

Effective Management of Storm water in Ibeju–Lekki Local Government Area of Lagos State, Nigeria

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Abstract

In recent years, many cities and rural areas are facing frequent waterlogging, run-off pollution, huge loss of resourceful rainwater, damaged ecosystem and many more rain water related problems. In regional perspective, how to construct a sustainable storm water management measures have been presented as an important issue in many cities and urban agglomeration in Nigeria. Ibeju Lekki area is usually faced with the problem of rain water leading to incessant flooding. This study therefore assesses storm water management in Ibeju-Lekki Area, Lagos state. The research employs a random sampling technique in selecting 204 (0.07 %) respondents for questionnaire administration. Descriptive and inferential statistical tools were employed in the analysis of the data. Pearson product moment correlation was used to test the relationship between the gradient analysis and vulnerability to runoff of Ibeju-Lekki. Also, the slope analysis of the study area was carried out using slope calculation. Findings revealed that natural green space, public parks and gardens and drainage system were the most available storm water management infrastructure in the area. The result of correlation analysis with $r = 0.971$ shows a strong positive correlation between gradient and vulnerability to runoff. The study concluded that physical planning policies such as thorough monitoring of building plan before approval and institution of effective development control agencies among others should be put in place to ensure proper management of storm water in Ibeju-Lekki local government area of Lagos state.

Keywords: environmental sustainability, Ibeju Lekki, Lagos State, Runoff, Storm water

Introduction

In recent years, city centres have been ravaged with the challenge of storm water usually resulting from changing precipitation pattern due to climate change (IPCC, 2018a). This phenomenon has been responsible for series of urban problems such as damage to roads furniture, vehicles as well as street closures, and power outages, due to collapse of relevant infrastructure. Also, incessant flooding has been recorded leading to loss of lives and properties (municipal and individual). While storm water is generally an urban problem, due to inadequate drainage system, impervious surfaces and lack of other storm water

management infrastructure, coastline cities are often ravaged at a higher scale, owing to the inundation of the lagoon, estuary and coastlands with ocean wave and storm surges, high tidal levels and arbitrary/unregulated modification of shoreline. It is a known fact that natural landscapes such as grasslands, forests and the soil play vital roles in the absorption of storm water (Heidt and Neef, 2008). Also, plants hold storm water close to where it discharges. But storm water in built-up environments, if not properly managed most times causes two major problems such as the volume and timing of runoff water (flooding) and the other related to potential contaminations from pollutants that the runoff is carrying (water pollution) (Alex & Robert, 2005).

Storm water is a veritable resource because the global demand for water far exceeds the available quantity of water especially in urban centres. Amidst this challenge of water security, there is the need for sustainable technique to harvest storm water from the point source. Storm water management and purification (treatment), can transform the urban centres with sufficient water supply to sustain the city's water needs (Novotny *et al.*, 2010).

Storm water in this part of the world has been a major contributor to environmental degradation of urban waterways because of poor environmental management practices. (Yao *et al.*, 2014) In most cities after precipitation, the runoffs carry along with it, debris from construction and demolition wastes, household wastes, agro-allied wastes, industrial and human wastes. The phenomenon of extreme precipitation has been severe in recent decades and it is apparent that the magnitude and occurrence of floods have also increased (Temi and Durowoju, 2004)

Traditionally, surface runoff from developed areas, considered undesirable can be removed as completely and as fast as possible (Boller, 2004). The aim has been to drain the urban runoff quickly with the help of channels and pipes. Typically, the conventional system comprises road side drains, channelization, rectification and enlargement of storm drains (Miguez *et al.*, 2014) and provision of cross drainage works.

The overall objective of storm water management is the control of rainwater to ensure minimum impacts with regards to flooding, erosion and the dispersal of pollutants within the urban environment and downstream (Philip, 2011). This management process encompasses the interaction between the amount of rainfall, the urban environment, the existing infrastructure and the water bodies into which the water finally ends up.

Urbanization results in an increase of impervious surfaces such as pavement, roads or roofs. As a result, the infiltration capacity of a catchment is reduced and the volume of storm water runoff increased (Kasper & Jenkins, 2007). An increased volume of urban runoff increases the likelihood of flooding and landscape changes that alter stream morphology

(Walsh, 2004; Wang *et al.*, 2001). High-velocity peak flows also lead to the accumulation of urban pollutants on impervious surfaces that may be washed off to receiving waters by storm flows (Birch *et al.*, 2006). Moreover, excessive urban runoff may have a detrimental environmental impact on ecosystems through increased bank/bed erosion, higher pollutant inputs and hydrologic disturbance (Niezgoda & Johnson, 2005; Olguin *et al.*, 2000). Water pollution, vegetation loss, erosion and altered stream geomorphology reduce habitat quality, biodiversity and a multitude of ecosystem services (Roy *et al.*, 2008). The sharp rise in urban development has led to an increase in impervious areas and a decrease in vegetated and pervious surfaces (Leopold, 1968). The conversion of natural surface into impervious cover like roads, rooftops, and parking lots decreases infiltration and increases runoff volumes. Conventional urban storm water infrastructure, comprising pipes and channels, is provided to remove these excess flows. However, in most cases, the channels are too small to allow for easy drain while the natural storm water flow paths also get altered, increasing the runoff velocities and thereby leading to overflow (USEPA, 1993; Roesner *et al.*, 2001; Claret *et al.*, 2004; Walsh *et al.*, 2005). As a result, there is a significant increase in the peak flow rates and frequencies in urbanized areas, when compared to pre-development conditions (Roesner *et al.*, 2001). The Ibeju Lekki area of Lagos as a recent target of developers and home owners has witnessed tremendous structural development, so much that more areas are now being developed at the expenses of open space. The massive concretization and road development thus lead to accelerated runoff and incessant floods due to low infiltration. Also, most development are either partly or wholly found to run contrary to the building plans approved by the planning authority, thereby militating against seamless flow of rainwater.

Therefore, this study examines the existing storm water infrastructure and the various measures for storm water management in Ibeju-Lekki area of Lagos state and proposes physical planning measures for effective storm water management in the study area. The study was carried out within Ibeju–Lekki local government area, Lagos state. The study only covers the developed area in the study area.

Materials and Methods

Ibeju-Lekki is one of the Local Governments areas of Lagos state, bounded in the East by Epe local Government, in the west by Eti-Osa Local government, in the North by Epe local government and edges the Atlantic Ocean in the South. Ibeju-Lekki is located at approximately between latitude 4°15' and 4°17' N, and longitude 13°15' and 13°20'E. At its widest point, Ibeju-Lekki is about 20 kilometers long (Aderogba, 2012).

It is one of the many local Government areas created by the then head of state, General Ibrahim Babangida. The name was derived from two communities: Ibeju and Lekki. Ibeju-Lekki was formerly a swampy area; a backwater suburb to the Epe central and north. Ibeju-

Lekki is predominantly occupied by Ijebu speaking people who initially settled in Local governments around Ibeju-Lekki such as Abijo, Awoyaya, Eputu and Elemoro to mention a few. There are now other people from different parts of the country and the world residing in the area.

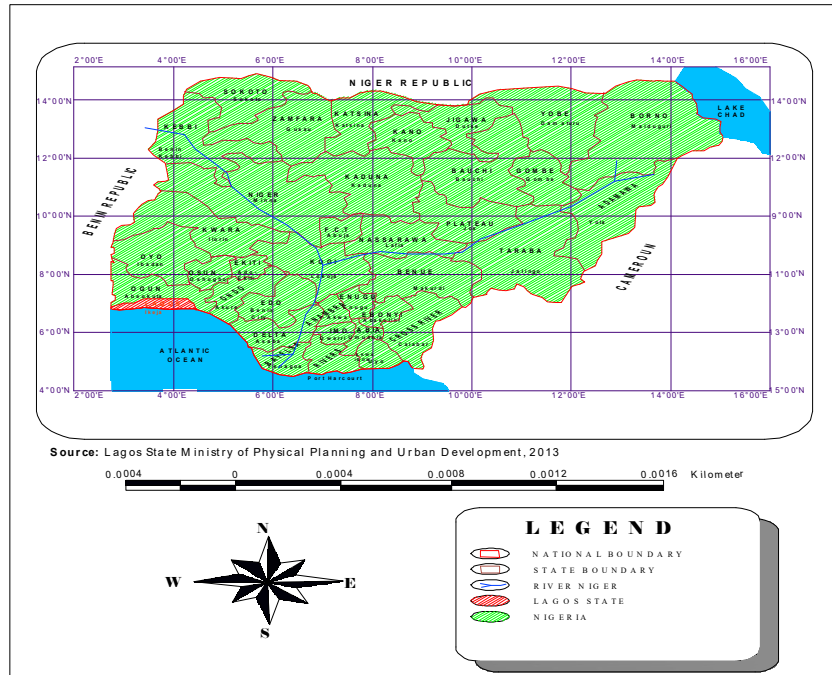


Figure 1: Lagos state in Nigerian context
Source: Authors' Fieldwork, 2019.

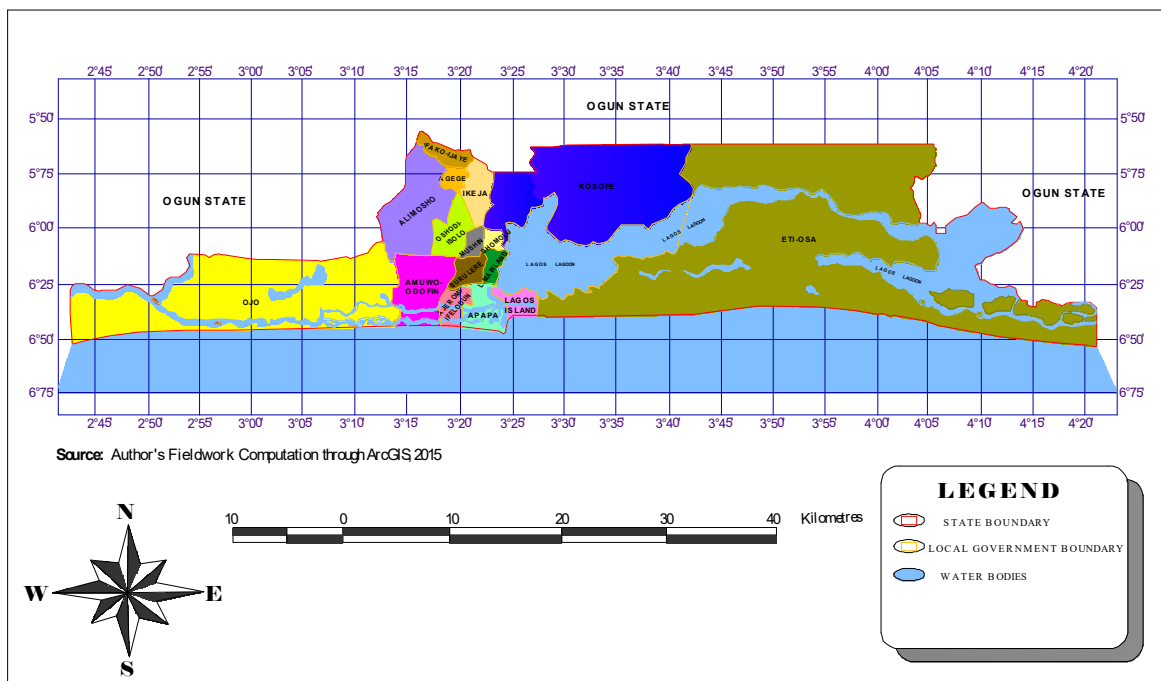


Figure 2: Local Government Areas in Lagos State

Source: Lagos State Ministry of Environment and Physical Planning

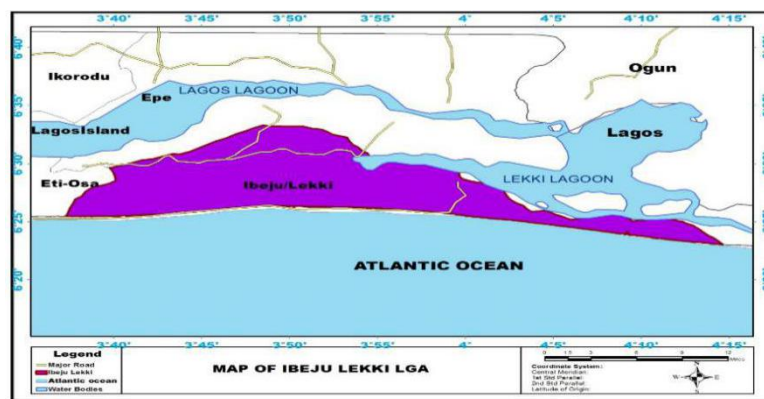


Figure 3: Ibeju Lekki in the context of Lagos State

Source: Lagos State Ministry of Environment and Physical Planning

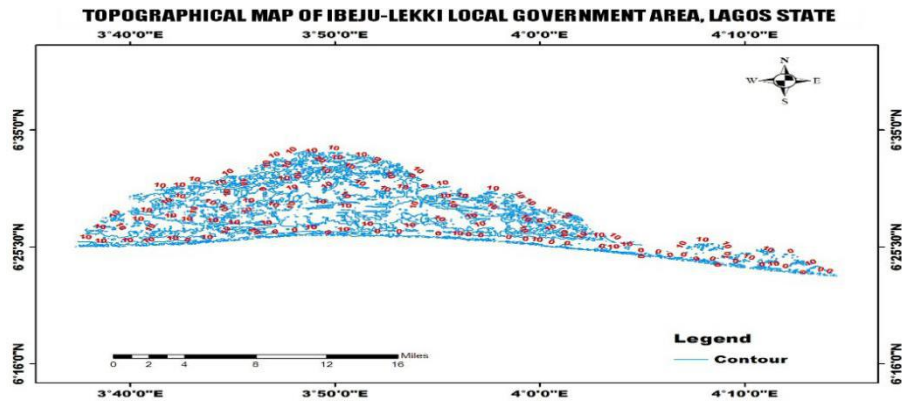


Figure 4: Topographical map of the study area

The development in the area is rapid and ongoing; some even refer to the area as the new Lagos. The commercial center of Lagos state seems to be shifting gradually towards the area with much effort being put into developing industries and infrastructure.

The district of Ibeju–Lekki is recorded as one of the fastest developing areas in the state following the location of countries leading industries, residential estates and proximity to the lekki free zone. Also, Ibeju–Lekki is an area bounded by water bodies (Atlantic Ocean and sea) which makes the area highly prone to water disasters (Adedeji and Kyoro, 2011). The rate of development tends to reduce the natural vegetation to a compact city with a lot of hard landscape. By population, the National Population Commission (2016) estimated the population of people in Ibeju-Lekki as at 2016 at 162,200 which included 60,729 males and 57,064 females. The projected population of the study area in 2019 was 267,763 using the exponential projection formula with the growth rate of 3.2% (NBS, 2011). The average temperature of the LGA is 26 degrees centigrade while the humidity level of the area is at an average of 76 percent. The total recorded rainfall in Ibeju/Lekki LGA is at an average of 3200 mm per annum. (Aderogba, 2012)

The area under study is below the sea level on the average, as the topography of the area increases its vulnerability to coastal hazards. This is illustrative on the contour map which shows that most of the areas are steep slope.

Basically, primary data was used in this study and the instrument of data collection was questionnaire administration. Two hundred and four questionnaires were administered on all the residents following (Yamene, 1967). This study adopted simple stratified random sampling technique to administer the questionnaire such that the residents have an equal chance of selection. This sampling technique was adopted so as to avoid bias and also to give each element in the framework equal chance of getting selected. Also, the slope analysis of the study area was carried out using slope calculation.

Both descriptive and inferential statistical tools were used for the analysis. While descriptive tools used included percentages, pie chart and bar chart (to present results of socioeconomic characteristics, availability and adequacy of infrastructure for urban storm water management), inferential statistical tool of Pearson Product Moment Correlation was employed in testing the relationship between the gradient of Ibeju-Lekki and its proneness to surface runoff.

Results and Discussion

Demographic features of Respondents

This section describes demographic characteristics of the respondents using frequency counts and percentage as illustrated in Tables 1-5. The study as revealed in Table 1 shows that out of 204 respondents that participated in the study, 107 (52.5%) were males, while 97 (47.5%) were females. From this it can be deduced that although the study sampled both gender, majority of the respondents were males. This is also a confirmation of more male than female in Nigerian population as recorded in the census figure of 2006 (NBS, 2011).

Table 1:Gender of the respondents

Gender	Frequency	Percent	Cumulative Percent
Male	107	52.5	52.5
Female	97	47.5	100.0
Total	204	100.0	

Table 2:Marital status of the respondents

Marital status	Frequency	Percent	Cumulative Percent
Married	69	33.8	33.8
Single	97	47.5	81.3
Divorced	14	6.9	88.2
Widow	24	11.8	100.0
Total	204	100.0	

Table 2 shows that out of 204 respondents that participated in this study, 69 (33.8%) were married, 97 (47.5%) were single, 14 (6.9%) were divorced, while 24 (11.8%) were widow. From this it can be deduced that, single respondents participated most in this study.

Table 3: Household size of the respondents

Number of households	Frequency	Percent	Cumulative percentage
1 - 4	134	65.7	65.7
5 and Above	70	34.3	100.0
Total	204	100.0	

According to Table 3, the study found that out of 204 respondents that participated in the study, 134 (65.7%) have the household size of 1 to 4, while 70 (34.3%) have the house hold size of 5 and above. From this, it can be concluded that the respondents with household size of 1 to 4 were dominant in the study area. This may not be unconnected with the nature of residential density of Ibeju-Lekki which is relatively low compared to most old Lagos areas.

Table 4: Monthly Income of the respondents

Income	Frequency	Percent	Cumulative Percent
₦5,000 to 10,000	22	10.8	10.8
₦11,000 to 20,000	42	20.6	31.4
₦21,000 to 50,000	68	33.3	64.7
₦51,000 and above	72	35.3	100.0
Total	204	100.0	

As shown in table 4 the study reveals that 22 (10.8%) were having monthly income of 5,000 to 10,000, 42 (20.6%) were having monthly income of 11,000 to 20,000, 68 (33.3%) were having monthly income of 21,000 to 50,000 while 72 (35.3%) were having monthly income of 51,000 and above. From this it can be deduced that, respondents who fell into the monthly income of 51,000 and above were in the majority, an indication that the area was dominated by the relatively high-income earners.

Table 5: Educational qualification of the respondents

Qualification	Frequency	Percent	Cumulative Percent
SSCE	10	4.9	4.9
ND/NCE	16	7.8	12.7
HND	23	11.3	24.0
BSc	37	18.1	42.1
MSc	67	32.8	74.1
Others	51	26.5	100.0
Total	204	100.0	

Table 5 shows that 67 (32.8%) has MSc, 16 (7.8%) has ND/NCE, 23 (11.3%) has HND, 37 (18.1%) has B.Sc. From this it can be deduced that even though all levels of educational qualifications were recorded in the study area, respondents with MSc qualification were in the majority. This would go a long way in assisting the respondents in better understanding of the subject.

4.1.1 Assessment of the existing storm water management infrastructure

This aspect of the paper examines the existing infrastructure for storm water management in the study area. The analysis is presented as follows:

Table 6: Storm water management infrastructure available in Ibeju-Lekki

Storm water Infrastructure	Frequency	Percent	Cumulative percent
Green / Vegetated Roof	2	1.0	1.0
Permeable / Porous Pavement	42	10.4	11.4
Public parks and gardens	78	19.3	31.5
Greenways	18	4.5	36.2
Drainage system	92	22.8	37.7
Natural green space	148	36.6	58.9
Agricultural and other productive land	11	2.7	97.1
Others	13	3.2	100.0
Total	404	100.0	

As shown in Table 6, the study assesses the available storm water infrastructure in the study area and it was found that natural green space were the most with 36.6%, this is closely followed by drainage system with 22.8%, public parks and gardens 19.3%, permeable pavement 10.4%, agricultural land 2.7% and green vegetative roof 1.0%. It can be deduced from the finding that while natural green space constituted major storm water management infrastructure, the least available infrastructure was green roof. This is an indication that very few strategies are put in place to manage storm water in the study area.

Table 7: The body responsible for the provision of storm water infrastructure in the study area

Stakeholder	Frequency	Percent	Cumulative Percent
Government	49	24.0	24.0
Private Organisation	57	27.9	52.0
Community	55	27.0	78.9
Individual	43	21.1	100.0
Total	204	100.0	

In Table 7, it was revealed that 49 (24.0%) of the infrastructure were provided by the government, 57 (27.9%) of the infrastructure were provided by private organizations, 55 (27.0%) of the infrastructure were provided by the community, while 43 (21.1) of the infrastructure were provided by individual. From this it can be deduced that most of the infrastructure are provided by Private Organizations such as the dredging companies and refineries.

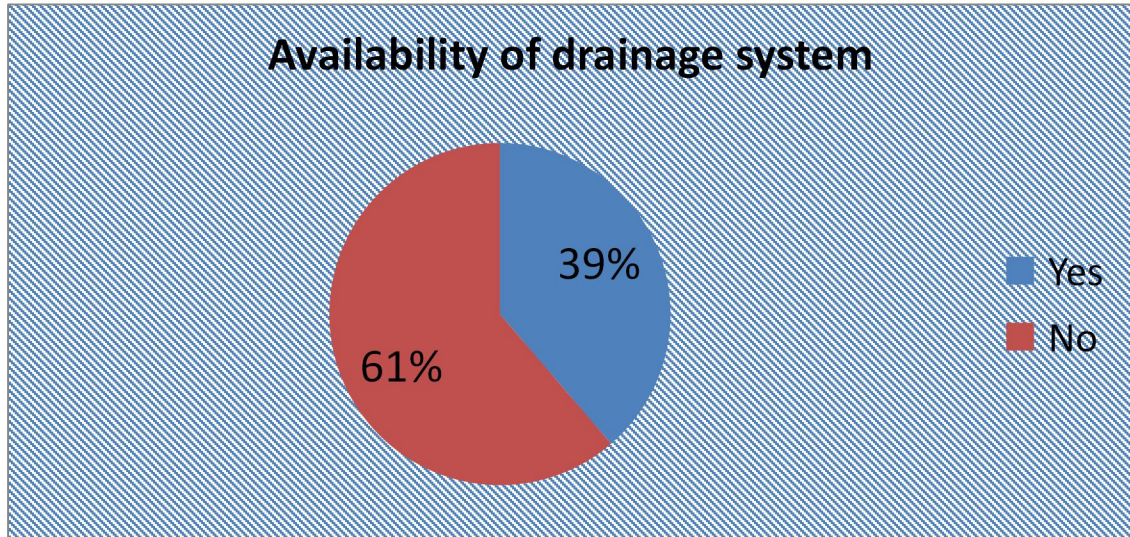


Figure 5: The availability of drainage system in the study area

Figure 5 shows the availability of drainage system in the study area, 39% of the area had drainage system while 61% had no drainage system. From this it can be deduced that majority of the study area had no drainage system where storm water can easily flow during rainfall.

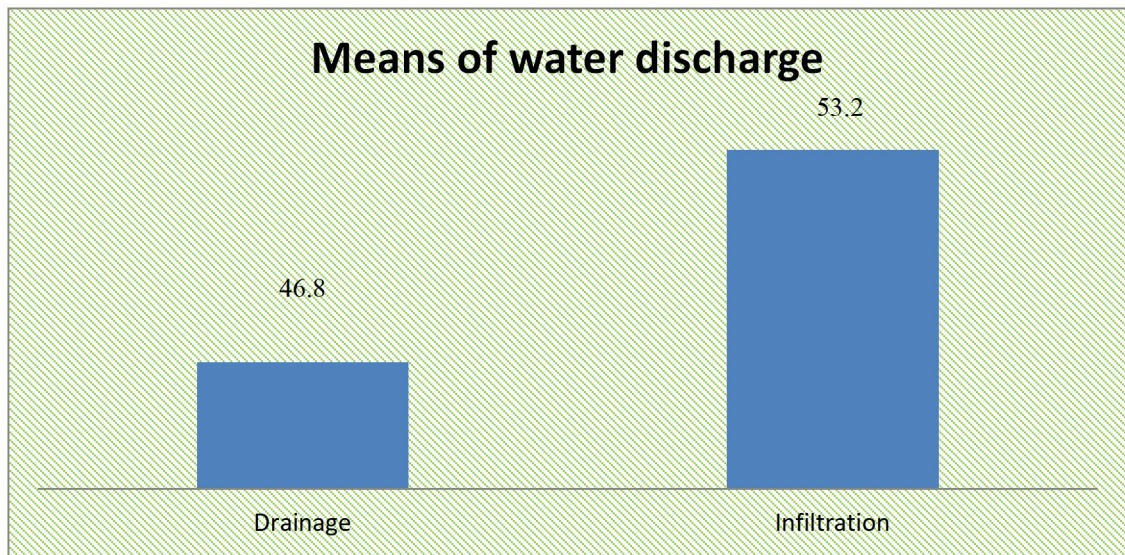


Figure 6: Means of water discharge after rainfall

According to Figure 6, the study revealed the mode of discharge of storm water when it rained. About 47% of the water got discharged from the environment through the available drainage system whereas 53% got infiltrated. The implication of this is that in cases where the terrain is characterized with impermeable features, storm water usually last longer before disappearance, the resultant effect of which could be mosquito breeding and disruption of free vehicular and human flow among others.

Table 8: Duration of storm water retention after rainfall

Number of days	Frequency	Percent	Cumulative Percent
less than one day	47	23.0	23.0
less than one next week	43	21.1	44.1
less than one month	53	26.0	70.1
more than one month	61	29.9	100.0
Total	204	100.0	

As shown in table 8, the study revealed that 47 (23.0%) of the respondents agreed that their environment usually retained storm water for less than a day after rainfall, 43 (21.1%) of the respondents do have the presence of storm water for less than a week after rainfall in their area, 53 (26.0%) of the respondents do have storm water retained for less than a month after rainfall in their area while 61 (29.9%) of the respondents settled for more than a month after rainfall in their area. From this it can be deduced that, storm water and all its attendant menace usually last for more than a month in most part of the study area before

disappearance. This could be as a result of non-availability of drainage system in some of the area.

Table 9 shows where the available drainage dispenses the storm water to. 26.6% of the drainage system dispensed water into the river or ocean, 18.9% have their drainage system dispensing water onto the road, 13.9% to another community while 26.6% don't really the knowledge of where the drainage system dispenses the water to. From this it can be deduced that, apart from river and ocean, a large volume of storm water is also emptied into other communities and roads around, this in a way may also constitutes nuisance to communities affected and as well contributes to road damage. (see plate1)

Table 9: Destination of storm water dispensed by drainage system

Receiving body	Frequency	Percent	Cumulative Percent
river or ocean	21	26.6	26.6
Road	15	18.9	45.5
another community	11	13.9	59.4
I don't know	32	40.5	100.0
Total	79	100.0	



Plate 1: Abandoned road due to the permanent presence of storm water

Source: Authors' Fieldwork, 2019

Table 10: Analysis of the percentage rise in slope of the study area

S/N	Percentage rise in slope	Area (Hectares)	Area (Percentage)
1.	0 - 18	9,060	12
2.	19 - 35	21,140	28
3.	36 - 53	3,775	5
4.	54 - 70	9,815	13
5.	Above 70	31,710	42
	Total	75,500 Hectares	100

Table 10 shows the percentage rise in slope of the study area. Out of the total land area of 75,500 Hectares, the percentage rise in slope ranging from 0 - 18 covers the land area of 9,060 Hectares (12%), the percentage rise in slope ranging from 19 - 35 covers the land area of 21,140 Hectares (28%), the percentage rise in slope ranging from 36 - 53 covers the land area of 3,775 Hectares (5%), the percentage rise in slope ranging from 54 - 70 covers the land area of 9,815 Hectares (13%), while the percentage rise in slope ranging from 70 - 100 covers the land area of 31,710 Hectares (42%). From this, it can be deduced that the percentage rise in height ranging from 70 – 100 covers the largest part of the study area. This shows that a very large percentage of the study area have a very steep slope which make many communities prone to surface runoff.

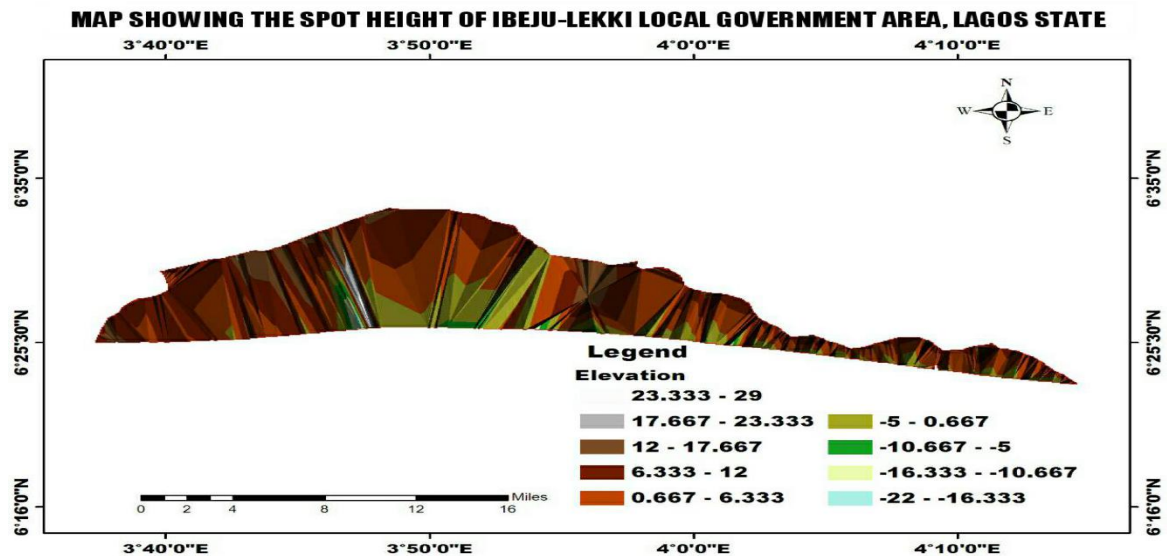


Figure 7: The spot height of Ibeju-Lekki local government area, Lagos state.

Table 11 shows the spot height of the study area. out of the total land area of 75,500 Hectares, the spot height ranging from 17.67 - 23.33 covers the land area of 3,020

Hectares (4%), the spot height ranging from 12.00 - 17.67 covers the land area of 9,060 Hectares (12%), the spot height ranging from 6.33 - 12.00 covers the land area of 24,160 Hectares (32%), the spot height ranging from 0.67 to 6.33 covers the land area of 13,590 Hectares (18%), the spot height ranging from -5.00 to 0.67 covers the land area of 10,570 Hectares (14%), the spot height ranging from -10.67 to -5.00 covers the land area of 8,305 Hectares (11%), the spot height ranging from -16.33 to -10.67 covers the land area of 5,285 Hectares (7%) while the spot height ranging from -22.00 to -16.33 covers the land area of 1,510 (2%).

Table 11: Analysis of spot heights in the study area

S/N	Spot Height (Meters)	Area (Hectares)	Area (Percentage)
1.	17.67 - 23.33	3,020	4
2.	12.00 - 17.67	9,060	12
3.	6.33 - 12.00	24,160	32
4.	0.67 - 6.33	13,590	18
5.	-5.00 - 0.67	10,570	14
6.	-10.67 - -5.00	8,305	11
7.	-16.33 - -10.67	5,285	7
8.	-22.00 - -16.33	1,510	2
Total		75,500 Hectares	100

From the table, it can be deduced that the spot height ranging from 6.33-12.00 which is the highest point in the study area covers the largest percent of the study area. This implies that most part of the study area are of very high spot height that may allow for extensive run-off, thereby leading the lower part of the study area to be prone to storm water problem especially in the event that adequate physical planning measures are not adopted.

Table 12: Result of Correlation analysis between the gradient and the proneness to surface runoff in Ibeju-Lekki

	Gradient		Level of runoff
Gradient	Pearson	1	.971
	Correlation		.000
	Sig. (2-tailed)	8	8
Level of runoff	N	.971	1
	Pearson	.000	
	Correlation	8	8
	Sig. (2-tailed)		
	N		

Correlation is not significant at the 0.05 level (2-tailed).

In order to test this hypothesis, the gradient of Ibeju-Lekki (Difference in height from the lowest Point) and the proneness to surface runoff (Level of runoff) was tested using Pearson Product moment Correlation. Table 4.12 shows the output of the analysis.

The study found that with $r = 0.971$ and $p\text{-value} .000$, there is a strong positive correlation between the gradient of Ibeju-Lekki and its proneness to surface runoff. This implies that increase in gradient of the area translate to increase in the level of surface runoff.

Conclusion

Having set out to assess the management of storm water in Ibeju-Lekki Area, Lagos state, the study reveals that larger percent of the available infrastructure are provided and maintained by private organizations and the community with low government provisions. It further shows that storm water is retained for more than one month in most areas in Ibeju-Lekki as a result of the topography and the climatic conditions, while larger percent of the communities in the study lack drainage system, inhibiting free flow of storm water in most part of the community. Most of the available drainage systems in the study area dispense stormwater to the river or ocean while some end up on the road and neighbouring communities.

It is on this basis that the study therefore proposes the following physical planning policies for sustainable storm water management in the study area, these include:

- i. Storm water master plan needs to be put in place to ensure adequacy (spread and capacity) and prompt delivery in their construction.
- ii. Adequate Drainage provision and construction should be part of criteria for development approval of any form by the planning authority.
- iii. Development control agencies should be up to the task in their routine monitoring exercise to ensure compliance with planning approval.
- iv. Effective environmental monitoring team is required to ensure appropriate cleaning of canal from refuse for free runoff.

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