UNIVERSITY OF PORT HARCOURT

MAN, RIVERS AND MORPHOLOGICAL TRANSFORMATION: ARE WE SAFE?

An Inaugural Lecture

By

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DEDICATION

This lecture is dedicated to members of my Family for consistently relentlessly spurring me up from behind the scene.

ACKNOWLEDGEMENTS

I must, as a matter of obligation, thank the Almighty God who has given me this wonderful privilege to be alive today to deliver this once-in-a-life-time lecture. He has led me through a twenty-five-year sojourn in this Institution. He calmly, visibly and strongly took me through a tortuous path to professorship and I am convinced that He will still be my Guide till the very end of my allotted time.

I would also like to express my sincere gratitude to the current Vice Chancellor of this University – Prof. N. E. S. Lale, during whose time my professorial dream happily and finally crystallized.

I will not forget to appreciate the foundational mentoring role played by several scholars at the University of Calabar and at the University of Nigeria, Nsukka. It will indeed be culpable if I fail to mention Prof. G. E. K. Ofomata – the first professor of Geomorphology in Africa: south of the Sahara and north of the Equator, whose tutelage and workmanship moulded me into a geomorphologist.

I am greatly indebted to my colleagues in the Department of Geography and Environmental Management for providing an intellectually stimulating environment for me to operate. They believed (and still believe) in me, fronted me and together we got full accreditation under my headship for the very first time in the history of our Department. I also have to sincerely thank my senior colleagues who deliberately decided not to give me any form of “soft landing”. You made my way rough and rugged but fortunately you at the same time toughened me and strengthened my resolve to trudge on irrespective of the terrain. I sincerely appreciate your concerted role in building a rugged geomorphologist.

I would also wish to acknowledge all the unique students that I had the challenge and privilege of teaching at

various levels. You unknowingly put me on the edge and I will ever cherish the memory of our geomorphological adventures. I will also not fail to mention the award-winning Unique Mappers Team of Africa (not just Port Harcourt and Nigeria) which is currently blazing the trail in volunteering geographic information for quick response to humanitarian disaster situations in different parts of the world. I am happy to serve as your Advisor and I am proud of your escapades and laurels in global “Catchatons and Mapathons”.

I am greatly indebted to my family because productivity in one’s work place can strongly depend on the stability of one’s home. I believe my beloved wife – **Mrs. Nkechi Umeuduji** is the woman described in Prov. 31, because she inspires accelerated confidence and boldness in me hence earning me a lot of respect among academic elders at the city gate. Also, my children: **Amarachi, Chike, Chiagbanwe** and **Chiamaka,** have given me a consolidated home required for optimal intellectual performance. This lovely nuclear family has spurred me to great ideals to merit much more than this work just being dedicated to her.

Finally, I am grateful to everyone who has, knowingly or unknowingly, made a positive impact in my life and career. I sincerely thank all of you from the depth of my heart.

ORDER OF PROCEEDINGS

2.45P.M. GUESTS ARE SEATED

3.00P.M. ACADEMIC PROCESSION BEGINS

The procession shall enter the Ebitimi Banigo Auditorium, University Park, and the Congregation shall stand as the procession enters the hall in the following order:

ACADEMIC OFFICER
PROFESSORS
DEANS OF FACULTIES/SCHOOLS
DEAN, SCHOOL OF GRADUATE STUDIES
PROVOST, COLLEGE OF HEALTH SCIENCES
LECTURER
REGISTRAR
DEPUTY VICE-CHANCELLOR [ACADEMIC]
DEPUTY VICE-CHANCELLOR [ADMINISTRATION]
VICE CHANCELLOR

After the Vice-Chancellor has ascended the dais, the congregation shall remain standing for the University of Port Harcourt Anthem.
The congregation shall thereafter resume their seats.

THE VICE-CHANCELLOR'S OPENING REMARKS.
The Registrar shall rise, cap, invite the Vice-Chancellor to make his opening remarks and introduce the Lecturer.

THE VICE-CHANCELLOR SHALL THEN RISE, CAP MAKE HIS OPENING REMARKS INTRODUCE THE LECTURER AND RESUME HIS SEAT.

THE INAUGURAL LECTURE

The Lecturer shall remain standing during the Introduction. The Lecturer shall step on the rostrum, cap and deliver his Inaugural Lecture. After the lecture, he shall step towards the Vice-Chancellor, cap and deliver a copy of the Inaugural Lecture to the Vice-Chancellor and resume his seat. The Vice-Chancellor shall present the document to the Registrar.

CLOSING

The Registrar shall rise, cap and invite the Vice-Chancellor to make his Closing Remarks.

THE VICE-CHANCELLOR'S CLOSING REMARKS.

The Vice-Chancellor shall then rise, cap and make his Closing Remarks. The Congregation shall rise for the University of Port Harcourt Anthem and remain standing as the Academic [Honour] Procession retreats in the following order:

VICE CHANCELLOR
DEPUTY VICE-CHANCELLOR [ADMINISTRATION]
DEPUTY VICE-CHANCELLOR [ACADEMIC]
REGISTRAR
LECTURER
PROVOST, COLLEGE OF HEALTH SCIENCES
DEAN, SCHOOL OF GRADUATE STUDIES
DEANS OF FACULTIES/SCHOOLS
PROFESSORS
ACADEMIC OFFICER

PROTOCOLS

- ❖ The Vice-Chancellor
- ❖ Previous Vice-Chancellors
- ❖ Deputy Vice-Chancellors (Admin and Academic)
- ❖ Previous Deputy Vice-Chancellors
- ❖ Members of the Governing Council
- ❖ Principal Officers of the University
- ❖ Provost, College of Health Sciences
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- ❖ Unique Students of UNIPORT
- ❖ Members of the Press
- ❖ Distinguished Ladies and Gentlemen.

MAN, RIVERS AND MORPHOLOGICAL TRANSFORMATION: ARE WE SAFE?

INTRODUCTION.

Mr. Vice Chancellor Sir, the topical task we are here to address today is: **"Man, Rivers and Morphological Transformation: Are We Safe?"** and we intend to do this from the perspective of the Chair of Fluvial Geomorphology. As a specialty, this is a terrain within which one has traversed for over two decades. As an outstanding branch of Physical Geography, Geomorphology is seen as the field that describes and analyzes the geometry and spatial variability of landforms as well as their origin and evolution in the course of time.

Historically, by the mid-19th Century, Geomorphology was initially domiciled in Geology and that was how some of the basic theoretical tenets and pillars of the field were developed by Geologists. Pitty (1982, p.2) observed quite aptly that "Geomorphologists are academic migrants, a vociferous, squabbling yet cohesive flock, tracking continually across the political boundaries of the established nation states of science". By the 20th Century, after the dominance of the uniformitarian thought by Geologists, Geomorphology finally came to roost in Geography (Umeuduji, 2017). The aspect of Geomorphology that is of interest to us and which will form the fulcrum of our discussion is Fluvial Geomorphology. This simply refers to the scientific investigation of landforms engendered by the erosional and depositional activities of rivers.

Focusing on the morphological accomplishments of rivers is not only worthwhile but also justified. As we have noted elsewhere: "In addition to the work of other denudational agents (such as glaciers, winds and waves), rivers not only play a major role in degrading much of the continental landmass but also in transporting the resultant materials…

lofty mountains and striking highlands are being relentlessly mowed down… gaping and yawning gullies develop…Over considerably long geological periods, thick layers of alluvium are laid down to form floodplains, coastal plains, deltas…"(Umeuduji, 2000, pp.2-3).

It is our intention to critically examine how rivers naturally transform the morphology of the landscape, how man inadvertently complicates this process as well as how man can possibly, cautiously and intentionally modulate this transformation to his own advantage while maintaining a relatively stable morphological setting. Our examination will, of necessity, be preceded by a definition of fundamental concepts.

BASIC CONCEPTS

Below are a few basic concepts that will feature prominently and regularly in this discourse. They have been isolated, defined and presented in a simplified manner while still retaining the technical essence.

River: In a classical sense, a river is used to refer to a stream of fresh water, confined within banks and flowing through a natural channel (Moore, 1981). Ofomata (2009) saw it as a mixture of water and rock particles moving progressively to a lower elevation from the source to the mouth along a definite path or course. Furthermore, he noted that rivers, streams, brooks and rivulets are used to denote, in a decreasing order of magnitude, the flow of a mixture of water and rock particles. From an aerial view, rivers are those intricate depression lines, which like arteries, conduct water, sediments and other fluvial materials from elevated areas down to oceans, seas or lakes (Umeuduji, 2015). Due to varying climatic conditions which govern the input of water to rivers, Adebola *et al* (2016) observed that the drainage network could be characterized by streams and rivers of various sizes which could be having perennial, intermittent and ephemeral flow regimes as the case may be.

Morphology: The second key term singled out for clarification is "morphology" (derived from the Greek root word *"morphé"* meaning "shape"). This connotes the shape or the geometrical properties of resultant forms in the course of the operation of a geomorphic process. In this case, we are looking at features or forms, whether erosional or depositional, being created or modified by the operation of fluvial or river-based actions. From a geomorphological perspective, forms are a function of processes and processes are relentless and dynamic with the result that the engendered morphology is continuously being transformed.

Man's action: Finally, we may have to add here that though morphological transformation is natural and inevitable, yet the impetus which **man's action** gives to transformation is quite astounding. In simple terms therefore, we are looking at how man has quickened or radically increased the ability of rivers hence achieving a heightened morphological transformation. Now, let us consider what rivers are naturally able to accomplish unaided.

WHAT RIVERS DO

The genesis and evolution of several landforms could be traced both directly and indirectly to the activities of rivers. This is because rivers have great potentials to do much work. In line with a fundamental principle of thermodynamics, that every matter or mass in motion possesses kinetic energy, rivers manifest and utilize their kinetic energy to carve out and build different landforms through fluvial processes. This inherent kinetic energy is dissipated or used up in removing and transporting water from the continents towards the oceans.

Fundamentally, energy defines the ability to do work and the enormous kinetic energy of rivers implies a great potential for topographic work. The topographical setting is naturally characterized by significant differentials in terms of the distribution of matter which in turn gives rise to disequilibrium. This scenario characterized by disequilibrium is what rivers automatically respond to in order to even off irregularities while tending towards equilibrium. This is why Ibisate, Ollero & Diaz (2011) noted that stream channels tend towards an equilibrium state in which the input of mass and energy equate the outputs.

The tendency towards equilibrium is characterized by a series of adjustments in both fluvial processes or activities as well as forms or resultant features. Montgomery and Buffington (1998) observed that any change in sediment yield, flow or slope would always lead to an adjustment in channel size, shape and profile. Adjustments in fluvial processes give rise to a commensurate change in fluvial forms with the result that the general morphology is being transformed accordingly. Our principal thesis here is that ***morphological transformation is a function of river action.*** To validate this thesis, it is pertinent to analyze, at least in a cursory manner, what goes on along the different reaches of the entire river profile. In this regard, Schumm (1977) isolated three dominant activities which are erosion, transportation and deposition and went on to argue that the trio provides a framework for examining channel processes. These three activities clearly stem from the fact that, like every other natural phenomenon, energy is not uniformly spread in space, and in fact, its dissipation varies greatly along the course of the river.

Usually, as a stream emerges from its source and flows down from an elevated region, the pronounced slope combines with an increased flow velocity to give the river a great energy to do some work, expressed in terms of erosion. According to

Ofomata (2009), river erosion involving the removal of rock particles can generally be of four types, namely: hydraulic action, corrasion, corrosion and attrition. He went on to note that hydraulic action is the process of river erosion carried out entirely by the sheer force of the river when energy is dissipated on rock masses on the valley sides, leading to the removal of loose materials by the force of impact of water alone.

Similarly, through corrasion, the river uses its load as weapons to remove more materials from the river bed and valley walls. Corrosion implies a breakdown or disaggregation of the basic channel materials through loosening by water and other associated chemical compounds formed with water as the major re-agent. Such disaggregated materials are then easy to remove by the river. The fourth form of river erosion is attrition whereby various sizes of rock materials such as boulder, stones, gravels and other particles are progressively broken into smaller sizes as they keep knocking against each other while being moved along the river. As these erosional processes go on, the river channel keeps widening through basal sapping and lengthening through head-ward extension. This is how the river artistically creates its own channel.

The second aspect of the work of rivers has to do with the relocation of eroded materials from higher grounds to lower grounds in relation to gravity. The materials being transported by the river constitute its sediment load. Materials such as salts and other compounds soluble in water are usually transported in solution. Very fine materials with insignificant density in relation to that of the river water are transported in suspension. Coarser and denser materials that sink to the river bottom are usually rolled along the river bed. The heaviest aggregates in terms of size and density (such as stones and boulders) are transported along the river bottom in short leaps or hops through the process of saltation.

As already noted, what a river does is a function of the energy available to it. A lot of energy is used to etch out materials and also to transport them to relatively lower regions. Deposition is therefore a logical complement or end to erosion as the energy of the river attenuates. Due to slope, potential energy is converted to kinetic energy as the river flows. This kinetic energy is dissipated in the two classes of erosional and transportational processes examined above. It is a fact that a fast flowing river gathers momentum because kinetic energy increases with pronounced gradient and water volume but decreases with friction and low gradient. As a result, under very low gradients, friction becomes so highly pronounced that the sediment load is forced to be deposited. This usually happens when the gradient becomes so reduced that the river flows sluggishly and meanders through the floodplain.

There is a direct relationship between energy and gradient on one hand and on the other hand an inverse relationship between gradient and friction/resistance. With pronounced gradient and energy, not much of deposition would be expected. When gradient begins to diminish, friction begins to increase. This results to some form of sorting or gradation in the materials being deposited. The largest-sized materials are first deposited, followed by the finer materials much later and farther off. This gradation is clearly observable when the river is emptying into the sea or lake and the larger materials would be seen on the shore while the finer materials would be deposited farther off shore.

It should however be pointed out that although the river uses a lot of energy to sculpturally erode and transport the massive volumes of sediment load, yet ironically the process of deposition still requires some form of energy to constructively build up new landforms. This is why the river is a key agent of denudation in that it erodes materials from higher lands, transports and uses such materials to build up landforms that elevate depressions. As long as the river exists, whether it is eroding or depositing, new features are being created or existing ones are being modified and the obvious result is that the general morphology is being modified.

MORPHOLOGICAL TRANSFORMATION

Universally, water is a notable transformer of several phenomena on the surface of the earth. For instance, Cakaric (2010) observed a functional relationship between water phenomenon and urban morphology and argued that water is a vital generator of the formation, sustainability and transformation of different types of cities. However, the morphology that is of interest to us here is that of fluvial landscape.

Operationally, morphology in the context of our discourse refers to the shape or structure which a fluvial landform assumes. We will first examine the mechanism of this process before looking at the associated products. Ibisate *et al* (2011) are of the view that fluvial morphology is conditioned by three elements: flow regime, sediment yield and valley characteristics and that furthermore, reach characteristics are the result of the interaction between upstream and downstream catchment and local conditions. In any reach of the valley, as they argued, if sediment load and flow are in a balance, neither channel erosion nor deposition will occur, implying the existence of equilibrium. However, in real life, disequilibrium is the norm and Renwich (1992) was right to have argued that short-lived states of disequilibrium often result when a geomorphic threshold is exceeded through a change in any of the variables defining the process in action.

Working empirically in the Sehir Creek, Karatas and Ekinci (2014) used concrete data on geomorphic structure to establish a relationship between cyclic erosion process and regional tectonism and clearly demonstrated the extent to which regional tectonism and lithological structure could affect fluvial process. They came to a conclusion that rivers are among the most important shareholders in shaping the earth's surface based on their functions such as erosion, conduction and accumulation. These functions or mechanisms that engender channel morphology were comprehensively articulated by Ibisate *et al* (2011) with typical examples drawn from the Iberian Peninsula, and the key elements are presented in Fig. 1.

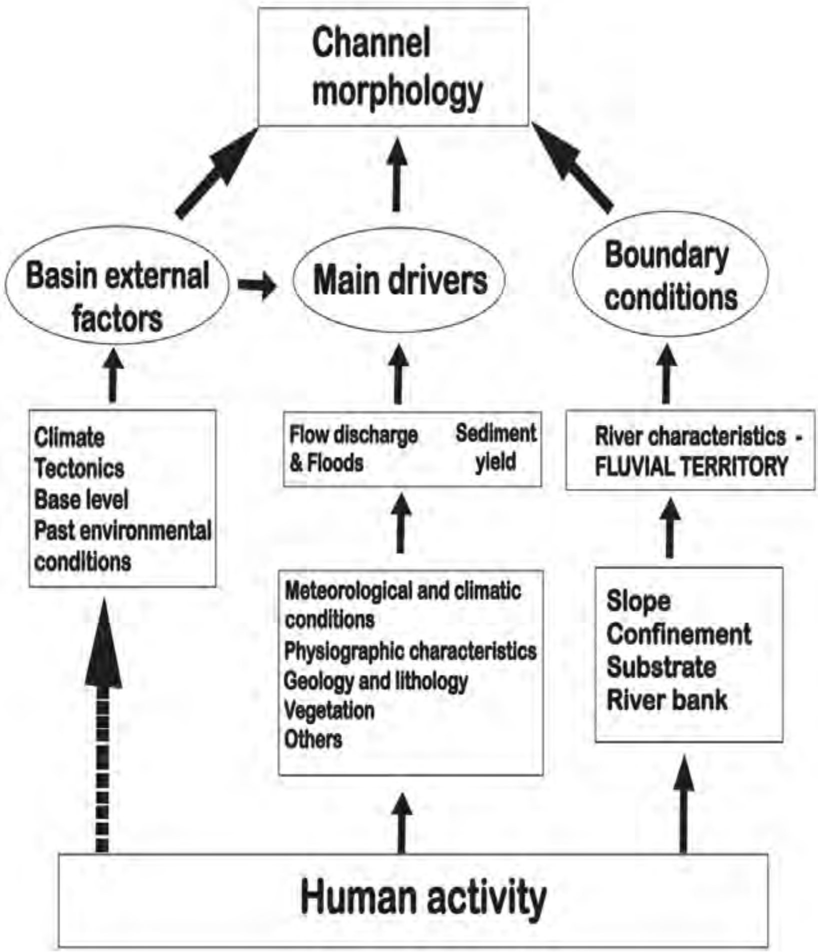

Figure 1. Schematic representation of the main factors that determine channel morphology in fluvial systems (Ibisate *et al*, 2011).

From the above schema, it is clear that morphological transformation is principally driven by the river but more importantly, other intrinsic and external factors and conditions can influence, modulate or accelerate the action of the main driver. For instance, certain natural factors such as tectonics, geology, lithology, slope, physiography and climate can impart a latent potential that can prompt a river for action. In other words, various combinations of the factors can determine the extent and effectiveness of river action.

Empirically, it has been demonstrated that slope is an index of a river's ability to transform the morphology of the landscape. In this regard, Blair and McPherson (1994), working in a piedmont setting, observed that the key hydraulic parameters of flow that are strongly influenced by the different slopes are velocity, flow regime and shear stress. In the arid Atacama Desert, Stepinski and Stepinski (2005) used 46 basins extracted from the western slopes of the Andes to establish a correlation between basin morphology and climate. Still exploring the climatic underpinning to morphological transformation, Mouri *et al* (2011), while studying a mountainous granitoid catchment in Japan, observed that extreme events such as large storms and floods due to heavy precipitation can trigger off surface landslides that can mobilize and entrain large volumes of sediments for fluvial relocation.

After studying the Nigerian section of the Chad basin, Adebola *et al* (2016) concluded that the morphology of the drainage channel can be used to interpret the geological conditions that generated the pattern. The implication is that the geology fundamentally influences the hydrology, which in turn, determines the rate at which the morphology can be transformed. More importantly, as the model shows, human activity can modulate or energize the river. Given the circumscribing natural setting, the pace of river action is normal while with thoughtless human interference, the pace becomes complicated and amplified. However, it is possible to carefully regulate human activities in relation to the river system in such a way as to control fluvial process so as to maintain a desired rate of morphological transformation.

Having examined the various means of channel morphological transformation through river erosion, it is logically appropriate to look at the other complementary aspect which is through deposition. Whereas scouring and incision create new forms by lowering the topography, the materials etched out are relocated to build up new forms. Fig. 2 shows some of the resulting features.

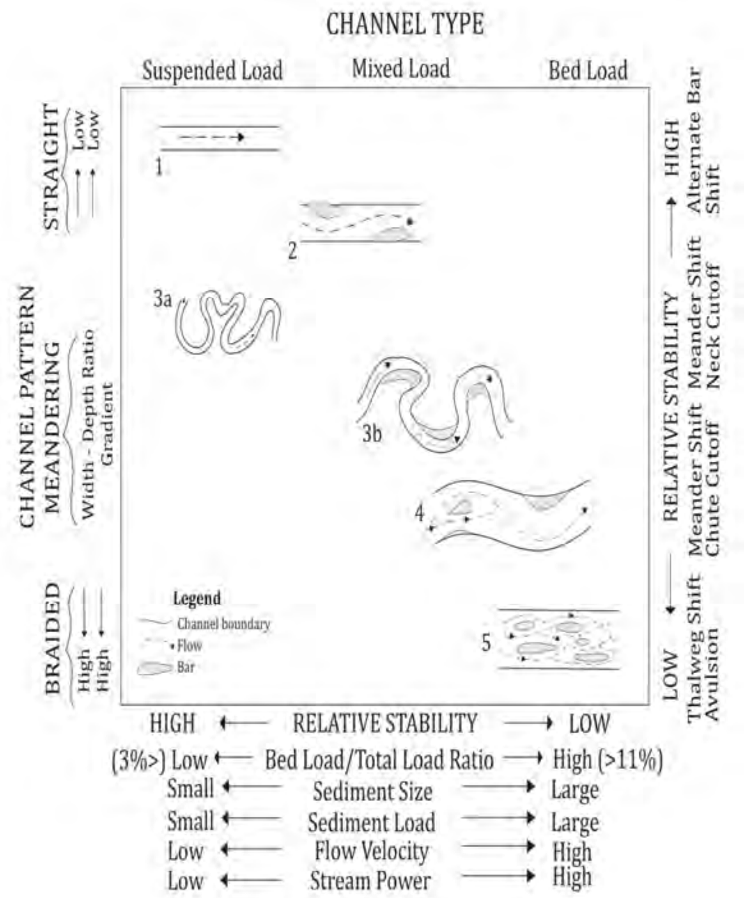

Figure 2: Channel pattern classification and relative stability of alluvial channels. (1 & 2: Straight; 3 & 4: Meandering; 5: Braided. After Schumm and Meyer, 1979 and Andrezejewski, 2015).

Montgomery and Buffington (1997) classified channel reach morphology in mountain drainage basins into bedrock, colluvial and alluvial channel types. Depending on the slope and energy available to the river, different types of morphological build-ups can result. In piedmont settings, alluvial fans develop and these, according to Blair and McPherson (1994), are semi-conical accumulations of coarse grained angular sediments deposited where a feeder channel of an upland drainage basin intersects the mountain front.

The interplay between erosion and deposition can be very much influenced by environmental factors causing sediment deficit or sediment excess (Ortega *et al,* 2014). Schumm (1977) had argued that a channel load increase produces an increase in channel slope and a corresponding decrease in depth and sinuosity. The obvious implication of the latter is deposition on the river bed and on the banks.

Along the Chou-Shui River in Taiwan, Liu and Tsai (2015) used the Hilbert Huang Transform (HHT) method to analyze flow, sediment transport and bed elevation processes to account for change in morphology. Similarly, Miwa *et al* (2006) used the flume test to investigate bar morphology and sediment discharge conditions. The bar or point bar is one of the most easily identifiable features of river accretion. It has been argued that construction activities introduce vast quantities of sediment into stream channels which cause stream aggradation and reduction in channel capacity (Chin, 2006). In the humid tropics, Odemerho (1992) attributed channel aggradation to excessive production, delivery and deposition of sediment as well as low competence.

As we noted earlier on in the section on Basic Concepts, a competent river should effectively evacuate water and sediment to the ocean or wherever it is emptying. Therefore, undue deposition along the course of the river is quite unusual. Haas *et al* (2010) argued that the dramatic shift accompanying loss of flow due to water impoundment by man imposes fundamental changes on natural landscapes by transforming rivers into reservoirs. Empirically, Tan *et al* (2016) observed that in China prior to the 1950s, the Yellow, Yangtze and Pearl rivers delivered more than 1.2 x 10^{12} m^3/a of fresh water and 1.3 x 10^8 t/a of sediment into the Western Pacific Ocean. From the 1950s to the 2000s, they argued that through human activities such as dam construction, water and soil conservation projects, the sediment regimes of the three rivers had decreased by 89.9%, 62.1% and 57.1% respectively hence causing the deltaic lower reaches of these rivers to transit from deposition to erosion.

When rivers become incompetent in conveying water and sediment load, the result is in-stream deposition. As shown in Fig. 2, this usually occurs when the river meanders or flows sluggishly. In meander loops, materials are deposited at the convex bends and bars develop mid-stream in broad channels at low gradient leading to braiding. However, if the materials were able to get to the coast, a delta might develop. This is similar to the alluvial fan that develops on the foot slopes in a piedmont setting (which we had examined earlier on). However, the accumulation of materials at the river mouth becomes so massive and extensive over a long time that the river creates a network of distributaries through the sediment to the ocean. This is how the river builds a delta and a typical example is the Niger Delta (Fig. 3).

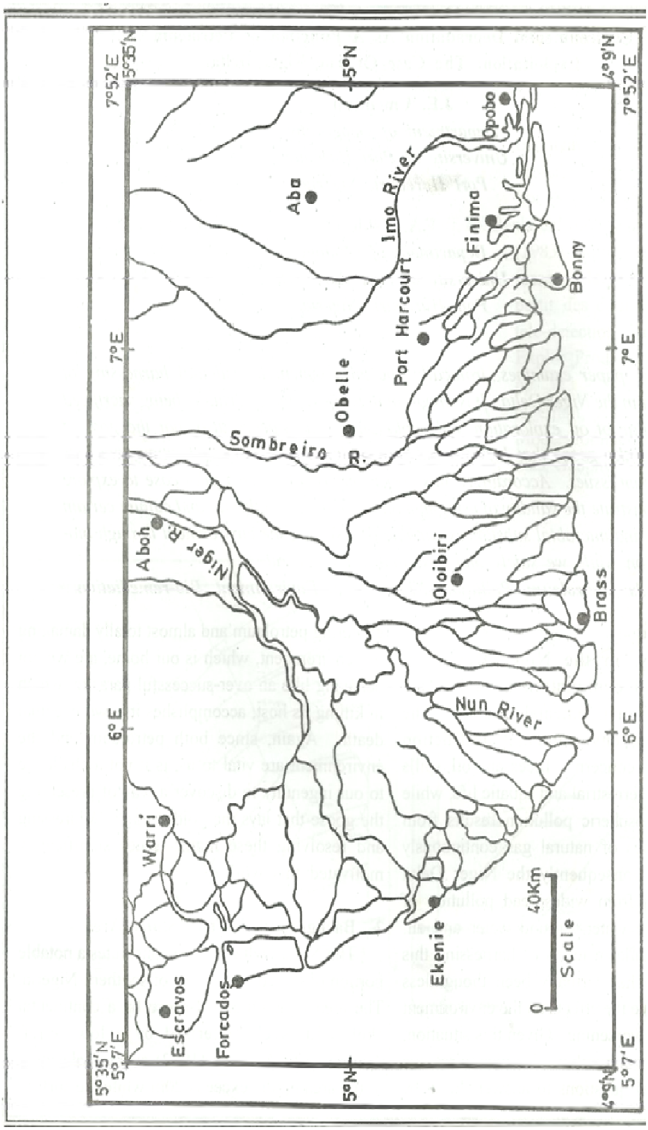

Fig. 3: The Niger Delta: showing the numerous distributaries.

It should be recalled here that following the continental drift that occurred about 200 million years ago, the Niger river (together with its tributaries) brought a lot of sediment from the continent which piled up to form the present Niger Delta. Morphologically, therefore, a delta is a long-term feature resulting from river accretion. In some cases, where the materials do not pile up and protrude out of the water near the outlet in form of delta, they are spread out to form shallow mudflats near estuaries. Extensive mudflats have been laid down at the wide mouths of rivers such as Imo and Andoni.

Apart from terminal deposits such as deltas and mudflats, rivers also build up other features such as levees and floodplains. As we noted elsewhere, a levee is a raised ridge-like feature that runs longitudinal to the bank of the river (Umeuduji, 2010). It is the river that actually builds the levee which could, later on be fixed or stabilized by riparian vegetation. The river channel is a product of the river itself and the levee defines its maximum capacity which can only be exceeded during extra-ordinary storm events.

Extending beyond the levee and away from the river channel, are floodplains which are also a product of the river. Essentially, they result from the accumulation of unconsolidated materials forming a fairly level land on both sides of the river. Actually, the river lays down much of its sediment load across a wide belt that makes up the river valley. The valley therefore comprises both the water-carrying channel and the aligning floodplains (Fig. 4). The river valley defines a belt within which the river channel (which occupies the top central part) swings or meanders.

Though the river flows through the channel, once in a while, exceptionally high storm events can cause the entire channel to be filled. Once this happens, the excess water and sediment will inundate the floodplain. When the water recedes eventually, some sediments will still remain and this is how the floodplain is built up through series of accumulations during subsequent inundations.

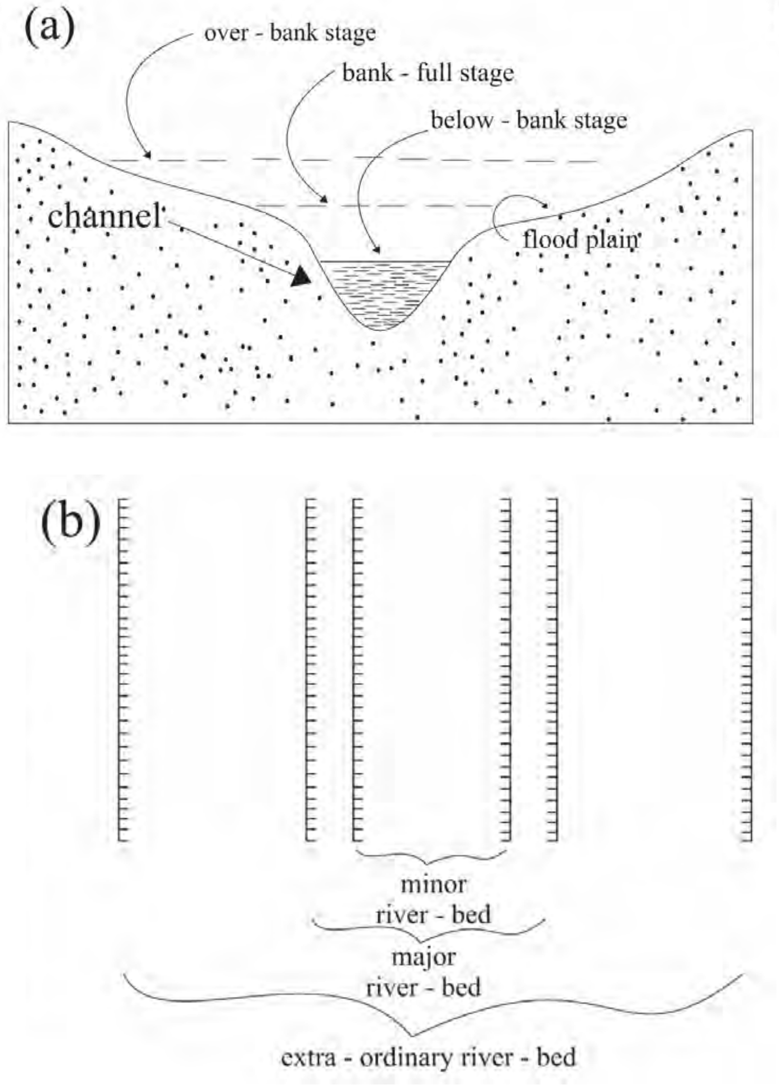

Fig. 4: The river valley: [(a) Stages of river discharge (b) Morphological representation of (a)].

Fig. 5 shows the floodplain as well as the magnitudes and frequencies of exceptional floods. For a perennial stream, the water in the channel maintains a normal level which does not overtop the bank or the levee. In some rivers, the floodplain is usually inundated yearly by seasonal floods. Beyond the annual floods and in increasing order of magnitude, are the 5-year floods with a 20% chance, 50-year floods with a 2% chance and 100-year floods with a 1% chance of occurring. In other words, the higher the flood magnitude, the longer its return period, and therefore, the slimmer its chance of occurring. From a morphological perspective, each flood incidence will always leave behind some sediments which will continue to build up the floodplain.

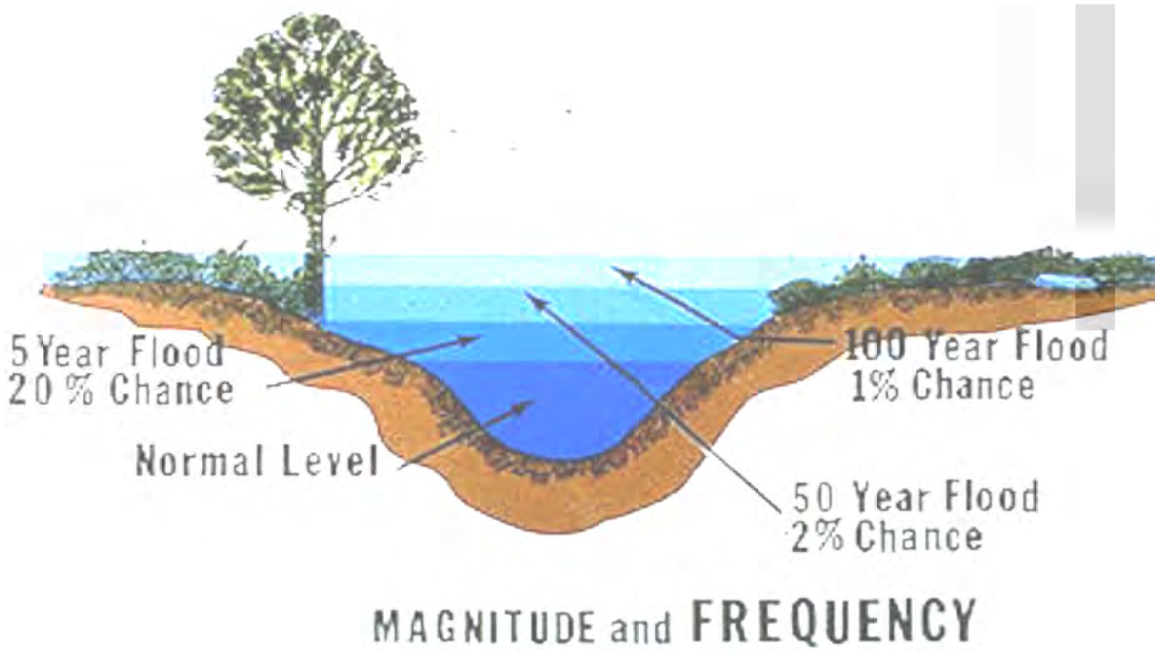

Fig. 5: Floodplain Morphology and Cyclic Floods. (After ODNR, 2008).

MAN AND RIVER SYSTEMS:

Having examined the sculptural and accretional morphological changes in the river channel, it is proper to have a complementary look at extra-channel morphological changes that are also traceable to what goes on in the channel. For instance, human activities such as construction of dams and reservoirs, river diversion, river bank concretization, channelization and creation of canals as well as quarrying or in-stream mining can induce changes that go beyond the channel into extra-channel areas. Some of these activities can induce more erosion and topographical lowering in extra-channel regions so as to supply sediment to fast flowing hungry rivers.

Knighton (1984) summarized man-induced changes in drainage basins in Table 1. Umeuduji (2000) noted that quarrying (of sand and gravel) directly interferes with the hydraulic parameters of the river as well as the associated fluvial processes and forms. Quarrying not only increases flow velocity but tends to create a vacuum down-streams which initiates a suction that increases the tempo of erosion up-streams, so as to provide more sediment to fill up the gap created by the removal. In this regard, we are fully convinced that in Anambra basin, quarrying along Mamu River provides a logical explanation for the high rate of accelerated head-ward erosion at Mamu head streams. This is where we have the notorious Agulu-Nanka gully complex.

It has been established that human activities, whether within or outside the channel, significantly accelerate topographical modification. Land uses in general affect runoff and sediment yield of any drainage system. Montgomery and Buffington (1998) observed that urbanization has the most detrimental effect on river channels, as it reduces soil permeability and increases peak flood magnitude. They argued that sediment delivery increases initially during construction but decreases afterwards. As a land-phase or extra-channel activity, urbanization has indirect but significant hydrologic and geomorphic effects on the drainage basin. Due to the presence of roofs, impermeable streets and pavements, a higher proportion of rainfall is turned into surface runoff which flows quickly into the river. This is shown in Fig. 6.

Table 1: Broad Types of Man-induced Changes in Drainage Basins.

Direct or Channel-phase Changes:
- River Regulation:
  - Water storage by Reservoirs
  - Diversion of Water
- Channel Changes:
  - Bank stabilization
  - Channel straightening
  - Stream gravel extraction

Indirect or Land-phase Changes:
- Land use Changes:
  - Removal of vegetation, especially deforestation
  - Afforestation
  - Changes in agricultural practices
  - Building construction
  - Urbanization
  - Mining activity
- Land Drainage:
  - Agricultural Drains
  - Storm-water sewerage systems

(Source: Knighton, 1984, p.189).

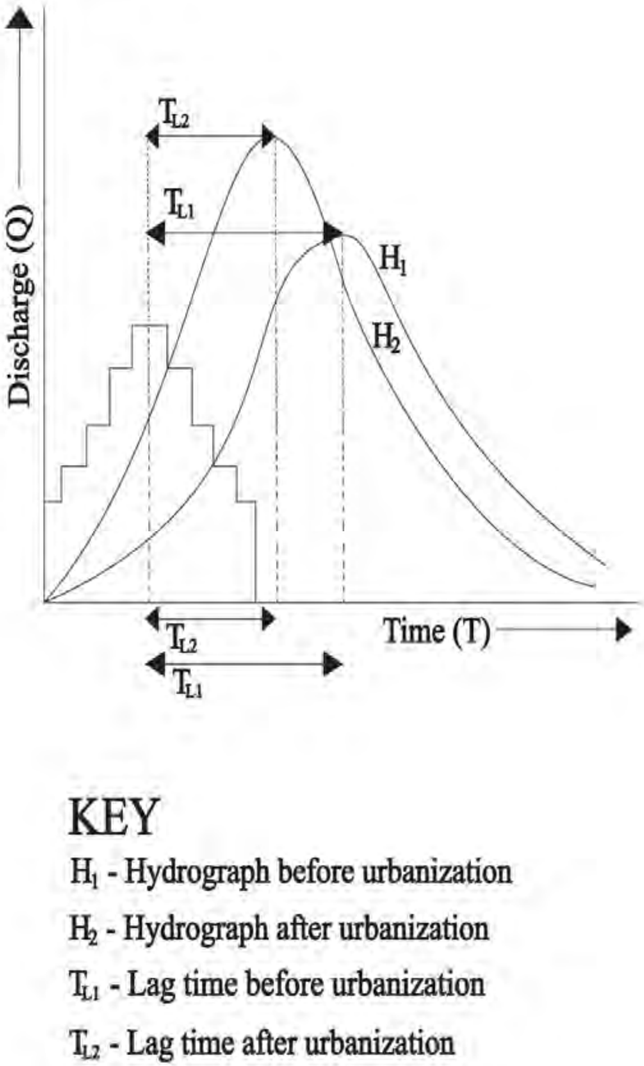

Fig. 6: Super-imposed rainfall and runoff graphs showing the effects of urbanization on hydrographs (After Umeuduji, 2000).

Urbanization shortens runoff travel time to the channel, reduces infiltration, increases flood peak, reduces lag time and steepens both the rising and falling limbs of the hydrograph. The morphological effects of urbanization are not limited to the shape of the hydrograph but are also extended to the entire basin. This is because the shortening of lag time and increasing flood magnitudes clearly indicate an accelerated catchment response to rainfall event.

Apart from urbanization, agricultural practices can also alter infiltration and runoff and then initiate or accelerate erosion on upper slopes and deposition on lower slopes of the river. With the Wisconsin Stream, it was observed that the conversion of a well-vegetated drainage basin land to farm land can increase the magnitude of floods with a return period of less than 5 years by as much as 3-5 times (Knox, 1977).

In our studies on the Awka-Orlu Cuesta, it was observed that intensive agricultural practices on deeply weathered and weakly coagulated soils have resulted to increased runoff and accelerated head-ward erosion at the head waters of Mamu River. From the yawning gullies around Agulu, Nanka, Ekwulobia and even up to Nkpologwu, a great volume of sediment load is released into Mamu River and subsequently into Anambra and finally into the Niger. The morphological result is clearly seen on the Niger at Onitsha near its confluence with Anambra where braiding is rapidly occurring due to massive deposition (Umeuduji, 2000, 2012). This braiding, in the absence of tasking and expensive dredging, remains a monumental obstacle to big vessels trying to access Onitsha.

In developed countries, with the use of advanced technology, the influence of man in the river system is even more dramatic. Montgomery and Buffington (1998) reported that the Iberian Peninsula has one of the highest numbers of dams per inhabitant in the world. The implication is that the dissipation of the rivers' hydraulic energy is regulated and of course this would reflect on the resultant morphology of the landscape in the region. Similarly, working empirically on the Kansas High Plains, Andrezejewski (2015) observed that anthropogenic modifications including a dam, irrigation diversion canals, and groundwater pumping for Centre Point Irrigation System have directly altered the hydrology of the Arkanas River by decreasing mean annual discharge, reducing peak annual flows and lowering the water table.

RIVER BASIN DEVELOPMENT.

What is implicit in river basin development is the improvement of conditions within the basin for the benefit of human beings. To set the stage for the discourse, we shall first look at what attracts people to riverine locations. It was Sewell (1969) who observed that one conspicuous feature of human settlement pattern is man's affinity for riverine locations. Due to thick deposits of rich alluvial materials on the floodplains of the Tigris, Euphrates, Nile, Indus and other rivers, very large agrarian populations have settled there. Rivers not only offer a cheap means of transporting bulky goods, but also provide a near flat floodplain for the construction of buildings, roads and railways. Close to the river, groundwater and river water can be more easily accessed by industries and settlements. For aesthetic reasons, a river scene can offer a good platform to interact with nature. For historical reasons, many have always been living on the floodplain while for economies of scale; others are still being attracted due to existing facilities.

Irrespective of the numerous attractions to the river system, there are certain vagaries associated with fluvial dynamics which can detract from the benefits if not properly handled (Umeuduji, 2015). For instance, violent erosion, unusual channel elongation, widening and swinging as well as excessive mid-stream sedimentation and flooding are issues that require to be carefully studied and put into proper check if man must maximize his use of any riverine setting. This is why river basin development is inevitable.

There is no doubt that Nigeria is blessed with a close network of rivers including the Niger, Benue, Ogun, Owena, Cross, Imo, Kaduna, Sokoto, Rima, Hadejia, Jama'are etc. and their tributaries. Water is a critical factor to the harnessing of natural resources and to national development and this is why it is important to properly articulate a national policy to drive water resource development. At the national level, some forays have been made in this regard, but one of them monumentally towers above them all. This is the division of the entire Nigerian drainage landscape into eleven (11) River Basin Development Authorities (RBDAs) by the then Federal Military Government through a decree on 15th June, 1976. These RBDAs as respectively shown in Fig.7, are as follows: Sokoto-Rima, Hadejia-Jama'are, Lake Chad, Upper Benue, Lower Benue, Cross River, Anambra-Imo, Niger, Ogun-Osun, Benin-Owena and Niger Delta.

According to Ayoade and Oyebande (1983), the RBDAs were empowered to acquire or lease land and to take over projects they deem fit in their areas of operation and to exercise the following functions:

(i) Undertake comprehensive development of groundwater resources for multipurpose uses;
(ii) Undertake watershed management schemes for flood and erosion control;
(iii) Construct and maintain dams, dykes, wells or boreholes, irrigation and drainage systems;
(iv) Develop irrigation schemes for the production of crops and livestock;
(v) Provide water from reservoirs, wells and boreholes for urban and rural water supply schemes;

(vi) Control pollution in rivers and lakes in the authority's areas in accordance with nationally laid down standards; and

(vii) Resettle persons affected by the works and schemes specified in (iii) and (iv) above.

Technically, from the perspective of drainage basin morphometry, a river basin is a topographic space shaped in such a way as to slope towards a central river hence enabling surface (and sub-surface) water to flow laterally from the summit and interfluves to the central channel and subsequently down and out through the outlet (Umeuduji, 1994, 2010). Looking at Fig.7, it is clear that the delineation of the eleven river basins did not in way follow the technical definition of drainage basin. However, it represents a fundamental recognition of the fact that rivers possess qualities that can enhance spatial development if properly exploited.

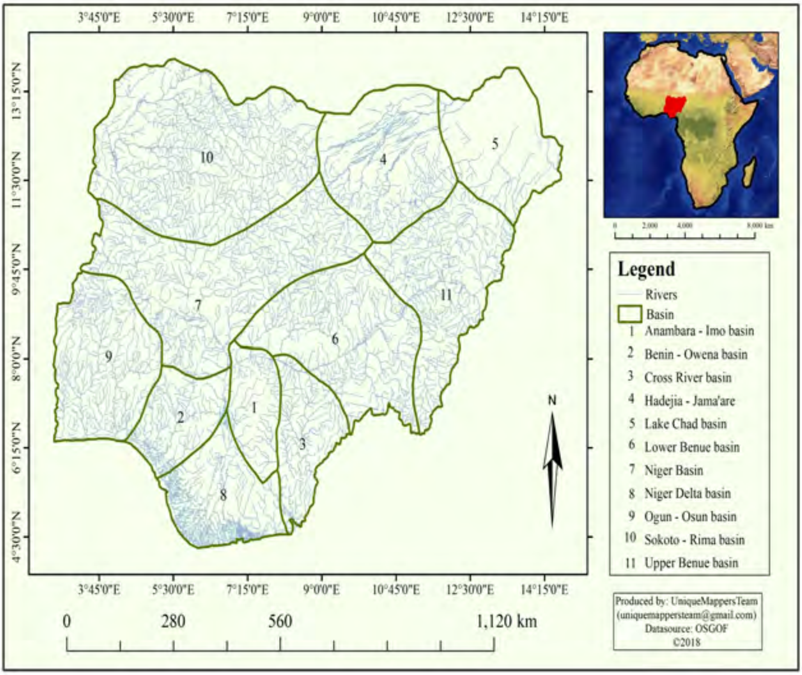

Fig.7: Nigeria: Showing the Eleven RBDAs (After Ayoade and Oyebande, 1983 p. 85.).

Currently, the major emphasis of the river basins appears to be in the area of rural development through the development of agricultural infrastructures. In the northern part of the country (around Kano and Hadejia Valleys respectively), the Bagauda and Tiga multi-purpose dams have facilitated both irrigation and flood control. In Sokoto-Rima basin, irrigation is also flourishing especially for the cultivation of rice, vegetables and other crops. Similarly, in the south at Adani (Uzuwani LGA, Enugu State), the Ada Rice Project depends heavily on irrigation from Adada River in the Anambra basin. In recent times, it has been observed that some Federal Legislators have used river basin authorities to execute borehole / water projects in their constituencies. However, the controversies associated with such politically motivated projects are outside the scope of the current paper. Of interest to us is that human activities within the river basins or along the river channels represent interventions that usually complicate and amplify fluvial processes which rapidly and obviously modify the morphology of the river landscape.

It should be noted that in spite of these RBDAs, there are increasing shortfalls in electricity / energy supply, agricultural production, together with the challenges of flooding and pollution. We rely heavily on gas turbines for energy generation instead of relying more on dams which constitute a renewable source. We also rely more on tons of imported rice in spite of the irrigation-assisted rice production in many of the river basin operational areas. The RBDAs are to control erosion and flooding and yet erosion is ravaging many parts of the country particularly within the Anambra-Imo river basin area. The horror of the 2012 flood incident that ravaged most areas in these river basins is still fresh in our memory.

From the foregoing, it is clear that the creation of the RBDAs is well justified and the functions are well articulated.
However, the fact that critical environmental and developmental challenges have remained elusive to the RBDAs calls for a re-thinking. There is no option than to re-appraise, re-strategize and pro-actively address the elusive issues, since the old methods, no matter how well-articulated, have not yielded the desired results. Emphasis should not necessarily be on financing and political expediency. When an issue is not resolved at the analytical level, any attempt to resolve it at the practical level will most likely amount to a leap in the dark. We therefore strongly advocate for a synergy: RBDAs offer a platform, the Governance (politicians) will bring the finance, while the Academia will bring the intellectual and technical know-how. With this more broad-based comprehensive approach, river basin resources will be harnessed in a carefully controlled manner without significantly accelerating the rate of morphological transformation. It should be noted that the success of notable river basin schemes such as the Tennessee Valley Authority (TVA) and several others in the advanced countries could not have been possible without proper analytical articulation.

SAFETY OF HUMAN STRUCTURES ON RIVER-BUILT SUB-STRUCTURES.

We have noted that several morphological forms such as levees, floodplains, braiding and deltas are a function of the river. It is equally important to note that sometimes, rivers serve as inlets of ocean water into the continent. Marine processes acting through long-shore drifts, waves, tides and currents can send in water and marine materials into the coastlands through the river mouths. Such periodic inundation, subsequent sea water retreat and deposition of marine materials must have played a major part in laying down coastal plains, beaches, barrier ridges and even mudflats.

Apart from more frequent tides and sea waves moving in water and materials into the continent through the river mouths, transgressions (normally followed by regressions) have been known to have occurred in the geologic history of most coastal regions. At such periods, a lot of materials must have moved into the continent through the river mouths that served as inlets. After regression, i.e. when the ocean water must have receded, the materials left behind would add to build up the morphology of the coastal belt. These features, whether marine or fluvial, often get consolidated and stabilized by vegetation in the course of time. Man has eventually, comfortably come to settle and set up structures on these river-built sub-structures. However, the safety of these human structures has become a major issue of concern in the light of current morphological dynamics, especially in the coastal regions.

Ironically, human activities constitute a formidable threat to human structures. For instance, quarrying or sand dredging destabilizes the attainment of a graded stream (i.e. when erosion and deposition are at a balance), creates a hungry water and initiates erosion at nick points due to increased flow velocity. Literally, the river becomes rejuvenated, leading to aggressive erosion at concave meander bends and a major threat to structures on the levees and floodplains concerned. A good case in point is Otuokpoti settlement on the Ekole Creek, a distributary of the Nun River, which has been grappling with the challenge of river bank erosion and flooding at the same time. In this case, as reported by Bell-Gam (1988), the construction of a flood protection embankment using sand-filled mattresses, was to preserve the levee and prevent inundation from Ekole Creek. However, after the construction, the inability of the drainage of rain water from Otuokpoti into the Ekole, caused a severe flooding in the settlement. In response to this, the then Rivers State government commissioned the Institute of Flood, Erosion, Reclamation and Transportation (IFERT) and **Zinkcon International bv** to embark on geotechnical and hydrographic investigations so as to harmonize drainage in the shore protection scheme.

The second major threat to structures on the floodplain is that of inevitable inundation by floods of long return periods. On Fig. 4 (shown earlier on), the return periods determine the flood magnitudes as well as the extent of the floodplain that can be inundated. The longer the return period, the more the extent of the floodplain expected to be under flood. In other words, the return period can be used as a morphological guide for dividing the entire floodplain into zones. On the floodplain, the risk decreases as one gets farther away from the river channel. Human activities that are less capital intensive and less permanent (such as agriculture) can be sited closer to the river channel while those that are more capital intensive and permanent (such as urban and industrial structures) should be sited farther off the river channel.

Human activities on floodplains can be consciously regulated through flood modelling which gives a scientific account of flood generating mechanisms. In this regard, Hillsdale County (2008) recommends the 100-year floodplain as the acceptable limit for development involving heavy capital outlay. In the process of development control, land use regulators can use heavy taxation and outright force to make developers site their structures in the appropriate zones of the floodplain.

From the above, it is clear that in most developing countries, human activities on the floodplain are not meaningfully regulated. Different land uses, whether capital intensive or not, are littered on the floodplains. To make matters worse, analysts are yet to cross-match long-term rainfall data with possible areas of the floodplain that can be inundated by rainfalls of different magnitudes. Not only that the data base is lacking, there is apparently little or no land use regulation on our floodplains. Land uses are simply sited at random and the implication is obvious. Any time a rainfall of longer return period occurs, the channel capacity will be exceeded and the extent of the floodplain to be flooded will depend on the magnitude of the flood generated. Again, due to population pressure and land scarcity, wetlands and other natural depressions that used to serve as natural sponge for evacuating surface drainage have all been reclaimed. In other words, all these structures on the floodplain are at the mercy of floods of long return period and it is just a matter of time.

The third major challenge waiting to engulf human structures on river-built sub-structures is sea-level rise due to global warming. It is a fact that is becoming more and more noticeable through a gradual and consistent rise in global temperatures. The implication is that much water is melting from high altitudes (such as mountain ice) and high latitudes (such as permafrost and ice-capped regions). This rapid melting is not only re-drawing the snow-line but is also adding to the volume of water in the ocean which will obviously end up re-drawing the coastline through coastal submergence. Once ocean water moves towards the continent, in addition to flooding adjoining coastal zones, much water will enter through the river mouths and subsequently inundate the floodplains.

From the above, we can see that all human structures sited on our floodplains as well as those close to the coast are at risk. In addition to the excessive water let in by the river mouths from the oceans, global warming is also argued to have the capacity to cause more lifting up of water from the ocean storage in form of evaporation into the atmosphere leading to excessive rainfall that will again cause the channel capacity to be exceeded, hence ultimately inundating the floodplain. From all indications, the safety of human structures on river-built substructures will be an issue to worry about. If current projections are taken seriously, the sea water entering through River Thames mouth will definitely submerge the entire London, just like that entering the Seine (Paris), Rhine (Rotterdam), Zaire (Kinshasa) and Niger (Port Harcourt) will erase the respective cities from the map.

No matter how incredible and unrealistic the above picture may look, we should not throw caution to the wind and so we must start doing something to prove that we are the master of the environment. We must first study and map out our floodplains and identify safer zones for relocation or resettlement of people to be flooded out. This is the time to put the necessary infrastructure and technology in place and to also sensitize and educate floodplain dwellers to come to terms with the fact that living on the floodplain is like sitting on a keg of gun powder.

There is a lesson for us to learn from the Dutch who experienced a catastrophic flood during the spring of 1953. It occurred in the south western part of The Netherlands where the Ijssel, Rhine, Meuse and Schelde rivers empty into the North Sea. In that tragic incident, existing dykes were battered at more than 500 locations, flooding about 200,000 hectares of land, drowning 1835 people and 10,000 cattle and displacing 70,000 households (Heer, Geurtsen and Bijnsdorp, 2006). Following this experience, the Dutch built several dams and water gates around their coastline. These include the Oosterschelde dam and the Haringvliet dam which has a busy high-way running on its top (Plates 1 and 2). The height of the barrier is projected to withstand any abnormal rise in sea level, and the flow of sea water into the canals through the river mouths is now technologically controlled.

It is a fact that irrespective of the massive finances already invested in coastal protection in Victoria Island, Lagos, coastal flooding has not abated. It is clear that if we could not succeed in that small Victoria Island, recommending the building of The Netherlands type of wall along the coast and across the river mouths of the Niger Delta would be quite unrealistic. Since the use of expensive high technology gadgets to guard the mouths of our rivers is virtually beyond our capability, we should at least do something within our reach. For instance, we can carry out a beach nourishment programme where we raise the beach level by pouring tonnes of dredged sand so as to prevent the onslaught of longshore drifts. We can also use local ***chikoko*** mud to raise bunds along our coastline in addition to raising the naturally existing barrier ridges.

Plate 1: The Formidable Haringvliet Dam at the mouth of Rhine River, South-west Netherlands. (Note that the North Sea lies to the left side of this imposing structure; Shot was taken by the Author during a study trip in 2008).

Plate 2: The portion of the Haringvliet Dam indicating where the Rhine River empties into the North Sea (the Rhine River lies to the right side; the shot was taken by the Author during a study trip in 2008).

A good example is around the Bonny Island where the materials brought in by the Bonny River and other marine materials have been used to raise a natural barrier along the Bonny coast. More dredged materials can be added to raise this ridge and ensure that it is stabilized by vegetation. It will, to a great extent, protect the lower inland areas from flooding.

It is clear that there are three basic approaches for addressing flooding (ODNR, 2008): the first is to keep the flood waters away from human structures through different levels of technologies or interventions, the second is to consciously keep people and structures away from floodable areas, while the third is to reduce the cost of any flood that has already occurred through the development of a quick disaster response mechanism. In the case of the envisaged climate change-induced flooding, the magnitude of which may likely exceed the coping capacity of the technologies of the developing countries, the best option will be to start relocating from floodable areas well ahead of time. This is not beyond us, we can create growth centres or growth poles well outside the floodplains and assist developers with necessary infrastructures, facilities and enabling environments quite conducive and enticing enough as to pull great populations out of the floodplains.

If people find it difficult to move out of the floodplains due to inertia, the government can buy off their properties and resettle them on higher and safer grounds. This strategy was successfully tried in the city of New Orleans, where the US government bought an area liable to flooding (together with its 25,000 properties) and converted the area into a wetland to act as a sponge for natural drainage. People should be taught and compelled to recognize and steer clear from the floodplains, wetlands and other natural depressions which the rivers normally use to drain off excess water into the ground. Knowing what we are in the developing world, we recommend a combination of outright purchase, forced eviction and complete demolition of urban, industrial and other capital-intensive land uses on the floodplains.

In view of the fact that virtually all our floodplains and coastal plains are at high risk in terms of liability to flooding, it is advisable that a persuasive civic education, enlightenment and re-orientation programme be put in place. People living within a 100-year floodplain should come to terms with the fact that their homes will be inevitably submerged at the appointed time and that they still have the chance to move out of the danger zone before it is too late. Facts and figures in relation to increasing annual temperature and rainfall figures should be used to establish and demonstrate a causal relationship between rainfalls of long return period and high magnitude cyclic flooding. Through the media, public enlightenment and formal educational programmes, floodplain dwellers should be made to understand the reality of their imminent plight and that this is not a false alarm.

CONCLUSION.

Mr Vice Chancellor Sir, distinguished ladies and gentlemen, it is crystal clear that many Nigerians are comfortably reclining on highly precarious river-built platforms. Ironically, we appear to be comfortably relaxing and resting on a keg of gunpowder! It is also true that due to low technological know-how and near-absence of highly advanced technological infrastructures, we lack the capacity to cope with moderate floodplain and coastal flooding. Again, it is true that in most developing countries, our slow response to hazardous events such as flooding can eventually result to a disaster. ***If we raced with footmen and they have worn us out, how can we compete with men on horseback, if we stumble in a safe country, how can we cope with the swelling and flooding of Jordan? (Jer. 12:5).*** If we can be caught unprepared by moderate floods (such as that of 2012), then how can we cope with those of long return periods capable of flooding out entire cities?

Mr Vice Chancellor Sir, it is not my intention to paint a bleak, pessimistic and discouraging picture in relation to our use of river-built structures. We have clearly highlighted the dangers facing these platforms. An announced battle, they say, does not take a cripple unawares and similarly, a problem clearly identified is virtually half-solved. Being a developing country is not an excuse for us to be complacent while facing an imminent danger. The pronouncement of woe to them that are at ease in Zion by the Bible is an indictment on those who resign to fate and refuse to act when they should act. Therefore, in our own case, we should not fold our hands now and leave ourselves at the mercy of fate when the chips are down. This is the right time to think globally and act locally because little efforts by different individuals can cumulatively become significant in addressing an issue on hand.

We strongly believe that this is the time to face reality. This is the time to educate and inform our floodplain dwellers on the imminent danger that must surely come. This is the time to map the floodplain into zones in line with the different cycles of flood generating events. This is the time for our government to acquire or demolish properties or forcefully evict occupants from certain zones of the floodplain and designate such zones as natural drainage areas. This is the time to articulate resettlement programmes, identify higher and safer zones for re-location. This is the time to re-orient and re-condition the minds of the floodplain dwellers to accept to move up and farther away from the danger zones before being flooded out. Mr Vice Chancellor Sir, this is the time for man to co-operate with river systems so as to circumvent immanent and imminent hazards and to maximize the benefits derivable from river-built morphological platforms.

Thank you very much for listening patiently.

REFERENCES

Adebola, A.O., Adeseko, A.A. and Ibitoye, M.O. (2016): Drainage basin morphology and terrain analysis of the Nigerian section of Lake Chad River Basin, Nigeria using GIS and remote sensing. **Confluence Journal of Environmental Studies**. http:www.journalhome.com/cles.

Andrezejewski, K.D. (2015): **Historical Metamorphosis of the Arkansas River on the Kansas High plains.** Unpublished M.Sc. Thesis submitted to the University of Kansas.

Ayoade, J.O and Oyebande, B.L. (1983): Water resources. In: Oguntoyinbo, J.S, Areola, O.O and Filani, M. (eds.): **A Geography of Nigerian Development**. Heinemann, Ibadan. pp. 71- 88.

Bell-Gam, W.I. (1988): **Land Reclamation and Environmental Management: A Guide for Policy-Makers, Earth Scientists and Developers.** Sterling Publishers, New Delhi.

Blair, T.C. and McPherson, J.G. (1994): Alluvial fans and their natural distinction from rivers based on morphology, hydraulic processes, sedimentary processes and facie assemblages. **Journal of Sedimentary Research.** Vol. A. 64, No. 3 pp. 450-489.

Cakaric, J. (2010): Water phenomenon – urban morphology transformation. **Architecture and Civil Engineering.** Vol. 8, No. 4 pp.375-388.

Chin, A. (2006): Urban transformation of river landscapes in a global context. In: James, L.A, Marcus, W.A. (eds.): **The Human Role in Changing Fluvial Systems.** Elsevier.

Haas, T.C, Blum, M.J and Heins, D.C. (2010): Morphological responses of stream fish to water impoundment. **Biology Letters.** Vol. 6, pp.803-806 doi:10.1098/rsbl;2010.0401.

Heer, R.J, Geurtsen, G.H and Bijnsdorp, H. (2006): **Southwest Netherlands: Field Trip to the Delta Works.** UNESCO-IHE Delft.

Hillsdale County (2008): **Hillsdale County Community Centre.** htt://www.hillsdalecounty.info/planning.edu 0010.asp.

Ibisate, A, Ollero, A and Diaz, E. (2011): Influence of catchment processes on fluvial morphology and river habitats. **Limnetica.** Vol. 30, No. 2 pp.169-182.

Karatas, A and Ekinci, D. (2014): Interpretation of the morphological characteristics of Sehir Creek basin (Ispir) regarding fluvial geomorphology and regional tectonics. **Procedia – Social and Behavioral Sciences.** Vol. 120, pp.576-585.

Knighton, D. (1984): **Fluvial Forms and Processes.** Edward Arnold, London.

Knox, J.C. (1977): Human impacts on Wisconsin stream channels. **Annals of the Association of American Geographers**. vol. 67, pp.323-342.

Liu, C.C and Tsai, C.W. (2015): Identifying the morphological change of a natural river using the Hilbert Huang Transform (HHT) method. **Geophysical Research Abstracts.** Vol. 17, EGU 2015-13287-1.

Miwa, H, Daido, A and Katayama, T. (2006): Effects of river bed degradation on transformation of alternate bar morphology. In: Parker, G and Gaecia, M.H. (eds.): **River, Coastal and Estuarine Morphodynamics.** Proceedings of the 4th IAHR Symposium on River, Coastal and estuarine Morphodynamics. Urbana, Illinois, Oct, 2005. Taylor and Francis.

Montgomery, D.R and Buffington, J.M. (1997): Channel-reach morphology in mountain drainage basins. **Geological Society of America, Bulletin.** vol. 109, No. 5, pp. 596-611.

Montgomery, D.R and Buffington, J.M. (1998): Channel processes, classification and response. In: Naiman, R.J and Bilby, R.E. (eds.): **River Ecology and Management: Lessons from the Pacific Coastal Ecoregion.** Springer-Verlag, New York, pp. 13-42.

Moore, W.G. (1981): **The Penguin Dictionary of Geography**. Penguin Books, Harmondsworth.

Mouri, G, Shiiba, M, Hori, T and Oki, T. (2011): Modelling reservoir sedimentation associated with an extreme flood and sediment flux in a mountainous granitoid catchment, Japan. **Geomorphology.** Vol. 125, Issue 2, pp. 263-270.

Odemerho, F.O. (1992): Limited downstream response of stream channel size to urbanization in a humid tropical basin. **Professional Geographer.** Vol. 44 (3), 332–339.

Ofomata, G.E.K. (2009): **Basic Geomorphology for Africa.** Jamoe Publishers, Enugu.

Ortega, J.A, Razola, L and Garzon, G. (2014): Recent human impacts and change in dynamics and morphology of ephemeral rivers. **Natural Hazards and Earth System Sciences**, vol. 14, pp. 713-730. www.nat-hazards-earth-syst-sci.net/14/713/2014/doi:10.5194/nhess - 14-713-2014.

Pitty, A. F. (1982): **The Nature of Geomorphology.** Methuen, London.

Renwich, W.H. (1992): Equilibrium, disequilibrium, and non-equilibrium landforms in the landscape. ***eomorphology*,** 5: 265–276.

Schumm, S. A. (1977): **The Fluvial System.** John Wiley, New York.

Schumm, S.A. and Meyer (1979): Morphology of Alluvial Rivers of the Great Plains. In Riparian and wetland habitats of the Great Plains: **Proceedings of the 31st annual meeting, Great Plains Agronomy Council Publication** 91, 9-17.

Sewell, W.R.D. (1969): Human response to floods. In: Chorley, R.J. (ed.): **Water, Earth and Man: A Synthesis of Hydrology, Geomorphology and Socio-economic Geography.** Methuen, London, pp. 431-451.

Stepinski, T.F and Stepinski, A.P. (2005): Morphology of drainage basins as an indicator of climate on early Mars. **Journal of Geophysical Research.** vol. 110, E12 S12, doi:1029/2005JE002448, 2005.

Tan, C, Huang, B, Liu, F, Yang, Q, Jiang, C and Zhang, S. (2016): Transformation of the three largest Chinese river deltas in response to the reduction of sediment discharges. **Journal of Coastal research.** vol.32, Issue 6, pp. 1402-1416.

Umeuduji, J.E. (1994): **Analysis of Topological Characteristics and Drainage Parameters in the Aboine Basin of Nigeria.** Unpublished PhD Thesis, University of Nigeria, Nsukka.

Umeuduji, J.E. (2000): **Principles of Fluvial Geomorphology.** Jodigs and Associates, Minna.

Umeuduji, J.E. (2010): **Drainage Basin Dynamics.** Emhai Books Port Harcourt.

Umeuduji, J.E. (2012): Contending with poverty on the scarp lands of Eastern Nigeria: the case of Aguata region.

Journal of African Contemporary Research, vol. 7, No. 1, pp. 133-139.

Umeuduji, J.E. (2015): Managing Fluvial Dynamics and Environmental crises in Nigeria. **Journal of Nigerian Environmental Society.** vol. 9, No. 1, pp. 153-158. www.jnes.org.

Umeuduji, J.E. (2017): **An Introduction to the Science of Landforms.** 2nd ed. Jodigs, Minna.

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INTRODUCTION:
It was exactly on the 12th of March, 1962 that Prof. Joel Ekwutosi Umeuduji was born to late Nze Okpalanwa Umeuduji and late Mrs. Deborah Umeuduji (Nee Ezeugo) both from Nkpologwu in Aguata L.G.A. of Anambra State. By providence, he is the third child out of four surviving children.

EDUCATION:
He started his educational journey in 1970 from the Kindergarten just immediately after the Nigeria/Biafra civil war. From 1971 to 1976 he attended Community School, Nkpologwu. In 1976, he was among the second set of students who entered Uga Boys' Secondary School, Uga which he left in 1981 with nine credits at a sitting. In that same 1981, he entered the University of Calabar, Calabar and came out with a B.Sc. (Hons, 2/1) in Geography and Regional Planning in

1985. After his NYSC, he proceeded to the University of Nigeria, Nsukka and came out in 1988 with an M.Sc in Geomorphology. He secured an admission to the University of Cambridge for a Ph.D programme but unfortunately, could not take it up due to financial reasons. As a result, he went back to the University of Nigeria, Nsukka the following year and started a tortuous and hectic Ph.D in Fluvial Geomorphology which was completed in February, 1994. As an icing on his qualifications and as if to compensate for the missed Cambridge opportunity, The Netherlands Fellowship Programme in 2008 granted him an opportunity to go for a fully funded post-doctoral short course on Watershed and River Basin Management at the UNESCO-IHE, Delft.

WORKING CAREER:

During his mandatory NYSC in 1985, he taught at Government Secondary School, Ningi (Bauchi State). From 1988 to 1993, he took up a teaching appointment at Community Secondary School, Akpo (Anambra State) to support himself during his Ph.D. programme. During both periods, he consistently taught English Language in addition to his regular Geography and related subjects. He joined the services of the University of Port Harcourt in November, 1993 as an Assistant Lecturer, became a Senior Lecturer in 2000 and headed the Department of Geography and Environmental Management from 2003 to 2005 and from 2012 to 2014. He was promoted to the Readership rank in 2010 and finally became a Professor of Fluvial Geomorphology three years later.

ACADEMIC ACTIVITIES:

For over two decades, he has taught his undergraduate and postgraduate courses with utmost dedication and in 2010 the students of his Department awarded him the best lecturer of the year. He has supervised over 120 B.Sc. projects, over 30 M.Sc. dissertations and 3 Ph.D. theses. In terms of publications, he has co-authored one book, written four books and published over forty works (including chapters in books and journal papers) together with several workshop and conference proceedings. During his second headship outing, he was able to bring his colleagues together to package a programme that secured a full accreditation for the very first time since the inception of his Department. He served as the Associate Dean of the Faculty of Social Sciences from 2015 to 2016. He served in the committee that drafted the General Regulations and Statement of Academic Policies for the University of Port Harcourt in 2016 on behalf of Senate and he is currently serving in SCAPP. Also, he currently serves as Chairman of the Graduate Result Verification Committee on behalf of the Board of Graduate School. In 2002, his teaching activities took him to Abia State University, Uturu where he was on sabbatical leave and again to Osun State University, Osogbo in 2014 for the same purpose where he briefly served as the Director for the Centre for Climate Change.

He was the National Assistant Secretary for Environment and Behaviour Association of Nigeria (EBAN) from 2002 to 2008. He also belongs to the Association of Nigerian Geographers (ANG) – the umbrella body of academic and professional geographers in Nigeria. From 2005 to 2013, he served in the Professional Ethics Committee – a body that promotes good ethical conduct by staff on behalf of Senate. He was an external examiner to Imo State University, Owerri (2006 to 2008) and University of Nigeria, Nsukka (2004 to 2006 and 2016 to date) at both undergraduate and postgraduate levels and Ignatius Ajuri University of Education, Port Harcourt (2018).

SOCIAL SERVICES:

During his undergraduate days, he served as Treasurer/Financial Secretary for the Student Christian Movement (UNICAL Chapter). In his Village, he served as the Secretary to Isioji Improvement Union. Here in the University of Port Harcourt, he served as the Secretary to ASUU Co-operative (2007 to 2010) and for two terms as the Secretary to Our Saviour's Chapel Management Council (1998 to 2001) where he is currently a member of the Board of Trustees. He is a down-to-earth, happy family man. His marriage to Mrs. Nkechi Umeuduji is blessed with Amarachi, Chike, Chiagbanwe and Chiamaka.

CONCLUSION:

Distinguished ladies and gentlemen, I present to you this simple, down-to-earth, silent achiever; this erudite, grammar-conscious scholar and this quiet Fluvial Geomorphologist – Professor Joel Ekwutosi Umeuduji to deliver the 155th inaugural lecture of the University of Port Harcourt.

Prof. Ndowa E. S. Lale.

Vice Chancellor,