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Spatial Analysis of Geomorphological Impacts of Channel Erosion in River Ajilosun Drainage Basin in Ado-Ekiti, Ekiti State, Nigeria

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Abstract
The geomorphological impacts of channel erosion in River Ajilosun drainage basin were examined. Data were generated through direct field measurement of some geomorphological variables of the cross sectional channel width and channel depth dimensions. The basic equipment employed for data generation is the tape, a piece of tie rod and ranging poles. The data generated were subjected to descriptive statistics such as the mean, standard deviation, range and simple percentages while the Student's't' and Snedecor's F tests were also used as the basic inferential statistics for testing the hypothesis generated. The result of the analysis showed that the geomorphological impacts of erosion in the Ajilosun drainage basin varied spatially both across and along the profiles of the river. However, such impacts were more pronounced in the lower non concrete channelised reaches of the drainage basin. The study discovered further impact of channel erosion to include channel bank collapse and in-caving, destruction of habitat structure, degradation of substrate quality and overall channel degradation among others. The paper suggests land use zoning, urban agriculture and channelization tracing the natural sinuosity of the river as some of the measures for controlling the undesirable effect of channel erosion in River Ajilosun drainage basin.

INTRODUCTION

Channel erosion is the removal of soil from stream banks and soil movement in the channel (Payne, 1997). Channel erosion is a process by which the widths of river channel are extended through lateral degradation (Arohunsoro, 2011). According to Cooke and Doorn Kamp (1974) and Strahler and Strahler (1977), channel erosion is one of the three interrelated geologic activities taking place within a river. Other two geologic processes are channel bed and channel bank erosion

River impacts on land surface forms by carving their channels and wearing away the earth surface through the process of fluvial erosion. A drainage basin is the area of land from which a river system derives water and rock wastes. A river system constitutes the area of land which channel water and debris into and out of the main river and its valley; as well as its tributary rivers and their valley (Chup, 2005). The various fluvial erosion processes operating in the drainage basin can impact on the surface land forms of a drainage basin. These impacts many be expressed through aggradations and degradation of the basin's terrains (Chup, 2005; Arohunsoro, 2011)

River Ajilosun is the trunk flow of the Ajilosun drainage basin in Ado-Ekiti in Ekiti State. Following the concrete channelization of the upstream reaches of the river in 1985 and the subsequent widening, deepening and retraining of its main course downstream, it has generated a number of impacts on the geomorphological relations of the basin. Such impacts seemed to have become more pronounced in the face of the increasing tempo of urbanization in the capital city. Cities build and inhabit watersheds which imply serious modification of the hydrogeomorphological equilibria of the city and their concomitant repercussions on the environment (Edward 1998). In order to entrench a sustain ably liveably city by protecting it from the wasting consequences of erosion there is need to understand the dynamics of the geomorphic processes operating in drainage basin particularly in a river traversing a primate city like Ado-Ekiti.

In the light of the above, the study is aimed at the assessment of the impact of channel erosion on the terrains of River Ajilosun drainage basin. However, the paper has the following specific objectives to achieve in relation to the drainage basin

(i) examine the spatial pattern of channel erosion in River Ajilosun drainage basin between the concrete channelised and non concrete channelised segments.
(ii) discuss the impacts of channel erosion on the drainage basin.

(iii) suggest measures for controlling channel erosion in the drainage basin.

In order to examine the spatial pattern of channel erosion in River Ajilosun drainage basin an hypothesis was formulated to test for any significant differences in the channel erosion in River Ajilosun.

STUDY AREA

River Ajilosun drainage basin is located in Ado-Ekiti, Nigeria 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 Greemich Meridian (fig 1). River Ajilosun drainage basin is a 4^{th} order basin with a planimetric area of 18.125km2. River Ajilosun, the trunk flow has a main channel length of 6.20km. The basin has a drainage density of 1.90/km2 and a stream frequency of 1.26 streams/km.

The drainage basin enjoys the tropical climate characterized by the rainy and dry seasons. The total annual rainfall varies between 1200mm and 1400mm with over 80% of the fall concentrating between June and September. On the average, there are 119 rainy days with between 75 and 80% of the rainfall consisting of the moderate to high intensity type. Temperature has a mean monthly value of between 27^0c and 28^0 and a small annnal range of 3^0c.

River Ajilosun drainage basin underlained by the Precambrian igneous and metamorphic rocks, the predominant of which is the coarse-grained and the medium-grained charnockite rocks forming about 86% of the total area (fig 2). The charnockite rock produces weathered mantle characterized by clastic materials of sand and silt with high erodibilty (Jumoh, 1997; Arohunsoro, 2011). The depth of the weathered mantle can be as much as 14metres although this depends on the lithology of the parent materials (Fig 3 or 1.8 thesis)

The rapid urbanization of the city of Ado-Ekiti in the wake of Ekiti State creation on October 1^{st}, 1996 has generated an upsurge in the spatial extent of impervious surfaces. This may have implication for instantaneous runoff and resultant impact of erosion in the river channels. With the annual growth rate of 2.5% per annum, the city has a doubling period of 31years; again this may have serious implication for urbanization and growth of imperviousness in the drainage basin.

The area extent of built up environment in Ado-Ekiti increased from 20.0km^2 in 1987 to 36km^2 in 2006 and projected to 134.7km^2 in 2030 (Oriye, 2008). At present over 64% of the entire drainage basin has been completely urbanized (Arohunsoro, 2011). The fast increasing population and the upsurge in physical growth of the environment may have an eventual repercussion on the river's channel, valley and floodplains.

METHOD OF INVESTIGATION

Data were collected on cross sectional channel width and cross-sectional channel depth of River Ajilosun. These two geomorphological variables typify fluvial erosion processes within the river channel. This is because a river can expand its channel through vertical dissection or lateral degradation (wasting) and expansion of its banks.

The cross sectional width dimensions of River Ajilosun were measured with the tape. Measurements were taken at every 10metres along the longitudinal profile of the river and the mean values calculated. Also, the channel depth was measured with a piece of tie rod and a ranging pole. The tie rod was calibrated in centimeters in order to facilitate reading. Measurements were taken at successive points along each transect and the average of such measurements was obtained all the measurement were generated in metres (see Figure 4).

Fig. measurement of cross sectional channel Depth

$$\text{Average channel depth} = \frac{d_1 + d_2 \ldots\ldots d_7}{7} \quad \text{-----------} \ (1)$$

Where d_1, d_2------d_7 are channel depths at successive points.

(i) The cross-sectional channel width in the upper reaches of River Ajilosun was measured with the tape and the tie- rod. The tape was laid across the banks with the help of two research assistants and measurement taken. However, in the lower reaches the channel width was measured with the aid of ranging poles and surveying equipment following the recommendations of Goudie et al, 1981). Goudie et al (1981) recommends that cross -sectional channel width exceeding 3metres need be generated with more sophisticated surveying equipment such as theodolite

(ii) The data were analyzed by computing the average values, standard deviation and simple percentages. The hypothesis was tested with Student't' statistics. All the statistical inferences and conclusions were carried out at 95% probability.

RESULTS AND DISCUSSION

Descriptive Statistics of the Geomorphological Variables

The variables used for the study comprises cross-sectional channel width and cross-sectional channel depth. A total of 150 observations were recorded for each variable. The result of their condescriptive statistics are shown in Table 1.

Table1: Condescriptive Statistics of Channel Width and Channel Depth of River Ajilosun.

S/N	Variable		N	Mean	Std. Deviation	Std. Error
1	Channel width	Upper segment	150	3.39	1.92	0.22
		Lower segment		8.37	2.26	
2	Channel depth	Upper segment	150	1.35	0.22	0.26
		Lower segment		8.32	1.06	

Source: Computer Analysis of Data.

The result of the data analysis in Table1 shows that there is a spatial variation in the dimensional values of the geomorphological variables of River Ajilosun between the upper and the lower segments of the river.

The analysis in Table 1 shows that the cross-sectional width for the entire River Ajilosun drainage basin had a mean of 5.88metres. However the average channel width in the upper segment of the river was 3.39 ± 1.92metres while the average channel width in the lower segment was 8.37 ± 2.26metres. Cross-sectional depth had a mean of 1.51metres in the entire drainage basin. While the mean dimension of cross-sectional depth was 1.35 ± 0.22metres in the upper concrete-channelised segment, the corresponding mean value in the lower non-concrete channel was 8.32 ± 1.06metres. The result of analysis in Table 1 depict clearly that both channel depth and channel width exhibit spatial variation in their dimensional values between the upper and the lower segments of River Ajilosun drainage basin.

SPATIAL PATTERN OF CHANNEL EROSION IN RIVER AJILOSUN DRAINAGE BASIN.

The causes of channel erosion in River Ajilosun were both physical and anthropogenic in nature. Qualitatively, the survey conducted in the drainage basin revealed the descriptive causes of channel erosion as heavy and frequent rainfall (45.6%), heavy and frequent rainfall (25.5%), absence of drainage channel (20.8%) and construction of buildings in the floodplain of the drainage basin. See Table 2 and Figure 5 Table and pie chart

Table 2: Causes of Channel Erosion in River Ajilosun Drainage Basin

	causes of flood					
Segment of the river	**heavy and high frequency rainfall (precipitation)**	**Dumping of refuse in the river channel**	**Construction of buildings in the flood plains**	**Farming in the flood plains**	**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, 2007.

Channel erosion was highest in the lower segment of the basin where the impact of illegal dumping of refuses was more prevalent (27.5%). The effect of refuse becomes obvious in its inducement of lateral migration of channel flow which resultantly promotes lateral migration of the area vulnerable to erosion. Heavy and frequent high rainfall was also a factor of channel erosion in the basin. The annual rainfall total of 1200-1400mm, the 119 average rainy days per annum and the characteristic high average intensity of the rainfall over the drainage basin contribute to erosion in the rover channels. Absence of and/or inadequate storm drains across the space of the drainage basin all contribute to spatial pattern of channel erosion channel in River Ajilosun. For instance, during stormy rainfall surface runoffs are not usually properly co-coordinated and channeled into the drainages. Even where there are drainages they are narrow and most of them perform sub-optimally having efficiency of low performance as 21.1% (Table 3).

Table 3: 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^2)	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	0.70	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
= $\sum x/5$	10.57	0.70	0.74	0.52	0.58	21.06

Source: Fieldwork by the Author.
Key: Rd (Right drain); Ld (Left drain)

The effect of this is that turbulent flow reaches the river channels and resultantly generates intensive erosion of the channels. Construction of buildings in the floodplains also causes erosion of channels in the drainage basin. This occurs through the obstructing impacts of building in storm flow absorption in the floodplains. Thus the natural role of this ecologically sensitive zone is hampered. Floodwater that should have infiltrated the floodplains now find their way to the channel creating excessive flow and resultant erosion of channel. The significant quantitative causes of channel erosion in the drainage basin are channel obstructions (-82.1%), valley slope (-14.9%), mean distance of building to river banks (16.40%), mean age of buildings (9.1%), floodplain width (3.8%) and channel hydraulic radius (Table 4)

Table 4: Regression Coefficients of the Relationship between Geomorphological Parameters and Channel Width Erosion in River Ajilosun Drainage Basin

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta	B	Std. Error
1 (Constant)	21.744	1.513		14.368	***.000
Mcs	-.001	.015	-.002	-.034	.973
Avs	-.150	.056	-.140	-2.673	***.008
Mab	.013	.009	.091	1.514	.132
Fpw	.002	.003	.038	.735	.464
Adb	.019	.006	.164	3.109	***.002
Hr Ce	.098	.184	.031	.535	.594
Noc	-1.358	.121	-.821	-11.179	***.000

a. **Dependent Variable: Y_1 (M_{cw}) (EROSION)**
Note: * significant at 0.05 alpha level**
Source: Computer Analysis

Channel erosion in River Ajilosun drainage basin varies spatially across and along the profiles of the river. Factors causing these variations are the variable morphometric properties of the river. The disparities in the channel morphometry between the concrete and non concrete (alluvial) channels generate variation in the occurrence and intensity of channel erosion valley side slope also contributes to spatial variation in channel erosion in the basin. The ANOVA F value of 209.93 for channel width was significant at 0.05 level indicating a significant result. (Table 5).

Table 5: **Analysis of Variance of the Effect of Valley Side Slope on Channel Width Erosion in River Ajilosun Drainage Basin.**

Variable		Sum of Squares	df	Mean square	F	Sig.
Channel width	Between Groups	926.333	1	926.333	209.925	***.000
	Within Groups	653.078	148	4.413		
	Total	1579.412	149			

Note: ***significant at .05 alpha level
Source: Computer Analysis

The implication of this is that valley slope contributes to channel erosion in the drainage basin and cause spatial variation in channel erosion. Anthropogenic activities through urban development also generate spatial variation in channel erosion across the basin space. ANOVA F value of 7077000 was significant at 0.05 level implying the effect of human activities on the variances of channel erosion in the basin (Table 6).

Table 6: Analysis of Variance of the Contribution of Anthropogenic Factors to Channel Width Erosion in River Ajilosun Drainage Basin

Variable		Sum of Squares	df	Mean square	F	Sig.
Channel width	Between Groups	994.130	1	994.130	222.689	***.000
	Within Groups	660.704	148	4.464		
	Total	1654.834	149			
Percentage of urban development	Between Groups	30033.375	1	30033.375	7077.000	***.000
	Within Groups	.000	148	.000		
	Total	30033.375	149			

Note: ***significant at .05 alpha level
Source: Computer Analysis

The factors of erosion discussed above have generated wide disparities in the incidence of channel erosion between the upper and the lower segments of the drainage basin. The hypothesis testing showed that the calculated 't' of 14.213 exceeds the critical value of 1.96 at 95% probability. (Table 7).

Table 7: 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	Pr
Width of channel erosion	Upper segment	75	3.39	1.92			
	Lower segment	75	8.37	2.26	148	14.213	***0.000

Source: Computer Analysis

This led to the rejection of the null hypothesis implying that there is a significant difference in channel erosion between the concrete channelized and the non-concrete (alluvial) channel zeal segments of the Ajilosun drainage basin. For urban the mean channel width erosion was 3.39±1.92 in the upper segments compare to 8.37±2.26 metres in the lower reaches. The wide contrast was due in part to the concrete channelization of the upper segment which yields increased volume of floodwater in the lower segment. The fact that the lower reaches was alluviated and erodible, and also that the geology and soils yields non-plastic and incoherent weathered mantles, the channel becomes more vulnerable to degradation.

Geomorphological Impact of Channel Erosion

Channel erosion in River Ajilosun drainage basin has generated a number of impact on the terrains of the drainage basin. The study has shown that channel erosion causes wanton degradation of land areas around the channel banks thus causing channel collapse, in-caving and slumping of soil mass of the precipitous slopes of the deeply incised channels. This process was brought about by the fluvial erosion created by increased storm flow particularly in the lower non concretized (alluvial) reaches of the basin.

The geomorphological impact is more conspicuous at Moferere, and the lower end of Ajilosun Street. Fluvial wasting of the adjacent land areas of the river channels were more pronounced in this area. Also, the rock-floored nature/characteristic of some reaches of River Ajilosun channel at lower Ajilosun Street beyond the Apostolic Faith premises promotes lateral migration of channel storm flow, thus extending the erosion processes of the channel on the surrounding area.

Lateral shifting of channel banks and boundaries reduces the spatial extent of riparian vegetation, reduces floodplain width and extension of the alluvial segment deposition. The poor substrate quality of the alluvial deposits is a loss to proportion of land area for cultural developments. This is because houses erected on such deposits may eventually become vulnerable to subsidence. In the face of increasing population of Ado-Ekiti and the concomitant upsurge in the demand for land for urban construction, such 'problematic' or shifting soils may be a loss and unavailable to the people, the cost of developing such a terrain maybe prohibitive.

Again, channel erosion impacts on the drainage basin land form through sedimentation of the basis of residential houses. This process causes aggradations of quaternary deposits of mud and clay around houses. This brings serious threats to safety and sustainability of residential facilities for the expanding population of the city, and particularly for those located in the drainage basin. The geomorphological process further reduces the environmental quality of the residential areas.

Water spilling the channel causes deposition of sediment of clay and mud which create nauseate sites around houses in the drainage. This deposition produces difficult situation and slippery terrains which impedes easy mobility. Houses at Ajilosun Street were found in the category of space affected by mud and clay deposition. These quaternary deposits often create impasse to residential buildings and the alleys in between such buildings.

Another geomorphological impact of channel erosion in the drainage basin is the hazard posed to residential buildings erected in the minor and major valleys of River Ajilosun. The hazard is particularly a feature of the lower reaches of the river at Moferere Street. The fast rate of channel banks erosion is gradually causing the channel degradation to encroach on the areas of human habitation. The house in Plate 1 is located in the major valley of the river at Moferere. The building, although a bungalow, now appears as a storey building due to pronounced vertical and lateral erosion activities in the channel. The picture was taken in 2007 if the rate at which the erosion of the channel is progressing is maintained for the next three or four years it may cause a serious disaster to the house.

So far, we have seen how channel erosion impacts on the terrains of the River Ajilosun drainage basin. The various geomorphological impacts are channel degradation, channel instability and collapse, sedimentation of houses, extension of marshes growth and degradation and destruction of valuable land.

Summary and Conclusion

The paper examined channel erosion in River Ajilosun drainage basin. Channel erosion is a fluvial process which entails removal of soil from stream banks and beds. Channel erosion in the Ajilosun drainage basin is caused by both natural and human oriented activities. The basic factors of channel erosion in the basin are refuse in channel, intensive rainfall, and human occupation of floodplains. Channel erosion exhibit spatial variation across the basin space. Factors causing the spatial variation of channel erosion in the basin are variable morphometric properties of the river, valley side slope and anthropogenic activities.

Geomorphological impacts of channel erosion in the drainage basin are degradation of channel bank areas, channel collapse and channel in-caving. Other impacts of the channel erosion in the basin include lateral shifting of the channel banks, sedimentation of residential buildings and other hazard posed to the safety and sustainability of residential buildings.

Erosion remains a global basic environmental issue in the contemporary world particularly in an urbanized drainage basin like Ajilosun. It is germane to adopt measures to combat the menace of channel erosion in urban watersheds. It is expected that adoption of the necessary measures of environmental management will help to curb the geomorphological impacts of channel erosion in our environment.

Recommendations

The following measures could be adopted to combat the geomorphological impact of channel erosion in River Ajilosun drainage basin.

(i) Riparian vegetation along the Ajilosun channel banks should be allowed to flourish and protected from illegal dry season bush burning and indiscriminate degradation. Appropriate sanctions must accompany such acts.

(ii) Erection of in the floodplains and valleys of River Ajilosun houses should not be allowed henceforth. Cases of erring landlords should be handled legally. Some houses may have to be demolished to pave way for free flow of floodwater. Although owners_such houses may need to be compensated by the government and alternative lands provided for them.

(iii) The Municipal government of Ado-Ekiti should provide adequate waste disposal facilities which should be located at effective distances in the drainage basin. There is need to provide more refuse metal bin in addition to the ones on ground at Ijigbo, Fayose market complex and at Atikankan – Irona junction.

References

1. Arohunsoro, S.J (2011): "Spatial Analysis of Geomorphological Problems in River Ajilosun Drainage Basin in Ado-Ekiti, Nigeria". *A Ph.D Thesis*, Department of Geography and Planning Science, University of Ado-Ekiti, Ado-Ekiti, Unpublished, 332pp.
2. Chup, C.D (2005): *A Synthesis of Physical Geography*. Joyce Publishers, Kaduna, Nigeria. p.6
3. Cooke, R.V and DoornKamp, J.C. (1974): *Geomorphology in Environmental Management*: *An Introduction*. Oxford University press, Oxford pp. 22-44.
4. Daniel, B.B and Edward, A.K (1998): *Environmental Science*, John Wiley and Sons, Canada, p. 388-391
5. Goodie, A., Anderson, M., Burt, T, Lewin, J., Richards, K., Whalley, B. and Worsley, p. (1981): *Geomorphological Techniques*. London, George Allen and Unwin.
6. Jimoh, I.H. (1997): "Effect of River Erosion on Houses: A case Study of Asa River Catchment in Ilorin, Kwara State, Nigeria. "*Environmental Issues*, 2:21-26
7. Oriye, O. (2008): The Impact of Urban Expansion on the Land use Types of Ado-Ekiti, Nigeria. In J.O. Aribisala, T.F. Jemiriye and S.O. Adewole (eds.) University of Ado-Ekiti *School of Post Graduate Studies PhD and Masters Theses Abstracts* 1997-2010 pp 50-51
8. Payne, R. (1997): Sustainable Resources in Water Erosion Information Sheet. www.soilpir.sa .gov.a
9. Strahler, A.N. and Strahler, A.H. (1977): *Geography and Man's Environment*. London, John Wiley, pp.216-341.

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