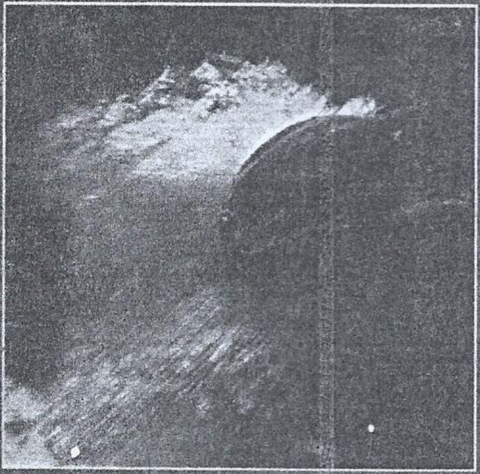

HYDROLOGY

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Hydrology of a small urban environment

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INTRODUCTION AND PROBLEM DEFINITION

In Lagos (Nigeria), urbanisation processes have resulted in land-use changes and subsequent changes in the hydrological fluxes within the city. The amount of impervious surface has increased significantly, shortening runoff travel time and increasing peak discharge rates within the city (Dar-Al-Handash Consultants, 1993). Furthermore, land expansion through artificial landfill of depressions, back swamps and wetlands/floodplain reclamation are common practice. These land reclamations generally reduce the flood storage capacity and have been known to increase flood risk levels, resulting in an increase in the risk of flood hazard in many parts of the metropolis (Dar-Al-Handash Consultants, 1993). Thus, metropolitan Lagos has experienced tremendous stress over the years as provoked by an intensive flooding problem.

Due to its geographical location, historical antecedents and political imbroglio, the menace of flooding has continued to ravage the inhabitants, particularly in the blighted and low-lying floodplains of the numerous creeks and lagoons within the metropolis. Also, population explosion has contributed significantly to human interaction and activities, accelerating the problem of flooding within the metropolis (Arbitrage Consulting Group, 1997) It is therefore not uncommon to read on the front page of the national daily papers, headlines such as "Anguish Trauma as Flood Overruns Lagos" (The Guardian, Thursday, September 21, 2000); "Flood takes over Lagos" (The Punch, Thursday, September 21, 2000). This, however, emphasises that the need for adequate knowledge to analyse and project the consequences of existing and proposed land-use planning on urban stormwater in Lagos is imperative.

FOCUS OF CURRENT RESEARCH

This paper focuses on how population pressure combines with unplanned land use to cause serious flood and other water-related problems in a small urban environment. Specifically,

1. To identify and map a small urban environment with a perennial flood hazard;
2. Estimate the population pressure of the catchment identified and the associated problem of water demand and supply;
3. Determine the extent of wetland encroachment and analyse the sources and implication of flooding within the small area.

STUDY AREA

Location and extent

The urban environment includes the Odunsi and Ilaje drainage systems of Bariga in the Shomolu local government area of Lagos State. It is confined within longitude 2^0 45' and 3^0 20' and latitude 7^0 10' and 7^0 2' and covers an area of about 3.10 km^3. Physiographically, the area has low relief and is adjacent to the Lagos lagoon. Most parts are perennially flooded while many other parts are permanently flooded. Vegetation coverage is scanty.

The landcover has been fully transformed to cultural landscape. Major drainage systems are canals. The housing pattern is cluster and predominantly residential.

Climate

The climate of the study area, and indeed the climate of Lagos and the whole of Nigeria, is basically monsoonal and experiences a contrast between the dry and wet seasons. These two climate regimes are very dependent on the two prevailing air masses blowing over the country at different times of the year:

(1) The warm, dry and dusty tropical Continental (CT) or the north-easterly air mass of Saharan origin
(2) The warm and moist tropical maritime (TM) or the humid maritime air mass blowing from over the Atlantic.

The mean monthly rainfall is about 1800 mm. There is a rainy season of 8–10 months, a short dry season in August and a more pronounced dry season generally between December and February; there are usually about 120 raindays per year.

Methodology

The land use / land cover mapping was done using Arcview 3.1. Map digitising was done using on-screen digitising. Ancillary data sources were derived from topographic and local government maps. Population and water demand were estimated using information from questionnaires. This was archived by obtaining data on family size and number of household per compound. Wastewater measurement was carried out using floating materials while flood waters génerated from rainfall were measured using a current meter. Areas inundated by floods of different magnitude were estimated.

RESULTS

Land use, drainage and flood inundation

There is no orderly layout of street and buildings. None of the houses, especially around the Oko-Cole, has a building plan and no conscious effort was made to adhere to building and health regulations. Access was through footpaths and there are only a few unconcreted drains. Although the few canals drain to the adjacent lagoon, lack of adequate plans has led to the blockage of some of these channels by buildings or a drastic reduction in the capacity of the channels. However, the drainage systems were totally inadequate as many streets were without any drainage while most parts were impervious, as shanty structures have been built all over the place. Given the poor planning, the inadequate drainage system and the high percent of impervious surfaces (Table 1) for both Berger and the Oko–Cole areas, a high coefficient of runoff was prevalent with frequent flooding.

In 2000, a series of high intensity short duration rainstorms occurred in September, especially on 20th, which flooded the entire area and causing large scale damage to property and disruptions to traffic flow. More than 100 houses were severely affected and properties worth over a million naira were damaged. The storm amounting to 75 mm, with the first initial fall occurring within 39 minutes. The 5-year storm in a 30-year flood featured prominently in the national dailies. The antecedent precipitation index (API) was high, as the storm was preceded by several days of long duration, low intensity rainfall. Also, increased generation of solid waste and inadequate sanitation facilities resulted in the dumping of wastes in the drainage channels and in obstructing the flow of water, especially during the raining season and the wastewater during the dry season. The consequence of this land abuse and unsanitary conditions of the flood plain were catastrophic floods that repeatedly affected the built-up parts of the flood plain.

It should be noted that the Oko–Cole, Lower Odunsi and Berber were formally wetland areas which have been converted to built-up areas. These wetland-converted areas within this small urban environment extend to 1.25 km^2 and represent about 40% of the small urban catchments. These areas were classified as flooded built-up areas, as shown on Figure 1. The areas are always inundated, right from the drop of the slightest rainfall, and can be categorised as floodable areas that needed urgent attention to redress the abuse of urban landuse systems.

Table 1. Percentage of pervious and impervious area

Area	*% Imperviousness*	*% Perviousness*
Oko–Cole	87	13
Berger area	79	21
Lower Odunsi area	69	31

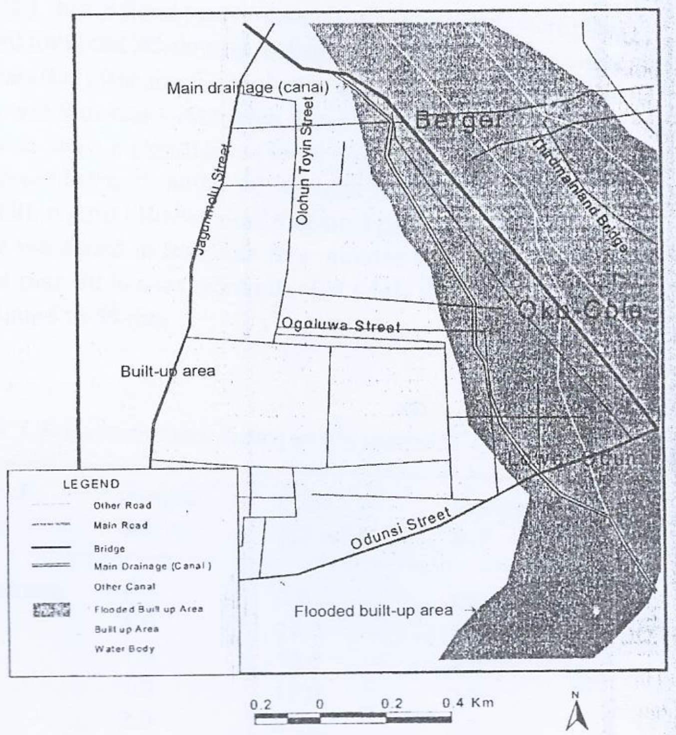

Fig. 1 Berger / Oko–Cole urgan drainage environment

POPULATION, WATER DEMAND AND SUPPLY

The average household size is five people, with most of the family living in single room. The average number of households within a compound ranges between 12 and 15. This reveals that every compound within the study area shelters well over 80 people. As mentioned earlier that a typical heavy rainstorm affects well over a hundred houses, this shows that well over 800 people are in a risk zone. In the case of unexpected heavy downpours, such as happened on 20th September 2000, several lives, especially those of children, could be endangered.

The area is considered blighted and there is no single government-initiated water supply project. 85% of the respondents to the research questionnaire obtained water from hand-dug wells while 10% claim they obtained water from commercial boreholes. The remaining 5% claim they obtained water from vendors and water tankers. The well water, which is the major source of water supply, is of poor quality; 64% of the respondents noted that the well water occasionally looks brownish and at times has a pronounced taste. It must also be noted that these hand dug wells obtain water from the topmost or water table aquifer, a layer which has been described as being polluted and unsuitable for human consumption. (Odunuga, 1996). Apart of the water quality issues, the supply is also unstable through natural fluctuations of the table, and its seasonal variability especially imposed difficulties on availability (Odunuga, 1996). On the issue of health and water supply, 75% respondents reported one form or other of water-borne disease in year 2001. Although the actual source of these diseases are not known, it must be noted that most of the respondents are artisans who live and work within the environment or in the neighborhood.

When the water table is low (dry season), respondents noted that women and children travel for over a kilometre to look for water, probably from a production well. This situation is pathetic as the population is predominantly poor. Water vendors / water tankers take undue advantage of the water scarcity situation of hand-dug wells to exploit the people. This, however, compounds the poverty level of the people. An average family household uses about 400 litres per day for various domestic purposes. During times of water scarcity, most families spent about a hundred naira (₦ 100) on water daily.

WASTE WATER GENERATION

Wastewater generation within the systems were measured during the dry season. There was no inundation during this period, which suggests that the flooding situation was as a result of storm water and high tides from the lagoon. Table 2 shows waste water measurements from one of the major sites within the small urban basin. The measurements also show that more water is generated in the mornings and evenings.

Table 2. waste water generation and flood

Hrs of day	*Height (H) cm*	*Flow (Q)* $m^3 s^{-1}$	*Inundation*
07	30.0	0.80	Nil
08	31.2	0.82	Nil
09	31.6	0.83	Nil
10	29.5	0.81	Nil
11	28.2	0.76	Nil
12	28.0	0.75	Nil
13	29.0	0.81	Nil
14	27.0	0.70	Nil
15	27.1	0.70	Nil
16	27.1	0.70	Nil
17	26.2	0.65	Nil
18	29.6	0.83	Nil
19	29.0	0.83	Nil

FLOOD GENERATION FROM STORM WATER

Table 3 shows flood measurement for a typical rainstorm that lasted for about 20 minutes in August 2001. The measurement reveals that after about 20 minutes of rainfall nearly the entire area was inundated. Although the rainfall lasted for about 20 minutes only, a significance reduction in the flood level was not recorded until about 40 minutes from the beginning of rainfall. It must also be noted that most parts of the area began to be inundated in less than five minutes into rainfall event. More than 80 houses were affected while the actual rainfall amounted to 55 mm.

Table 3. Area inundation during storm rainfall

Rainfall (time)	*Height (H) m*	*Flow (Q)* $m^3 s^{-1}$	*Inundation* km^2
0–1 minute	0.3	0.9	Nil
5	1.6	15.5	1.9
10	1.9	18.0	2.0
15	1.9	17.0	2.7
20	2.0	21.0	3.0
25	2.0	22.0	3.0
30	1.7	20.9	2.9
35	1.5	15.4	2.2
40	1.4	13.0	2.0
45	1.2	11.9	1.7

CONCLUSION

The environment was unplanned and is densely populated. Average household size is about five people per room and more than ten households live in a compound. Most parts of the area are impervious while hand-dug wells form the major source of water supply. Flooding is as a result of drainage blockage, indiscriminate land development and a high water table.

Recommendations

1. Encouraging the residents and corporate organisations on urban renewal projects for the area.
2. Mobilising and involving the residents concerned with these problems at an early stage in planning towards solving the problem
3. Enforcing planning regulation laws to the letter.
4. Embark on flood alleviation programmes and provision of adequate facilities for the people.

REFERENCE:

Oyebande, L. 1990. Aspect of Urban Hydrology and the Challenges for African Urban Environments. *African Urban Quarterly*, **5**, 1 and 2, 39–65.

Odunuga, S.S. 1996. Spatio-Temporal Variability of Water Table in Bariga Causes and Effect. Unpublished B.Sc Thesis, University of Lagos.

Dar-Al-Handash Consultants. 1993. *World Bank Assisted Stormwater Drainage Study for Lagos*. Final Report volume II, Ministry of Environment and Physical Planning, Ikeja, Lagos. Nigeria.