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Geomorphological Impacts of Urbanization in Ado-Ekiti city, Ekiti State, Nigeria

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ABSTRACT

The paper assesses the impact of urbanization on the landform parameters of Ado-Ekiti city. Data were collected directly from the field on variables such as the river channel morphometry, number of potholes, number of refuse dump sites, depth of foundation exposure, depth of sediment in storm drains and extent of road width covered with sediment among others. The basic instrument employed for carrying out the measurement are the tape, a tie-rod, and ranging pole. Analysis of the data using the descriptive method of frequency counts and percentage ratings showed that the impact of urbanization includes modification of river and stream channels, sedimentation/fragmentation of riparian vegetation, headward advancement of gully and erosion channel and excavation of the foundations of buildings among others. The paper suggests measures for controlling the various geomorphological impacts of urbanization in the city to include channelization of the streams, effective management of slopes, construction of storm drains of adequate number and hydraulic capacity and provision of proper waste management measures, among others.

Keywords: Assessment, Geomorphological, Impact, Urbanization, Ado-Ekiti and Nigeria.

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INTRODUCTION

Cities are centers of urbanization where a lot of physical growth and development take place. Urbanization, which is a process by which settlements develop to assume secondary and tertiary functional statuses and perform central place functions, is an obvious feature of the cities. Through urbanization, settlements grow in size with concomitant ecological problems.

One visible area in which the process of urbanization impacts on cities is in the modification of the city terrains (Olorunfemi and Jimoh, 2000; Arohunsoro, 2011; Arohunsoro, 2015). Various construction works, deforestation activities and other anthropogenic activities taking place in the cities could lead to alterations in the landform equilibrium of the city terrains and could generate problems in the area of urban management if proactive measures are not taken. This requires a commitment to the course of human development by the policymakers and municipal authorities saddled with the responsibility of city planning and administration.

The paper assesses the specific impacts of the processes of urbanization on the landform relations of the city of Ado-Ekiti. The paper also discusses the various ways by which the impacts of urban growth and development could be managed effectively to entrench a sustainable livable urban environment in the city.

MATERIALS AND METHODS

The Study Area

Ado-Ekiti is located in the southwestern part of Nigeria between latitude $7^0 40^1$ North of the Equator and Longitudes $5^0 11^1$ and $5^0 15^1$ East of the Greenwich

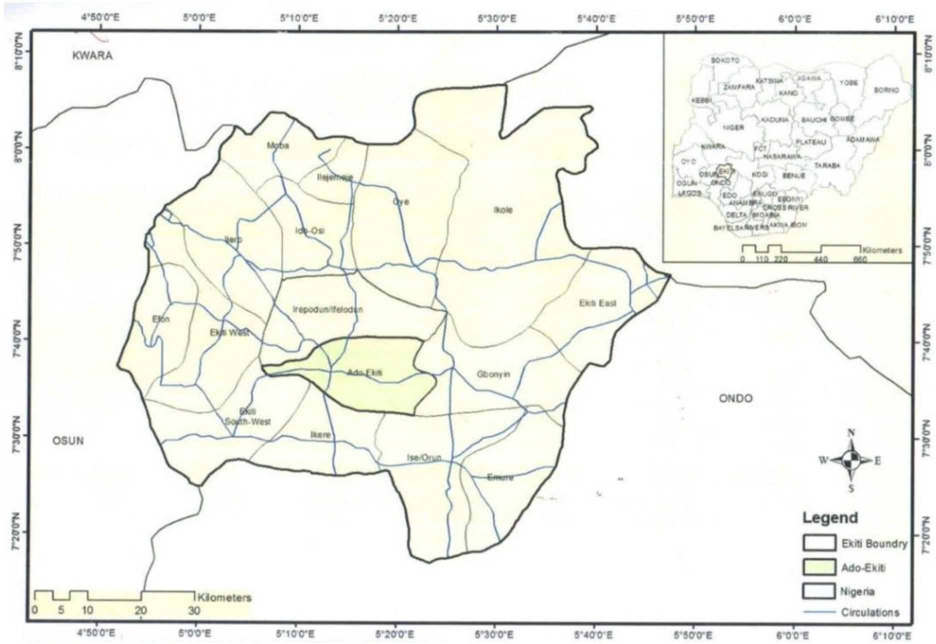

Figure 1. May of Ado-Ekiti.**Source:** Catographic unit, Department of Geography and Planning Science, University of Ado-Ekiti.

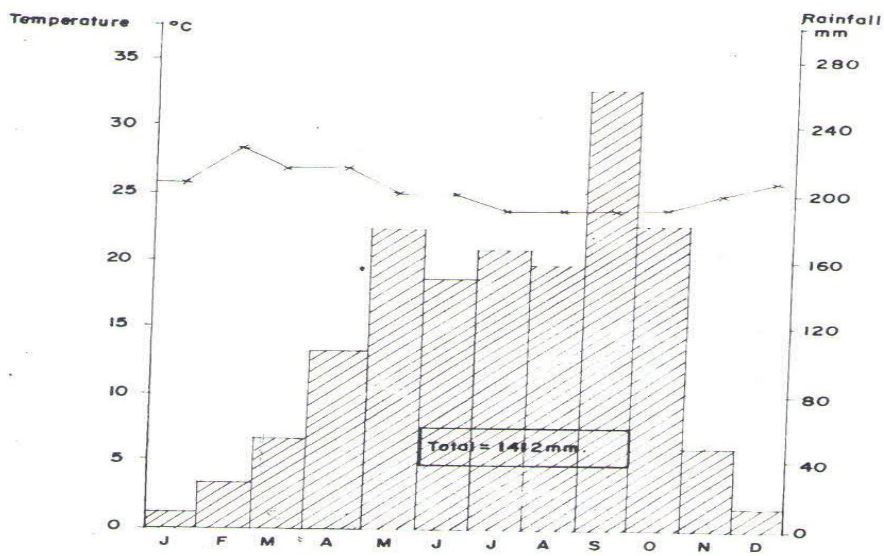

Figure 2: Temperature-Rainfall relationship in Ado Ekiti Source: Nigeria Meteorological station.

Meridian (Figure 1). Ado-Ekiti, the capital city of Ekiti State is one of the thirty-six (36) states that comprise the Federal Republic of Nigeria.

Being a tropical location, Ado-Ekiti experiences two climatic seasons, namely the rainy and the dry seasons. Rainy season covers April to November while the dry season extends from November to March (Figure 2). The city experiences an average annual rainfall total of between 1200mm and 1400mm with more than 70% of the rainfall events characterized by medium to high mean intensities.

Geologically, a greater segment of the city surface is underlain by the Precambrian basement complex rocks of South Western Nigeria. The dominant rock types are the charnockite and the migmatite-gneisis complex (Figure 3). Also, quaternary deposits of alluvial sandy-clay and mud are found along the water courses and the old river and stream beds.

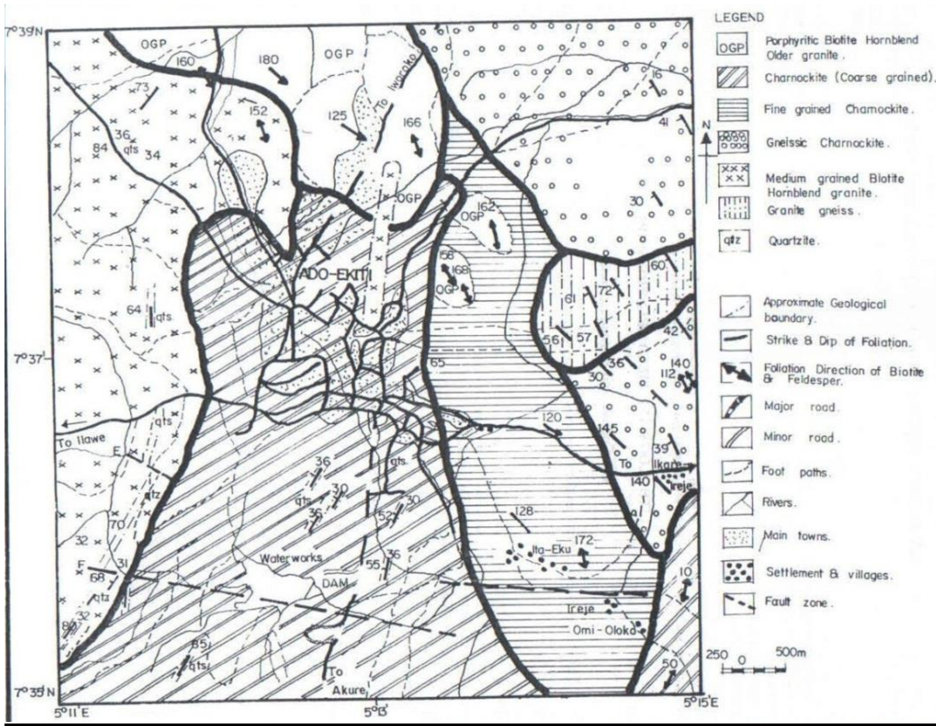

Figure 3: Geological Map of Ado-Ekiti Areas compiled by Fadipe and Adeduro (1993).

Table 1: Spatio-Temporal Growth of Ado-Ekiti City 1956-2030.

Year	Population	Total Built-up Area	Cumulative increase
1952	24646	*NA	-
1956	99,923	2.5km^2	2.5 km^2
1963	157,519	*NA	2.5 km^2
1966	120,855	6.9km^2	9.4 km^2
1986	*NA	20.0Km^2	29.4 km^2
1991	149,472	*NA	29.4 km^2
2006	409,065	36.7km^2	65.1 km^2
2030*	1,111,953*	134.7km^2*	-

Sources: Adebayo, 1987; Oriye, 2008. *Projected Figure; NA: Not Available.

The charnockitic geological formations in the city determined to a great extent the nature of relief in the city. Generally, the terrain of the city consists of undulating plains broken by gradients of slopes ranging mostly between 3^0 and 4^0. The gentle relief was enclosed by a chain of bornhardt and foothill inselbergs and isolated cases of inselbergs which dot the landscape of the city. There are also regolith mantled hills the most notable of which is the Ayoba and Oke Oniyo hills. The more spectacular Ayoba hill stood at 540 metres above the sea level and had an average slope gradient of 31^0.

Since the creation of Ekiti State, and the naming of Ado-Ekiti as the capital city, there has been an upscale in the processes of urbanization in the city. The spatial extent of the built-up area in the city increases from 20km^2 in 1986 to 36km^2 in 2006 and (Adebayo,1987) is estimated to increase to 134.7km^2 in 2030 (Oriye, 2008). Table 1 shows the temporal and spatial growth of Ado-Ekiti over the years depicting an increasing trend in the physical growth and development of the city.

Both the increase in population and the pattern of physical growth of the city are capable of generating modification of the city.

Data Collection

The variables on which data were collected include the non-channel morphometry, number of potholes, refuse sedimentation (number of dumpsites), depth of foundation exposure, depth of sediment in storm drains, extent of road width covered with sediments. Tape measure, tie-rod and ranging poles are the basic instruments employed for the acquisition of the various data needed for the study.

Table 2: Descriptive Statistics of Channel Depth in River Ajilosun Drainage Basin.

Variable	N	Mean	Std. Deviation	Std Error
Channel Depth Upper channel	75	1.35	0.22	0.26
Lower channel	75	8.32	1.06	1.26
Total	150	5.882	3.2558	.2658

Source: Computer Analysis of data collected by the Author .

Data Analysis

Analysis of the data was done using simple frequency counts and percentages. This is in addition to the calculation of the descriptive statistics of the mean, range and standard deviation of the various data. All the statistical decisions and inferences were drawn at the 95% probability level.

RESULTS AND DISCUSSION

Urbanization processes in Ado-Ekiti in Ekiti State, Nigeria have generated a number of geomorphological impacts in the city. The specific areas in which city growth and development have had effects on the landform units and systems (terrains) are the river/stream channels, the transportation of storm runoff, increase in runoff generation and slope surface wash, and exposure of foundation of buildings. These are discussed in turn below:

(i) Geomorphological impact of urbanization on the river and stream channels;

Urban development through the various on-going construction works in the city of Ado-Ekiti has altered the river/stream channel forms. Urbanization causes modifications to the already existing equilibrium in the geometric relations in the channel- valley floodplain relationship. For instance, channelization which is a response action to the urbanization and development of the river valley and floodplains has generated a lot of changes in the hydrological systems of the rivers/streams on which channelization has been embarked upon. The Ajilosun river, the Agere, the Atan and some other streams in the city have been concrete channelized to reduce overflow in their channel during storms. However, channelization has had an unintended consequence on the streams morphometric features. This is due to the fact these streams automatically assumed new geometric and hydraulic relationships in the channel floodplain, ecological relationship.

Although channelization creates more hydraulic capacity for storm flow accommodation in the channels, increased channel flooding and erosion are the experiences in the lower reaches of such channels. This is the reason why particularly in River Ajilosun, more channel flood flow causes greater vertical channel dissection at Moferere,Olope and in the Southern end of Ajilosun street. To buttress this discussion, it was conspicuously observed that there were variations in the dimensions of the channel depth and width between the concrete channelized and the alluvial reaches of the river in the lower segment. While the main channel depth in the upper segment was 1.35m. The lower segment had a mean channel depth of 8.32 m (Table 2).

Actually the deforested and paved surfaces facilitate increased runoff to the adjacent stream channels. Particularly in the concretized reaches, such increased runoff could not infiltrate the ground with maximum capacity which results to more overland flow reaching the channel, the river valley and the floodplain areas. The increase in storm channel flow causes more impact on the geomorphological relations of the channel. Consequently, more land area of the channel banks are rendered more susceptible to degradation and are wasted away due to the voracious effect of the storm flow. The implication of this causes geomorphic processes such as channel collapse, in-caving and extensive sediment deposition. The rate of lateral channel degradation was comparatively higher in the lower alluvial channel compared to the concretized upstream channel which had maintained a constant width dimension of 3.39m as a result of its non erodible concrete geometry. But the lower reaches had a mean channel width of 8.37m (Table 3).

Thus, within a span of 38 years (from 1985-2013), the average river channel width degradation, particularly in the lower reaches (8.367m), had roughly progressed at a rate of 0.22m per year. The implication of this is that urbanization causes more impact on channel erosion and land area wasting in a river channel particularly in the lower reaches of the channel.

One vital planning implication of the geomorphological process of urbanization on river channel is that it diminishes the available land area that could have been put to various urban for construction works. It also

Table 3: Descriptive Statistics of the Channel Width Erosion in River Ajilosun Drainage Basin.

Variable		N	Mean	Std. Deviation	Std Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Channel width channel	Upper								
	Lower	75	3.397	1.9241	.2222	2.954	3.839	2.1	11.3
channel		75	8.367	2.2634	.2614	7.846	8.887	5.1	15.6
	Total	150	5.882	3.2558	.2658	5.356	6.407	2.1	15.6

Source: Computer Analysis of data collected by the Author.

Plate 1: Erosive impact of River Ajilosun at Moferere lower reaches of the river.The building in the picture was excessively elevated due to the pronounced vertical dissection of the river Ajilosun channel. The building, although a bungalow, now appears as a storey building.

reduces the substrate quality of the surrounding land areas of the floodplains.

(ii) Sedimentation and Fragmentation of Riparian Vegetation Cover;

Increase in the processes of urbanization in Ado-Ekiti is usually preceded by extensive deforestation, which exposes the city terrains to the direct heat of the sun, causes surface encrustation and sealing and the resultant reductive effect of these processes on the infiltration capacity of the soils. The exposure of the ground surface provides large extent of areas from which sediments are derived. The clearing of the patches of forest cover consequently yields more sediments which are moved during rainfall. The characteristic rainfall totals positively influence the rate of detachment and volume of the sediments moved and annual rainfall total of between 1200 to 1400mm and the characteristic high rainfall intensities increase the erosivity of the local rainfall. The effect of such rainfall parameters is operative on the terrains of the city for as long as for an average period of 119days every year. The increased river flow in the channels has resulted in soil degradation and an increase in depth of dissection of channels. Plate 1 shows the effect of high channel flows on sediment generation and splitting of the riparian vegetation along a section of River Ajilosun. The implication of this is that large volume of sediments is moved in river channels and also across the space of the city. Large sediments movement is further facilitated by the characteristic geological formations which yield plastic, non-plastic and incoherent weathered mantles in a large area of the city. For instance, the charnockite rocks which underlines about 86% of the city

Table 4: Gully Dimension in some Streets in Ado-Ekiti.

Street	Gully Dimension(meters)	Area (Km2)
Ilupeju Avenue	1.5 width by 2.3 depth	3.45
Onala	1.8 width by 0.8 depth	1.44
Maryland	0.9 width by 0.75	0.68
Maria Avenue	0.9 width by 1.9 depth	1.71
Oke Ureje	1.2 width by 0.83 depth	0.996

Source: Fieldwork by the Author.

Table 5: Descriptive Statistics of the Depth of Exposure of Foundation of Buildings in River Ajilosun rainage Basin.

Variable		N	Mean	Std. Deviation	Std Error	95% Confidence Interval for Mean		Minimum	Maximum
Depth of foundation exposure (metres	Upper channelized segment)	75	1.00	.526	.061	.88	1.12	0	3
	Lower non-channelized segment	75	1.24	.763	.088	1.06	1.41	0	3
	Total	150	1.12	.664	.054	1.01	1.22	0	3

Source: Computer Analysis of data collected by the Author.

weathers to silty-sand overburden. The weathered materials have a low capacity for flood storage meaning that they are highly vulnerable to erosion. The effect of the high erodibility of the soils also reflects in the much depth of dissection of the river and streams in the city. Some of the rivers, for example Elemi and Ajilosun, have a depth of dissection ranging between 3m and 8m. The geomorphological implication of this is that the earth's surface of the city becomes carved into deep channels which encourage a higher rate of degradation of the channel areas. Increase in the rate and volume of sediment production, no doubt, is capable of increasing the cost of water treatment. The dendritic drainage pattern of the river and stream systems encourages the mixing of the surface streams. The implication of this is that water dammed for the municipal supply of water to the city may be highly charged with sediments and may increase the cost of effecting a corrective measure to meet the required quality for water consumption.

(iii) Expansion of Gully and Erosion Channels

Runoff generated by the reduced infiltration capacity of the impervious surfaces created by urbanization in Ado-Ekiti city often yields more overland flow with erosive impacts on the terrains. Rapid movement of surface flow during the heavy and intensive rains leaves their imprints on the surface of the city. The impact of the geomorphic process in mostly felt in the areas which are being newly developed in the city. Such new areas generally lack proper drainage channels which are needed co-ordinate the haphazard surface flows generated by increased runoff from the devegetated and impervious surfaces. Olorunda, Moferere and NOVA school junction areas, off Adebayo-Iworoko road, are some of the places where absence of storm drains have aggravated the development of erosion channels and gully, for several times during the rainy season, the untarred roads in these areas often become impassable. Car owners do usually resort to the 'park and ride' option in order to commute to work and also take their children or wards to school.

Aggradation of sediments is usually the sight at some of these areas. This is particularly the situation of the places in the lower end of pediment slopes. Thick depth of sediments of about 1metre is commonly observed in places where there is an abundance of incoherent and loose weathered mantles. Table 4 shows the spatial pattern of gully dimensions in some sections of the city. The average depth of gully varies between 0.8m and 2.3m between channel(Arohunsoro, 2011; Adebayo and Arohunsoro, 2014; Arohunsoro, 2015).

(iv) Effect on foundation of Buildings;

Another area in which increasing urbanization of the city of Ado-Ekiti has impacted on the land surface morphology is in the excavation and exposure of foundation of buildings. The hardening of the exposed ground surface layer generates an effect which causes a reduction in the infiltration capacity of the topsoil horizon. The implication of this reflects the fast building-up of storm flow during rainfall, which impacts erosively on the foundation of buildings. Random survey and measurements of a number of buildings in the traditional core areas of the city showed that the depth of exposure of foundation of buildings varied between 0.88m and 1.12m with a mean value of 1.00 ± 0.526m at Okesa, Odo, Aremu, Isato and Atikankan (Table 5). More rapid runoff from the terrains in these areas is accentuated by the extensive outcrop of lateralized surface which precludes and reduces the infiltration capacity of the ground drastically. The implication of this process is the increase in the storm flow with its denudational impact on the terrains. Similarly, the ferruginised basement outcrops in the area have also contributed to accumulated overland flow with its concomitant erosive process that excavates the foundation stones of building and consequently render such buildings precarious to live. Conversely, the lower reaches experience of foundation exposure is rampant along slopy terrains and other areas where urbanization had exposed the surface as a result of deforestation. The concrete channelized upper reaches of Ajilosun area of Ado-Ekiti promotes spillage of channel run off to adjacent areas of River Ajilosun channel. The implication of this is that water spilling on the adjacent areas of the channel impacts negatively on the foundation of buildings. The mean depth of exposure of foundation in the area was 1.12±0.664m; the values ranged between 1.01m and 1.22m (Table 5).

The erosive effect of increased overland flow caused by urbanization or (the city's physical growth) was further exacerbated by the pattern of location of buildings across the city space. For instance, most of the buildings did not follow any regular pattern in their location. Most of the buildings were located without conforming with the 'Town Planning Regulations.' The improper supervision of building construction in the city is an aspect of urban development which impacts or has a direct effect on the co-ordinated and comprehensive accommodation and transportation of overland flow during storms.

(v) Increased sedimentation of River Channels and Storm Drains;

With the advent of urbanization, large-scale deforestation often follows the desirability for city expansion. One effect of forest removal on urban terrains is the increased surface wash. The initial stage of soil removal through sheeting soon develops into several rills and eventually into gullies.

Increased formation and deposition of sediments are occurring in the channels of some first order segment in the city. Also, some storm drains with grossly inefficient hydraulic capacity are also susceptible to sedimentation.

When sediments are removed from the ground surface and transported into a stream or river channel the beds of such streams or rivers becomes aggraded. The implication of this is that the channel area can hold less volume of water. Consequently, during the high weather flow, water spills, the channel banks on to the adjacent areas. Similarly, the silted up storm drains may become totally or partially blocked. Both situations could also cause water spilling on the roads with attendant damage to the capital-intensive infrastructure.

Conclusion

The study shows that urbanization has generated a series of geomorphological impacts in the city of Ado-Ekiti. The impacts include increased channel runoff and channel degradation, sedimentation and fragmentation of riparian vegetation cover, creation and growth of gully and erosion channels, excavation of foundation of buildings and sedimentation of river channels and storm drains. Appropriate measures are therefore required for entrenching an urban environment free of landform related hazards.

Recommendations

Geomorphological impacts of urbanization in Ado-Ekiti require implementation of specific measures for ensuring equilibrium of the various landform parameters in the city. Such measures include the ones outlined below:

(i)The major river and other streams should be concrete channelized to curtail their rate of erosion and sediment generation.

(ii)The scarp faces of the hills and foot slopes of the inselbergs should be allowed to flourish under shrubs vegetation cover of shrubs and creeping grasses.

(iii)Storm drains of adequate number and hydraulic capacity should be constructed alongside existing roads and new ones to be constructed.

(iv)Sufficient drainage channels should be constructed around buildings to provide free passage for storm runoff.

(v)As a corollary to (iv) above, rainwater harvesting devices should be incorporated into every building to harvest rainwater and channel it into soakaways to reduce surface runoff.

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