CHANGES IN CHANNEL WIDTH ALONG THE DASIN – GERENG SEGMENT OF RIVER BENUE, ADAMAWA STATE, NIGERIA

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Abstract
This paper assesses the spatio-temporal adjustments in stream channel width in response to geotechnical characteristics along the Dasin-Gereng segment of River Benue. The active channel width of this segment of river Benue was measured on multi temporal satellite imageries (Viz LandSat MSS Images of 1975 and LandSat ETM Images of 1987 and 2005). ArCGIS 9.3 was used to undertake the extraction of the channel outlay and measurement of the channel width on the imageries. Paired t–test was used to compare changes in channel width for the 1975 –1987 and 1987 – 2005 and1975-2005 periods. The result of the Paired t-test suggests that there is a significant variation in channel width with t-values of 7.406 for 1975 –1987 period, -2.76 for 1987 – 2005 period and 3.015 for 1975-2005 period. Based on the findings of this study, it is recommended that a buffer zone be established along the bank line of the segment with a view to stabilizing the bank.
Key Words: Bank material, Dasin-Gereng, Channel Adjustment, Channel Segment, River Benue, Urban Settlement.

Introduction

Adjustments in river width result from a wider range of morphological changes and response of the channel to external perturbations such as clearing of riparian vegetation, trampling by livestock and the textural characteristics of the bank materials. The pattern of adjustment in channel width can either be widening or narrowing. Widening can occur as a result of erosion of one or both banks without substantial incision (Hereford, 1984 and Pizzuto, 1994). In braided rivers, such as river Benue, bank erosion by flow deflected around growing braid bars is a primary cause of widening as earlier observed in similar rivers in USA (Leopold and Wolman, 1957; Best and Bristow, 1993 and Thorne *et al.*, 1993). Another factor that results in the collapse of the banks which inadvertently leads to widening is the removal of vegetation. Vegetation influence channel morphology by providing cohesion, either locally on the river bank or diffusively across the landscape (Bashir, 2014).

Channel narrowing on the other hand occurs as a result of diverse morphological adjustment and response. Relative stability in bed level and encroachment of riparian vegetation into the channel which is often identified as causing the growth, stability and in some cases the initiation of berm or bench features (Schumm and Lichty, 1963, Harvey and Watson, 1986 ; Simon, 1989), are the mechanisms through which channels are narrowed as a response to bank stability.

Understanding the pattern and rate changes in channel is fundamental to routine river management and restoration efforts. It is also important, as channel widening will negatively impact on agricultural output from farmlands located at the precinct of the active channel. The main aim of this paper is the assessment of the adjustment in channel width segment of river Benue from 1975-2005 with a view to examining the spatio-temporal variation of channel width along a segment of river Benue. The study is based on a hypothesis that there is no significant variation in the channel segment over the study period, notwithstanding the variations in the geotechnical characteristics of the banks and the changes in land use/land cover around the segment (Bashir, 2014).

Study Area

The area selected for this study is a segment of river Benue of a length of 54 km situated between latitude $9^{o}\,02^{'}$ and $9^{o}\,30^{'}$ N $12^{o}20^{'}$ to $12^{o}\,54^{'}$ E. River Benue is a major tributary of river Niger and it is the major river that traverses Adamawa State. The selection of this segment and catchment drained by the river could be justified by the fact that it supports substantial population of mainly rural farmers, pastoralist and fishing communities in a rural area that has a functional relationship with Jimeta and Yola townships which are the major urban centers within the catchment. The population of the area is 20,855, (NPC, 2006).

The area has a typical Tropical Savanna climate with distinct wet and dry season. The rainy season lasts for an average of 6 months from May to October, with an average of 41% of the rain falling in August and September. The mean annual rainfall ranges between 850 – 1000 mm. All locations within the study area have a fairly uniform climate as they are in the same latitude, and on flat terrain devoid of altitudinal influence on the local climate.

The topography of the area is generally low laying undulating terrain of 183.3 – 200 metres Above Sea Level with gentle undulation and hill ranges punctuating the extensive flat flow plain at various locations notably across the river Benue eastward from Jimeta, the land rises steeply to attend a maximum height of 240 metres above mean sea level (Eziegbo, *et al*). The geology of the area is made up of two main geological units namely; the Bima sandstone and the alluvial sand deposits. Alluvial sand deposits formed the bank material which confines the river; it is a recently deposited sandy loam deposit with very low cohesion.

The vegetation cover around the channel segment was a woody savanna which forms a gallery forest of different plant species along the river banks. However, the primary vegetation in the area has since been replaced with secondary vegetation and grassland scenery that constitutes a pastoral block (Tukur and Ardo, 1999). The agricultural, water, and land resources potentials of the area have attracted a considerable intensity of human activities that have transformed the general land use pattern within the study area thereby increasing the vulnerability of the channel morphological variables to changes.

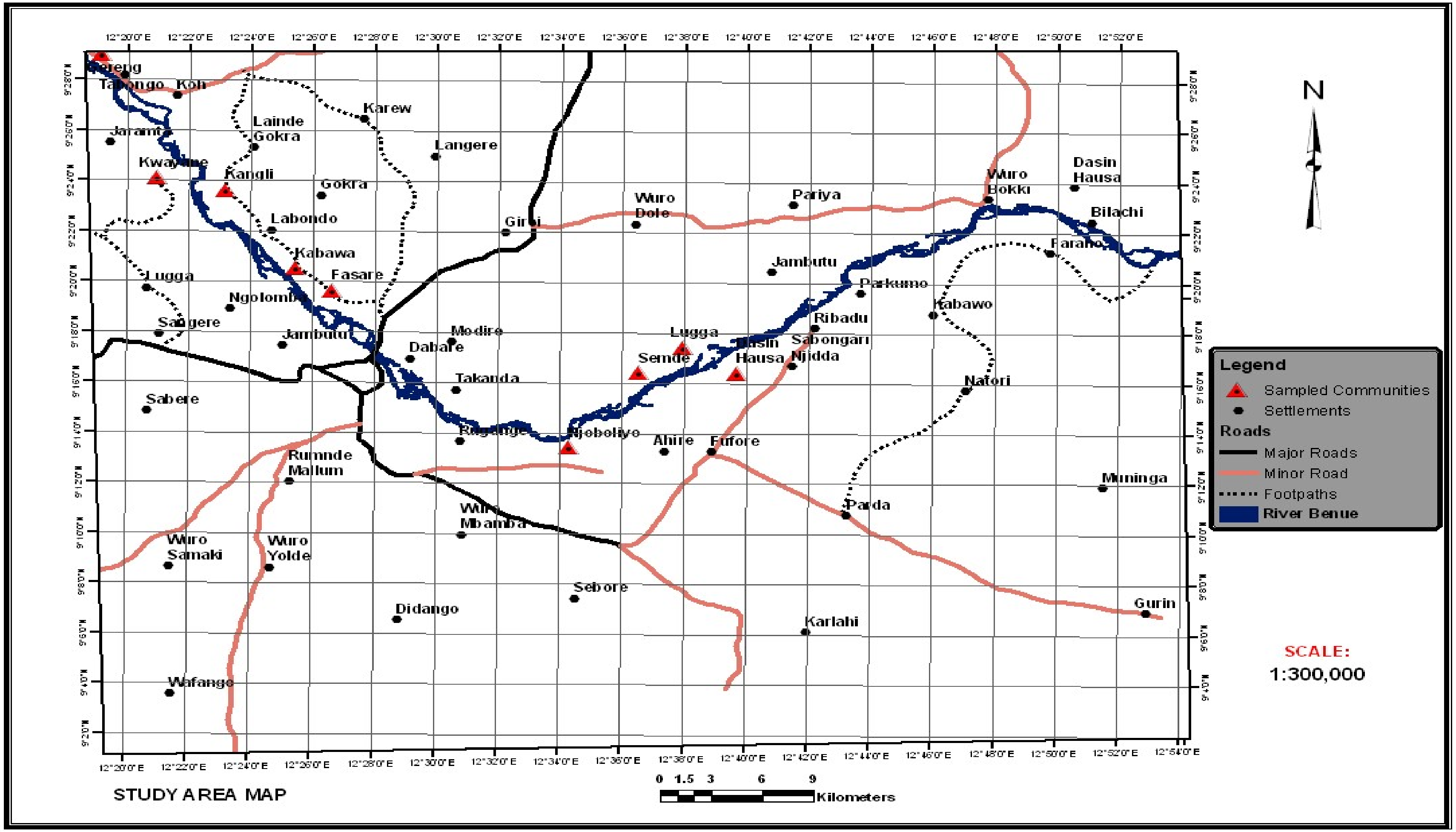

Figure 1: The study area

Materials and Methods

Multi- temporal satellite images of the study area were used; thus LandSat MSS image of 1975 and LandSat ETM 1987 and 2005 were subjected to GIS analysis using the ArcGIS 9.3. Channel width was measured at an interval of 3 km. The river channel was extracted from the classified images of 1975, 1987, and 2005. The channel falls under the cluster of water bodies with specific grid code, thereby requiring vectorization which discretely sums up the clusters as polygons.

After classification, each image was vectorized using the ArcGIS spatial analyst which gave rise to polygons of about eight grid codes. The grid codes are the number of classes assigned to each image during the creation of signature vector files for maximum likelihood classification. Vector files of each image were saved as a shape file within the working frame which represents on extends for reprocessing and analysis of all aid features in this work.

The vector files were then added to the map view after which the attribute table of each file was opened. The grid code that represents water bodies was selected from the table using Structured Query Language (SQL) giving rise to only polygons that represent water bodies. A further selection was made using the selection tool to identify the extent of River Benue. The selected channels were later exported as features giving rise to River Benue. This exercise was repeated to extract River Benue in 1987 and 2005 respectively.

The channels were exported to geodatabase that consist of all the project features. The geodatabase calculates the channel parameter, and channel area. The result was automatically returned as a table. Channel width was calculated at specific grid intervals. The Map view was switched to layout view where grids were produced to divide the map into measured grids, at every two (2) minutes interval (Approximately 3 km). The measurements were taken from North to East (N- E) using the measure tool on Arcmap, and finally compiled in a tabular form for statistical analysis. A paired t-test analysis was conducted (5% level of significance) on the channel width between 1975 -1987, 1987-2005 and 1975-2005. The result of the paired t-test analysis is to highlight the spatio-temporal pattern of channel width adjustments within the study period.

Results and Discussions

Active channel of the segment of River Benue selected for this study was extracted from LANDSAT MSS image 1975 and LANDSAT ETM image of 1987 and 2005. Channel width were determined at regular interval of 3 km, Table 1 represents the variability in channel width along the channels. From Table 1, it could be seen that the average channel width was 512 meters in 1975 as against 409 meters in 2005. It decreased at a rate ranging from 1.2 meters/yr in reach 2 and 17.6 meters/yr in reach 16. The pattern of channel changes presented on Table 1 could be explained by the combination of various factors, such as the nature of the bank material, which is generally composed of 60 – 65% sand and very low clay content which increase its low resistance to erosion (Bashir, 2014).

Table 1: Changes channel in width along the segment

Reaches	Width 1975(m)	Width 1987 (m)	Width 2005(m)	% Change in width b/w 1975- 1987	% Change in width b/w 1987-2005
1	392	299	347	-23	+16.05
2	484	259	447	-46.5	+58.30
3	504	222	379	-55.95	+70.7
4	413	315	544	-23.7	+72.7
5	404	315	544	-22.02	+72.7
6	560	259	415	-53.8	+60.2
7	606	311	541	-48.7	+73.95
8	631	410	432	-35.02	+5.4
9	479	280	368	-58.3	+31.4
10	357	399	413	+11.8	+3.5
11	488	235	368	-51.8	+56.6
12	548	410	340	-25.2	-17.07
13	432	297	450	-31.3	+51.5
14	454	333	293	-26.7	-12.01
15	464	346	238	-25.43	-31.2
16	851	420	321	-50.6	-23.6
17	568	387	476	-31.9	+22.9
18	587	321	265	-45.3	-17.4
Mean	512	323.2	409		
S. Dev	111.6	63.3	80.3		
CV (%)	21.8	19.6	19.6		

NB: (+) indicates widening, while (-) indicates narrowing

The pattern of changes in channel width presented in Table 1 is further illustrated in the Figure 1.

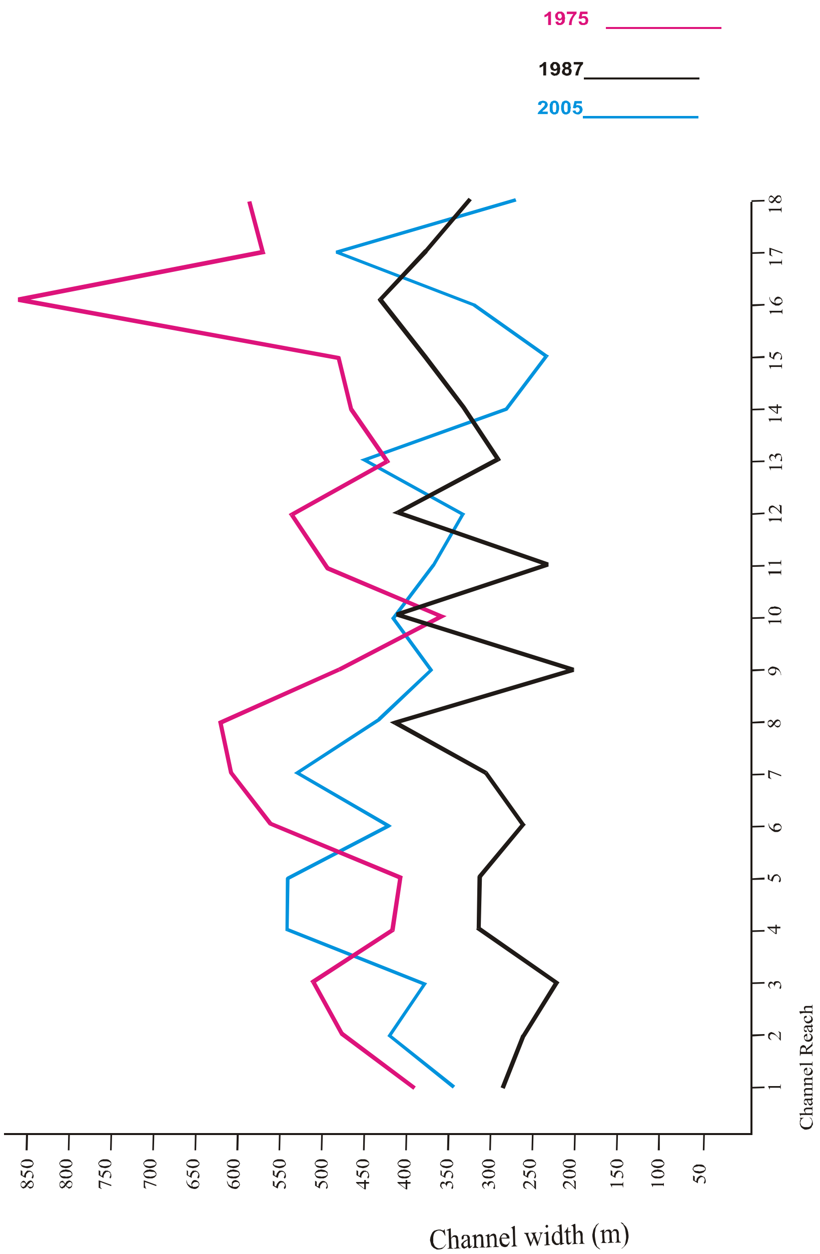

Fig 1a . Spatial and temporal Changes in channel width of River Benue for the Period of 1975 - 2005

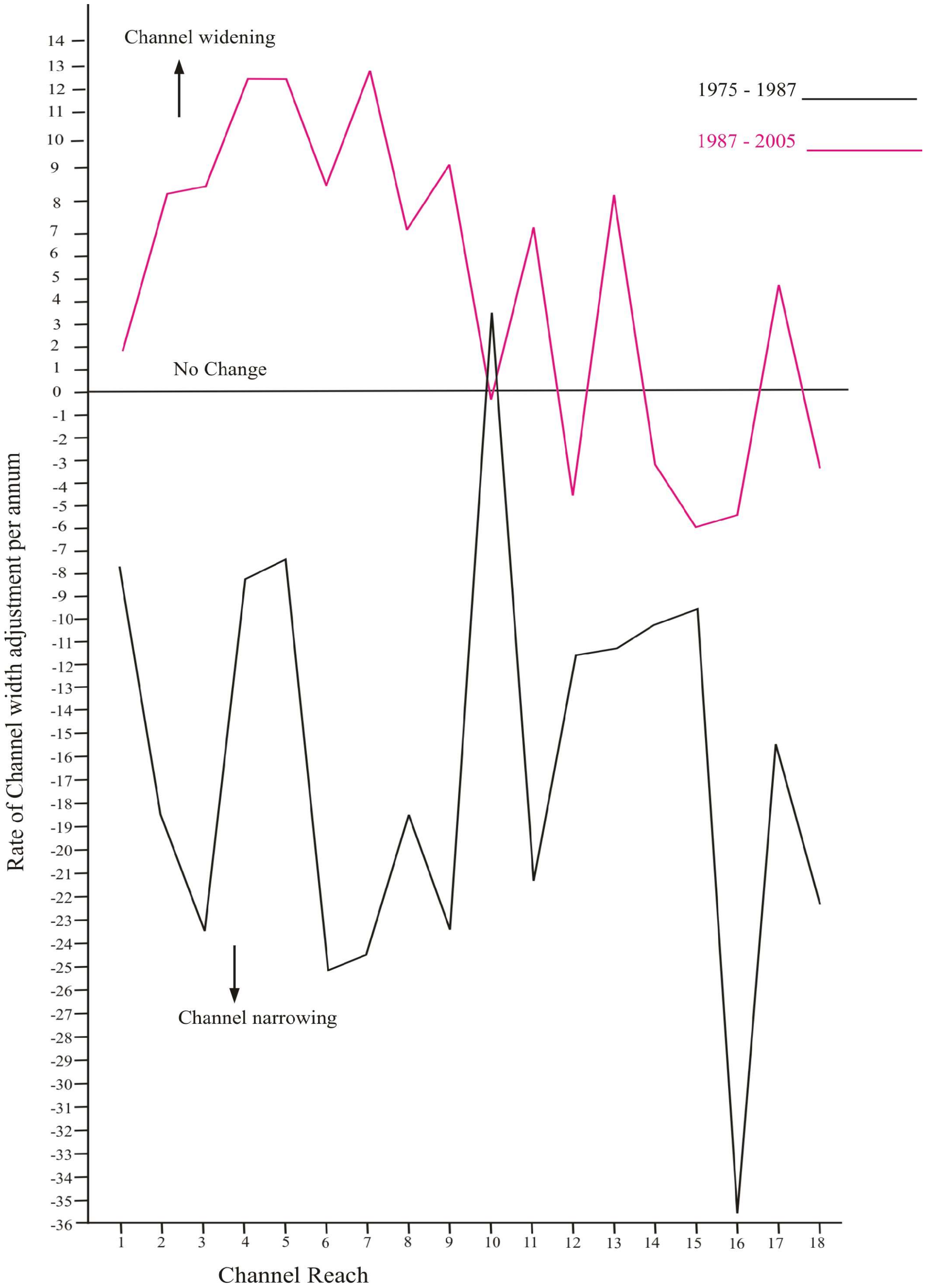

Fig .1b. Rate of spatial and temporal Changes in channel width of River Benue for the Period of 1975 - 2005

From the temporal perspective, a paired t-test was used to evaluate changes in channel width between 1975 – 1987, 1987 – 2005, and 1975-2005. The t-values of the paired t- test are 7.406 for 1975 –1987, -2.763 for 1987 – 2005 and 3.015 for 1975-2005. These t-values (5% level of significance) suggest a very significant adjustment in channel width within the study period. For instance; the period of 1975 – 1987, significant decrease in channel width occurred with the exception of reach 30 km, this contrast to changes in 1987 – 2005 periods where the channel width widens in all the reaches with the exception of 36 km, 39 km, 42

km and 53 km which are coincidentally reaches that are confined with bedrock and coarse alluvial bank materials. The narrowing of almost all the reaches in the 1976 -1987 period could be attributed to the construction of Lagdo dam in the upper course of the river in 1984 and consequently the channel width widens as a result of changes in the configuration of the channel bank especially through deforestation and growth in adjacent urban settlements which result to human activities such as increased cultivation.
Proliferation of impervious surfaces due to urbanization have resulted to increase routing of runoff into the channel, which invariably mean most of the confined reaches having their depth larger than other reaches as a result of increased scour.

Conclusion

Assessment of adjustment in channel width is an important study, as it presents the trajectory of changes in channel width over both time and space. The combined effects of human, natural and inherent characteristics of the banks of River Benue have resulted to the pattern of change presented in this study. Channel widening has a serious implication on adjacent lands, leading to large scale loss in crop yield and large parcels of land; consequently triggering a socio economic impact on the riverine communities, through displacement of population and economic activities from the riverine areas, destruction of adjacent vegetation and reduction in crop yield.

Recommendations

In view of the enormity of the real and potential impacts of channel widening, it is very pertinent to adopt measures aimed at ensuring bank stability, through checking bank erosion. This could be achieved through.

- Government, collaborating with private land owners and communities along the river bank to adapt agro forestry as a means of controlling bank erosion.
- Construction of a revet wall and pavements in the critically affected reaches, will so much aid bank stabilization.
- Upper Benue River Basin Development Authority (UBRBDA) should also consider the evolution and implementation of flood plain zone land use planning and regulation which will define the type/intensity of land uses relative to their distance from the channel.

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