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Diagnostic of Access to Water Infrastructure and Sanitation in the Commune of Abomey-Calavi in Benin (West Africa)

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Abstract: ***In the commune of Abomey-Calavi, the populations have very little access to water and sanitation. This research analyzed the problems of access to water and sanitation in the commune of Abomey-Calavi. The methodology used is based on desk research, interviews with 65 resource persons, observation and field surveys of 398 households selected according to their access to water and sanitation infrastructure. The collected data were processed with the descriptive statistics tools. At the end of the analyzes, it appears that in the commune of Abomey-Calavi, 319 works provide drinking water (FPM, BF, PEA, AEV) of which 259 works are functional or 81.19% and 57 are in failure is 17.87%. The water supply rate is 57%. These indicators (breakdown rate and service rates) are responsible for the difficulties of access to water in Abomey-Calavi. The lack of a site for grouping and treatment of waste in the municipality, the shortage of public and family latrines as well as the inadequacy of wastewater treatment sites are all factors that limit people's access to sanitation services. In response to these problems, measures are being taken by state and local authorities supported by technical partners to facilitate access to basic water and sanitation for the population.***

Keywords: Benin, Abomey-Calavi town, unequalled distribution, infrastructure of water-sanitation

1. Introduction

Water and sanitation are fundamental elements in the fight against poverty in the world. According to AEPHA (2011), these are vital sectors that require significant effort. Conscious of this reality, each State has the duty to guarantee access for all to water and sanitation and to ensure a sustainable management of water resources in order to reach the sixth Sustainable Development Goal (SDG) (Hounguèvou et *al.*, 2014).

Benin has provided a lot of effort in terms of drinking water supply. Indeed, 2.6 million people have access to drinking water in Benin in 2015 against 1.2 million people in 2006 and the national coverage rate has increased from 48% in 2006 to 82% in 2015 (SONEB, 2016). In the Hygiene and Sanitation component, little effort has been made. According to Sossou (2012), 66% of Benin's population does not have access to adequate basic sanitation services, and only 15% dispose of their waste properly. In addition, 53% of Benin's population practices open defecation (WHO / UNICEF, 2015).

In the commune of Abomey-Calavi, the populations are also confronted with the problem of water and sanitation. In 2012, only 42% of the population has access to drinking water (PCEAU, 2013; Zalé, 2017). In the face of population growth and the diversification of economic activities, communal authorities can not find answers to the problems of the hygiene and sanitation sector (WASH, 2011). This results in the consumption of unsafe water, the proliferation of wild dumps, open defecation and the filling of gutters with waste (Sagbohan, 2011).

The analysis of the water and sanitation problems in Abomey-Calavi is therefore a prerequisite for setting up the infrastructures needed to remedy the problems of access to these basic social services. The commune of Abomey-Calavi is located in the south of Benin in the department of the Atlantic. It is between 6°20'20" and 6°41'48" north latitude and between 2°12'39" and 2° 25'38" east longitude (figure 1).

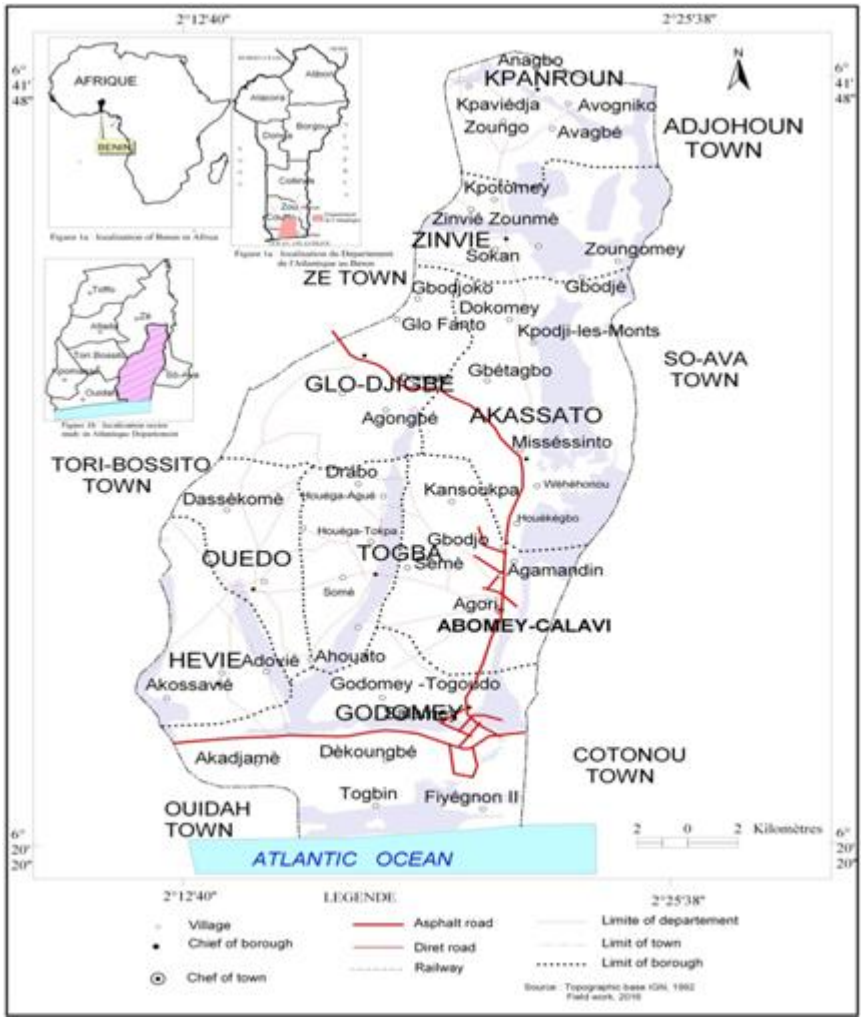

Figure 1: Geographic location of Abomey-Calavi

The commune of Abomey-Calavi is 4 km from Cotonou and covers an area of 650 km^2 representing 0.48% of the national area. It is the largest municipality in the Atlantic Department and occupies more than 20% of it. It is bounded on the north by the commune of Zè, on the south by the Atlantic Ocean, on the east by the commune of Cotonou in the department of littoral and Sô-Ava on the west by those of Ouidah and Tori-Bossito.

The Commune of Abomey-Calavi has seventy (70) villages and city districts (MDSC, 2012) with a population of 656358 inhabitants in 2013 (INSAE, 2015). It is divided into nine districts namely Abomey-Calavi, Akassato, Glo-Djigbe, Godomey, Hévié, Kpanroun, Ouèdo, Togba and Zinvié. To carry out the study, a methodology was developed.

1.1 Data used

The data used for the realization of this study are:

- Rainfall data: These are quantitative rainfall height data collected at ASECNA. For reasons of absence of synoptic station and reliability, the data of the synoptic station of Cotonou Airport were collected. The series of rain used covers the period 1985-2018. These data made it possible to analyze the evolution of the rain in the commune of Abomey-Calavi.
- Demographic data: They come from INSAE's general censuses of population and housing (1992, 2002 and 2013). They are supplemented by information collected in the specific works in order to better understand the evolution of the population of the municipality of Abomey-Calavi.
- Data on the nature of the existing water and sanitation infrastructure in the commune of Abomey-Calavi were also collected. They are available at the town hall and the departmental direction of the water of the municipality.

Field surveys were also conducted to collect socio-economic data from households. The reasoned choice technique was used to identify these households. The criterion of choice is based on the existence of hydraulic infrastructures and sanitation in the area.

Based on the formula used by Ogouwalé and *al.*, (2014), 398 households were surveyed. In addition, 65 resource persons identified by taking into account their responsibility in the water and sanitation sector were interviewed to supplement the information collected from households.

Several approaches have been used to process the collected data.

2. Methods used

The indicators targeted in this study are the climate balance, the availability of infrastructure, the density of hydraulic structures and the rate of service.

- **Climate balance study**

The climate balance is an indicator of soil water availability (Vissin, 2007). It makes it possible to highlight the evolution of the climate through the rainy inputs and the losses by evaporation. It is expressed by the formula of Sutcliffe and Piper quoted by Vissin, (2007):

Bc = P - ETP, with: Bc, climatic balance in mm, P, total annual rainfall in mm and FTE, actual evapotranspiration in mm.
FTE is defined as the climatic demand for water vapor.

- If P – ETP > 0, then the balance sheet is surplus;
- If P - ETP < 0, then the balance sheet is deficit;
- If P - ETP = 0, then the balance is balanced.

The Truc formula from the agronomist's Memento (1974) was used for the calculation of potential evapotranspiration.

$$ETP = (Ig + 50)0,40 \frac{t}{t+15}\left(t + \frac{50 - HR}{70}\right)$$

With Ig: average value of global solar radiation in Cal / cm^2 / day; t = t 12h (average temperature at 12h); HR: daily average humidity (use only if HR <50%); ETP is in mm / month.

- **Inventory and spatial distribution of water points**

The exhaustive inventory of available water points in the municipality was made taking into account the database on the coverage of the town of Abomey-Calavi in water points. The approach used to analyze the spatial distribution of water infrastructure can be summed up in two phases. First, the geographical coordinates of the infrastructures underwent cartographic treatments with QGIS 2.6.0. Then, after extraction from the study area, geographic coordinates are projected for each type of infrastructure.

- **Density of hydraulic structures and service rates in drinking water**

The calculation of the density of hydraulic structures per square kilometer was made with the following formula:
With D = density per rounding ; New = Number of buildings in the borough and Sup = borough area.

The service rate is an indicator of the satisfaction of people's drinking water needs. Thus, the calculation of the service rate takes into account public water works that provide drinking water such as FPM, FB, public PEA and active connections of SONEB. For this fact, the drinking water supply standard for structures is summarized in table I.

Table 1: Standard for drinking water supply

Acronyms	Standard of the National Drinking Water Supply Strategy	Value on EPE
BF	1 standpipe (or ramp) for 500 inhabitants	2
FPM	1 Drilling equipped with human powered pump for 250 inhabitants	1
PEA	1 autonomous water station per 1000 inhabitants	4
BP	1 Special connection (AEV) equals 12.5 inhabitants	0,05
In urban areas, 1 subscriber to the SONEB network equals 12 inhabitants		0,048
	1EPE = 250 inhabitants served	

Source : *PCEAU, (2013)*

Table I shows the drinking water supply standard for structures according to the National Drinking Water Supply Strategy. This service standard made it possible to calculate the drinking water supply rate by district and at municipal level. Only the functional works are taken into account in the calculation of this rate.

The formula used by PCEAU (2013) was used to calculate the drinking water supply rate:

$$TD = [(NbrEPE * 250) + (NbrabS * 12)] * 100 / EffPopuT$$

With

$$TD = PopuD / EffPopuT$$

With TD = Rate of service; NbrEPE = Number of equivalents Water point;
NbrabS = number of SONEB subscribers; EffPopT = Total number of the population; PopuD = Served Population.

Based on the sanitation infrastructures identified in the field, the existence or not of latrines in the surveyed households and the Communal Sanitation and Sanitation Plan, a categorization of the sanitation infrastructures in the municipality was carried out.

The data collected and the methodological approach used led to the following results.

3. Results and Discussion

In Benin, despite the many efforts made in the water and sanitation sector, there are still densely populated municipalities like Abomey-Calavi that have difficulty accessing these services. Before analyzing these problems, it is important to take an interest in the availability of water in the commune of Abomey-Calavi.

3.1 Availability of water in Abomey-Calavi

The analysis of the availability is made through the study of the rainfall regime, the climatic balance and the hydrogeological characteristics of the municipality.

Climate report at Abomey-Calavi

The climatic record of the commune of Abomey-Calavi from 1985 to 2018 shows that the deficits occur during the months of low rainfall (July to August and from mid-November to mid-April), which is clearly characterized by two dry seasons (figure 2).

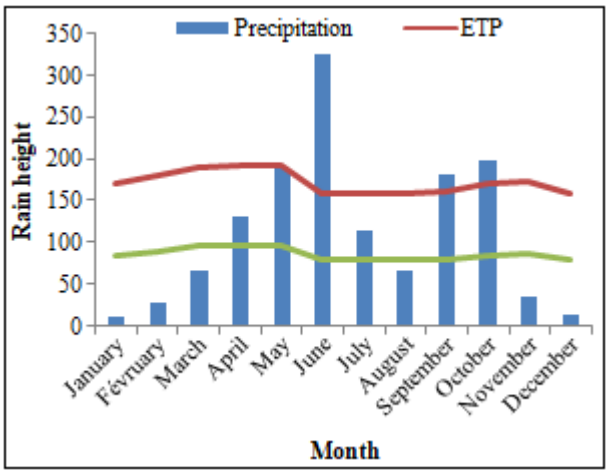

Figure 2: Climate balance (1985-2018)
Source: ASECNA data processing, 2019

The most severe deficits are observed from November to March. During these months, the rainfall is less than half the evapotranspiration. This leads to a drying up of soil reserves and a gradual decline in the water level of the rivers and water bodies of Abomey-Calavi. Similarly, the surpluses are observed during the month of June, during the great rainy season, during the month of September during the small rainy season. These rainfall surpluses contribute to the recharging of the water table and to the increase of the level of the courses and body of water. These factors are reinforced by a hydrogeological context favorable to access to water.

Hydrogeological characteristics of the municipality favorable to the availability of water

The commune of Abomey-Calavi belongs to the coastal sedimentary basin of Benin which has four superimposed aquifers, separated from each other by clay-marly assemblages. In Atlantic Canada, the Continental Peak open water aquifer and the upper Cretaceous captive aquifer are the most important. The drinking water of the Abomey-Calavi commune and Cotonou is absolutely drawn from the aquifers of Continental Terminal (Figure 3) (PCEAU, 2013).

In the commune of Abomey-Calavi, there are several aquifer horizons more or less well differentiated. They are identified approximately in the first two hundred meters and consist of a superficial horizon (superficial aquifer) and three lower horizons (lower aquifers) separated from each other by discontinuous clay layers (PCEAU, 2013). Figure 3 gives an overview of the hydrogeological context of the municipality of Abomey-Calavi.

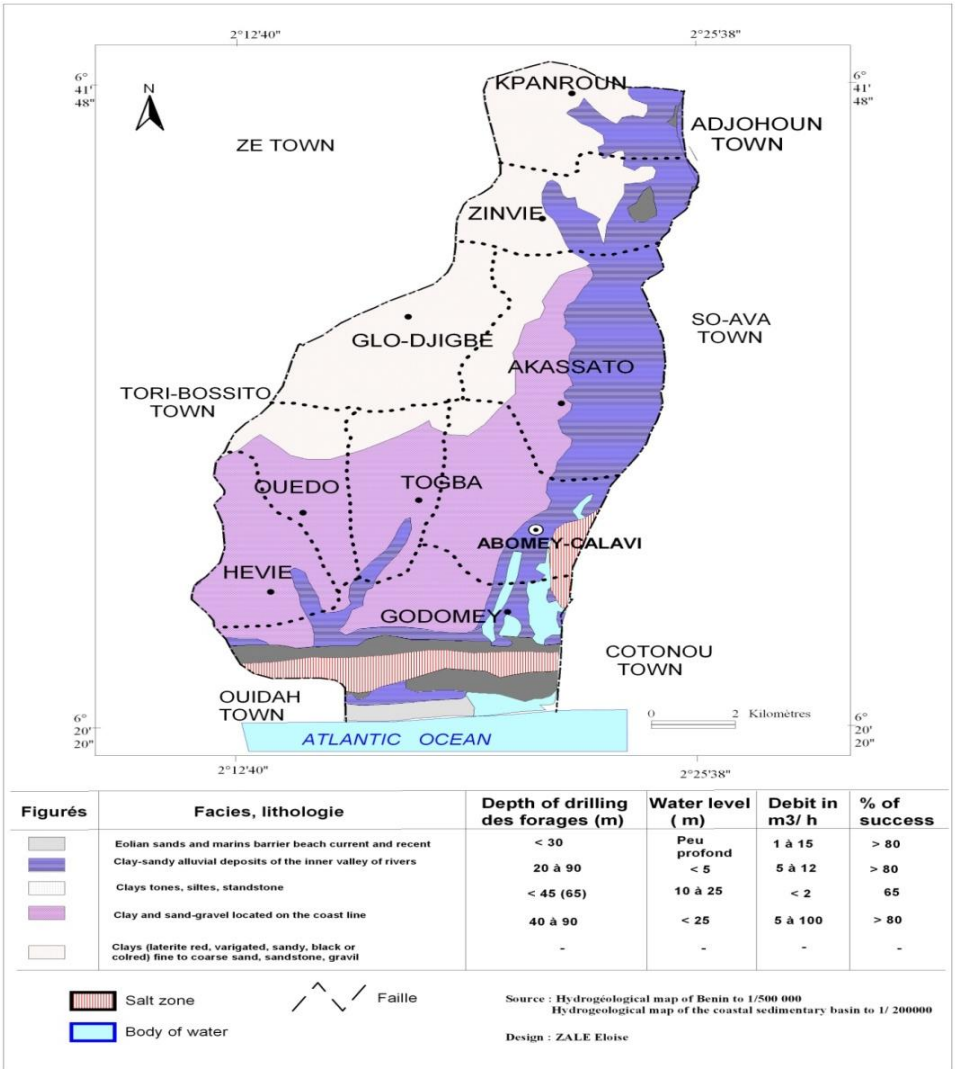

Figure 3: Hydrogeological map of the commune of Abomey-Calavi

In addition, the cumulative analyzes of the hydrogeological maps of Benin at 1: 500,000 and the coastal sedimentary basin at 1: 200,000 indicate that the catchment works carried out in the municipality exploit the resources in two continuous continents:

- The aquifer of sands, sandstones and gravels with sandy-clay levels (lateritic red, variegated, black or colored) of the Continental Terminal. Indeed, it is this aquifer which is solicited by all the drilling and some very modern of our sector of study ;
- The aquifer made of clay, gravel sands and quagmary sandy-clay alluvium. It is a superficial aquifer, generally exploited by traditional wells found in all the concessions of the municipality (PCEAU, 2013).

In addition, the development capacity from groundwater is generally very favorable, in the aquifers of Continental Terminal or Quaternary, except the area near the coastal lagoon (Togbin and its surroundings) where it is modest. The municipality belongs to the coastal sedimentary basins that cover 10% of the area and holds 32% of the exploitable groundwater potential. The annual water recharge of aquifers in the coastal sedimentary basin is 600 million mm^3 and 0.05 million mm3 / km^2 (Odoulami, 1999).

These parameters condition the establishment of hydraulic infrastructures for abstraction of groundwater exploited in the commune of Abomey-Calavi.

3.2 Water infrastructure in Abomey-Calavi

The existing hydraulic structures in the town of Abomey-Calavi are of five types, namely: the Village Water Adduction Castles (AEV) which feed the Bollards Fountains (BF); Drilling Equipped with Human Motor Pump (FPM); Public and Private Water Stations (PAE), modern wells, and traditional wells.
Table II presents the distribution and condition of public water works providing drinking water in the municipality of Abomey-Calavi

Table II: Points of public water works in the municipality of Abomey-Calavi

Municipality	Population 2015	FPM f	FPM p	FPM A	T FPM	BF f	BF p	BF f	T BF	PEA f	PEA p	T PEA	AEVf	AEVp	T AEV
ABOMEY-CALAVI	134141	12	3		15	16	0		16	0	1	0	1	0	1
AKASSATO	69746	30	2		32	2	3		5	2	0	2	0	0	0
GLO-DJIGBÉ	31995	11	0		11	42	4	1	47	1	0	1	1	0	1
GODOMEY	288336	1	1		2	1	0		1	0	0	0	0	0	0
HEVIE	76527	5	1		6	11	0	32	43	0	0	0	1	0	1
KPANROUN	11019	13	1	2	16	0	4		4	0	1	1		1	1
OUEDO	31333	15	3		18	0	20		20	0	0	0	0	2	2
TOGBA	83487	5	1	1	6	17	1		18	0	0	0	1	0	1
ZINVIE	20672	21	3		24	16	3		19	0	1	0	2	1	3
TOTAL	733455	113	15	3	130	105	35	33	173	3	3	6	6	4	10

Sources: *HRD (2015) and fieldwork (2018)*

Legends:

FPM f = Functional Manual Pump Drilling
FPM p = Manual Pump Drilling Down
T FPM = Total Drilling Manual Pump
PEA f = Functional Autonomous Water Station
PEA p = Standalone water station down
T PEA = Total Standalone Water Station inoperative
BF f = Functional Closed Fountain of AEV BF f
BF p = Fountain Terminal Faulted
T BF = Total Bollard Fountain
AEVf = Functional Village Water Adduction
AEVp = Village water supply failure
TAEV = Total Village Water Supply

These hydraulic infrastructures allow the population of the commune of Abomey-Calavi to have at their disposal drinking water in abundance for the social well-being. The analysis of the spatial distribution of water infrastructures makes it possible to assess their distribution (figure 4).

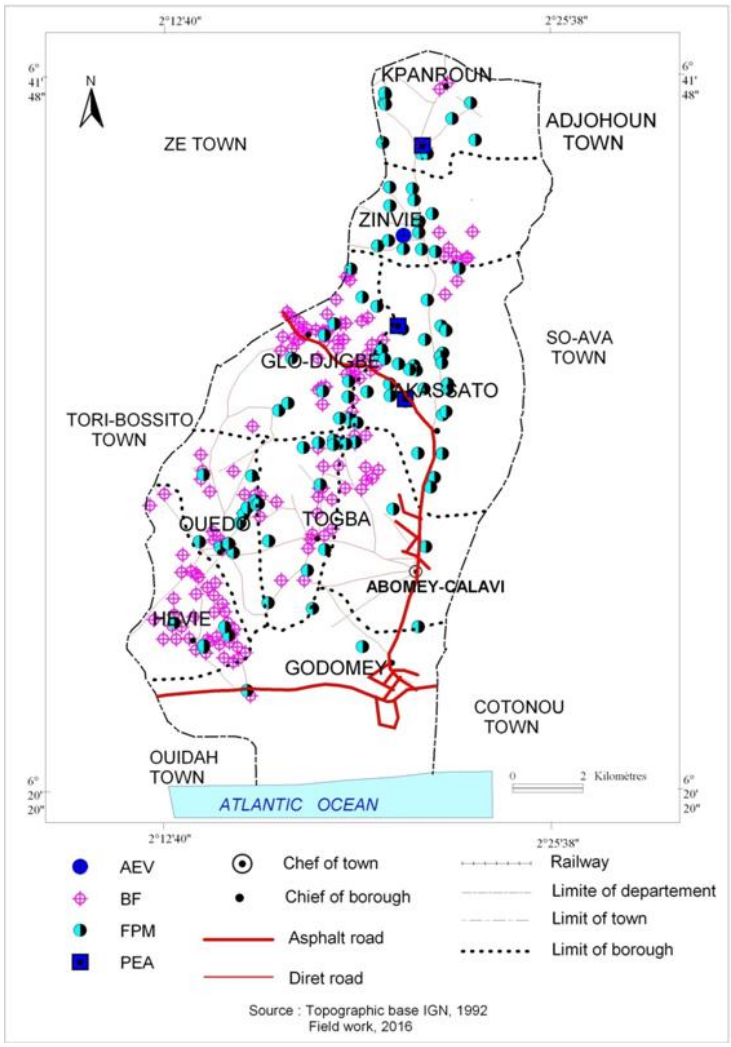

Figure 4: Spatial distribution of water infrastructure in the commune of Abomey-Calavi

Figure 4 shows that infrastructure is concentrated in some places and absent in others. The districts of Abomey-Calavi, Godomey and Akassato are partially fed by the Soneb network. Zinvié and Togba are poorly served with 119 and 16 subscribers, respectively. People who do not have drinking water make use of modern and traditional wells. Despite efforts by the authorities at various levels to meet the drinking water needs of the population, the problems persist. Even in localities very close to Cotonou, populations continue to suffer the martyrdom of water (Dégbey and *al.*, 2010). Indeed, these authors have made a case in their sector of study, a low coverage of drinking water supply.

To better understand the issue of access to drinking water in the town of Abomey-Calavi, the rate of access and the density of drinking water were analyzed.

3.3 Analysis of the indicators of satisfaction of drinking water needs in Abomey-Calavi

3.3.1 Water supply rate in Abomey-Calavi

At the municipal level, the drinking water service rate calculated is 57%. Figure 5 shows the rate of service by district in the municipality of Abomey-Calavi.

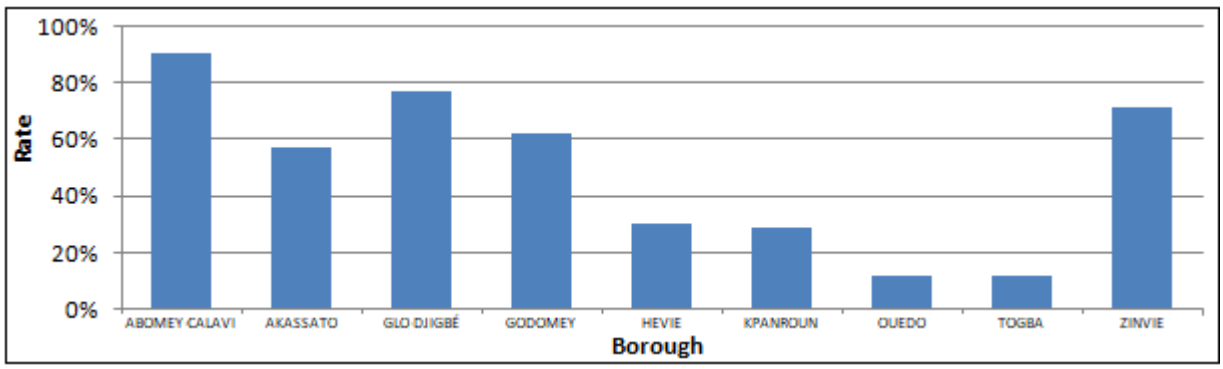

Figure 5: Drinking water supply rate
Source: Fieldwork, January 2018

Figure 5 shows that the districts of Abomey-Calavi, Akassato, Glo-Djigbe, Godomey, Hêvié, Kpanroun, Ouèdo, Togba and Zinvié have a respective rate of 90%, 57%, 77%, 62%, 30% %, 29%, 12%, 12%, 71%. Thus, the town of Abomey-Calavi has made considerable progress in terms of drinking water supply. It serves 42,318 inhabitants with a service rate of 57% against 21,111 inhabitants in 2013 with a service rate of 42% (PCEAU, 2013). This rate of 57% is a performance compared to the previous service rate. But, the service rate of 57% is low compared to the Millennium Development Goals (MDGs) which is to reach a rate of 75% in urban areas and 67.3% in rural areas by 2015 and meet 100% of the drinking water supply needs by 2022 (PCEAU, 2013).

The districts of Glo-Djigbé and Zinvié have also exceeded the rate set by the MDGs in rural areas. The districts of Akassato, Godomey have a low rate. The districts of Kpanroun, Ouèdo, Hêvié and Togba are still far from the objective of the MDGs and the national strategy of Drinking Water Adduction (AEP).

Overall, it should be noted that despite these high rates, there are villages that do not have easy access to water due to frequent failures on existing structures. These problems are exacerbated by income poverty, according to 70% of respondents. These findings are also made in the commune of Dangbo in southern Benin where Akambi (2006) has shown that poverty is one of the main factors limiting decent access to drinking water services. According to the author, the lack of financial means leads 78% of surveyed households to pay the bare minimum of drinking water or to fall back on free water points such as wells. However, the water from these wells and other traditional sources is generally unfit for consumption.

3.3.2 Density of hydraulic structures

Rural hydraulics takes into account rural areas and urban seedlings. Thus, the districts of Godomey, Abomey-Calavi, Akassato and Zinviés are partly served by the SONEB network. This justifies this low density rate. Figure 6 shows the density of hydraulic structures.

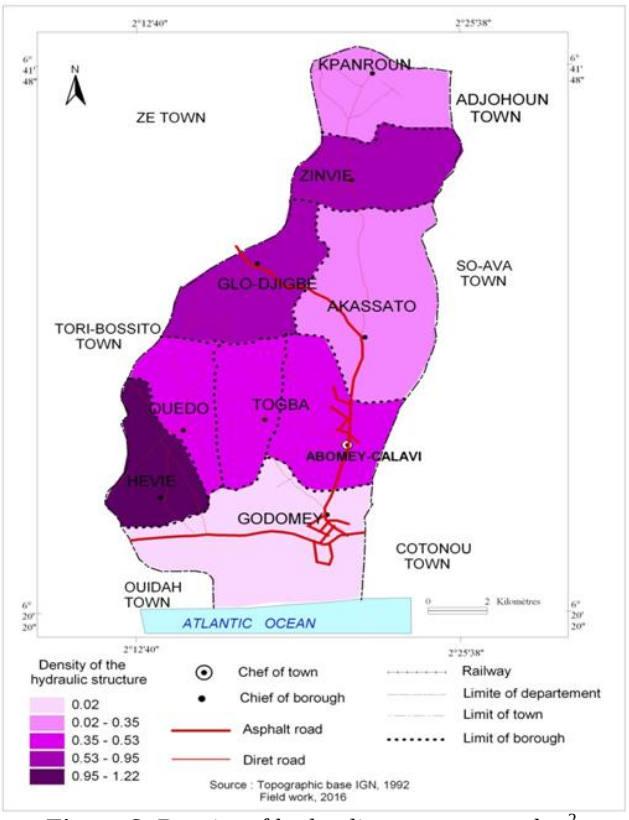

Figure 6: Density of hydraulic structures per km^2

Figure 6 shows that no borough of the municipality of Abomey-Calavi has a drinking water point per km^2 outside the district of Hêvié despite the more or less acceptable service rates in certain districts such as Glo -Jigbé (77%), Zinvié (71%) and Akassato (57%). Despite the low service rate of Hêvié at 30%, the borough has a water point per square kilometer with a density of 328habitant / km^2. The districts of Glo-Djigbé and Zinvié have respectively 127 inhabitants / km^2 and 320 inhabitants / km^2 with less than one water point per square kilometer. Dureste, it appears that the density of coverage in point of drinking water is more related to the spatial distribution and the area of the borough than the rate of service.

The provision of drinking water to the population and sanitation are two inseparable components of any policy aimed at the physical and mental well-being of the population. This leads to the diagnosis of sanitation problems in the commune of Abomey-Calavi.

3.4 Private latrines in Abomey-Calavi

In the commune of Abomey-Calavi, the mode of comfort of the populations remains precarious. This is explained by the lack of latrine and the rural character of the districts of Kpanroun, Zinvié, Togba, Ouèdo, Hèvié. Figure 7 shows the rate of households surveyed with latrines or not in their homes.

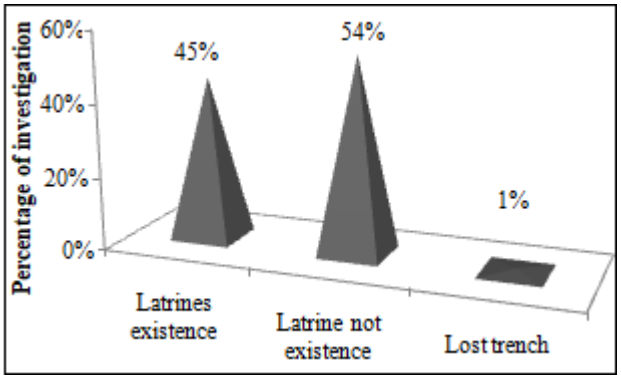

Figure 7: Presence of latrines or not in households
Source: Fieldwork, February 2018

Figure 7 shows that 45% of households have latrines, 54% who do not have latrines and 1% of households have latrines lost pit. The 45% with latrines are distributed as follows: Traditional latrine 7%, ventilated latrine 34% and sanitary latrine 4%. Of those who do not have a latrine, 49% are in the bush and 5% are in the bush and garbage heaps. Studies conducted by WASH in (2011) show that, at the national level, the proportion of households disposing of a latrine rose from 39.4% in 2009 to 44.4% in 2010. This situation is not without consequence on the life of the peaceful populations who continue to pay heavy tribute of infectious and parasitic diseases related to the hydro-fecal danger. Thus, in Benin, diarrheal diseases constitute the fourth leading cause of morbidity among children under five (WASH, 2011). Similarly, the studies conducted by Sagbohan (2011) and Honvou, (2015) in the commune of Abomey-Calavi showed that diarrheal diseases are the third leading cause of morbidity in children from 0 to 5 years old. These diseases are linked to poor sanitation and sanitation in the study area.

3.5 Institutional and public latrines in Abomey-Calavi

Institutional latrines are those built in schools and health centers. These latrines are 460 modules with 4 cabins or 5 places in 2013 according to the Abomey-Calavi Town Hall. Public latrines are those present in markets, bus stations, public spaces. There were 12 public latrines during field work. Table III provides information on the situation of public latrines by district.

Table III: Situation of public latrines by district

District	Public latrines
Akassato	1
Godomey	7
Glo-Djigbé	2
Hêvié	0
Kpanroun	0
Ouèdo	0
Togba	1
Zinvié	1
Abomey-Calavi	0
Total	12

Source: Fieldwork, February 2018

Table III shows that the districts of Hêvié, Kpanroun and Ouèdo and Abomey-Calavi do not have a public latrine. Overall, there is a shortage and disparity of public latrines in the commune of Abomey-Calavi.

3.6 State of the gutters in Abomey-Calavi

Gutters are the sanitation infrastructure used to drain rainwater into the natural environment. Plate 1 shows some gutters containing waste.

Plate 1: Open culverts filled with waste in Dèkoungbé in the district of Godomey (a) and in the district of Abomey-Calavi (b)

According to the General Directorate of Town Planning and Land Reform, the number of linear meters of gutters made from 1990 to 2009 is 14,047 m (DHAB, 2010). And the current point made by Abomey-Calavi town hall is 49050 linear meters. This is a performance in terms of the number of linear meters made in the years 1990 to 2009. These covered or uncovered works serve as dumps for residents.

3.6 Domestic wastewater treatment site

This site is located in Tokpa Zoungo in the district of Abomey-Calavi; it is managed by the NGO DCAM Béthesda through the BENEAU project for characterization and treatment of wastewater. Plate 4 shows the wastewater treatment devices of this site.

The Tokpa-Zoungo lagoon wastewater treatment plant (STEP) strives to ensure collection through a small diameter network and wastewater treatment in a set of three basins (optional anaerobic and ripening). This wastewater is collected from both the market and surrounding homes (DCAM-Bethesda 2015, Plate 2).

(c) (d) (e)

Plate 2: Lagooning pond (c); Maturation basin (d); Maturation pond (e)

Plate 2 shows the sewage treatment ponds. These basins function as ecosystems with symbiotic relationships between different populations of bacteria, and algae. These organizations intervene to eliminate the polluting load contained in the waste water.

4. Conclusion

This study focused on the inventory of water and sanitation infrastructures in the commune of Abomey-Calavi. The research work yielded 319 works providing drinking water (FPM, BF, PEA, AEV), 259 structures are functional or a rate of 81.19%; 57 down or a rate of 17.87% and 3 abandoned works or 0.94%.

It should be noted that the municipality of Abomey-Calavi has made considerable progress in terms of drinking water supply with a service rate of 57% in 2016 compared to 42% in 2012. However, certain factors limit people's access to safe drinking water. Drinking water supplies such as the distance traveled to obtain drinking water, poverty, salt intrusion and vandalism frequently observed on these structures are all factors limiting people's access to water. drinking water that make use of wells. In addition, the lack of sanitation facilities (family and public latrine, wastewater treatment site, gutters) and the lack of a site for grouping and treating solid household waste are the basis of the insalubrity that reigns in the commune of Abomey-Calavi.
Drinking water and sanitation are essential for public health. They represent one of the priorities of the growth strategy for poverty reduction in Benin. They are often the basis, as once everyone has been guaranteed access to drinking water and adequate sanitation and hygiene, regardless of their living conditions, fight against communicable diseases will have made a huge leap.

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