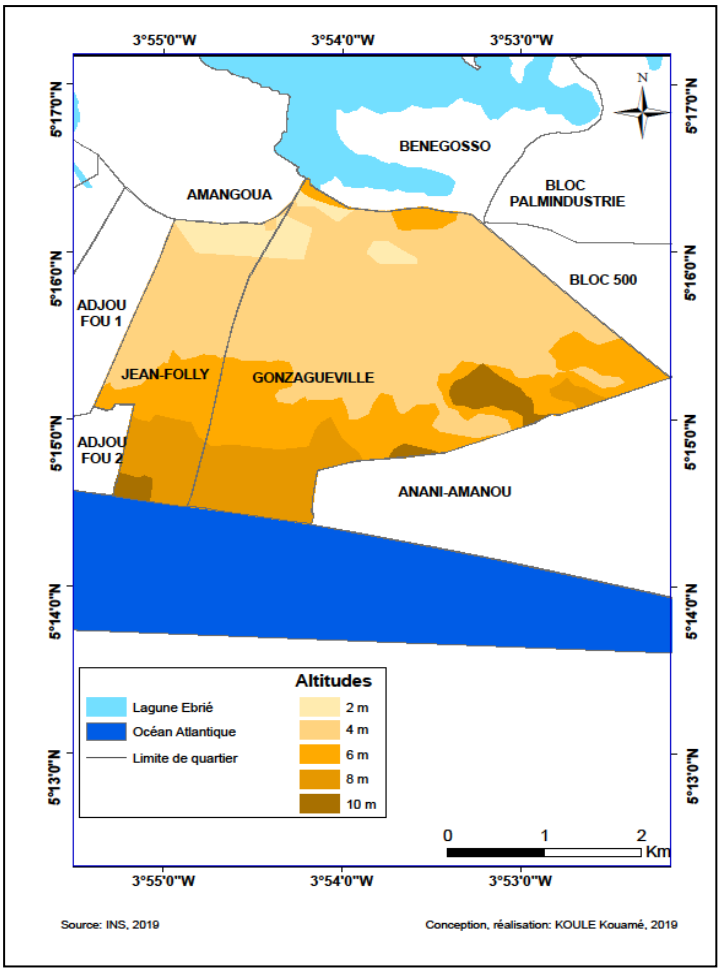

Figure 2: Digital Terrain Model of Gonzagueville and Jean-Folly

A geological context that is also favourable to flooding

The coastal strip on which Gonzagueville is located is part of the Abidjan coastal plain (alluvial plain). It isolates the lagoon systems from the ocean and is made up of quaternary sediments. Geologically, the plain is formed by Quaternary clayey sands and marine sands, as well as fluvio-lagoon formations (Alla, 2014, p. 7). Consequently, the existence of marshy areas and the proximity of the water table make it a particularly difficult area to build in, due to the problems of rainwater drainage.

Indeed, the marine sands, laid down during the Holocene period, constitute the substratum of the barrier beach. They form a thick layer of up to 45 metres or even 70 metres. These sands cover the marine Miocene. These marine sands are of various colours. However, whatever their colour, they are formed of grains with an average size of more than 260 µm. These grains can reach 840 µm, with less than 10% of grains smaller than 150 µm (Direction de la Géologie, 1992) quoted by Alla (2013). These sands are therefore coarse sands.

For building purposes, these soils are not very resistant to erosion due to the porosity of their constituent materials. They can support low-rise houses and light industrial equipment. The installation of multi-storey housing and heavy industrial equipment requires bearing capacity studies. However, the low altitudes which induce the presence of the water table at shallow depths favour the rapid rise of the water table to the surface during the rainy season. This poses a drainage problem.

Moreover, the above-mentioned conditions, together with high rainfall, favour the development of podzolic soils where leaching due to fluctuations in the water table is at its maximum (Leneuf, 1956; Roose et al., 1966). According to these authors, this type of soil is

very sandy, essentially made up of coarse quartz sand and is very permeable. These soils are limited to the lower zone of the barrier beach. The accumulation horizon becomes deeper and thinner as one moves towards the coast, the water table becomes progressively deeper and no longer affects the upper horizons in the area of the red sands with ochre soil of little recent contribution. In the central part of the barrier beach, where elongated depressions have formed, humic hydromorphic soils with podzolic tendencies occupy these areas. This type of soil is also found along the lagoon.

From the above, it can be seen that the materials that make up the sub-basement of the barrier beach that shelters Gonzagueville and Jean-Folly, as well as the soils that cover it, can subject this area to flooding in the event of heavy rainfall.

Heavy and intense rainfall

When the morphological and pedological conditions are met, the hazards that occur are normally triggered by the heavy and often brutal rainfall that is recorded (Brou et al., 2017). As a trigger for hydrometeorological accidents, it is therefore necessary to know the characteristics of these rains. Although the rainfall observed in these localities in Table 1 is abundant on the whole, it is their high concentration during the long wet season that is remarkable. The main rainy season begins in March and ends in July. It is during this period that rainfall is very frequent and violent. The months of May, June and October are when the rainfall reaches its peak. Gonzagueville and Jean-Folly receive a lot of rain, with rainfall of up to 675.5 mm.

Table 1: Distribution of rainfall in Gonzagueville and Jean-Folly, Port-Bouët commune

Month	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
P (mm)	5	44,9	58,5	**245,8**	**399**	**602,8**	21,6	89	33	**675,5**	**299,8**	69,5	**2371,9**

Source: SODEXAM, 2021

They are concentrated in two periods: April to June, during which 52.59% of the year's total rainfall falls, and October to November, with 41.11% of the rainfall in 2021. But more significant are their violence and intensity, with daily rainfall of up to 10 mm. These heavy rains, in an environment where the relief is too flat and the soil too fragile in view of its low resistance, naturally exposes the Gonzagueville and Jean-Folly districts to flooding (photo 1).

Photo 1: Flooded street in the "Elephant" sub-district of Gonzagueville
Photo: Koulé, 2019

Although these hazards are obvious, the growing impoverishment, the lack of buildable land in the commune and the rapid increase in the population are pushing the population to occupy the marshy areas (Boka et al., 2020). The analysis of the elements constituting the physical framework (relief, geology, soil, climate) shows that Port-Bouët and its neighbourhoods, notably Gonzagueville and Jean-Folly, are developing on a fragile area capable of subjecting the populations living there as well as their property to the risk of flooding.

Manifestations and Extent of Flooding in Gonzagueville and Jean-Folly

During the rainy season, the shallow water table is rapidly saturated by the water from successive rains. This causes groundwater to rise to the surface. This results in flooding in certain sectors of the Gonzagueville and Jean-Folly districts ("Eléphant", "Deux Plateaux", "Colonel", "Deux poteaux", "Siaba" and "Belleville"). In addition to flooding due to rising groundwater, the flatness of the land and the rapid saturation of the soil with water cause flooding due to the concentration of water on the surface, which in most cases is combined with flooding due to rising groundwater. Even if the slopes are gentle, runoff is also a source of flooding in some places, as in the case of the houses located near the "terre rouge" road. Moreover, Gonzagueville and Jean-Folly have not benefited from any rainwater drainage infrastructure. There are therefore no rainwater drains in the entire area occupied by these neighbourhoods. The sanitation infrastructure consists mainly of individual sanitation structures. These are septic tanks attached to the dwellings for the evacuation of wastewater and excreta. These floods occur from April to July or from October to December, depending on the year. They last from a few hours to several months and vary according to the topography of the location. The average height of the water during floods also varies. The intensity of flooding in streets, yards and homes varies according to the sub-neighbourhoods in Gonzagueville (Figures 2, 3 and 4).

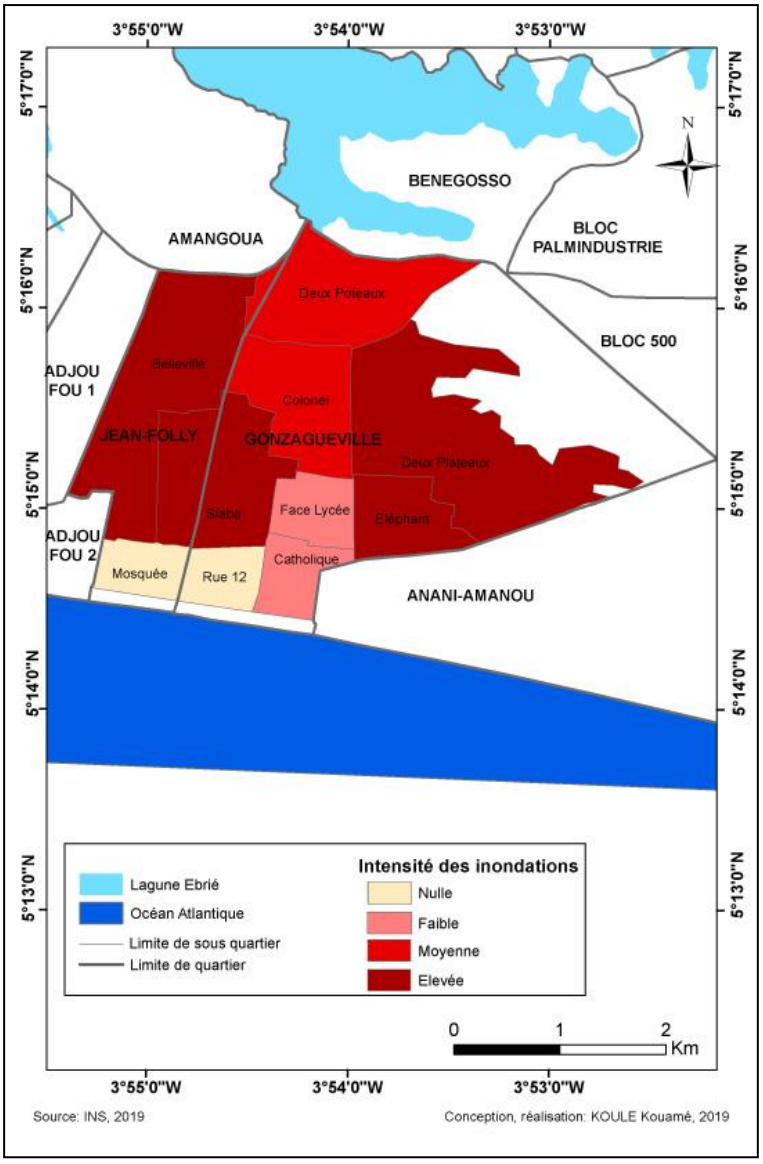

Figure 3: Flooding intensity in Gonzagueville and Jean Folly streets

The level of flooding in the streets of Gonzagueville varies according to the sub-districts. The highest level of flooding is found in the sub-neighbourhoods "Siaba", "Belleville", "Elephant" and "Deux Plateaux". The sub-neighbourhoods where flooding is of average importance are Colonel and Deux poteaux. The streets in the "Catholique" and "Face lycée" sub-neighbourhoods are affected by minor flooding, while the streets in the "Rue 12" sub-neighbourhood are not affected by flooding.

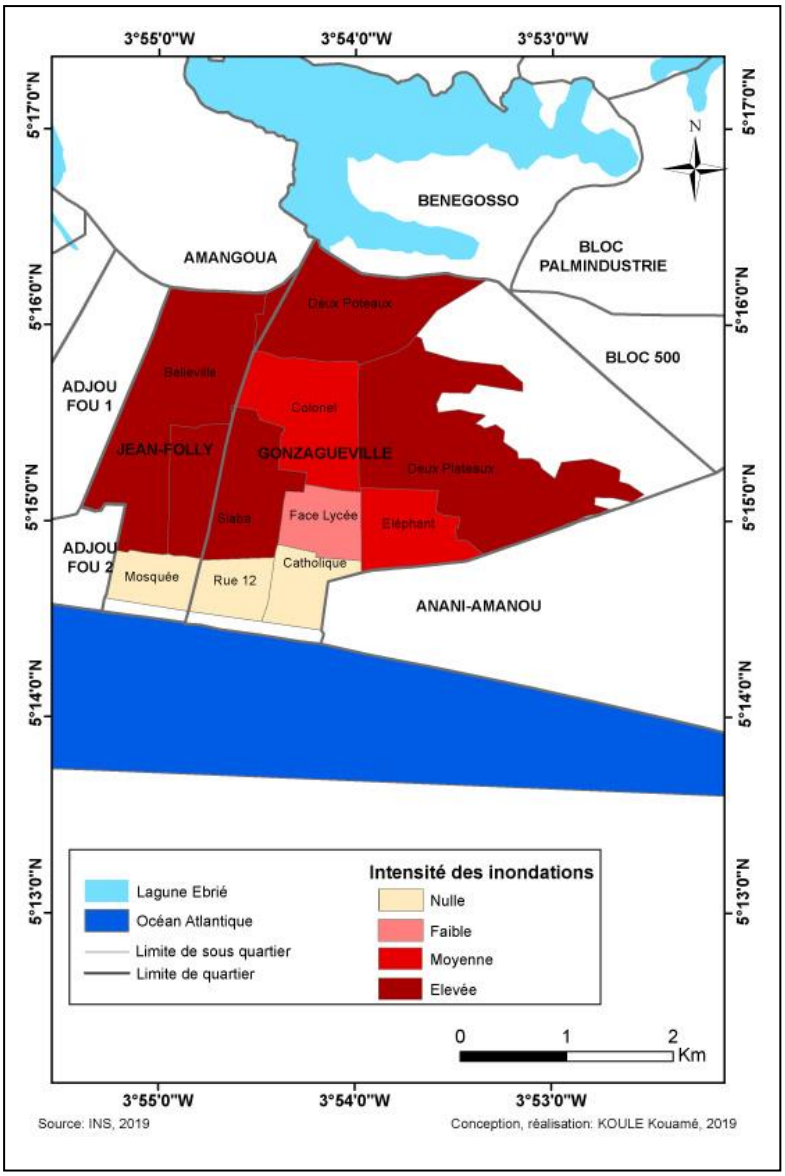

Figure 4: Intensity of flooding in the yards of Gonzagueville and Jean Folly

The yards of the inhabitants of Gonzagueville and Folly are also flooded during the rainy seasons. However, if the sub-neighbourhoods of Rue 12, Face Lycée and Catholique and Mosquée are spared from flooding, it is the opposite of the sectors of "Deux Plateaux", "Deux poteaux", "Belleville" and "Siaba" with a high level of flooding where the water can reach nearly 60 centimetres. In the courtyards of the sub-districts "Elephant" and "Colonel" have an average level of flooding with more than 30 centimetres of water height.

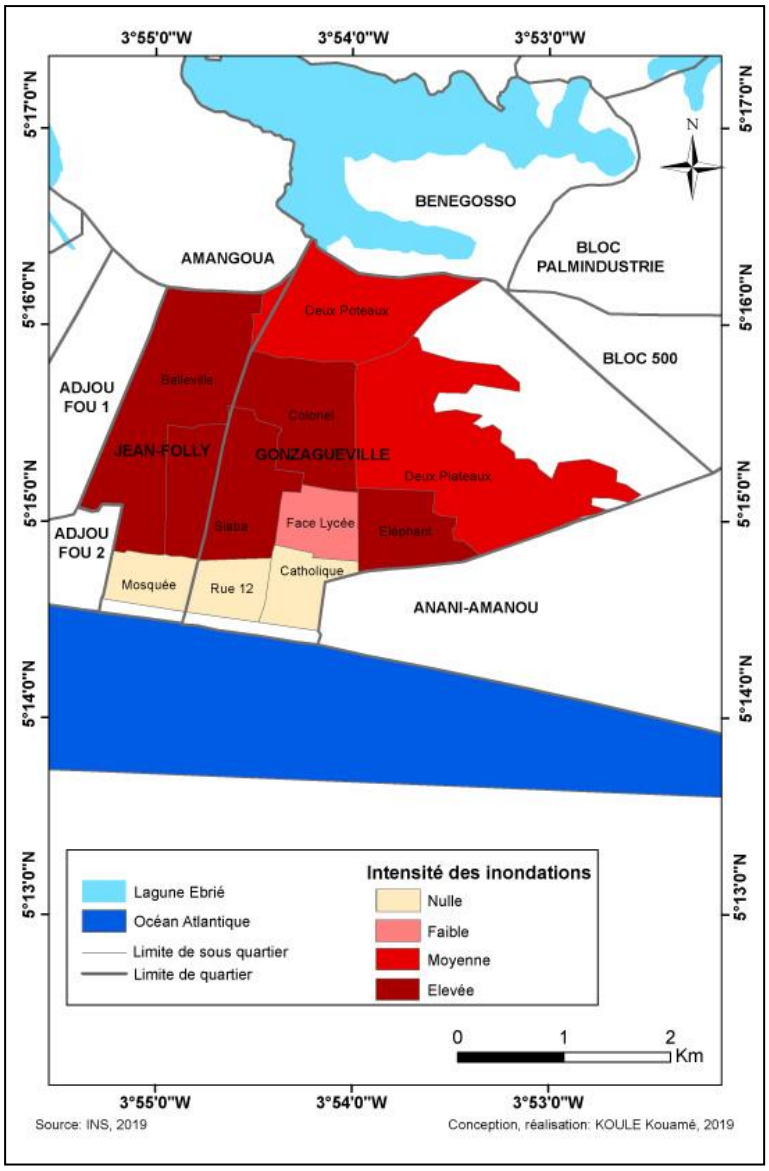

Figure 5: Flood intensity in the houses of Gonzagueville and Jean-Folly

The dwellings of the resident populations of Gonzagueville and Jean-Folly are not spared from flood waters. The extent of the flooding that affects the houses during the rainy seasons in Gonzagueville and Jean-Folly varies from one sub-district to another. Thus, in the sub-neighbourhoods "Elephants", "Colonel", "Belleville" and "Siaba" the houses are subject to a high level of flooding which can reach 58 centimetres. Whereas in the sub-neighbourhoods "Deux Plateaux" and "Deux poteaux", the level of flooding is average and the houses in the sub-neighbourhoods "Rue 12", "Face Lycée", "Mosquée" and "Catholique" are exempt from flooding.

Conclusion

The coastal strip that shelters Gonzagueville and Jean-Folly is a homogeneous and flat area with a low slope and low altitudes (2 to 10 m). The water table is located at a shallow depth of between 1.5 and 10 m. The geological material of this area is essentially made up of coarse, highly permeable Quaternary sand. The lower margins of the barrier beach are covered by podzolic soils, while hydromorphic soils occupy the central depressions and ochre soils the coast. Rainfall is very high, with an annual average of 2371.9. Thus, the physical

and anthropic characteristics of these neighbourhoods subject the residents to different levels of risk. The levels of risk are a function of the level of the flood hazard, the importance of the issues and their vulnerability.

References

Alla, D. A. (2008). Les inondations à Grand-Bassam : un risque permanent. In: Pottier, P. & Anoh, K. P., *Géographie du littoral de Côte d'Ivoire : éléments de réflexion pour une politique de gestion intégrée, coopération universitaire Cocody Abidjan (Côte d'Ivoire) / Nantes (France)* (pp. 221-236).

Alla, D. A. (2013). *Risques naturels dans l'agglomération d'Abidjan (Côte-d'Ivoire*). Thèse d'Etat, Institut de Géographie Tropicale, Université Félix Houphouët-Boigny, 385 p.

Avenard, J.-M., Eldin, M., Girard, G., Sircoulon, J., Touchebeuf, de L. P., Guillaumet, J.-L., Adjanohoun, E. & Perraud, A. (1971). *Le milieu naturel de la Côte d'Ivoire*. ORSTOM, 401 p.

Bailly, S. A. (1996). Environnement, risques naturels, risques de société in risques naturels de Société, Paris. Economica, 103 p.

Boka, A. C., Dakouri, G. D. F., Ouattara, D. & Doumbia, K. (2020). The factors of the recrudescence of floods and their consequences in the Divo district in the municipality of Koumassi. *Agric. Sci. Res. J.*, pp. 283 – 290.

Brou, K. M. (2007). *Les risques d'origine naturelle en milieu urbain : Le cas des inondations dans la commune de Cocody.* Maîtrise de Géographie, Institut de Géographie Tropicale (IGT), Université de Cocody, 163 p.

Brou, K. M., Dakouri, G. D. F., Alla, D. A., & N'kA, N. M. (2017). Les facteurs de recrudescence des inondations dans la commune de Cocody (Abidjan-Côte d'Ivoire). *Cahiers du Centre Béninois de la Recherche Scientifique et de l'Innovation, 11,* 79-97.

Carry, G. & Veret, Y. (1996). La prévention des risques : l'exemple français est-il transportable dans les pays en développement ? In: *Cahier des sciences humaines* (pp. 423-445).

Dauphiné, A. (2001). *Risques et catastrophes : observer - spatialiser - comprendre. gérer*, Paris, Armand Colin, 288 p.

Descroix, L., Mahé, G., Olivry, J.-C., Albergel, J., Tanimoun, B., Amadou, I., Coulibaly, B., Bouzou, M. I., Faran, M. O., Malam, A. M., Souley, Y. K., Mamadou, I., Vandervaere, J.-P., Gautier, E., Diongue-Niang, A., Dacosta, H., & Diedhiou, A. (2013). Facteurs anthropiques et environnementaux de la recrudescence des inondations au Sahel. In: Sultan, B., Lalou, R., Amadou, S. M., Oumarou, A., & Soumaré, M.A., *Les sociétés rurales face aux changements climatiques et environnementaux en Afrique de l'Ouest* (pp. 153-170).

Faure, J.-F. & Castro, E. (2003). Cartographie des zones inondables et gestion des risques d'inondation dans l'agglomération de Belém. In: *Espace tropical et risque du local au global de Gilbert David* (pp. 379-395).

Kangah, A. & Alla, D. A. (2015). Détermination des zones à risque d'inondation à partir du modèle numérique de terrain (MNT) et du système d'information géographique (SIG) : Cas du bassin-versant de Bonoumin-Palmeraie (commune de Cocody, Côte d'ivoire). *Geo-Eco-Trop, 39*(2), 297-308.

Kassy, L. P. (2004). *Site urbain, assainissement et risques naturels à Grand-Bassam*. Mémoire de maîtrise, Institut de Géographie Tropicale (IGT), Université de Cocody, 196 p.

Noiville, C. (2003). *Du bon gouvernement des risques*. Paris, PUF, 235 p.

Pires, A. (1997). *La recherche qualitative. Enjeux épistémologiques et méthodologiques*. Montréal : Gaëtan Morin, Éditeur, 405 pp.

Roose, E. & Cheroux, M. (1966). *Carte du bassin sédimentaire ivoirien* 1p.

Thouret, J.-C. & D'ercole, R. (1996). Vulnérabilité aux risques naturels en milieu urbain : effets, facteurs et réponses sociales, Acte de colloque international : Croissance Urbaine et Risques Naturels dans les Pays en Développement, Clermont-Ferrand France, *Cahier des Sciences Humaines*, pp. 407-422.

Veyret, Y. & Chocat, B. (2005). Les mégalopoles face aux risques etaux catastrophes naturelles. *La jaune et la rouge, 606*, 38-41.