Urbanisation And Geomorphic Characteristics Of Warri River

By

J. O.A. MOGBORUKOR
Department of Geography and Regional Planning,
Delta State University,
Abraka - Nigeria

Abstract
The work examined the effect of urbanisation on some geomorphic characteristics like river bankfull discharge, sediment yield and channel capacity of Warri River. A three-fold research strategy was adopted. 20 sites along the river profile were selected to obtain information on the characteristics mentioned above. Suspended sediments was also determined using filtration method and data on urbanisation was through direct field work. In order to understand the relationship between the process – response variables, bivariate and multivariate statistical techniques was applied. It was discovered that there is a marked linear relationship between urbanisation and channel capacity. The work also established a positive relationship between channel capacity and bankfull discharge. However, there was a negative correlation between sediment yield and the degree of urbanisation, the same was true for discharge attribute. In order to minimize the amount of surface discharge from the city into the river, government should put up a long range strategies of stream channel stabilisation and downstream impact mitigation aimed at keeping rapid storm flow. There is also urgent need for the development of green belts and lawns to encourage infiltration in urban areas to reduce rapid flows into existing river channel.

Introduction

In the past decade a verity of studies have shown that urbanisation of a drainage basin could significantly affect its hydrology by increasing flood magnitudes and increasing lag times (Carter 1961, Anderson 1970; Hammer 1972; Odemerho 1992; Oyegun 1994). Recent studies have also shown that changing conditions imposed by urbanisation have profound effects on stream morphology and dynamics. Leopold 1973; Ebisemiju 1976; Slymaker 1993; Oyegun 1994 has shown that progressive urbanisation of a drainage basin can result in changes of river channel size and form with time.

According to Wolman 1967, channel shape and form are adjusted to the quantity and characteristics of sediment load provided by the drainage basin. However, this state of equilibrium in a river system can be disturbed by urbanisation due to the removal of vegetation, creation of impervious surfaces and parking spaces, all of which lead to an increase in surface runoff. Gregory and Walling (1971), affirm that the construction of houses and related civil engineering works tend to increase sediment generation and yield in a drainage basin.

Despite the results from the studies cited, there still remain great shortages of quantitative data on the effects of urbanisation on stream systems (Richards 1993, Rhoads 1994). Commonly, a major problem is the shortage of baseline data for comparison in such studies. The lack of information concerning urbanisation of small drainage basins is particularly acute, where stream gauging records and baseline data are almost non-existent.

Assessing fluvio – geomorphic characteristics of a stream is therefore particularly important because if a steady state is disturbed systematic changes will occur to restore a balance between process and form. During this period, the river is unstable and reshapes its channel through accelerated erosion and deposition.

Purpose of the Study

The study therefore, is aimed at investigating the following in the Warri river basin:

1. Urbanisation in the basin has significantly affected both short term and long term river regime;
2. Increased development in the basin has resulted in increased channel instability for a given storm discharges as a result river channels have significantly enlarged.
3. Channel enlargement is related to, but not directly proportional to increased flood magnitudes; therefore, increased flood discharges are partially accommodated by increased over bank flow and greater peak velocities.

In the light of these considerations, the study will help to reduce the dearth of quantified data in the problems of small urbanising river basin.

The Study Area and Method

The Warri River is one of the major coastal rivers in the Niger Delta area of Nigeria with an outlet through the Forcados estuary to the Atlantic Ocean. The navigable outlet gave the river an important commercial status. Warri River has one of the largest port in Nigeria which consequently has enhanced growth and the concomitant urbanisation and industrialisation of Warri and other riparian towns. This phenomenon took a rapid turn in the 1970's with the establishment of industrial and or residential estates by Shell Petroleum Development Company (SPDC), Nigerian National Petroleum Company (NNPC) etc. The activities of these oil exploring companies and their servicing associates imposed new demand on the Warri river.

The Warri river ($5^{0}21'$ – $6^{0}00'$N, $5^{0}24'$ – $6^{0}21'$E) (see Fig 1) lies in the northern outskirts of the mangrove saline zone in the Niger Delta, Nigeria (FPDDPRK, 1980). The river took its source at Utagba – Uno and flows south – west for about 74km through Amai – Otorho – Abraka, Otokutu and Warri before emptying into the Atlantic Ocean through the Focados estuary. The water in the river is the black type and its flow is unidirectional except during the flooding period. Warri has a terrain of about 20m above sea level. The area is also characterised by hydromorphic soils, which is made up of mixture of coarse alluvial and colluvial deposit. The area has a tropical equatorial climate with mean annual temperature of 28^0C and rainfall of 3000mm. Rainfall ranges from January to December, with the minimum rain value of 53mm in January and over 600mm in September. There is however a double rain maximal in the months of July and September. There is a little dry spell in the month of August. Conventional type of rainfall is predominant in this city. Rainfall in most areas results in urban flood. Fringing vegetation are mainly shrubs (*Chromolaena Odarantum Xymphea spp, Dryopteris spp)* and trees (*Bambusia Vulgaris, Raphia vinifera, Symphonia spp*). These trees shade portions of the river.

By all estimation, Warri is one of the rapidly urbanising cities of Nigeria. For instance, the population of Warri has risen over the years from 19,526 in 1952, to 55,256 in 1963 and to 280,000 in 1980 (Sada, 1981). At present, the population of Warri metropolis is 500,000 (1991 census). Apart from population growth, the areal expansion of Warri within the past three decades has been remarkable. From a small river settlement, Warri has grown to engulf the surrounding villages of Effurun, Ekpan, Enerhen, Edjeba, Ogunu, Jakpa, Ovwain-Aladja, and Udu etc; with the result that Warri is now over a 100 sq km. (See Fig 2).

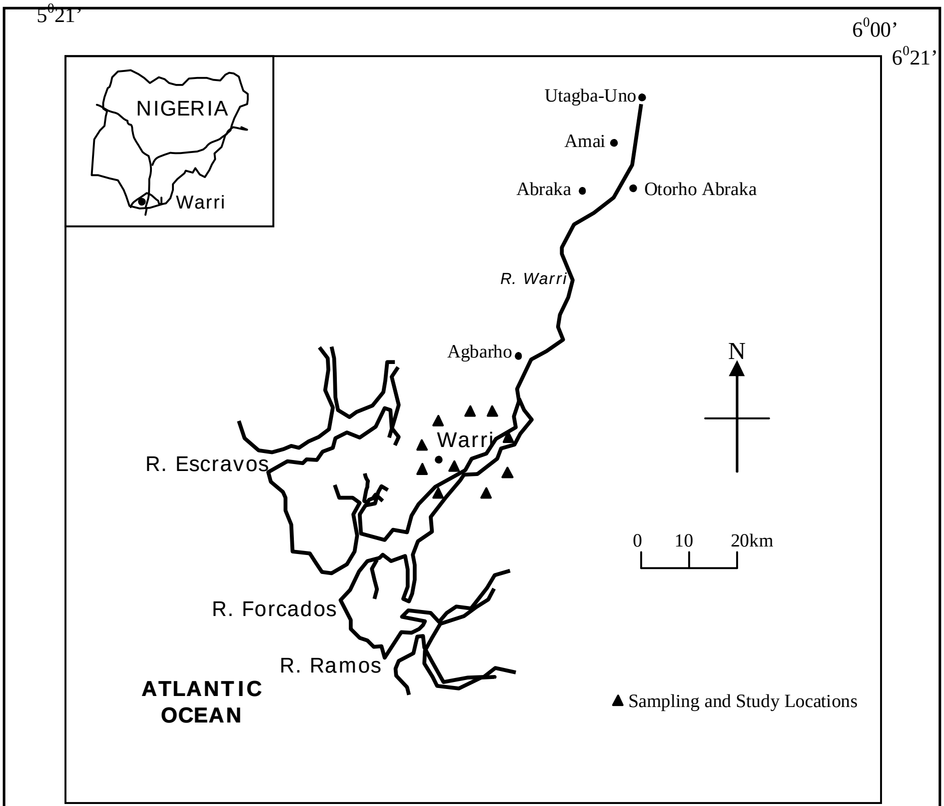

Fig 1: Map showing the location of Warri River in Nigeria (Inset) and Map of Warri River Indicating Study Areas

To investigate the fluvio – geomorphic characteristics of the Warri river system a threefold research strategy is adopted. First, 20 sites were selected along the river long profile in order to obtain information on stream channel bank full cross sectional area, basin morphometry and other land use characteristics. Data on channel capacity was measured at each sampling point as the product of the average channel depth and width, which were determined with the aid of ranging poles and a 30 meter measuring tape. Bank full discharge was computed as the product of bankfull width, the average depth and velocity of the river at the various sampling points.

The concentration of suspended sediments per unit volume of river water was determined in the laboratory. The filtration method was used in this study and the apparatus include Whatman's filter papers, plastic funnels, beakers, a stirrer and a 25mm pipette, 100 millilitres of sampled river water was obtained from a properly agitated sample and filtered with filter paper which had previously been dried and weighed. The resulting filter was over dried at 105^0C for 3 hours and then cooled in a desiccator and weighed. The dry weight differences of the filter paper before and after filtration, constituted the sediment concentration per 100 millilitres of sampled river water, which was subsequently converted to sediment concentration per litre (See Table 1).

Data Analysis and Results

Table I: Characteristics of Channel Capacity, Sediment Yield and Discharge

Parameters	Mean	Standard deviation	No of places
(x_1) Bankfull discharge (m^3/s	3.2677	1.2241	20
(X_2) Sediment yield (gms/l	0.2451	0.1233	20
(X_3) Channel capacity (m^2)	2.1374	1.2204	20
(Y) Degree of urbanisation	30.1271	13.47482	20

Source: Fieldwork, (2008)

Data on the degree of urbanisation and geomorphic characteristics were colleted through direct fieldwork. In order to understand the relationship between the process–response variables of this study, the multiple regression model was used in this study.

Urbanisation and Geomorphic Characteristics of Warri River

The Person's Product Moment Correlation Coefficient was used to establish the relationship between channel capacity and the degree of urbanisation. The correlation coefficient (r) of 0.731 (See Table 2), shows that there marked linear relationship between the two variables which is significant at 99.9% confidence level. The coefficient of determination (r^2) for this correlation is 69.32% meaning that as much as 69.32% of the total variation in channel capacity is explainable by variation in the degree of urbanisation of the basin. This explanation is born out in theory, that the higher the degree of surface imperviousness the more runoff is available to the river channel.

Table 2: Correlation Matrix

	Bankfull discharge X_1	**Sediment yield X_2**	**Channel capacity X_3**	**% built-up area (Y)**
Bankfull discharge (x_1)	1.00	-0.043	0.834*	0.624
Sediment yield (x_2)		1.00	-0.032	-0.001$^+$
Channel capacity (x_3)			1.00	0.731
% Built-up Area (Y)				1.00

+ Not significant

* Significant at the 0.1% level.

However, a more significant relationship was established between channel capacity and bankfull discharge. The correlation coefficient (r) between these variables is 0.834, which indicates a marked positive relationship that is significant at the 99.9% significance level. The coefficient of determination (r^2) is 99.19, meaning that as much as 99.19% of the total variation in channel form is explainable by variation in bankfull discharge.

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The negative correlation (r) or –0.001 between sediment yield and the degree of urbanisation of the basin gives creditability to the assertion of (Wolman 1967; Oyegun 1994), that as the process of urbanisation proceeds, sediment generation in the basin decreases.

The same is true for discharge attribute, which is negatively correlated with sediment yield (r = -0.032). On the other hand, bankfull discharge is positively correlated with the degree of urbanisation of basin with a correlation coefficient (r) of 0.624, which is significant at the 99.9% significant level. This means that with coefficient of determination of about 85% of the total variation in bankfull discharge is explainable by the degree of urbanisation parameters. This finding goes to corroborate the fact that, index of urbanisation of a river basin increases with the peak flow discharge into the river channel Oyegun 1994. This is primarily due to the increased creation of impervious surfaces within the basin area. Arising from this, no sooner does rainfall than it runs off through gutters and other storm drainage devices into the river channel.

Analysis of variance chart (Table 3) shows that the coefficient of determination (r^2) between bankfull discharge and the degree of urbanisation of the basin is 84.9% implying that as much as 85% of the overall variation in bankfull discharge is explainable by variations in the degree of urbanisation of the basin.

Table 3: Analysis of Variance for variable

Source of variation	**Sum of squares**	**Degrees of freedom**	**Mean squares**	**F-Ratio**	**R^2**
Regression	14628.2140	1	14628.2140	270.58*	0.896
Residual	2592.0113	48	54.0627		
Total	17223.2253				

* Significant at the 0.1% level.

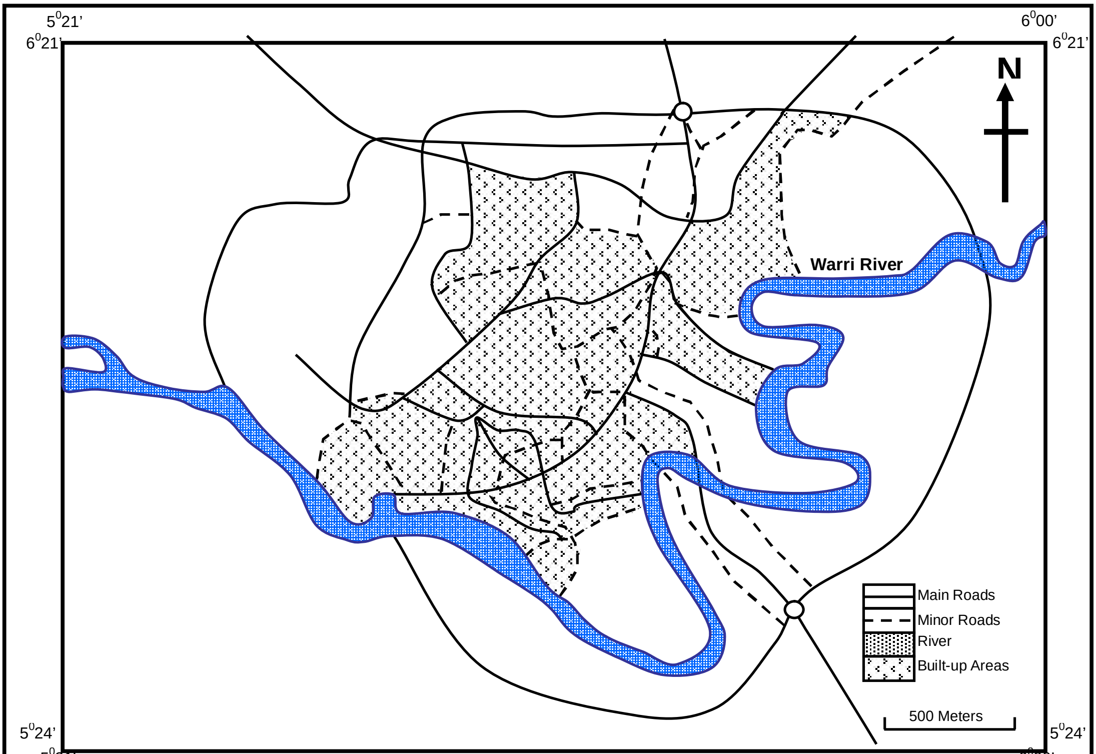

Fig. 2: Map of Warri Showing built-up area contributing run-off and sediment to the River

Conclusion and Recommendations

The study has shown that urbanisation has some serious impact on river basin response through variations in sediment yield, bankfull discharge and channel capacity. The study has also shown that with increased urbanisation of a river basin, sediment generation is not only minimal but is also negatively correlated with channel capacity and bankfull discharge. The positive relationship between the built-up area and the amount of discharge in the study area calls for government attention for the need to create a stabilisation scheme in the Warri river basin in order to contain excess runoff generated by increased impervious surface that is consequent on urbanisation.

The development of green belts/lawns and other options that will encourage infiltration in urban areas will be more successful than development of storm sewers both because of capital constraints and the need to reduce rapid flows into the existing river channel. Government and individuals are encouraged to pursue an integrated programme of basin landuse and structural alternatives which are good solutions to the issue been addressed.

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