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Research Paper

Constraints Related to Storm Water Management for Sustainable Development in the 2nd and 3rd Boroughs of Porto-Novo (Benin)

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ABSTRACT : *This study is conducted to analyze the causes of the malfunction of the storm water management system in the city of Porto-Novo and especially in the 2nd and 3rd boroughs. The use of climate and demographic data, statistics of the monthly variability of rainfall and erosivity and field investigations constitute the bulk of the methodological approach. Of the 35 districts that comprise the 2nd and 3rd boroughs of the city of Porto-Novo, 24 districts were surveyed following the urban typology (dense, less dense, structured) and activity (residential, commercial, administrative, mixed), through a reasoned choice, that is 68.57%. Rainfall and soil characteristics of the city of Porto-Novo offer a natural predisposition to runoff phenomenon. But 70% of human actions have intensified the scale of this phenomenon. In addition, 50% of sanitation facilities do not facilitate good management of runoff water during showers. This is due to inadequate intake of measures for sustainable water management in land use policies at different levels. The social and economic costs to be paid by the population and the municipality are important. Sustainable management of rainwater pass through ecological landscaping inspired by the natural functions of retention and treatment of rainwater.*

Keywords*: Porto-Novo (Benin), storm water, sanitation, sustainable development*

I. INTRODUCTION

The hydrology of urban areas appears largely conditioned by the influences and mechanisms often unknown. Climate and hydraulic urban studies revealed regional differences in managing stormwater [1]. Thus, in the late 1960s, there is a climatic deterioration due to drought, urban and other low areas basins, which dried up during the long drought were used as densely populated urban area expansion and without formal remediation plan [2]. Waterproofing of infiltration areas of rainwater, due to the high occupancy of the soil causes rapid concentration of runoff in the new districts. In recent decades, there has been a return to wet conditions, which also causes flooding. To drain water as quickly as possible runoff, open underground drainage systems or sky cities carry runoff to sewage treatment plants or water courses [3].

The stormwater management problem increases with urbanization, increasing transport, aging infrastructure and climate change [4]. Like the other cities in the world, those of Benin did not remain on the sidelines of this phenomenon. Flooding in the city of Porto-Novo is becoming more frequent. The population of the two districts (2nd and 3rd) of the city of Porto-Novo does not understand why, despite the new facilities built in the city rain events can also have a negative impact on their daily lives [5]. Control and stormwater management today therefore become an important issue for local officials responsible for urban development and anxious to ensure the safety and comfort of their citizens.

Better manage runoff is not only fight against the risk of flooding, but also help clean up the urban environment. Indeed, the sanitation scheme designed generally to the city level provides insight into the socio-technical, economic and financial, in their succession, their complexity and bring lasting global solutions [6]. The present research on stormwater management in urban areas for sustainable development focused on the 2nd and 3rd boroughs of the city of Porto-Novo (figure 1).

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Figure 1: Location of the study borough in Porto-Novo

1 Data and method

1.1- Data :

Collected information is climate data (on the city of Porto-Novo and demographics in the 2nd and 3rd districts). It is also, that on the construction of roads and sanitation in the study area. The information is also collected on the practicability of streets, areas of erosion and threats to homes in Porto-Novo. In addition, there is the phase of carrying out laboratory work. It complements field studies. From the average annual rainfall height (H), erosivity (R) was calculated using the formula R = H x 0.5 [5]

1.2- Sampling

For the purposes of the study, 24 districts were surveyed in two boroughs (2nd and 3rd boroughs) on 35. The selection criterion was based on urban typology (dense, less dense, structured) and activity (residential, commercial, administrative, mixed). Within selected neighborhoods, household surveys are selected according to the hierarchy of roads (primary, secondary, tertiary, service). Table 1 presents the respondent sample. Of the 15,661 households, 350 were investigated, that is 2.2%.

Table 1: Introducing sampling.

Boroughs	2nd	3rd	Total	Sampling rate
Number of districts	13	22	35	----------
Total households	8807	6854	15661	----------
Total number of households surveyed	130	220	350	2.2%
Number of surveyed districts	08	16	24	68.57%

Source: INSAE (2012) and field surveys, 2013.

1.3 Technical Investigations

Data has been collected on the underground storm drainage system and how it works to build a database. Two surveys were conducted: one on looks without opening and another opening on looks. In the latter case, it is a question of assessing the state of the domestic network through the eyes.

Information was collected on the status of drains and looks to assess the causes and impacts of degradation. This survey was conducted on 845 points (manholes and drains) in 13 districts of the two streets with a total length of 20 km.These surveys provided cross information between the network status and activity areas.

II. RESULTS AND DISCUSSION

2.1. Results

2.1.1 Natural constraints on storm water management in the city of Porto-Novo

The damage caused by erosion in tropical countries are awarded mainly to rainfall aggressiveness. This is mainly due to the high intensity of the tropical rains. We must consider the intensity, volume, frequency of rainfall and its distribution during the year. The effects of these ground rainwater depends on the size of the plant cover which opposes the runoff by absorbing water.

The rainfall erosivity in Porto-Novo is manifested during the two rainy seasons.

The average rainfall is 1300 mm, erosivity (R) is of the order of 650.

The figure2 illustrates the monthly variability of rainfall and erosivity in Porto-Novo.

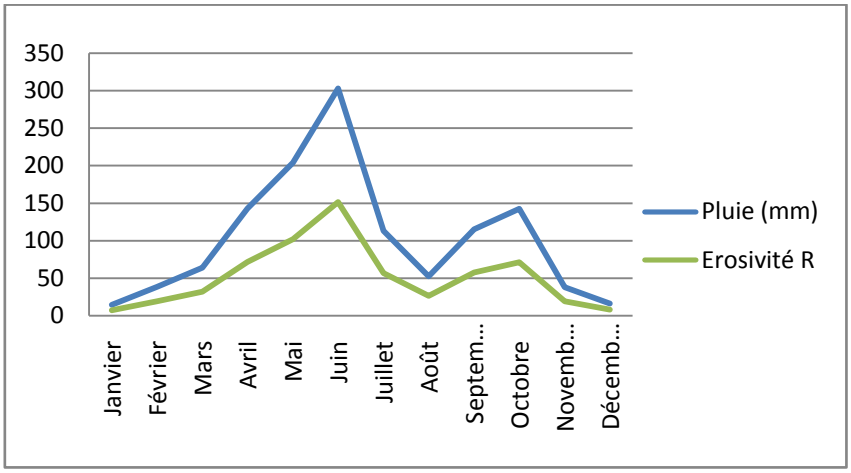

Figure 2: Monthly variability of rainfall and erosivity in Porto-Novo 1982-2012.
Source: ASECNA and fieldwork, 2013.

The curve of average heights of rain shows two periods of rainy and two dry seasons. Periods of rain are those from April (143 mm) and July (113 mm) on one hand and September (115 mm) to October (142.4 mm) on the other. These periods correspond to the great and the small rainy season. June is usually the wettest months with rainfall amounts to 302,9mm. As against the other months, that is to say those of August (52.5 mm) and November (37,9mm) to March (63,7mm) are the small and large dry season respectively. The curve of the values of erosivity follows the same trend as the curve of rainfall. Considering the rainy months, we retain that for six months of the year, the soil is exposed to the aggressive climate and the showers in Porto-Novo are intense.

2.1.2- Runoff from rain

Runoff flow is more or less rapid rainwater. It plays a very important role in the erosion mechanism. It can be concentrated or diffuse. When it is concentrated, it tends to create multiple gullies on the floor (photos1a and 1b). When it is diffuse, it is unable to gully.

Photo1a: gully in the district of Attakè in Porto-Novo	Photo 1b: Gully nearby concessions Avakpa-Kpodji neighborhood in Porto-Novo

Shooting: BETE A. June 2013.

During the runoff, the water charge silty materials, hard solid particles it carries. There is therefore progressive etching (erosion) of the surface of soil (photo 1c).

Photo 1c: deposit silt materials and solid particles nearby concessions Attakè neighborhood in Porto-Novo.
Shooting: BETE A. June 2013.

The photographies1a, 1b, and 1c show the impact of runoff in Attakè,Avakpa and neighborhoods. This is the creation of gullies (pictures 1a and 1b) and deposition of silt and particulate materials (photo 1c).

2.1.3- Analysis of urban storm water management system in the 2nd and 3rd districts of the city of Porto-Novo The river system is a system that ensures the drainage of an area defined by a watershed line. This function is performed by a hierarchical system of manifolds which transfer the water to a building drain the lagoon of Porto-Novo.

In the second district, the water is drained to the watershed Donoukin that handles converge towards the lagoon of Porto-Novo. Similarly, in the third district the water is drained to the watershed of the Zounvi which also converges towards the lagoon of Porto-Novo.

The network consists of two types of structures: the underground network (closed drains) and the open network (photo2a and 2b).

Photo 2a: Outdoor Network at Kandévié
Shooting: BETE A., June 2013.

Photo 2b : Buried Network at Sèdjèko

The two photos show two works of storm water management network of the city of Porto-Novo. The presence of sand and materials observed in the picture 2a and stagnant water observed on the second indicates the maintenance issue faced by sanitation works in the city of Porto-Novo.

The area of Porto-Novo in the city network is characterized by:
- important equipment with networks buried in the third district;
- a variation of the type and rate of equipment with the hierarchy of the road as the center to the suburban area.

The underground network (gutter) is the book most used in the city of Porto-Novo.
The underground network has a reduced discharge capacity which produces even overflows to the important sections on rainy current events.

The area drained by this network is also facing the problem of stormwater drainage. This is an issue with one hand blocking drains and looks and secondly to obstruction of the section by waste (picture 2c).

Photo 3a: Gully clogged at Kandévié

Photo 3b: Ditch cluttered with garbage at Avakpa-Kpodji

Shooting: BETE A., June 2013

Pictures 3a and 3b are illustrative of the state of the ditches in the two districts. They show a ditch filled with solid and liquid waste. This raises once again the wastewater management problem. Fouling is a significant factor of hydraulic malfunction drainage structures. According to field observations, about half of the network studied is a section bite at more than 50% of waste (table 2).

Table 2: Internal condition of visible eyes: eyes closed, visible through their drains, manholes with closure broken or removed.

Number of visible sights	Filling state by waste or debris			
	A	B	C	D
845	85	380	105	275
100%	10%	45%	12%	33%

Source: Field survey, november 2013.

A: almost entirely filled by waste or debris.
B: half of the section of the eye filled with the waste or scrap.
C: slightly filled by waste or debris.
D: almost clean.

It is clear from Table II that wild deposits are favored by the absence of looks closure. The latter also causes safety problems for pedestrians with serious and sometimes fatal accidents. The drains are also sensitive points of the stormwater management system. According to field observations, on average 45% of the studied drains are clogged which 15% are deliberately by local residents who complain about the bad smell and the water overflow.

2.1.4- Suggestions for sustainable management of urban stormwater in the 2nd and 3rd districts of the city of Porto-Novo

The strategies to help the good management of rainwater in the 2nd and 3rd boroughs of the city of Porto-Novo are among others the organization and supervision of the population and sustainable water management.

* The organization and supervision of the population.

The participation of the population is considered as an important element for sustainable development. On this point, the city has an important achievement. The census means households and their willingness to participate to define the capital works funding opportunities and other types of participation (labor, study) for the management of the works.

According to survey results, 45% of households surveyed want a structure at the district and 30% want at the neighborhood level. It is up to local authorities to better manage this important achievement, by outsourcing the technical structures of stormwater management in the boroughs in general and especially in the 2nd and 3rd districts of the city of Porto-Novo.

* Sustainable Stormwater Management

Natural functions can be used to manage the rainwater. This is to promote the establishment of green spaces to slow runoff, use of green spaces to preserve the natural drainage network, (eg with vegetated ditches) adopt infiltration practices in areas where soils are permeable, to restore the micro-topography (hills and valleys) to

slow runoff. Similarly, the green features are much more embellish or greening the scene: when combined on the same site, they contribute to reproduce the natural functions of a place and manage rainwater on site. One of the environmentally friendly features is the design of green roofs. Green roofs are designed for plants. Some amenities include small gardens or flower boxes, while others cover the entire roof. Rainwater is collected, retained and filtered by the soil. Plants absorb water and spewing.

Moreover, the swamp area which means all of the major bed plans and streams, this natural area or urban, should be considered as a useful and rewarding part of the city. However, the marshes of Porto-Novo are structurally and conceptually hidden without any integration into the urban landscape. This confinement contributes to the degradation of streams and limit their functionality (hydraulic and others). It is therefore necessary to extend the swamp Zounvi since Ouando up Djassin-Zounmè as shown in figure3.

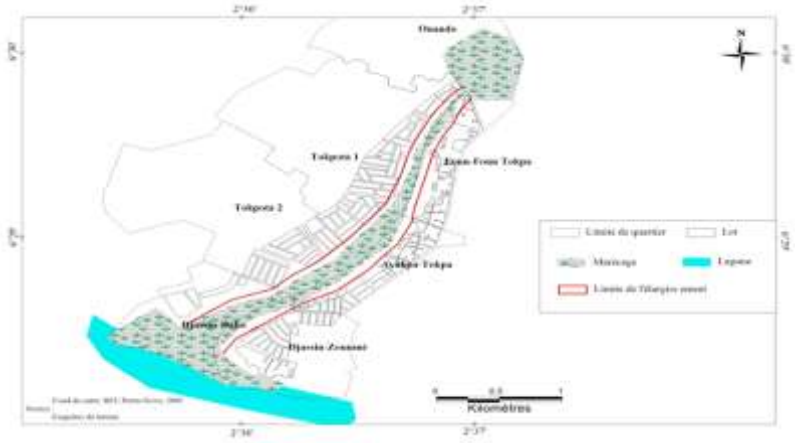

Figure3: enlargement of Zounvi Plan.

The analysis shows that figure3 enlargement Zounvi valley will allow to channel rainwater and identify people who close the valley to settle.

II. DISCUSSION

The management of urban water resources involves the implementation of all the processes that control wastewater, stormwater and groundwater. The results of the research in this field show that mastery of rainwater depends on the nature and land use on the one hand, the real will of the local authorities and the other plants. This is noted with [3], which showed that the maintenance work of the sanitation service in the city of Parakou concern more urgent interventions for the cleaning of the most critical networks during the inevitable excesses both dry season than rainy season. It shows that the lack of ownership of works is another factor dysfunction.
The effects of erosion have a negative impact on certain infrastructure of the National Water Company of Benin (SONEB), Society Beninese Electric Energy (SBEE) and Benin Telecom SA Service. The repair cost for network dealers is exorbitant and depends on the extent of the damage caused [5].

In the third borough, water drained to the watershed Zounvi not properly converge on the lagoon of Porto-Novo. This state of affairs is due to the anarchic construction of houses near the Zounvi, and residents are flood victims. These results differ from those of [7] who studied the erosion phenomen on Aplahoué. According to geological phenomena predisposing rocks to erosion and degradation are the weathering of rocks [8] and [9]. It shows that the degradation is due to abiotic factors. The flood phenomenon is observed more in Porto-Novo than in Aplahoué because Aplahoué soils have a good capacity of water retention reaching over 10 meters deep without the presence of curasse and shell in places. Note also that the annual amount of rain in Porto-Novo is higher (1300 mm) compared to Aplahoué 1100 mm.

IV. CONCLUSION

The storm water management is one of the major issues in the city of Porto-Novo. The issue requires even more attention because of the constraints that the city is facing. Therefore sustainable stormwater management requires a comprehensive reflection that takes into account all the problems, constraints and issues of space considered. Mismanagement of space on the urban stormwater management system involves urban policy in general. The experience of the management of technical works by the use of popular participation proved inconclusive due to lack real commitment. To make the most of the popular contribution, we must precisely define its role and assign it to a territory and a clearly defined function through respect of the Land Use Plan (POS). Therefore, the population of these two districts aided by the authorities should be educated on

measures for good sustainable stormwater management. Also the municipal structure in charge of the development and maintenance of the various drainage structures (Directorate of Operational Services) must be more rigorous in the practice phase achievements of works and granting permission to prevent stagnation rainwater.

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