

Accidents Related to the 2014 Rains and Their Socio-Economic Consequences in the City of Abidjan: The Case of the Municipalities of Abobo and Attécoubé (Côte D'Ivoire)

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Abstract

The urban environment is confronted with recurring calamities including floods, landslides and forced escapes of populations during periods of rain. In Côte d'Ivoire, the municipalities of Abobo and Attécoubé suffered enormous material and human damage following the torrential rains of 2014. These urbanized areas are built on large plateaus bordered by thalwegs where 61% of these areas have no drainage network, thus facing a lack of sanitation. Moreover, topographical, rainfall, anthropogenic and technical conditions are factors explaining the occurrence of natural disasters and their consequences in the said communes. The objective of this article is to assess the socio-economic impact of the occurrence of hazards. It focuses on the identification of risk sectors in the municipalities of Abobo and Attécoubé and the material, human and economic consequences that result from rain accidents.

Keywords

Abobo, Attécoubé, Disasters, Environment, Thalwegs

1. Introduction

These last decades are increasingly disturbed by both natural and anthropogenic phenomena that continue to disrupt the environment. Floods, mass movements, coastal erosion, cyclones and hurricanes, earthquakes, technological accidents, tsunamis are disasters that cause more and more damage in the world. Faced

with such threats to cities, particularly those in developing countries with high population growth, several authors including Bailly (1996), D'Ercole (1996), Robin and Hauhouot (1999a), Robin and Hauhouot (1999b), Veyret and Nancy (2004), Abé (2005), Ramade (2006), and Alla (2013) addressed the issue of natural hazards and consequences. Others, such as Assako (1996), note that floods and mass movements in Cameroon are a real concern for cities located in areas with high rainfall rates because at the base of many damages such as in Abidjan, the economic capital of Côte d'Ivoire.

In 2014, the municipalities of Abobo and Attécoubé, which lie on a dissected plateau, a very rugged sheep, were prey to hydrometeorological incidents. They are located in the northern part of the city of Abidjan (**Figure 1**).

Indeed, urbanization in these two municipalities extends beyond the constructible and developed areas to non constructible areas to the detriment of the rules of urbanism and construction. As a result, pockets of precarious and spontaneous housing appear due to demographic pressure and impoverishment. But in environments where rainfall is abundant; more than 1800 mm of rain per year and where topographic, anthropogenic and technical conditions no longer follow the rhythm and the specifications of the existing urbanisation (Alla, 2013); (Brou, 2008); (Brou, 2015) and (Tamboura, 2008); the increasing vulnerability of the population and the degradation of the immediate living environment are legion; floods and mass movements are the result of frequent landslides and landslides.

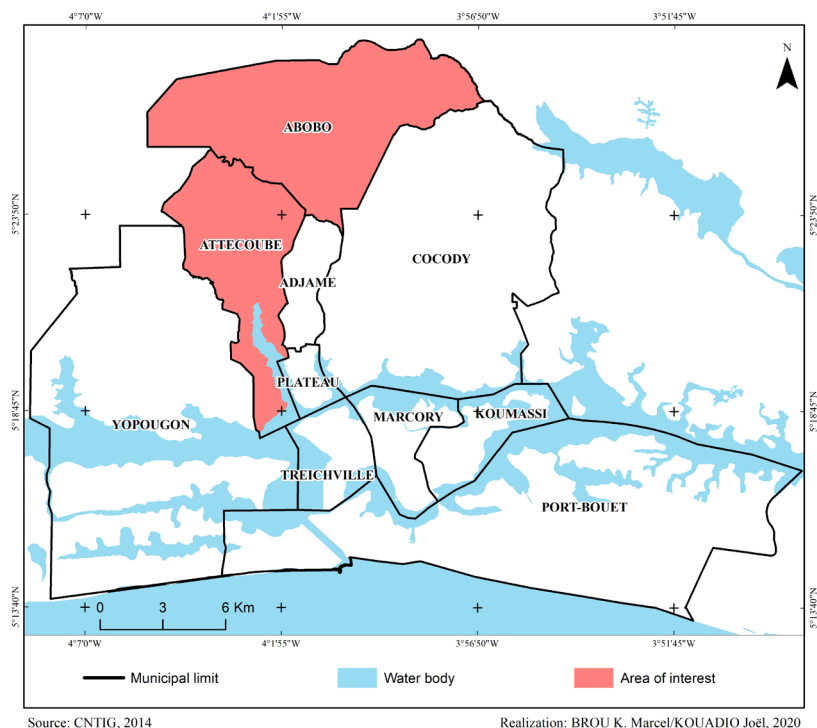


Figure 1. Geographical situation of the municipalities of Abobo and Attécoubé in Abidjan.

These municipalities suffered the disastrous consequences of heavy rains during May-July 2014. Despite the actions taken by the authorities to reduce the harmful **consequences** of the heavy rains, the situation remains unchanged.

The objective of this article is to assess the socio-economic impact of the occurrence of hazards. It focuses on the identification of risk sectors in the municipalities of Abobo and Attécoubé and the material, human and economic consequences that result from rain accidents.

2. Method

The methodological approach is a hypothetico-deductive approach based on the literature search, the field observation carried out from 2014 to 2015 and interviews with resource persons (local populations and municipal authorities).

Concerning the documentary research, the information collected relates to existing natural phenomena and their consequences.

With the population surveys, we were able to identify the most vulnerable areas and exposed to natural hazards. All the neighborhoods of the two communes have travelled. This allows us to know the risks that people face during each rainy season. To identify the socio-economic consequences on the immediate environment and on populations.

For further information, interviews are held with local authorities. In particular, agents of the technical services, environment and population of the town halls. These questions focused on the site where the populations, habitat types, the different phenomena that occur, the moments of rain, their consequences and their interventions are built. (Assistance to populations, risk management techniques and recovery strategies, etc.). All the data have been processed and restored in the form of tables, maps which have been the subject of brief analyses.

3. Results and Analysis

3.1. Identification of Risk Sectors in the Municipalities of Abobo and Attécoubé

3.1.1. Abobo, a Rugged Site

Located in the north of the city of Abidjan, the municipality of Abobo extends over a plateau site broken down on sides by basins called natural depressions. These are natural rainwater collection areas, which are therefore difficult to urbanize. There are about 30 of them in the current urban area. The sizes of these depressions vary between 100 and 130 meters for a depth of up to five meters as shown in **Figure 2**.

This municipality of Abobo has 18 storm basins and 10 ravines as shown in **Table 1**. Among these storm basins, 8 critical basins are likely to cause enormous damage. In particular, the Houphouët-Boigny, Agnissankoi, Red plate, Cayman Lake, Pays-Bas, Glacier, Monastery, Bougounisso.

The conditions of occurrence of the hazards of Attécoubé are identical to

Table 1. Identification of the different risk areas in the municipality of Abobo.

AREAS AND SECTORS AFFECTED	NEIGHBORHOODS
STORM BASINS	
Banco	Banco
2nd Stop	Abobo 2nd Stop
Houphouët Boigny (critical)	4 floors near the l'H.P.B
Nest of the Doves	Akéikoi
Agnissankoi (critical)	Avocatier
Bougounisso (critical)	PK 18
Red plate (critical)	PK 18
N'Dotré	N'Dotré
Cayman Lake (critical)	Anonkoua
Pays-Bas (critical)	Anonkoua 2
Glacier (critical)	Avocatier
Nanti	Anador
Samaké	Samaké
Monastery (critical)	Monastery
SOS	Housing SOS
Gendarmerie	Abobo Gagnoa station
Pharmacy Maténé	Abobo Avocatier
Sacred Forest	Abobo Banco up to PK 18
RAVINES	
Houphouët Boigny	Colatier housing behind 4 floors
Green Island	Behind hospital Houphouët Boigny
Deposit 09	PK 18 behind college ISSEA
Colombie	Behind the station la S7
Sagbé	Behind the rail
Agbékoi	Agbékoi
Plate	Plate
N'Dotré	N'Dotré
Nangui Abrogoua University	Anador extension
Akéikoi	Akéikoi

Source: Our surveys 2014 and 2015.

those of the previous zone. However, site conditions are different from land use and development conditions.

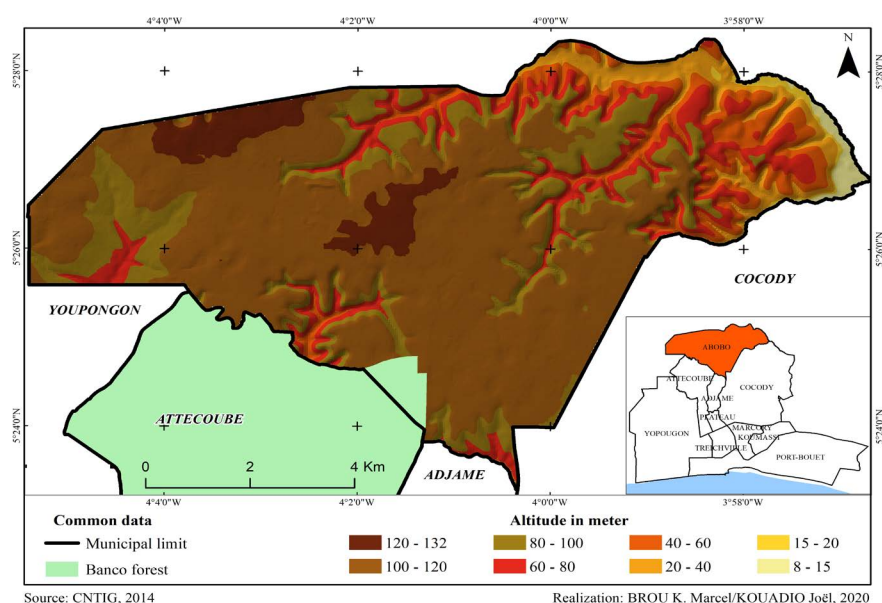


Figure 2. The Abobo relief.

3.1.2. Attécoubé, a Site with Pronounced Topographical Constraints

The site of Attécoubé is a plateau relief cut in half by the bay of Banco (river). This relief has different characteristics from one cardinal point to another. To the east, it is separated from the interfluve of Adjame-centre by a valley whose encashment is 35 meters; this gives it the appearance of a large mound elongated in the north-south direction. This relief is itself composed of two interfluves divided by a very deep valley of the order 50 - 60 meters. It starts from the original site of Attécoubé by passing by the Marian Shrine, the Fairmont city to the bay of the banco by a steep. To the west of the bay of the banco, we note the presence of valleys with steep slopes with relatively wide bottoms. The ramifications of the eastern ledges of the banco plateau have reduced the altitudes of the summits from 40 - 50 to 50 - 60 meters.

To the south a flat surface of 30 - 40 meters more or less favorable to urbanization. **Table 2** and **Figure 3** provide an overview of the risk areas and terrain of Attécoubé.

From the above, we consider that Abobo and Attécoubé are two municipalities established on potentially dangerous sites where risks of landslides and floods in case of rain are proven. Even worse, in these urbanized areas, we have noticed a rough servicing of land intended for the construction of habitats, a regular lack of sanitation and irregular urban development (Adomon and al, 2018). Such failures expose any urbanized area and said environment to serious consequences in the event of natural disasters.

3.2. The Consequences of Rain Accidents in the Most Affected Neighbourhoods of the Two Municipalities

The heavy amount of rain during the month of June (89 mm/daily rain and 946.1/monthly rain) caused multiple accidents in the Abidjan District. These are

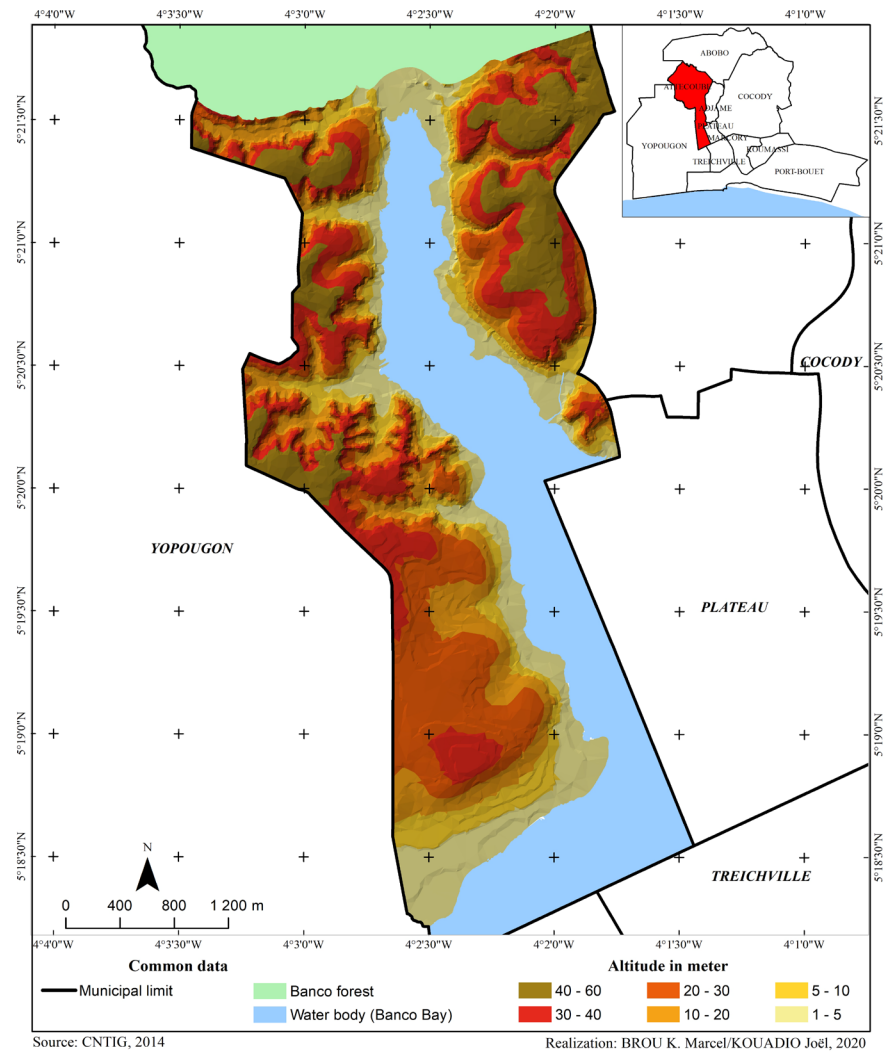


Figure 3. The relief of Attécoubé.

Table 2. Identification of the different risk areas in the municipality of Attécoubé.

NEIGHBORHOODS	AREAS AND SECTORS AFFECTED
Agban-Attié	The whole neighborhood (versant)
CFI	The whole neighborhood (versant)
Santé III	Deinde (versant)
Gbebouto	Pharmacy Rehoboth Boulevard of peace, complex (natural depression)
Boribana	Lagoon edge
Espoir	Canal vigou sector
Lagune	Lagoon edge
Nematoulaye	All along the hillsides

Source: Our surveys 2014 and 2015.

mainly floods in Abobo on the one hand and landslides and mudslides on the other hand in Attécoubé.

3.2.1. Consequences of Floods in the Neighbourhoods of the Municipality of Abobo in 2014

They concern the loss of life, injuries, material damage, destruction of homes and economic activities as shown in **Tables 3-6**.

From the analysis of **Tables 3-6**, it appears that the floods had harmful and catastrophic effects on the environment and the living environment of the populations in the municipality of Abobo. Worse still, losses of human lives and property damage were reported in the said municipality following the landslides. **Table 7** and **Table 8** give an overview of these losses in human lives and property damage.

3.2.2. The Consequences of Landslides and Landslides in the Municipality of Attécoubé

The municipality of Attécoubé is a high risk area due to the dangerous landslides that occurred there. With the support of local authorities, we have identified the consequences of this natural disaster as shown in **Tables 9-11**.

As for landslides, their effects are more noticeable at Attécoubé with the corollary of significant material damage as shown in **Tables 12-14**.

In total, it should be remembered that the rains of 2014 caused more deaths in the commune of Attécoubé than Abobo. We counted 07 in Abobo and 16 in Attécoubé. These torrential rains made more than 2000 displaced. On economic activities, the rain caused the destruction of products from the various stores located at the edge of the sewerage and drainage networks. The destruction of goods and materials from the shops during and after the floods. Finally, it resulted in the destruction of economic infrastructure in both municipalities.

Table 3. Overview of the economic damage provoked by the floods in Abobo.

NEIGHBOURHOODS	RAIN IN (mm)	DAMAGE RECORDED	DATES
Assin Monastery	58.0	16 stores destroyed	Thursday 12 th June 2014

Source: Our surveys 2014 and 2015.

Table 4. Overview of human lives lost in the Abobo Floods.

Neighbourhoods	Rain in (mm)	Number of Deaths	Dates
Biabou	89.0	01	Friday 06 th June, 2014
Bocabo		01	
Celeste	58.0	01	Thursday 12 th June 2014
Monastery		01	
Cayman Lake	74.0	01	Sunday 15 th June, 2014
Bourguinisso		01	
Green Island	58.0	01	Sunday 29 th June, 2014

Source: Our surveys 2014 and 2015.

Table 5. Overview of material damage provoked by Floods in High-Risk Neighbourhoods in Abobo.

NEIGHBOURHOODS	RAIN IN (mm)	DAMAGES	DATES
PK 18, site known as the Red Plate Stormwater Outlet on the N'Dotr� Road	88.0	Fences fallen under the weight of water; houses damaged; Several families put to the shelter; Huge losses in furniture and various.	Tuesday 03 rd June 2014
Pays-Bas in Anonkoi-Kout�	89.0	At least 10 houses underwater with extensive property damage.	Friday 06 th June, 2014
Glacier Basin in Bocabo		03 houses destroyed; 40 flooded habitats; A submerged CIE Transformation Station	
Basin Monastery road to Abobo-Baoul�	58.0	04 houses destroyed; 10 flooded houses; Losses in property; Populations held hostage by the waters.	Thursday 12 th June 2014
Assomin PK 18 Cayman Lakes		At least 20 flooded houses.	
Dove Nest Basin at BC Neighbourhoods, Ak�ikoi Road	89.0	At least 10 houses flooded, populations taken hostage because of access roads closed by water, loss of property.	Friday 06 th June, 2014
Houphou�t Boigny Basin in Neighbourhoods C in front of General Hospital	58.0	Severe flooding of the site, at least 10 flooded habitats.	Thursday 12 th June 2014
Road Gendarmerie Brigade-CampCommando		Several vehicles under water of about 2 meters, 01 mosque flooded.	
Expressway in front of Mobil Station		Impracticable way	
Kennedy Sector	74.0	16 houses destroyed, 28 flooded and 01 abandoned schools.	Sunday 15 th June 2014

Source: Our surveys 2014 and 2015.

Table 6. Overview of the floods in the municipality of Abobo in 2014.

NEIGHBOURHOODS	RAIN IN (mm)	NUMBER OF CLAIMS	DATES
Monastery	58.0	131	Thursday 12 th June 2014
Agnissankoi	89.0	62	Friday 06 th June, 2014
Nest of doves		189	
Houphou�t Boigny	58.0	132	Thursday 12 th June 2014
Nanti-Dokoui		69	Sunday 29 th June, 2014
Glacier Bocabo	74.0	151	Sunday 15 th June, 2014
Banco	58.0	53	Thursday 12 th June 2014
Pays-Bas	74.0	130	Sunday 15 th June, 2014

Continued

Abobo Baoulé		27	
Abobo 2 ^{ème} arrêt	58.0	122	Thursday 12 th June 2014
Cayman Lake		121	
Anokoi Kouté	89.0	79	Friday 06 th June, 2014
Red plate	88.0	60	Tuesday 03 rd June 2014
Total 1326 claims			

Source: Our surveys 2014 and 2015.

Table 7. Overview of material damage following the landslides at Abobo in 2014.

NEIGHBOURHOOD	RAIN IN (mm)	DAMAGES	DATES
Biabou		02 housies destroyed	
Bocabo	89.0	03 houses destroyed; Losses in furniture	Friday 06 th June 2014
Agbekoi-Clouetcha		More than 10 houses collapsed	Thursday 12 th June 2014
Celeste	58.0	03 houses destroyed	

Source: Our surveys 2014 and 2015.

Table 8. Overview of the victims of the various neighbourhoods affected by the landslides in Abobo.

NEIGHBOURHOOD	RAIN IN (mm)	NUMBER OF CLAIMS	DATES
Biabou		70	
Bocabo	89.0	130	Friday 06 th June 2014
Agbekoi-Clouetcha		54	
Celeste	58.0	80	Thursday 12 th June 2014
Total		334 claims	

Source: Our surveys 2014 and 2015.

Table 9. Overview of loss of life by neighbourhood following landslides in Attécoubé.

NEIGHBOURHOODS	RAIN IN (mm)	NUMBER OF DEATHS	DATES	VICTIMS	NATIONALITY
Banco nord	84.9	01	05 th June 2014	FOROMO Tokpa Eugène (24 years)	Guinean
Santé 3 (Safari sector)	71.1	04	Tuesday 17 th June 2014 at 04:00 AM	- TOUKARA Issa (30 years) - FOFANA Djeneba (29 years) - COULIBALY Korotoum (25 years) - SOUMAHORO Fatoumata (04 years)	Ivorian
Mossikro (unspecified)	64.7	05	Wednesday 18 June 2014 from 03:30 AM to 04:00 AM	Unknown identities	Unknown
Mossikro (Boribana)	61.4	06	Thursday 19 th to Friday 20 th June 2014 at 4 AM	- OUMAROU Ibrahim (28 years) - DALLOU Yacouba (26 years) - ABDOUL Karim (19 years) - MAMADOU Aminou (25 years) - Moussa SAIDOU (30 years) - YAHAYA Ibrahima (17 years)	Ivorian

Source: City Hall Technical Service 2014-2015.

Table 10. Overview of injuries in the various neighbourhoods following the landslides in Attécoubé.

NEIGHBOURHOODS	RAIN IN (mm)	NUMBER OF WOUNDED	DATES
Banco Nord	84.9	04	05 th June 2014
Santé 3 (Safari sector)	71.1	Undetermined (several)	Tuesday, 17 th , June 2014
Mossikro (unspecified)	64.7	04	Wednesday 18 th June 2014
Mossikro (Boribana)	61.4	Undetermined (several)	Thursday 19 th and Friday 20 th June 2014

Source: City hall technical service 2014 and 2015.

Table 11. Overview of damage by neighbourhood as a result of the landslides in Attécoubé.

NEIGHBOURHOOD	RAIN IN (mm)	DAMAGE	DATES
Banco Nord	84.9	01 house of 02 rooms destroyed	05 th June 2014
Santé 3 (Safari sector)	71.1	01 yard with 03 doors destroyed + various materials	Tuesday 17 th June 2014
Mossikro (unspecified)	64.7	02 houses destroyed	Wednesday 18 th June 2014
Mossikro (Boribana)	61.4	01 Koranic mosque destroyed + various materials	19 th Thursday and Friday 20 th June 2014

Source: Technical service of the town hall 2014 and our investigations 2015.

Table 12. Overview of landslide-related loss of life at Attécoubé.

NEIGHBOURHOOD	RAIN IN (mm)	DATES	NUMBER OF DEATHS	VICTIMS	NATIONALITY
Loukoukro (Djene Ecare)	84.9	04 th and 05 th June 2014 (night from Wednesday to Thursday)	02	01 Unknow (30 years) - SOUMARE Mohamed (35 years)	Unknown Ivorian
Santé 3 (Deinde sector)		05 and 06 th June 2014 (night from Friday to Saturday)	04	- YANE Seydou (13 years) - COULIBALY Yaya (04 years) - COULIBALY Tenan (07years) - YANE Madjara (38 years)	Ivorian

Source: Technical service of the town hall 2014 and our investigations 2015.

Table 13. Overview of landslide injuries in Attécoubé.

NEIGHBOURHOOD	RAIN IN (mm)	WOUNDED	DATE
Santé 3 (secteur Deinde)	84.9	04 (Mr. BILE 57 years, one of the wounded identified)	05 th and 06 th June 2014
NEIGHBOURHOOD	RAIN IN (mm)	DAMAGES	DATE
Loukoukro (Djene Ecare)	84.9	01 housing destroyed + various materials	04 th and 05 th June 2014
Santé 3 (Deinde sector)		02 rooms destroyed + various materials	05 th and 06 th June 2014

Source: Technical service of the town hall 2014 and our investigations 2015.

Table 14. Overview of material damage following landslides into Attécoubé.

NEIGHBOURHOOD	RAIN IN (mm)	DAMAGES	DATE
Loukoukro (Djene Ecare)	84.9	01 housing destroyed + various materials	04 th and 05 th June 2014
Santé 3 (Deinde sector)		02 rooms destroyed + various materials	05 th and 06 th June 2014

Source: Technical service of the town hall 2014 and our investigations 2015.

Faced with such a reality of natural disasters, relief actions and financial support have been carried out.

Who are the perpetrators and beneficiaries? How much assistance can we assess for victims?

3.3. Relief, Aid and Support Measures for Victims and Survivors of Natural Disasters in Abobo and Attécoubé

These include aid and donations to disaster victims during and after floods, landslides and mudslide. This assistance is provided by the people, charities, municipal and government authorities.

3.3.1. About the Population in the Two Municipalities Studied

People in disaster areas did not sit idly by during and after the accidents. They expressed a desire to help each other. Also, the victims received from their hands from other populations; food and material of primary necessity. These include mattresses, bed sheets, loincloths, rice, mats, shoes, etc. There was no deduction in cost, because it was voluntary acts between neighbourhood brothers.

In Abobo, for example, two NGOs, Lion's Club and the Red Cross, have relieved more than 500 households by bringing them food and non-food items. These donations are estimated at tens of millions. However, they could not be valued in cash.

3.3.2. Actions of Government Authorities In Attécoubé,

Given the scale of the crisis, the State has instituted a management of the people affected to the tune of 533,866.77 USD. This included accommodation (maximum duration of 03 months) for 66 people (including 15 for the municipality of Attécoubé alone). Thus, it is made available to them Assistance Kits which included assistance for the resettlement of the victims, according to the municipality of Attécoubé.

- Many gifts make a living, including rice bags, boxes of powdered milk, cartons of oil, boxes of tomatoes and pasta. All these donations are estimated at 12,979.13 USD.
- Assistance to bereaved families in the amount of 1854.16 USD each. For the 23 we count 42,636.24 USD.

In addition, the State has also committed to pre-finance the new rents of the victims to the tune of 03 months of guarantee and 02 months of rent paid in advance due to 370,841 USD per month.

In order to avoid similar disasters in the rainy season, a programme to assist people to evacuate dangerous sites was drawn up by an interdepartmental committee. However, the evacuation of exposed populations is difficult to implement due to lack of financial means. The different aspects of this program are:

- Demolition of houses, threatened houses and relocation of residents at an estimated cost of 56,264.10 USD;

- Transportat costs, personal effects = 0.05560 USD per household for moving expenses;
- For the 1947 households of the said municipality, the amount is 108,301.55 USD;
- Resettlement assistance: 03 months of security 02 months of rent or 185.40 USD for 1947 = 360,824.12 USD;
- Providing land parcels to resident landowners, with the State having a land reserve of 11 hectares on the Biabou side.

In Abobo

The State has distributed dignity kits (recasement aid or allowance) to the affected populations to meet immediate needs. 278.10 USD were distributed to 1.003 households or an amount of 278,933.32 USD.

The State has also made donations of live and not food to the 10 neighborhoods most affected by the hazards (Nest of doves; Houphouët Boigny; Glacier; Monastery, Red plate, Netherlands, cayman lake, Nanti, Banco, Anonkoua village). **Table 15** is an inventory of donations made.

3.3.3. Actions of Local Authorities

In Attécoubé

- Disaster assistance: 278.09 USD to 606 people, for a total of 166,878.62 USD.
- Donations of food and non-food items for which the cost is not estimated.

In Abobo

The municipality first identified public schools to provide shelter to victims. Stadiums, hospitals, etc., have been requisitioned for this purpose. In addition, these victims have benefited from the food and non-drinking estimated at millions.

Table 15. Overview of state donations in 2014.

DONATIONS	QUANTITIES
Mattress	280
Seals	460
Plastic basins	460
Blankets	470
Mosquito nets	460
Kettles	460
Riz Rice	185 bags of 50 kg or 10 tonnes
Tomato	470 boxes
Oil	280 bottles
Sugar	47 boxes
Milk	47 boxes

Source: Our surveys 2014 and 2015.

4. Conclusion

The year 2014 was the scene of hydrometeorological accidents where major material damage and loss of life were recorded. The human toll was heavy in both municipalities. More than 20 people perished under the rising water, landslides and landslides, not to mention numerous material damage recorded. It is also a very dramatic situation which has been plagued with heavy expenditures by the authorities and the population.

However, the scale of the crises in 2014 made the policy aware that the torrential rains are a serious problem for its municipalities. Thus, initiatives have been taken by these companies to anticipate and manage the impacts of bad weather. One of the actions taken is the release of the Gobelet districts in early 2015 by the Minister of Environment and Urban Sanitation and the destruction of the fence of ALPHA Blondy located on the natural drain of water in Bonoumin (Riviera 2) in Cocody. As for Attécoubé and Abobo, after several resistance attempts, the operation was finally implemented.

At the end of this study, the aim is to reinforce the operation of getting rid of occupied non aedificandi neighbourhoods for the constructions and the monitoring of the specifications for the occupation of urban spaces in order to avoid possible risks and their enormous damage.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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