Environmental Effects Of Urbanization Of River Ajilosun Drainage Basin In Ado-Ekiti, Ekiti State, Nigeria.

PROF. ADEBAYO, WILLIAMS OLUWOLE
DEPARTMENT OF GEOGRAPHY AND PLANNING SCIENCE,
EKITI STATE UNIVERSITY, P.M.B. 5363, ADO-EKITI,
EKITI STATE, NIGERIA.E-MAIL: oluwadebayowilli@yahoo.com

AROHUNSORO, SEGUN JOSEPH (Ph.D)
DEPARTMENT OF GEOGRAPHY AND PLANNING SCIENCE,
EKITI STATE UNIVERSITY, P.M,B. 5363, ADO-EKITI,
EKITI STATE, NIGERIA.E-MAIL: segunaros2002@yahoo.com

Abstract

The study examined environmental effects of urbanization of River Ajilosun drainage basin in Ado-Ekiti, Nigeria. Data were generated on flood width, channel width, and storm drain dimensions with the aid of a ranging pole, tape measure and a piece of plank. Also, 150 copies of structured questionnaire were administered on respondents who were also landlords of houses in River Ajilosun drainage basin. The data were analyzed with descriptive statistics such as mean, standard deviation, range and simple percentage. The Student's't' test was used to compare the differences in the occurrence of flooding and erosion between the upper and lower segments of River Ajilosun. In addition to these, photograph of some features were taken to complement the various data. The findings of the study revealed the environmental effects of urbanization in the drainage basin to include increase in spatial extension of flooding and flood prone areas, increased erosion of River Ajilosun channel, and sediment pollution of the basin surface, indiscriminate refuse disposal/refuse sedimentation of streets and general pollution of the environment. The measures suggested for curbing these problems are relocation of illegal structures, adequate implementation and enforcement of Town Planning Laws, construction of new storm drains, rehabilitation of the old ones and regular desilting of the storm drains among others.

1.0. Introduction

Urbanization can be descried as the process of building towns and cities and making them bigger. It is a process by which settlements take on higher socio-economic and political responsibilities and perform central place functions to other setlements (Oredipe and Bakare, 2009). A drainage basin can be defined as a whole area of land from which water and debris are channeled into a river or a network of rivers (Arohunsoro, 2011). Urbanization is a phenomenon of post industrial revolution. Most settlements started witnessing rapid growth in size since the late 17th and early 18th centuries (Onokerhoraye, 1985). Rapid expansion as a result of technological breakthrough also added its quota to the ever increasing process of urbanization. However, the phenomenon of urbanization began in the more economically and technologically advanced nations and later spread to the less advanced nations with a fewer range of opportunities for the initial rapid growth. But by 1950, virtually all parts of the world became involved in the process of urbanization (Onokerhoraye, 1985).

One of the areas in which urbanization had its impact on cities is in the alteration of environmental equilibrium in urban drainage basin particularly with regards to its hydrology and water resources (Olorunfemi and Jimoh, 2000). Since urban centres occupy water sheds, the process of building towns and cities has altered the hydrological regime of rivers and cause emergence of other environmental conditions in cities.

River Ajilosun is the principal of the ten(10) streams that traverse Ado-Ekiti on which this study focuses. It is the most urbanized of the streams. River Ajilosun drainage basin is a highly urbanized section of Ado-Ekiti. The persistent influx of people into the city and the resultant escalating spate of human interaction with the basin space, have generated attendant environmental effects which manifest variously in the drainage basin. Some of these effects may have threatened the sustainable and liveability of the environment and even the prospect of man's survival in it. The need to assess the spatial pattern of environmental feedbacks to urbanization in urban centre drainage basins in Nigeria, and Ado-Ekiti in particular, prompted this paper.

In the light of the foregoing, the paper discusses the various effects of urbanization of River Ajilosun drainage basin on the environment. The paper also recommends measures for the management and control of adverse environmental effects of urbanization on the drainage basin.

2.0 Objectives of the Study

The overall objective of this paper is to examine the spatial pattern of environmental consequences of urbanization of River Ajilosun drainage basin in Ado-Ekiti in Ekiti State.

However, specific objectives of the paper are to:

(i) Identify and discuss environmental effects of man's development of River Ajilosun drainage basin.

(ii) Suggest measures for effective management and control of adverse environmental feedbacks to urbanization in River Ajilosun drainage basin.

3.0 Conceptual Framework/Definition of Concepts

The concepts of environmental interaction, basic necessities of life and sustainability are very germane to our understanding of the effects which urbanization may have on river basins. According to Afolabi (2005), the environment, is defined as oneself, the point in which one is found at a time, the surroundings, the more distant places, other earth components, conditions, prospects and problems which accounts for its flourishing or otherwise. Interaction may be conceptualized as the effects which two things have on each other. The basic necessities of life include the four principal requirements for survival of man which are food, shelter, clothing and recreation. Sustainability is learning how to sustain our environmental resources so that they can continue to provide benefits to us and to the larger environment of which we are a part (Botkin and Keller, 1998). The concept of sustainability also connotes lasting out, enduring and exploiting natural resources for the need of the present generation without hampering the needs of the future progeny.

By 1600, global population increase by about 0.1% per year. The rate of increase of about one-tenth of a percent was maintained every 50 years until 1950 (Onokerhoraye, 1985). This rapid increase occurred because of the discovery of causes of disease, inventions of vaccines, improvement in sanitation, other advances in medicine and health, and advances in agriculture that led to a great increase in the production of food, shelter and clothing, which are man's fundamental needs for survival.

The crave for the basic necessities of life prompted man's interaction with the environment. The equilibrium effects which man's interaction with his environment may have, necessitates consideration for today's needs vis-à-vis prospects and passionate consideration for generation unborn.

4.0 The Study Area

River Ajilosun drainage basin is located within Latitudes $7^{0}35^{1}$ and $7^{0}38^{1}$ North of the Equator and Longitudes $5^{0}10^{1}$ and $5^{0}15^{1}$East of the Greenwich Meridian in Ado-Ekiti in Ekiti State of Nigeria (Figure 1). Ado-Ekiti doubles as the headquarters of Ado-Ekiti Local Government Area. The city has a total population of 308,626 in 2006 according to the National Census and a projected population of 1,111,953 in 2030 (Oriye, 2008). The settlement has a growth rate of about 2.5% per annum. Using the current population growth rate, the city has a population doubling period of 31 years. With a total land area of about 700km^2, Ado-Ekiti has an average population density of about 441 persons/km^2

The study area falls within Koppens A_W climate classification and consequently enjoys the sub equatorial climate characterized by double rainfall peaks which coincide with the passage of the 'equinoxes'. The annual rainfall totals in the region ranges from 1200mm and 1400mm while the highest mean monthly value varies between 105mm and 261mm. Eighty percent of the monthly rainfall occurs between May and October each year. September and October are usually the wettest months. The dry season spans November to March. However, the global warming phenomenon and the general global climatic fluctuations seem to have triggered alterations in the onset and cessation of rains in the area. Mean monthly temperature of the area is 27^{0}c while the hottest months are in February and March (Figure 2)

Geologically, the area is underlain by the Precambrian Metamorphic and igneous rocks. Specifically, the rocks suites in the area consist of the fine and coarse-grained charnockite which occur in more than 85 percent of the area. However, intrusions of quartzite formations are also noticed widely across the quarternary deposits of sand and mud along the river course (Adeduro, 1993).

Of all the ten (10) principal drainage basins traversing the space of Ado Ekiti, the Ajilosun is the largest. The drainage basin has a planimetric area of 18.125km^2, a drainage density of 1.90km/km^2 and a stream frequency of 1.26 streams/km^2.

Over 60% of the drainage basin is completely built up with the head water of the drainage basin coinciding with the core of the traditional quarters of the city. The built up area of Ado-Ekiti was 20.0km^2 in 1986, increased to 36.7km^2 in 2006 and projected to 134.km^2 in 2030 (Oriye, 2008). The rate of spatial growth of Ado-Ekiti is quit enormous and could generate great expanse of impervious.

The role of Ado-Ekiti as the headquarters of Ekiti State with effect from October 1, 1996 has exposed the city to continuous influx of immigrants in to it. This situation has also increased the rate of absorption and consumption and consumption of land in the city, and in particular, within the River Ajilosun drainage basin.

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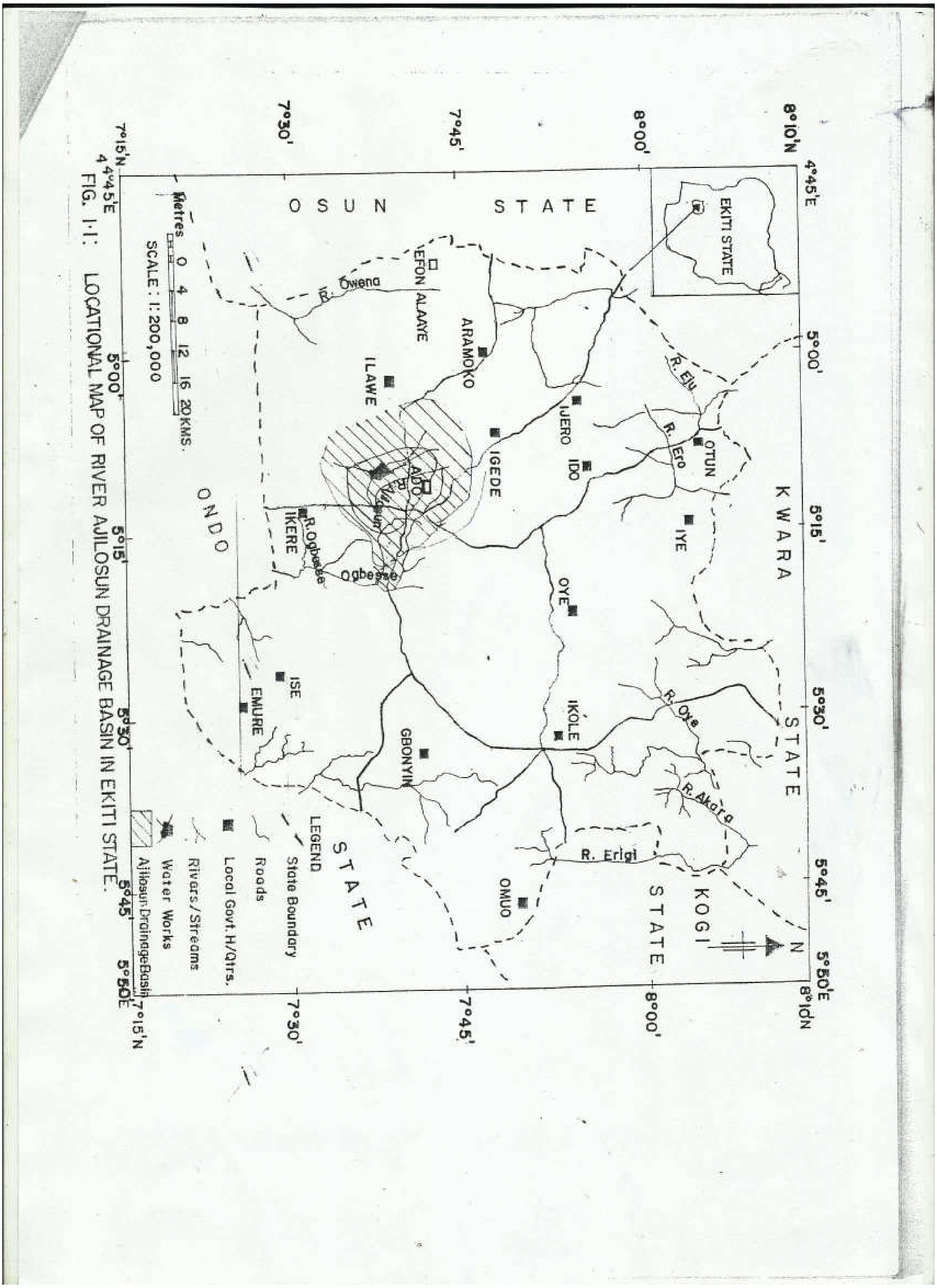

FIG. 1·1: LOCATIONAL MAP OF RIVER AJILOSUN DRAINAGE BASIN IN EKITI STATE.

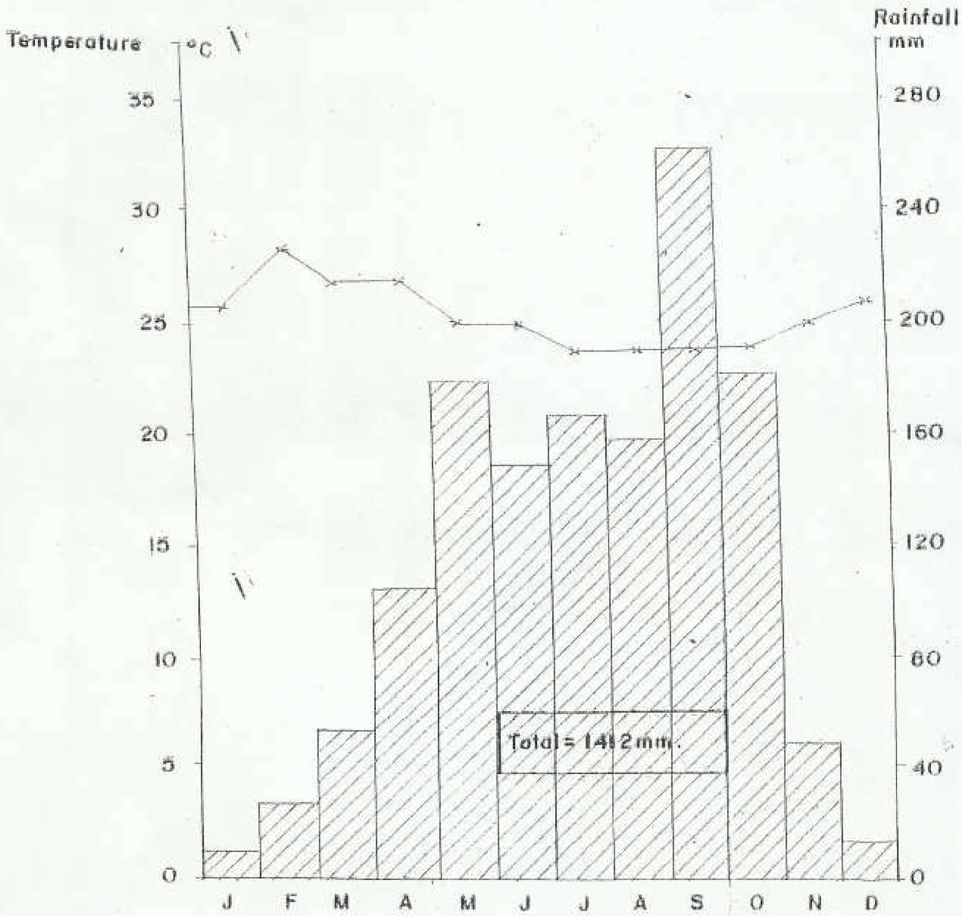

FIG. 12 Temperature-Rainfall Relationship in Ado-Ekiti.

5.0 Methods of Investigation

The data collected covered environment effects of urbanization in the area of flooding, channel erosion, sediments pollution and capacity of storm drains. For convenience and comparison of data collection, the drainage basin is spatially dichotomized into the upper and lower segments. In each segment, data were generated on flood width, channel width, sediments in-filling of storm drains, sediment alluvials at road junctions, and the storm drains capacity among other variables.

Standard equipment such as the tape measure, ranging pole and a piece of flat board were employed for the measurements of the flood width, channel width, and depth of sediments in storm drains. The equipment were also used to determine the dimensional values of storm drains and the depth and extent of sediment fans at road junctions. Simple arithmetic models were also used to generate data on the capacity of the storm drains. The capacity analysis of storm drains was calculated thus:

$$\% \text{ Efficiency} = \frac{\text{Depth of drain-Depth of debris in-fill in storm drains}}{\text{Depth of storm drains}} \times \frac{100}{1}$$

In addition to 150 structured questionnaire systematically administered to the respondents, published records of academic and non academic publications were also consulted.

The descriptive techniques used for analyzing the data include the mean, range, standard deviation and percentages. The Student's 't' test was employed to compare the mean values of the flood width in the two segments of the river. Also, photographic records of some sections of River Ajilosun were taken to illustrate the status of refuse in the channel.

Hypothesis Formulation:

I H_0: There is no significant difference in the width of flooding between the upper and lower segments of River Ajilosun drainage basin in Ado-Ekiti.

H_1: There is a significant difference in the width of flooding between the upper and lower segments of River Ajilosun drainage basin in Ado-Ekiti.

II H_0: There is no significant difference in the width of erosion between the upper and lower segments of River Ajilosun drainage basin in Ado-Ekiti.

H_1: There is a significant difference in the width of erosion between the upper and lower segments of River Ajilosun drainage basin in Ado-Ekiti.

6.0 Results and Discussion

The environmental effects of the urbanization of River Ajilosun drainage basin are discussed below.

6.1 Flooding and Growth of Floodable Zones

Extensions of flooding and spatial growth of floodable zones have increased in River Ajilosun drainage basin since rapid urban growth progresses in the basin. The creation of Ekiti State in October 1996, has increased the spate of urban development in the city. For instance, the built up area of the city increase from 20.0km^2 in 1986 to 36.7km^2 in 2006 and projected to 134.7km^2 in 2030 (Oriye, 2008). This is quite enormous in terms of the impervious surface such spatial growth can generate. Since the drainage basin occupies a central location in the city, the degree of interaction with the space of the basin has increased as well. A wide disparity was observed in the width of flooding between the upper and lower segments of the river basin.

6.1.1 Hypothesis Testing 1

Table 1: 't'-test of the Width of Flooding in the Upper and Lower Segments of River Ajilosun Drainage Basin

Variable		No of Cases	Mean	Sd	Df	t-value	t-table	probabity
Width of Floodbelt	Upper segment	75	77.58	57.00				
	Lower segment	75	66.67	50.00	148	11.39	1.96	-0.168***

***p>0.05
Source: Computer AnaIysis

As seen in Table 1 the calculated 't' value of 11.39 exceed the critical value of 1.96 at 95% confidence level. The difference was statistically significant as 0.5 probability level. Hence, the null hypothesis of no significant difference in flood width between the two segments of the river was rejected. This implies significant increase in the spatial extent of flooding between the two segments of the drainage basin. For instance, while the mean width of floodable belt in the upper segment was 66.87±50.73 metres, it was 77.58±57.004metres in the lower segments; this represents 16.02%difference in the width of flooding between the upper and the lower reaches of the river. The channelization of River Ajilosun which began in 1985 had converted the upper segment of the river to a non-erodible concretized channel thus interflow and subsurface flow within the confines of the river may have been drastically reduced. The accumulated runoff from the concrete channelized segment migrates laterally downstream. This promotes lateral extension of the floodable belt of the river. Extension of flood width connotes inundation of larger areas and encroachment of more arable and economically viable land by floods.

Lateral migration of floodable areas has extended spatial coverage of marshes and riparian bushes. Extended flood widths have promoted the effects of flood flow on ecological balance in the vegetation communities of the area which hitherto the spread of flood are fundamentally terrestrial in character. The spatial extension of floodable belt may portend increased need to protect larger areas against flood. This is especially the case where human population and farming enterprises and other economic venture, have taken firm root particularly in the lower reaches at Olope and Moferere areas. Neglect of such delicate situations may connote increases in budgetary expenditure for capital and urban development with the drainage basin.

6.2 Channel Erosion in River Ajilosun Drainage Basin

Progressive urbanization of Ajilosun drainage basin has contributed to increase in the erosive momentum of the accumulated storm run off from concretes, tarmacs, pavements, zinc roofs and the denuded and compacted soil surfaces. The various peculiar urban surfaces in the drainage basin reduce infiltration capacity of the urban space through surface and sub surface sealing generated by the eluviation processes of rain water. In River Ajilosun channel, increase volume of run off impacts on the width of the channel. This resulted from turbulent flow characterizing the accumulated run off from the non-erodible concretized channel which performed greater channel carving and excavation in the downstream reaches.

Attritive and corrosive processes become pronounced below the non-concretized alluvial channel. A comparison of the channel width of erosion in the upper and lower segments showed wide and statistically significant variations between the two segments (Table 2).

6.2.1 Hypothesis Testing II

Table 2: 't'-test of the Channel Width Erosion in the Upper and Lower Segments of River Ajilosun Drainage Basin

Variable		No of Cases	Mean	Sd	Df	t-value	t-table	probabity
Width of Floodbelt	Upper segment	75	3.39	1.92				
	Lower segment	75	8.37	2.26	148	14.213	1.96	***0.000

***p>0.05
Source: Computer Anaysis

The calculated 't' value of 14.213 was greater than the critical value of 1.96 at 0.05 significant level. Thus, the null hypothesis of no significant difference in the width of channel erosion was resultantly rejected. The implication of this is that ther is a significant difference in the width of erosion between the two segments of River Ajilosun.

Table 3: Descriptive Statistics of Channel Width Erosion in River Ajilosun

Variable	No of Cases	Mean	Std Deviation	Std Error	Interval	Mean
Upper segment	75	3.39	1.92	0.22	2.95	3.84
Lower segment	75	8.37	2.26	0.26	7.85	8.89
Total	150	5.88	3.25	0.26	5.36	6.41

Source: Computer Anaysis

For instance, while the mean width of erosion in the upper segment of River Ajilosun drainage basin was 3.39±1.92metres in the upper reaches of the river it was found to be 8.36±2.263metres in the lower reaches of the river. This implies the differences in channel erosion brought about by channelization which is a response action to urban development.

Progressive channel erosion reflects increased kinetic denudational power of the storm flow which was prevented from infiltrating the ground in the concrete channelized reaches. Increased channel erosion has a concomitant effect on availability of arable and developable land area. Advancing channel erosion increases the spate of land degradation particularly down stream of the drainage basin. Extension of channel width brings about degradation of the environment around the river channel. Engineering structures such as culverts and bridge have been affected negatively by the abrasive components of erosion in the channel at Olope, Moferere and Ajilosun bridges/culvert. The permanent, seasonal and temporary sections of River Ajilosun valley have been eroded seriously and wasted. In figure 3, the area marked 'C' and hatched diagonally coincides with the segment of the Ajilosun drainage basin where increased channel erosion and land degradation were severest.

Besides increased channel erosion, urbanization by way of reduced infiltration of the impervious urban surfaces has increased street erosion across the urban space. The street erosion has initiated several rills which mark the incipient stage of the development of gullies in the area. The charnockite and quartzite rock suites which form the predominant geological formations in the drainage basin also contribute to occurrence of erosion in the basin. These rocks basically weather to sand and silts materials which are easily erodible. The implication of these processes reflects in the low plasticity, non-cohesiveness and Extreme negligible shear strength of such soils. Consequently, their depositions on the channel banks and floodplains have a degrading effect on the riparian bushes in the drainage basin. The deposits of quaternary sediments of clay and mud have also created nauseating scenery on the floodable sections of the river valley especially around Fayose Market at Ijigbo Street.

6.3 Sediment Pollution

Another effect which urbanization processes within River Ajilosun drainage basin has generated is the sediment pollution of the streets in the drainage basin. Large mass of sediments of sand, silt, clay and muds are moved during each storm. Most of these sediments are moved in storm drains, across the space of the drainage basin. The implication of this is that at the cessation of storms, such sediments are deposited in storm drains and road surfaces and at junctions when the kinetic energy of storm overland flow ebbs substantially. The result of such deposit is either the pollution of streets, roads or sediment infilling of drainages with the concomitant reduction in their hydraulic capacity and efficiency (Arohunsoro, 2011). Table 4 shows the capacity analysis of some sampled roads within the drainage basin and their corresponding percentage efficiency of performance.

Table 4: Capacity Analysis of Some Storm Drains in River Ajilosun Drainage Basin.

Location	Road Width (m)	Width of drain (m)	Depth of drain (m)	Area of Drainage (m)	Thickness of debris in-fill	Percentage Effectiveness of drainage
Ajilosun old Garage Road (Rd)	9.20	0.80	0.80	0.64	0.70	12.50
Old Garage Okeyinmi Ojumose road (Rd)	7.36	-.70	0.90	0.63	0.85	5.60
Post Office - Atikankan road (Ld)	9.00	0.70	0.90	0.63	0.52	42.2
Mathew Junction - Irona road (Ld)	13.00	0.60	0.60	0.36	0.45	25.00
Mathew road (Rd)	14.30	0.70	0.50	0.35	0.40	20.00
-∑x/5	10.57	0.70	0.74	0.52	0.58	21.06

Source: Fieldwork
Key: Rd (Right drain); Ld Left drain)

The information in Table 4 shows 21% efficiency of performance of the drains in the drainage basin in the transportation of water and debris during each storm. The low efficiency of the storm drains was due in part to the paucity of their hydraulic area compare to the area of impervious surfaces and created by the current geometric increase in the population and the spatial growth of the city.

Roads/storm drains along sloping terrains are characterized by free flow and transportation of runoff and debris under effect of gravity. Such roads and drains are minimally affected by accumulated debris and sediments unless at the base of slopes where there is break of slope and the inception of a pediment.

Alluvial fans at road junctions form major source of environmental nuisance in the Ajilosun drainage basin. Mass of sediments moved in large widespread surface flows on the basin space end up at road junctions and spread in triangular dimension. Such accumulated sediments, which are also formed at the sides of the tarred roads are capable of causing road traffic accident, when vehicles run over them. The automobile accident which occurred at the front of Omolayo Standard Press in the city in 2008 resulted from accumulated sediments on the edge of the Ado-Ekiti-Ikere road

6.4 General Pollution of the Environment

Pollution from wastes brought by increased runoff caused environmental or visual blight. A common sight after each rain storm event is the littering of the basin surface with household garbages and other wastes of different sorts and grades. The people in Ado-Ekiti, and particularly in the drainage basin, often result to converting river channels and water courses to dumpsite (See Plate 1). Indiscriminate dumping of refuse and use of the channel of River Ajilosun for such bad act constitute major cause of river floods in the drainage basin; see table (Arohunsoro, 2011). The questionnaire administered on the respondent to find the factors of flooding in the Ajilosun drainage basin showed that 45.6% of the respondents who were also residents in the in the drainage basin agree that dumping of refuse in water courses in them Ajilosun drainage basin cause river floods (Table 5).

Table 5: Causes of Flooding in River Ajilosun Drainage Basin

Segment of the river		Causes of flooding					
		Heavy and high frequency rainfall (precipitation)	dumping of refuse on the river channel	Construction of building on the flood plain	Farming on the flood plain	absence of drainage channel	Total
Upstream	Count	23	27	5	2	10	67
	% of Total	15.4%	18.1%	3.4%	1.3%	6.7%	45.0%
Downstream	Count	15	41	5	0	21	82
	% of Total	10.1%	27.5%	3.4%	0.0%	14.1%	55.0%
Total	Count	38	68	10	2	31	149
	% of Total	25.5%	45.6%	6.7%	1.3%	20.8%	100.0%

Source: Fieldwork

Again 27.7% of the respondents also affirmed to have at one time or the other dumped refuse inside River Ajilosun channel (Table 5). Of specific notice are areas at Isato, Atikankan, Agere and Odo Otu segments of the drainage basin where heaps of refuse in stream channels create ugly sights particularly during the dry season (Fig

). The stench emanating from such sites pollutes the ambient air over the drainage basin, and is capable of creating an insalubrious situation in the environment.

6.5 Indiscriminate Refuse Disposal/Refuse Sedimentation of Streets

Refuse generation and its illegal disposal grow in tandem with population increase across the space of River Ajilosun drainage basin. Rampant cases of such illegal refuse disposal are common along the river and stream channels in the drainage basin. The idea of using water course/converting water courses to refuse dumpsite is common with residents of the Ado-Ekiti and particularly within Ajilosun basin. Plates 1 and 2 illustrate instance of urban refuse disposal in River Ajilosun at Agere and Atikankan during the dry weather flow periods. During a previous survey of the respondents in the drainage basin it was reveled that between 9.5% and 18.2% of them used the stream channels particularly River Ajilosun for the discharge of their household and other wastes (Table 6).

Table 6: Methods of Waste Disposal Adopted by the Respondents in River Ajilosun Drainage Basin

Segment of the river	Methods of waste disposal						Total
	Use of Dustbin	Indiscriminate Dumping/open Space	Designated Dumping Site	Communal Sanitary Land	Inside River Ajilosun	Total	
Upstream Count % of Total	24 16.2%	4 2.7%	15 10.1%	6 4.1%	14 69.5%	5 3.4%	68 45.9%
Downstream Count % of Total	24 16.2%	5 3.4%	20 13.5%	9 6.1%	13 8.8%	9 6.1%	80 54.1%
Count % of Total	48 32.4%	9 6.1%	35 23.6%	15 10.1%	27 18.2%	14 9.5%	148 100.0%

Source: Computer Anaysis

This unethical practice has generated inaesthetic environmental situation in the drainage basin and in the entire city of Ado-Ekiti. The situation of illegal refuse disposal becomes more problematic during rains when people throw refuse of different sort neatly packed in black polythene bags into storm drains lining the frontage of their houses. The implication of this socially irresponsible habit is the blockage of the drains, spillage of storm runoff and resultant flooding of the adjacent areas of the drains.

7.0 Summary and Conclusion

The paper has shown the different ways in which the processes of urban growth and development have impacted on River Ajilosun drainage basin. The paper showed that increase in population, rising level of construction activities, generation of waste and illegal methods of refuse disposal have resulted to unsightly environmental blights in the drainage basin. Much of the environmental problems emanating from urbanization in the drainage basin are rooted in the unethical behavior and unresponsive socio-inclination of the people to environmental issues. It is also linked with important disregard for social responsibility and obligations of the residents. Regular environmental education and enlightenment campaigns in view of maintenance of environment-friendly behavior are germane for curbing some of the problems caused by the urbanization of River Ajilosun drainage basin. Similarly, sincere enforcement of the building codes and their proper implementation will help to address most of the environmental problems emerging with the urbanization of the drainage basin.

8.0 Recommendations

Since most of the environmental problems of Ajilosun drainage basin discussed in this paper are related to urban development, it is therefore pertinent to ensure effective organization and reorganization of the spatial structures in the basin. In the first places, houses which have already encroached on water course should be demolished. Such houses are found along the banks of River Ajilosun at Odo Aremu, Atikankan, Odo Ugbehin, Odo Otu, Ologoro, Ajilosun and Moferere streets. However, alternative areas should be provided for the relocation of the affected houses. The Town Planning Authority should enforce/strict observance of the Town Planning Authority Regulations and other building codes.

Storm drains should be constructed to commensurate with the contemporary population growth and the extent of physical development in the drainage basin. Regular clearing and desilting of the already existing lined drains should be undertaken earnestly by the public works department of the local or municipal government, in order to facilitate transportation and evacuation of storm runoff and silts during and after rains. Sediment culverts/intakes and underground storm sewers should be constructed at the intersection of roads such as at the Atikankan-Irona roads junction adjacent to Fayose Market Complex (see plate – take the picture).

Provision of adequate refuse disposal facilities is imperative to keep a check on the illegal disposal of refuse in the storm drains and the streams within the drainage basin. Refuse skips should be placed strategically within the basin at effective distances of 200 metres in order to ensure effective utilization of the facilities. Regular emptying of the refuse facilities/skips should be done by the Ekiti State Waste Management Board to avoid littering and outbreak of epidemics. Appropriate landfill sites should be located at the outskirts of the city for the central discharge of all the wastes. However, while deciding the location of the landfills proper inspections/analysis of the terrains should be done so as to avoid their location in depression and areas of complex geological discontinuities. This is because such location may open underground water to leachate pollution.

Also, the lower reaches of River Ajilosun around Moferere should be allowed to flourish under vegetation and urban agriculture. Riparian vegetation, floricultural and market gardening ventures will improve the water infiltration capacity of the soils in the river valleys and the floodplains. This will help to attenuate extent of flooding in the valley and generally in the drainage basin.

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