Strategies for Combating Urban Flooding in a Developing Nation: A Case Study from Ondo, Nigeria

E.O. ORIOLA*

Department of Geography, Obafemi Awolowo University, Adeyemi College Campus, Ondo, Nigeria

Summary

Flooding has become an inherent problem in most urban centres close to the Nigerian coast. In the last decade it has extended to large settlements in the interior of the country where rainfall is more sporadic. This study has revealed that various socio-cultural activities have promoted flooding in many of these Nigerian urban environments. These activities are characterised by stream or river channel encroachment and abuse, increased paved surfaces and poor solid waste disposal techniques, due to a high level of illiteracy, a low degree of community awareness, poor environmental education, ineffective town planning laws and poor environmental management. Government, at various levels, needs to address these issues.

Introduction

Nigeria, like many other developing nations, is experiencing rapid rates of urbanisation. This has led to increased land fragmentation and the indiscriminate building of structures often in places which are within the natural courses of streams and rivers. Consequently, storm waters from roofs and paved surfaces have no natural channels to follow. The solid waste disposal habits of Nigerian urban dwellers are relatively poor, people dump their refuse into nearby streams or otherwise prevent the natural flow of rain water. These features, coupled with changes in the rainfall regime often result in extensive flooding in the urban environment.

It is therefore not surprising that flooding is no longer confined to the coastal and riverine areas of Nigeria, where the relief is low, or to the humid region where rainfall is abundant. The urban environments of the dry sub-humid and semi-arid regions such as Kano, Sokoto, Minna and Borno may also be affected. (*African Concord*, September, 1988, *Daily Sketch*, November, 1988).

Flood occurrence in some Nigerian cities has been documented (Akinola, 1966; Obateru, 1978; Akintola, 1982; Enendu, 1981; Olaniran, 1983). Many lives have been lost, properties worth millions of Naira destroyed, vast hectares of fertile land have desertified to become badlands, and thousands of people have been rendered homeless. These recent occurrences of floods in the Nigerian urban environment call for a detailed investigation into their nature and causes in order to try to reduce the hazard, if not to eradicated it completely.

This study examines some of the socio-cultural activities and human behaviour which may be flood-inducing factors. It evaluates local awareness of flood hazards and makes practical suggestions that could reduce, if not prevent, flooding in the Nigerian urban environment.

The Study Area

Ondo is one of the major towns and an indigenous urban centre in Ondo State. It is located on latitude 6° 30′N and longitude 4° 45′E and is about 45 km South of Akure, the State capital (Fig.1). According to current estimates, Ondo has a population of 150,000 (Ondo State Master Plan 1980–2000 AD).

The physiography of the area is made up of gently undulating hills of granite outcrop of igneous origin, ranging between 200 m and 266 m above sea level. The terrain is partially underlain by metamorphic rock of the basement complex. There

* Mr E.O. Oriola is a Lecturer in the Department of Geography at Adeyemi College Campus of Obafemi Awolowo University. His special field of interest is in natural resource management, focusing on the implications of environmental degradation and sustainable development.

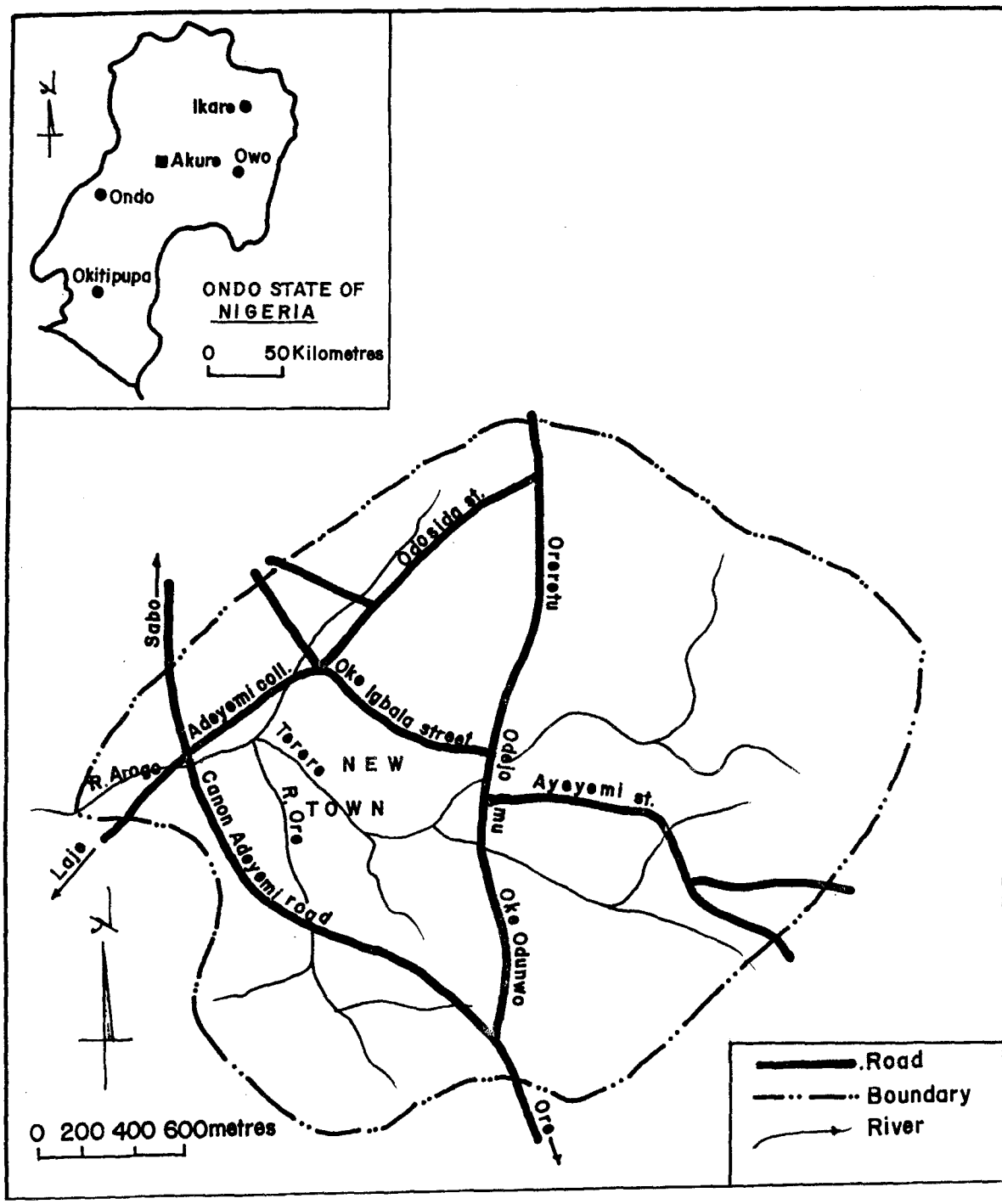

Fig.1 The New Town area of Ondo, Nigeria.

are some towering granite inselbergs rising up to 463 m above sea level, *e.g.* the Dumule Hills. The land slopes towards the south-west. The town has no major rivers, rather the land is drained by numerous streams among which are the Lisaluwa, Mode, Arogo and Aride. Most of these streams have extensive flood plains along which, in the dry season, vegetable farming takes place.

According to the climatic classification by Koppen (1936), Ondo falls within the 'tropical wet and dry climate' with a relatively small dry season. Consequently, a high annual rainfall, totalling between 1,200 mm and 2,000 mm is a typical occurence. The dry period comes between

Table 1 Landuse pattern and level of education of respondents in New Town, Ondo, Nigeria (September, 1989).

Landuse type	Percent	Education	Percent
Residential	68.50	No formal education	27.50
Industrial	3.25	Primary school	40.83
Educational	7.92	High school and above	31.67
Public buildings	12.15[a]		
Commerce	5.53		
Vacant	2.15		

[a] Including court, garage, church, hospital and library.

Table 2 Terrain properties in New Town, Ondo, Nigeria (September, 1989).

Average slope of land	3°
Width of stream	2.0–7.0 m
Depth of stream	0.5–4.0 m
Main stream gradient	1 in 20
Distance of building from stream	0.5–80 m
Drainage basin shape	Oval
Street drainage present	Only Ore-Oluwa Street

Table 3 Flood-inducing socio-cultural activities, New Town, Ondo, Nigeria (September, 1989).

Period in which buildings were erected	Percent	Distance of buildings from stream (m)	Percent
1914–1945	5.0	0–10	19.2
1946–1965	11.7	11–20	28.3
1966–1975	23.3	21–30	21.7
1976–1989	60.0	Above 30	30.8

Nature of surroundings to building	Percent	Method of refuse disposal	Percent
Impervious surface	63.3	Stream channel	55.8
Cultivated	19.2	Refuse depot	22.5
Covered with grass	17.5	Refuse burnt	21.7

November and February. The annual mean temperature is 27°C, with a maximum of 30°C. The town falls within the moist/wet lowland forest, *i.e.* it has thick forested vegetation.

Methodology

The study involved a questionnaire survey of the persons occupying buildings bordering the streams that traverse the New Town area of Ondo, and a field exercise. The New Town falls within the Arogo stream catchment area and the area was ideal for the study because:

- It falls within a pragmatic unit (a stream catchment area) (Faniran, 1972).
- The area is a newly developing part of Ondo where one would expect adequate town planning laws to be properly executed and obeyed.

Flood occurrence in the Ondo urban environment was taken as a function of the following factors: land use pattern, refuse disposal habits, the nature of surrounding buildings, distance of buildings from the course of the stream, rainfall amount and duration, the relief of the terrain, slope, gradient, and other stream basin parameters.

The questionnaires were distributed among the landlords using a systematic sampling technique. Selection involved every third building. Where the building was vacant or uncompleted, the next building was selected. The questions were selected to seek the opinion of the people in the area about their living environment, their awareness and experience of flooding, the nature and characteristics of their buildings, the age of the building and their educational background. A total of 120 questionnaires were distributed and collected for analysis.

The field exercises involved observation and measurements. Measurements were taken of the stream width, the distance of the building from the stream, the gradient of the main stream and the average slope of the land. Observations were made of the types of building, their roofing material, the drainage along streets and for other indicators that cannot be adequately measured.

The study was largely exploratory, therefore

simple percentage responses of the views on the questions were used in the data analysis. The discussion, therefore, reflects cumulative rather than specific views for the area.

The Urban Environment

Urban environments may readily alter the hydrological characteristics of natural channel flow. Typically there is increased surface run-off. Akintola (1978) reported that the impervious surface area of Ibadan, Nigeria, increased from 9.5 percent in 1949 to 28.4 percent in 1965. A similar observation was made and reported by Olaniran (1983) for Ilorin. In 1961, the built up area in Ilorin was put at 13 km^2, which represented 9.2 percent of the total area, by 1981 it had increased to 20.9 percent. In this present study, in 1975 the impervious surface area in Ondo was 13.2 percent, this had increased to 28.6 percent in 1989.

The implication of rapid urbanisation is that it utilises the use of sewers to transport storm run-off from paved surfaces directly to nearby streams for discharge. This process reduces the run-off travel time to the stream channel and the run-off water proportion is greatly increased (Strahler, 1975). In most towns, water from the sewers during rain storms constitutes the largest proportion of the flood water. Human occupation of river or stream channel areas for agricultural activities tends to loosen the soil, which in turn, may silt up the stream channel and block culverts, *i.e.* soil erosion is accelerated by farming. Siltation and blocked culverts may also cause the stream to overflow its banks. Urbanisation normally reduces the infiltration capacity of the surface. Lack of drainage or poor drainage along the streets also accentuates the tendency to flooding.

Observations and Results

The New Town area of Ondo was proposed as a residential neighbourhood in mid-1959. By 1989, of the total land area of 233 ha, 68.5 percent had been occupied by residential buildings while 20 percent was being used for public and educational purposes. Industry and commerce shared 3.3 percent and 5.5 percent, respectively, and only 2.2 percent was unused (Table 1).

The literacy level among the respondents to the questionnaire was high when compared with the level attained by those in rural or less urbanised areas. More than 70 percent of the inhabitants had attended at least a primary school. However, less than one-third were well educated. From field observation and personal contact with the respondents, most of those with primary school education could not be distinguished from their counterparts with no education in their level of awareness and behaviour related to flood processes.

Table 2 shows the observed and measured terrain properties in the study area. The area falls within the Arogo stream catchment where the land slopes gently towards the west and south. The average slope is 3° and the gradient of the main stream is 1 in 20. The district roads that bound New Town (Fig.1) are bitumen covered but with no drainage. Only Ore-Oluwa Street which is bitumen surface possesses concrete drainage on both sides of the street. However, the concrete drains terminate abruptly. All other streets within the study area are neither surfaced nor provided with drainage. Some people dig out temporary drainage ditches in front of their buildings to prevent the rain water from washing the base of the buildings.

Table 3 shows some of the major flood-inducing socio-cultural activities in the Ondo urban environment which was studied. The table reveals that 60 percent of the buildings were completed between 1976 and 1989, only 17 percent predated 1965. Less than 48 percent of the buildings in this area contravened the Town Planning Authority's law which determines that for a low density area buildings should be 20 m from the stream. But a larger proportion (nearly 70 percent) failed to keep to the 30 m distance which is specified for high density areas. The study area is of a high density occupation type.

The surroundings for most of the buildings in the study area were open and impervious (63.3 percent). Only 17.5 percent was covered with grass, the rest was cultivated. More than 55 percent of the respondents dumped their refuse into nearby streams.

Table 4 clearly shows flooding occurred frequently in the area of study, 40 percent of the respondents experienced flooding after every rain

Table 4 Flood perception and experience, New Town, Ondo, Nigeria (September, 1989).

Frequency of flood	Percent	Causes of flood	Percent
After every rain	40.8	Abuse of stream channel	30.8
Occasionally	39.2	Poor drainage	17.2
None at all	20.0	Heavy rainfall	50.0

Fig.2 Street flooding in the study area; Ondo, Nigeria.

and only 20 percent were flood free. The perceptions as to the reasons for the occurrence of flooding are remarkable. One half of the respondents believed that the flooding was a natural phenomenon caused by heavy rainfall. In their belief it had nothing to do with man's socio-cultural behaviour or activities related to the area.

Discussion

Flooding has become an annual event in Ondo, particularly in the New Town area. Floods bring inherent problems, especially in Yaba Street, Odojomu Street and Adeyemi College/Cannon Adeyemi roads (Fig.2). The rainfall in Ondo is high, normally about 1,250 mm in total, and it is concentrated within eight months of the year. Table 5 reveals that between 1984 and 1989 the total annual rainfall never fell below 1,400 mm and the annual amount may be increasing. Within this period, the monthly rainfall for the six months (May to October) only fell below 120 mm in four instances. With this amount of concentrated rainfall the moisture accumulation is often such that the land is saturated with water and any additional rainfall causes the streams to overflow and run into nearby buildings.

The years 1984 to 1989 were remembered as the 'flood years' in the study area by the respondents. This was the period when the New Town area, and Ondo town in general, experienced rapid expansion and physical development in terms of buildings and landscape development. This increased the percentage of impervious surfaces (Akintola, 1978; Olaniran, 1983).

The years 1976 to 1989 were a period of rapid expansion and physical development in Ondo, and in the New Town area in particular. This period encompassed the oil boom of the 1970s and the cocoa boom of 1988 which improved the income of the civil servants, business men and women The farmers gained particularly from the cocoa boom. Consequently, there was rapid increase over the period in the number of completed buildings in the study area.

The streams in the area are typically choked and silted up by refuse deposited in them. The stream channels have become shallow and narrow, preventing the easy flow of water. The lack of adequate street drainage tends to aggravate the flood menace. The refuse disposal habits of the larger proportion of the respondents reflects their ignorance and low level of awareness of the implications. Their hope is that when rain comes it will wash the refuse away. But the dumped materials often solidify and constitute a barrier to the free movement of water in the stream channels.

The buildings in the area are mostly of a bungalow type with galvanised iron sheet roofs. The roofing materials and shape do not absorb or retard rain water. Moreover, more than two-thirds of these buildings are less than 30 m from the stream channel, disregarding the Town Planning Authority law.

The land surrounding the buildings is mainly of impervious surfaces (concrete and bare ground) which reduces the infiltration capacity of the soil and increases the runoff rate. The lack of grassed surfaces probably reflects the fact that grass harbours mosquitoes and therefore increases the potential for malaria. The cultivated land serves as

Table 5 Monthly rainfall (mm) between 1984 and 1989 for Ondo, Nigeria.

Year	Jan	Feb	Mar	Apr	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec	Total	Average
1984	0.0	0.0	172.2	121.2	199.5	130.8	214.8	232.5	263.9	124.6	17.4	1.1	1,478.0	123.17
1985	TR	41.9	212.8	482.7	410.7	259.8	335.4	285.2	372.4	109.4	32.0	0.0	2,542.3	211.86
1986	40.6	25.4	190.7	41.6	211.1	271.9	170.7	102.6	256.9	132.3	23.4	0.0	1,566.6	130.55
1987	0.0	32.1	145.4	91.2	86.6	140.8	244.4	355.1	230.5	263.2	0.8	6.6	1,596.7	133.06
1988	3.7	92.3	93.9	193.9	240.4	223.4	141.7	101.4	301.7	244.8	27.7	29.7	1,694.6	141.22
1989	0.0	TR	115.0	200.7	245.1	230.0	300.3	210.5	158.9	124.2	23.6	TR	1,608.3	134.03

Source: Department of Meteorological Services, Ondo Station, Ondo State, Nigeria. Altitude = 285 m (942 feet). (TR = Trace)

vegetable plots from which people realise some economic benefits (Sewel, 1969). At the same time, water erosion conveys loose soil to the stream channels from this source assisting in their siltation and eventual blockage. Trees whose leaves could break the rainfall (*e.g. Tarminalia calapa*) might be advantageously planted to prevent the soil erosion. Grasses, when properly looked after, also retard soil erosion and, when properly sprayed, no longer harbour mosquitoes.

It is very apparent that the level of formal education is generally low among the people living in the study area. There is correlation between the literacy level and human behaviour. The low level of education was revealed in the methods of waste disposal. People with better and a higher level of formal education either burn or bury their refuse. The majority of the people who have built close to the stream are the more illiterate. An insignificant proportion of the respondents with a higher level of education contravened the Town Planning Authority's law on building some distance from the stream. 75 percent of the buildings in the 'no flood at all' group were owned by the more highly literate group. About 70 percent of the more illiterate respondents and 75 percent of those with primary education were convinced that the flooding was a natural phenomenon and had nothing to do with man's activities, while only 10 percent of the more literate group had a similar view. It can be concluded that majority of the people in the study area are ignorant of the implications of their flood-producing activities. It is therefore necessary to improve their awareness, to educate the local people about their interaction with, and behaviour in, their living environment.

There is clearly a need to entrench environmental themes in certain subjects at the Junior and Senior Secondary School level. The new Nigerian mass literacy commission should undertake similar actions for the adult literacy and non-formal education curricula. The themes should be taught through practical and field exercises. This will improve the students' awareness of their interaction with the natural environment. The formal environmental education should be reinforced by a strong community awareness (on a national scale) of environmental issues and problems, and by very strong mass-media support for the environmental movements. Mass-media communication can influence overt behaviour, as observed and reported by Church and Keller (1989).

On a practical level, the streams need to be properly channelled and street drainage installed. It might be possible to undertake this construction by employing an environmental task force. The local or municipal government should provide refuse collecting depots or incinerators at convenient locations within walking distance from every building locality. Failure to use these facilities correctly, once installed, should be governed by strict legislation and punishment.

There should be a mandate for buildings to have either overhead or underground basement storage tanks or reservoirs where the storm water can be stored and utilised or released later. The water in such reservoirs could serve as a source of domestic water supply for the dry season periods in cities where domestic water supply is an acute problem. However, such reservoirs would have to be properly cared for to prevent other health hazards. The old and conventional flood control methods of building earth dams in the upper reaches of the stream catchment are no longer satisfactory. The practice brought a serious greater disaster in the case of the Kano flood of 1988.

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