Evaluating the Effects of Storm Water Infrastructure Projects on Flooding in Ghana

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Abstract— Accra, the capital of Ghana experiences flooding every year. For the past six years, several storm water infrastructure projects have been undertaken to reduce flooding in the city. The impact of these projects on flooding is not known. This paper discusses a project conducted to evaluate the effect of various storm water infrastructure projects on flooding in Accra. Data from the National Disaster Management Organization was used to determine the extent of flooding over several years. Similarly, using GPS, data on storm water infrastructure data was captured and used to develop a storm water facility map using ArcGIS. GIS based impact analysis was then used to determine the value of these construction projects on flood reduction in Accra. The results of the study vary on type, size, location and extent of flooding. The results provide users of the relative significance of the implementation of storm water structures on flooding.

I. INTRODUCTION

Floods are the most frequent and widespread of all natural disasters that happen around the world [1]. In most third world countries, flooding is a major, frequent phenomenon during every rainy season. Inadequate storm water infrastructure, poor sanitation and improper planning are some of the main causes. Poorly laid out drainage systems, blocking of major waterways, poor sizing of drainage structures and erosion are some of the contributory factors to the consistent flooding problem.

Ghana, comparative to its neighboring countries, is a geographically low lying area. The capital Accra is a low-lying and potentially flood-prone. Since 2000, flooding in Accra has been perennial every rainy season and has left city officials grappling to find ways to effectively deal with the situation [1]. Flooding is a major socio-political and economic problem as it affects various sectors of the economy. Besides the over 2.5 million inhabitants that get affected by floods, transportation, businesses and other socio-economic activities virtually come to a halt when the city experiences floods.

The situation is compounded by the increase in rural-urban migration [2]. This has led to the springing up of unapproved structures in various parts of the city. It is interesting to note that, most of these unapproved structures are found on waterways. City officials have undertaken some demolition exercises over the past years to help minimize the situation. Various storm water infrastructure have also been constructed with the same objective in mind. However, due to the absence and lack of proper periodic maintenance of drainage infrastructure, flooding continues to plague the city.

The paper discusses the effect of the storm water infrastructure developed over the years. It assesses the extent of flooding before and after the development of some of the main storm water infrastructure in the capital city.

II. APPROACH

The paper is based on case studies of flood prone areas across the capital. Data collected from the Accra Metropolitan Assembly (AMA) was used to identify and select the case studies. The areas selected were Achimota, Apenkwa, and Darkuman all flood prone suburbs. Visits were taken to the various sites to assess the storm water infrastructure available. Interviews were conducted with residents to help ascertain the extent of flooding before and after the development of the structures. Global Positioning Systems (GPS) was used to collect the coordinates of the infrastructure and the extent of flooding in the all areas. GIS based analysis was then conducted to ascertain the extent of flooding in the three areas.

III. CASE STUDIES

LOCATION I: ACHIMOTA

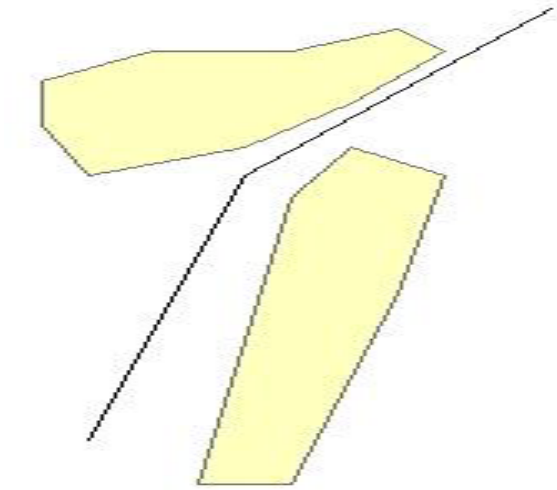
Achimota is one of the suburbs in Accra that experiences flooding during heavy down pour. In terms of drainage infrastructure, Achimota is a major route for one of three major drain basins in the Accra metropolis: the *Odaw* basin. The other two (2) basins are the *Sakumono* and *Kpeshie* catchments. The *Odaw* is the centre-most of the 3 catchment basins, receiving major rushing storm-

waters upstream from *Nsawam* through *Dome*, into the major storm-water infrastructure at *Achimota*. It then goes through *New Town*, *Caprice* and *Avenor* to join the main *Odawna* at the Nkrumah Circle, which flows into the *Korle lagoon* and into the sea.

The plain, gravel-like earth surface was massively eroding, threatening nearby housing structures and the main Accra-Nsawam railway. Flood waters were rising as high as 5ft during heavy rains. Houses located some 5m from the edges of the drain were constantly getting flooded during rainy seasons. Walls of 6ft high were getting pressurized by 3ft high flood waters. In some instances, the stability of these walls was all but lost forcing occupants to demolish and reconstruct.

Figure 1 shows the extent of flooding in the area before the construction of a storm water structure.

Figure 1: Extent of Flooding at Achimota before construction of Storm Water Infrastructure



Source: Field Survey

The line in Figure 1 represents the storm water infrastructure. The two polygons show the extent of flooding in the area. Both areas have roads, residential, commercial and church buildings. There is also a railway line located in the area on the right of the infrastructure. The extent of flooding in the left and right areas is 3.51acres and 2.96 acres respectively.

The storm water structure which was built to help manage flooding in Achimota is shown in Figure 2. It starts from an over head bridge and runs through to Apenka and Alajo.

Figure 2: Storm Water Infrastructure

Table1 below provides a brief description of the storm water infrastructure that was built to help manage the flooding situation in Achimota.

Table 1: Description of Achimota Storm water drainage

Shape	Measurements		Structural make	General condition
	Height	Width		
Squared entrance (under bridge	12ft	24ft	Pre-stressed reinforced concrete slabs	Bad; Poorly maintained
Trapezoidal open-end	15ft	40ft		

Source: Field Survey

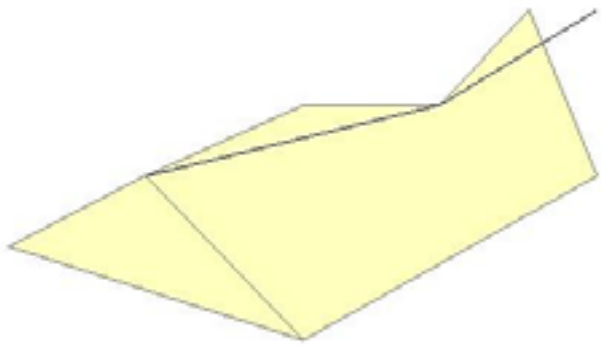
Following the construction of the huge drain, flooding in the area is now a thing of the past. Areas that were previously submerged in water are now unaffected when it rains heavily. However, if the current state of the drain is not checked, it might not be able to serve the purpose for which it was constructed.

LOCATION II - APENKWA FREE PIPE

Apenkwa – Free Pipe carries a major sub drainage system from *Apenkwa* through *Abeka* to *Tesano* before joining the *Achimota* drainage infrastructure. Prior to the development of the drain, the major problem faced by the residents was the flooding of the main road linking the township to *Abeka.* The flooding led to massive erosion in the area affecting some of the access roads. City authorities and highway officials had to raise the road close to the drain and construct a bridge to help the situation.

Figure 3 provides a pictorial view of the extent of flooding experienced in the area

Figure 3: Extent of Flooding at Apenkwa before construction of Storm Water Infrastructure



Source: Field Survey

The area covered by the floods during heavy down pour is approximately 4.16 acres. The floods cover residential and commercial buildings and some of the main access roads in the area.

The structure in Figure 5 below was constructed to help direct the flow of water and reduce flooding in the area.

Figure 4: Storm Water Infrastructure

The general description of the constructed drain is provided in Table 2 below.

Table 2: Description of Apenkwa Infrastructure

Shape	Measurements		Structural Make	General Condition
	Height	Width		
Squared	6ft	6ft	Concrete reinforced, cast in-situ	Not lined or plastered; Poorly maintained
Ends of drain at the mouth of bridge	6ft	7ft		

Source: Field Survey

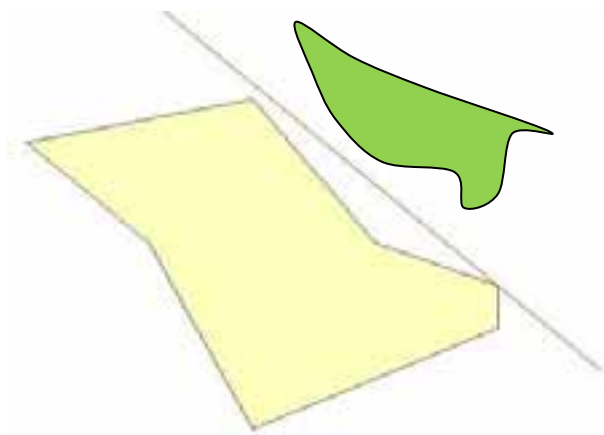
The construction of the bridge and the storm water drainage has not helped the situation. There is a spill over from the drain when it rains continuously for days. According to local residents, an expansion of the current infrastructure will help in solving the flooding problem in the area. Currently, the extent of flooding is still the same even though a drain was constructed. An assessment of the area indicates that an expansion can only be done if neighboring structures are demolished.

LOCATION III - DARKUMAN

Darkuman is also a flood prone suburb located in the capital Accra. The structure assessed is located in an area known as *Sunflower*. Prior to the construction of a storm water structure houses around the area were always flooded during the rainy seasons. Most surrounding structures in the area are low, making it easy for flood waters to invade them.

The extent of flooding in the area is depicted in Figure 5 below.

Figure 5: Extent of Flooding before and after Storm Water Infrastructure at Darkuman



Source: Field Survey

The line represents the storm water structure. The area on the left side of the structure represents the flooding area before the construction of the drainage structure. This flooding area is estimated at 3.0 acres. This area is mainly occupied by residential buildings with some access roads. The area to the right depicts the flood situation after the construction. The flooding area has significantly reduced to 0.70acres.

Figure 6 provides a pictorial view of this structure. The polygon shows the extent of flooding in the area. The infrastructure *was* constructed about three years ago.

Figure 6: Storm Water Infrastructure at Darkuman

Table 3 also provides a brief description of the structure.

Table 3: Description of Darkuman Infrastructure

Shape	Measurements		Structural make	General condition
	Height	Width		
Squared	7ft	12ft	Concrete reinforced, cast in-situ	Fairly good; Completion at left end is needed to guarantee optimum results

Source: Field Survey

IV. CONCLUSION

Data collected from the field on selected major storm water infrastructure shows the impact of storm water structures on flooding. In two areas flooding reduced significantly following the construction of the storm water infrastructure. In Apenkwa, there was no significant change and this was attributed to the small size of the structure. The data collected from the three areas though limited, shows that if structures are properly sized and well maintained they will have the desired effect.

REFERENCES

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2. Ward, D. et al (1999) Monitoring Growth in Rapidly Urbanizing, Areas Using Remotely Sensed Data. *Professional Geographer*, Vol.52 (3), pp. 371-386