CAUSES AND IMPLICATIONS OF RIVER/STREAM EROSION

(A CASE STUDY OF RIVER BOSSO)

BY

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CERTIFICATION

This Thesis has been read and approved as meeting the requirements for the award of a Postgraduate Diploma in Environmental Management Federal University of Technology, Minna.

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Dedicated to Abdullahi Baba Umaru Doggi and Dr. Usman M.T.

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ABSRACT

River/Stream erosion occurrences have become very common with increasing incidences both locally and globally and equally increasing losses to property. Damages include those to crops, livestock, buildings, and socio-economic infrastructure.

Today, large segments of the global human family living along low-lying coastlines and along river and stream courses, are under a constant threat of River/Stream erosion.

The Bosso stream is not exempt from this. Measurements taken at 7 serious bed and bank erosion points along unchannelized sections reveal that more than 150,000m^3 of soil has been lost. Changes over a four-year were also ascertained and they show intensification in erosion processes. The implication of these have been discussed. Suggestions have also been given as to how to solve them.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND

Most river channels are bordered by a relatively flat area or valley floor. When the water fills the channel completely, its surface is level with flood plains or many overflow its bank. The flat floor of a valley is constructed by the river during lateral migration and by deposition of sediment.

At first, the river occupies position on the river channel. Through time the river/channel moves laterally by erosion on one bank and simultaneous deposition on the other. Throughout this process of lateral movement the channel could not maintain its width and depth. With continuous deposition, a new flat land is built at that level as it moves laterally and the flat channel is the most direct evidence of lateral migration.

If there is a change in climate or a change in water channel, condition by grazing, urbanisation or other influences, the river may change its level. The stream acts down or builds up because there is a new relation between research and sediment production.

The flood plain is frequently flooded causing erosion as a natural attribute of rivers and is indeed part of the river not under storm conditions, the river channel flowing full has a special significance from the fact that at higher flow, water spills out of the channel and over flows the flat lying land near the river. The river does not construct its channel enough to accommodate the highest discharge overflow increasing the erosion of the river/stream.

This, not withstanding, it is human activities on the flood plains of a river/stream that account for the majority of flood damage. Ordinarily, overflowing water especially rare events could be destructive to plants and animals thereby disrupting ecosystems. Human related losses however, occur only when human activities over time and space attempt to obstruct a free flow of water. Ironically, river/stream bank provides fertile agricultural lands and enable the pursuit of other socio-economic activities.

This often necessitates human habitation on the bank, it is noteworthy in the light of this that rivers/streams have historically provided the basis for siting human settlements. The challenge of protecting human lives and property should lie with planners whose responsibility it should be to strike that balance between human exploitation of rivers/streams and human safety. The pre-requisite to achieving this balance is, without doubt, an understanding of the rhythm of the river/stream in question.

1.2 PROBLEM STATEMENT

River/stream erosion has been an environmental hazard for a long period. This usually causes a lot of damage to properties, agricultural lands, villages and even service roads.

For Bosso river channel, erosion occurs during the wet months especially during the peak of the wet months. Human activities as well as natural causes on the flood plain alter some aspect of the hydrologic cycle with some concomitant effect on the water collecting in the channel system. The drainage network, being an interconnected system can pass on a variety of effects to places for distant from the location where the change were made.

Change made on the landscape alter the timing and amount of water flowing especially flood flows and low flow conditions over time. These also affect shape and instability especially because changes of the latter kind are delayed and off-site and may have unwanted often costly results.

Today active stream bank erosion is evident along unchannelized section. The effects have included threat to buildings and agricultural lands especially orchards. The trend is towards increasing erosion and soil loss. Without proper understanding, the losses are bound to accumulate.

1.3 AIMS AND OBJECTIVES

This project aims at analysing factors in Rivers/Stream erosion and strategies for effective management.

Specific objectives

- To estimate the extent of soil loss due to erosion
- To identify human factors responsible for the erosion
- To determine the rate of erosion area over a five-year period (1995-1999)

1.4 JUSTIFICATION

This project intended to provide a framework on which river/stream erosion can be estimated. Scarcity of land has necessitated the use of river/stream erosion areas for construction and agricultural activities by man. This interference results in erosion which causes the flood plains to become filled up with water resulting in the destruction of buildings farmland, road and other structures. This study will therefore focus on the River/Stream erosion and strategies for effective management of inhabited portions of a river/stream erosion site so as to serve as a basis in the planning of erosion prone areas.

1.5 STUDY AREA

The Bosso river takes its name from Bosso, one of the ward in Minna. It has its source upstream of Bosso dam and descendents in South West direction. It flood plains are extensive and alluvial. The River also cuts through the Federal University of Technology, Minna before descending towards Kpakungu area through Dutsen-Kura.

1.5.1 GEOLOGY

The channnel within the study section is underlain by extrusive igneous rocks and which dip in a South-West direction. Its flood plains are extensive and alluvial.

1.5.2 CLIMATE

The temperature of the study area varies from one season to another season. The mean annual temperature ranges between 25° to 29°. The relative humidity varies considerably between 265.80% in July and 22-45% in January. Rainfalls normally between the months of April to October and ranges between1000 to 2500m and between November to march ranges between 0-350mm.

1.5.3 VEGETATION

The area lies within the tropical Savannah woodland which consists of orchard bush. "The major vegetal cover types are trees, shrubs and grasses. Some of the trees include mango, cashew and guava. They forms covers and attain heights of about 9.13 metres. Underlying these trees are the park like grasses and sparsely populated shrubs or non-farms areas. During the wet season, the grasses sprout and grow rapidly. The elephant grass for example grows to between 3.5 to 4.5 metres". Most of the fruit trees grew wildly through periods in the past when interference was little or absent.

1.6 SCOPE AND LIMITATION

The River/Stream takes its source from Bosso Dam. Data utilized was limited to unchannelled to River sections. Thus, this study is limited to a stretch from a point outside the police headquarters. The result as displayed and discussed do not therefore have any implication beyond Bosso River.

Influence could be drawn from the study about similar events elsewhere within the same geo-environmental area but condition is advised. The unavailability of data prevented the spatial extension of this research effort.

CHAPTER TWO

LITERATURE REVIEW

2.1 SIGNIFICANCE OF RIVERS/STREAM

By an original usage, a river is flowing water in a channel with defined banks. Modern usage of rivers are multi-channeled, intermittent or ephemeral in flow and channel that are practically bankless. The New Enc. Britannica vol. 26 page 843.

However, the word stream emphasises the fact of flow synonymous with river. Rivers are nourished by precipitation, by direct overland runoff.

At various intervals of history, rivers have provided the easiest, and in many areas the only, means of entry and circulation for explorers, traders, conquerors, and settlers,

The urban stream/rivers is so important for numerous contributions to human usage. Akinyeye, (1999) suggests river water flows in the channel and are used for domestic purposes.

A river basin is all of the land surrounding and drainage into a stream river (Adejumo, 1978). Large rivers basins are made up of smaller river basins while each of the smaller river basins is an aggregate of numerous streams and streamlet basins (Jeje, 1986) (Adejuwon, 1978).

Conceptually, the river basin is a specific segment of the earth's surface, a set off from adjacent segments by a more less clearly defined boundary.

Halilu, (1999) Drainage basin is dynamic feature that is in influenced by sedimentation.

Sediment moving near the bed concentrates near the convex bank and tends them to be deposited (Leopold 1974)

Meander bends of a river are neither semicircular nor sinusoidal river meander rather than flow straight the meandering up pattern is a closer approach to minimum uniformly distributed work than are alternative shapes. (Leopold and Langbeim 1966).

The inner valleys of some great alluvial contain the sites of ancestral permanent settlements including pioneer cities. For instance, similar settlements in the Tigris – Euphrates and Nile valleys. The first settlers are thought to have practised a hunting economy, supplemented by harvesting of wild grain on the flood plain. Conversion to the management of domesticated animals and cultivation of food crops provided the surpluses that made possible the rise of towns.

The influence of climatic shifts on these prehistoric communities has yet to be worked out satisfactorily. In desert environments, increased dependence on the rivers may have provided as much as matter of necessity as of choice.

All of the rivers have broad flood plains subject to annual inundation by rivers carrying heavy sediment loads. Prehistoric works of flood defense and immigration of demanded firm community.

Elaborate urban systems arising in Mexico, Peru, and the eastern Mediterranean from about 4000 BP onward were immediately dependent on the resources of rivers.

Where riverine cities did develop, they commanded ready means of communication. The two lands of upper and lower Egypt, for instance were unified by the Nile.

The relative importance of environmental and social deterioration in prehistoric hydraulic civilizations however, remains a matter of debate. Furthermore, defective design and maintenance of irrigation works promote the spread of malaria mosquitoes which certainly afflicted the prehistoric hydraulic communities of the lower Tigris – Euphrates valleys. These same communities also may have been affected by bilharziaris or schistosomiasis (blood fluke disease) which requires a specifies of freshwater snail for propagation and which even today follows many extensions of irrigation into arid lands.

Rivers in mediaeval Europe supplied the water that sustained cities and the sewers that carried away city waste and were widely used.

Western Europe history records the rise of 13 national capital on sizeable rivers and feeder streams.

The location of provincial and corresponding capitals is even more strongly tied to reparin sites, as can be readily seen from the situation in the United Kingdom, France and Germany. (Enc. Britannic vol. 26 page 844).

In establishing the relationship between stream situation and human sustenance Akinyeye (1999) explained that water flowing in river channels are used for domestic purposes; these may include, household consumption and community based water resource management; Thence cooking, washing, and daily and consumption of safe water.

In the study area it was observed that more than one of such activities was going on, giving a true meaning to community participation in stream water harnessing; though it flows a sequence of seasonality i.e. these activities are less engaged upon in severity during the dry season, when there is recession of water volume in the channels.

However, at the peak of the raining seasons when discharge is colossal in water volume; floods are experienced. These flood are, according to Adejumo (1978) equally harnessed by the watering systems of domesticated animals and the subsequent deposition of the rich alluvial soil are harnessed for agricultural production.

2.1.2ENVIRONMENTAL PROBLEMS ATTENDANT ON RIVER USE

The ever-increasing exploitation] of rivers has given rise to variety of problems.

Extensive commercial navigation of rivers resulted in much artificial improvement of natural channels example Suez Canal (Egypt) Panama Canal (Panama).

In some cases, the lowering of the river bottom has caused the water table of the surrounding area to drop which has adversely affected agriculture. (Enc. Britannica, vol. 26 page 844).

Water pollution, pesticides and herbicides are now employed in large quantities throughout much of the world. The widespread use of such biocides and the universal nature of water makes it inevitable that the toxic chemicals would appear as stream pollutants. Biocides can contaminate water, especially of slow-flowing rivers and are responsible for a number of fish kills each year.

In agricultural areas the extensive use of phosphates and nitrates as fertilizers may result in other problems.

Urban centres located along rivers contribute significantly to the pollution problem as well.

Still another major source of pollutant is industry. Untreated industrial chemical wastes can alter the normal biological activity of rivers, (Enc. Britannica vol. 26 pg, 845).

Effects of vegetation on river bank erosion and stability

The influence of bank properties on channel geometry has been clearly demonstrated both in empirical studies (Charlton 1982, Andrews 1984, Bray, 1984 Hey and Thorne 1986)

Wiberg and Smith (1987) analysing the stability of a non-cohesive bank with respect to flow erosion.

However, for natural rivers, the practical application of analysis for non-cohesive banks are limited by the fact that most alluvial banks materials exhibit some cohesion. Due to presence of silt and clay fraction.

Cohesive bank material is used usually eroded by the detachment and entertainment of aggregate or crumbs of soil. The motivating forces are the same as those for non-cohesive banks but resisting forces are primarily the result of cohesive bonds between particles and aggregates. The bounding strength and hence the bank's erosion resistance depend on the physico-chemical properties of the soil and the chemistry of the pore and eroding fluids (Arulanandan, Gillogley and Tully 1980).

Freezing of soil moisture can seriously reduce erosion resistance, demonstrated by Lawler (1986).

Flow erosion, a great deal of sound theoretical and empirical work on vegetation and flow resistance has been undertaken by Nicholas Kouwen at the University of Waterloo, Canada Kouwen, 1970, Kouwen and Unny, 1973; Kouwen and Li, 1979; Kouwen, Li and Simons, 1980. This has shown that the extremely complicated nature of flow over a vegetated surface precludes a complete mathematical description based on the physics of flow.

Reduction of Soil erodability

Compared to an unvegetated or fallow state slopes covered by a good stand of close-growing vegetation experience an increase in erosion resistance of between one and two orders of magnitude (Carson and Kirby, 1972; Kirby and Morgan, 1980).

Bank stability:- The impact of vegetation on slope stability has been the subject of careful and sustained research by Donald Gray at the University of Michigan (Gray, 1978; Gray and Leiser, 1983; Gray and MacDonald, 1989).

River banks constitutes a particular class of slopes in general, and in this context many of the findings from slope studies can be applied to river bank stability.

However, care must be exercised to take full account of the characteristics of bank erosion and failure when applying results and conclusions based on studies of other types of slope.

Bank Drainage:- Compared with unvegetated banks, vegetated banks are drier and much better drained. The better drainage of vegetated banks occur because of the more open structure of a soil penetrated plant root produces order of magnitude increases in bulk hydraulic conductivity (Thorne 1990).

Sources of stream flow:

The watershed, or catchment, is the area of land draining into a stream at a given location. Precipitation contributes to various storage flow processes. Channel flow is the main form of surface flow. Determining flow rates in stream channels is a central task of surface water hydrology. The precipitation which becomes stream flow may reach the stream by overland flow (Akinyeye, 1999; Horton 1933).

Hortonian overland flow occurs rarely on vegetated surfaces in humid regions (freeze 1972, 1974; Dune, Moore, and Taylor, 1975). Under these conditions, the infiltration capacity of the soil exceeds observed rainfall intensities for all except the most extreme rainfalls. Surface flow then becomes a primary mechanism for transporting storm water to streams.

Adjustment of a stream to its climate and geology takes place continuously, causing changes in slope, rate of sediment transport and channel configuration. Associations of stream organisation are established in harmony with this dynamic nature of the channel's physical conditions (Cummins, 1986, Vannote et al; 1980)

From either a biology or hydrological viewpoint, the characteristics of a stream are dependent on the downstream transfer of water, sediment, nutrient and organic debris (Petts and Foster 1985)

Progressive changes in temperature, stream width, depth, channel pattern, velocity, sediment load and in stream biota occur from headwaters to mouth. Vennote et al, (1980) hypothesize that the conditions gradient of physical conditions within a stream system results in a predictable structuring (a "continum") of biological communities.

Recent literature by Bencala (1984), Bencala et al, (1984), Fortner and White (1988), Triska et al, (1989), and White et al, (1987) has investigated the subsurface characters of streams.

The work brings out the point that the interstitial zones in stream beds are important in the storage of dissolved gases and nutrients, and that for ecological purposes, the stream a "boundary" may lie deep within the streambed. Triska et al (1989 b) define this boundary as the interface between groundwater and channel water.

There is no reason to draw the boundaries of a stream at the water's edge Cummins, 1985). It is preferable to consider the catchment area as the basic ecosystem unit. (Lotspeich, 1980; Moss, 1988), especially if it is extended in the vertical direction to include subsurface processes and considered over time.
Stream flow and ecology are both affected by catchment conditions. The catchment and the stream system are integrated; thus a change in one part of the system will be felt elsewhere (Morisawa 1985).

Changes in stream discharge and sediment loading caused by modification of a catchment re reflected in variations in the rate of sediment transport, channel shape and stream pattern (Boree, 1982).

Vegetation removal, as shown from five or logging or conversion from forest to pasture, can change the natural drainage system and the rate at which water and sediment runs off land surface. Road construction can be a major point source of sediment.

Urbanisation has a source of sediment effect on hydrology roads, perking lots and houses prevent infiltration, increasing total runoff and the magnitude of peak flow (Morisawa 1985).

Regulation, channelisation and catchmnet condition were all considered by Macmillian (198, 1987) in the development.

The state of the streams survey was a major collaborate effort of several water resources agencies to conduct an inventory of all rivers in Victoria. Australia (Mitchel, 1990). The 1986 study identified the current status of the stream for effective management,

The major controls on bank erosion remain unclear at present (Hasegawa, 1989, p.219), and this is reflected in the divergence of conclusions concerning the dominant mechanisms of bank retreat, as embodied in the following quotations:

Banks retreated primarily by mass failures of over heightened and over steepened banks (Little Thorne and Murphey, 1982 p. 1321)

The shearing of bank material by hydraulic action at high discharge is a most effective process, especially on non-cohesive banks and against bank projections. (Knighton, 198A p. 61)

The erosion of a (river) bank is not the result of erosion by high-velocity water, whether in a concave bank on a curve or in a straight section. Rather, for effective erosion to occur, the material must be loosened which in this stream is done by formation of crystals in winter (Leopold 1973, 1850)

Many authors argue that it is combinations of processes that are important (Hooke, 1979; Thorne, 1982; Lawler, 1987). Perhaps in view of the wide range of alluvial materials, riverine forms and hydroclimatic environments encountered, a variety of conclusions is to expected.

However, it is argued below that the following three factors also have to be considered when trying to disentangle competing hypothesis of process – dominance in river bank erosion systems:

1. Limitations of present field monitoring techniques
2. Temporal change in bank erodability
3. Downstream change in bank erosion processes

Limitations of present field monitoring techniques:

Nature of the problem

Considerable progress has been achieved in bank erosion process work through building and testing models of bank retreat rates in relation to spatially distributed hydraulic variables in meander bends (e.g. Pizzuto and Mackeln Diplas and Akiyama (1983) form of the St. Venant equation on the Brandywine Creek, Pennsylvania). Another route to explanation, though. Is through the temporal approach, in which short-term (e.g. individual event, monthly, or seasonal) changes in erosion rate at individual sites are interpreted in terms of temporal fluctuations in the stresses applied by the suspected influential variables (e.g. Hooke, 1979; Kesseal and Baumann, 1981).

One major problem with the latter methodology at present however, is that no automatic, quasi-continuous, erosion monitoring technique has been available to quantify the erosional and depositional impact of each event that affects the site. Existing methods of field monitoring (Thorne 1981) and Lawler (1991) for reviews are based on some form of manual resurvey method (Hudson, 1982; Pizzuto and Meckelnburg, 1989).

Human activities dependent upon streams/rivers.

2.2 The desire of any human community ---- on the environment is in its

sustainability in utilizing maximally what resource they can harness from their surrounding.

Thus, in truth of the many resources that are of primal importance to man, water (in any format of stream, rains, snow, sea etc) plays substantial role in the continued inter-relationship between various levels biotic realm particular at the instant of tropic level of food chain.

Hence, amongst the many human activities so intricately connected to sustenance of civilization is the area of agricultural production. This encompasses the idea of both crop production and animal husbandry. Guni 1995 suggested this drought and crop production.

The majority of inhabitant of the tropics dwell in the Savannah, Adefolalu 1985, and thus are rural settlers whose main pre-occupation is farming. They produce the bulk of the consumables food materials to the utility of flowing streams especially during the dry season, on irrigational procedures and system of production. Thus, they produce though small scaled but in droves and bulks and as such sustaining the population.

This practically is more into fruition when there is little or no observance of drought episode. It is observed that after drought year of 1968/84 agricultural lands in Borno state never recovered their desired level of productivity (Gumi 1995).

Other likely occupational tendencies of human settlement lies in arts and crafts. They include traditional artisans ware of metallurgy and pottery. Thence is smitting e.g. in the old Benin empire, moat were constructed both for fortification of the defence systems and in channeling water inlets through to smitting compound in cooling down molten metal. And in deposition, is the alluvial clayey deposits which is the then used for pottery these is facilitated by slow moving stream on flood plains.

However, modern trends of substituting adobe burn brick is in the casting of cement hardened blocks so into construction of drilling quarter both for man and animals.

Another human activity dependent on streams is domestic consumption. Water treatment plants are priority to different localities both government supplied and/or run entirely on the edifix of NGOs. Hence cooking, washing and drinking water are located before being finally distributed to consumers. Others areas includes fire fighting, beautification procedures as in holiday resorts and tourists attraction. People and the plant magazine page 9-10 vol. 8 No. 4 The ecology of hope for the millennium 1999.

2.3 The effects of erosion and flood

These are a combined characteristics of varying degrees of the same seasonality. Floods are a result of surface run-off (Wister & Brater 1959) which fills up the stream channel and hence over flow its banks (Saidu 1998). The turbulence in the flow is strong enough to dislodge particulars from the bed and banks of the channel hence deepening further the cause way creating huge gullies (Umoh 1999)

The resulting effects are seen as indicated by Guni 1995) hence low crop production and animal husbandry.

The occurrence and expansion of gullies results to diminution of cultivated lands, changes in topography and hydrology. This can be seen already in the case of Bakolori dam area (Baba, 1999).

The aggregative multiplier effects of flood and erosion does not only stop of degradation of the environment but equally embraces the destruction of lives and property worth much in magnitude in reference to money, effort and time. (Saidu, 1998).
This was however blamed on improper land use and settlement pattern which regrettably are unplanned (Abubakar 1993).

2.4 The River/Stream Flood Control

Tropical Africa had had consistence of two prominent environmental hazards associated with rainfall, these are drought and flooding. Drought episode of some years back has had a cyclical orientation with an accompanying flood episode (Adefolalu, 1985).

Unfortunately however, all that are ever highlighted are the empty rhetorics at alleviating the destroyed human lives and settlement (Adefolalu 1985).

However, in stream/river flood control, communities so affected, have initiated thróugh some corporate participation and private participation, technologies and/or schemes to help sustain the stream channels and hence the environment.

Amongst the many techniques of flood control includes Terracing. Terracing involves the stepping of strong river bank to create a broader gentler river bank whose instance can be supported by the seasonal flow of stream channels. This is buttressed by river rejuvenation.

River embankment too can be engaged upon where some bags are placed around areas of possible over flooding at river bank or areas liable to flood to forestall or initial causeaway of the channel.

Over the banks at the shore cover cropping is another technique used to break the velocity of streams that have over flown their natural channels. These embankment though natural would have their regenerative tendencies attached to deposition during flooding of fertile alluvial soil on the shore and banks of the rivers.

However, government can enforce laws at the primal stage. This is in legislation against dumping of refuse at the causeway of streams and rivers. This entails firm enlightenment on environmental consciousness and in the events of rubbishing the law the culprit should be made to face the consequences.

CHAPTER THREE

3.1 DATA DESCRIPTION

Data used in this study were of the following types:

(i) Measurements of dimensions of major bank and erosion sites taken in 1994 and 1999. The seven (7) major sites existing as at 1994 and about which data exists in literature, were visited. Just as in the previous case, the lengths(L), Breadth (B) and Heights (H) of the erosion sites were taken in metres using a tape.

(ii) Existing literature on the channel.

(iii) Photographs acquired during field work

(iv) Responses from some stakeholders during oral interview.

3.2 DATA ANALYSIS

The volume of soil lost to erosion as at 1999 estimated by L x B x H. the results in m^3 for all the sites were tabulated and compared to those of 1994.

The volume of soil lost between 1994 and 1999 was ascertained by taking the difference between the two data sets.

The result obtained were then related to human activities to establish causes and consequences of observed patterns. These formed the basis of the conclusion and recommendations.

Photographs acquired have been used to illustrate the activities and implications mentioned herein.

CHAPTER FOUR

4.1 PRESENTATION AND DISCUSSION OF RESULT

The aim of this study was to find out the degree to which factors in rivers/stream erosion and strategies for effective management – a case study of river Bosso. It was hoped that the study would promote further research into problems of river/stream erosion in Bosso. Population around river are badly managed the lands and in the process turned hectares into erosion sites and waste-land in a few years. There has been a disruptive in river regimes and these induced in the process, river bank erosion and in certain instances, the death of the rivers and streams.

Factors of splash and run off erosion set in as there were changes in surface topography and loosen the topsoil around the settlement in the process of construction or related activities resulting in deep gullies.

This study addresses the problems of rivers/streams erosion and strategies for effective management in Bosso in order to achieve the objectives of this study, the nature of the problem in terms of the causative factors, present and potential impacts, trend and solution need to be highlighted.

Certain questions needed to be asked. What is river/stream erosion in the study area context?

Stream/River flow erosion is the rate of water in cubic metres per second (m^3/s) along a defined natural channel (Maidmentand, 1992).

Stream/River erosion is the ability of running water to loosen soil particles to carry them away. According to the study, stream/river erosion is generated by a combination of base flow return flow from ground water. Rapid flow through macrophores and seepage zone in the soil and saturated overland flow from the surface of poorly permeable or temporarily saturated soil. It is perennial and intermittent as well as it is the characteristics of the study area.

Erosion increases as water velocity increases where resistance of the run-off declines, that is for smooth soil surface. In other words, the amount of erosion which occurs depends on the force with which the water acts upon the soil and the degree to which the soil can resist this force. Where stream water collects, the scouring action of the water is greater and rills may be formed there. This becomes bigger through collapsing of the side walls and scouring until a gully several metres deep is formed.

The Bosso river has witnessed a lot of changes as a result of and out-channel uses. The drainage or water channel constructed between the years, 1990 and 1991 cover only two small sections of the length stream passing through the town, the sections are: the University of Technology, Minna and the Police Headquarters in Dutsen-Kura also in Minna.

4.2 CONSTRUCTION:

According to the study, the Bosso river flood plain has experienced a good number of developments as regards building. The people who comprises of various ethnic groups construct their houses very close to the rlver channel itself or flood plain. Research has shown that the flood of 1986 was so devastating that virtually all the buildings on the flood plains were destroyed. This was an experienced of barely 10 years ago and people are occupying the flood plains once again. The buildings could be under serious threat when the floods of higher magnitude are experienced. The great disaster of 1986 even necessitated assistance from disaster relief fund. There are other structures that were constructed either very close or on the river channel. The Federal University of Technology, Minna wall constructed in 1984/85 along the channel also collapsed the year after. Some few metres downstream, some buildings are being threatened, if no measures are taken, these buildings can give way any time rainy season sets in. the Okada bridge is also under threat simply because of the extraction of the sand deposit at the bridge site. Some trees have been brought down as a result of the erosion and some could be seen tilted or bent.

These also exists extensive evidence of economics activities one of which is agriculture. Agricultural activities seem to be prominent among these various ethnic groups along the floodplains or channel. There is no complete two hundred metres stretch of the channel that is not being used for dry season farming. Methods of farming are mostly traditional and with very little knowledge of using fertilizers. Perishable crops are grown on the flood plains during the dry season, the exception of this is the portion within the University.

Upstream of Bosso bridge, there is a dry season farm where spinach and other vegetables are grown. At the point where the drainage in the University terminates, there are lots of dry season farms spread along the channel down to Dutsen-Kura extending to Kpakungu. These dry season farms are either located on the flood plains or even on the River channel itself since the river is now virtually seasoned.

The dry season farmers now use the effluent or domestic water discharged into the river channel for irrigating their crops. This is done form of construction of ridges of barrages to store the discharge. The yearly cultivation of the stream bed usually weakens the soil and makes it loose for easy transport by water. This in essence means that the stream channel will continue to widen and deepen.

4.3 CHANNELIZATION

The clearing and straightening of a stream to improve water conveyance is termed channelization. This usually increases channel slope and this velocity and sediment transport capacity, which causes scouring in some sections and sediment deposition in flatter sections downstream. Higher peak flows also inevitably occur downstream. Sediments increase temperatures and lower organic nutrients for biota. Water tables are also affected.

The channelization work of Bosso river which cuts across the Federal University of Technology, Minna was completed in 1991. Before the construction a gallery forest dominated the course of the channel but was cut down and the ground surface left bare.

Since the surface of the channel has become impervious, water cannot infiltrate and percolate into the ground therefore runoff is generated. The velocity of the flooding river is also increased, thereby causing destruction downstream of the channel. This destruction takes the form of bed and bank erosion which widens the river channel.

A lot of suspended sediments are deposited at the convex part of the channel during heavy storm. The deposited sediment accumulate to such an extent that they favour the growth of vegetation. It forms a kind of obstruction to the flow of the water.

Generally, therefore, the channelization work has caused an increase in run off which has caused more erosion downstream. The agricultural and construction activities have reduced the volume of flow from perennial to seasonal. The only source of flow during the dry season is the domestic water discharge. Most of this discharge presently comes from the student hostels and the cafeteria of the Federal University of Technology, Minna. The health implications of using waste water dry-season farming are better imagined.

Unless the channelization is completed for the entire course of the stream within the town, severe erosion is bound to continue along exposed banks. As highlighted earlier, the removal of vegetal cover on the banks coupled with farming and construction activities, exposes the soil to agents of erosion. The sediments washed into the channel by run off, add to the erosive ability of the stream water. An urgent need therefore exists fashion out a perfect balance between farming practices on the conservation of vegetal as well as land resources. Buildings should be discouraged as this exposes the occupants to risks associated with collapse of structures and flooding.

4.4 ESTIMATES OF SOIL LOSS DUE TO EROSION

Measurements were taken at 7 points where active erosion is presently occurring to ascertain the quality of soil scooped away or lost. The data is shown in table 2 and plates 1-15 show scene during field survey.

Table 1 shows measurements of the dimension of 7 erosion sites along the channel as obtained in 1994 by Usman and Abubakar (1994). Total soil loss then was 55481.98m^3. measurements of the dimensions of the same erosion sites in 1999 are shown in table 2. The largest magnitude change occurred at point 1 along Awwal Ibrahim road (which is the sight with the most intense human interference) where soil loss increased from 9812.67m^3 to 42586.5m^3 in 1999. Interestingly, the point with the least volume of soil loss in 1994 also had the least in 1999. This was because the sediment deposit in these central portions are largely inaccessible to collectors who derive tippers directly into the channel. Thus, the deposits have encouraged vegetal growth which have helped to stabilize the erosion sites.

On the whole, an estimated total of 149444.41m^3 of soil had been scooped away by 1999. Thus, between 1994 and 1999, soil lost to erosion was a staggering 93962.43 m^3. This represents reduction in agricultural potentials.

Something that river bank cultivation was originally meant to promote. Perhaps the accumulating losses from erosion being incurred by stakeholders will engender concrete action towards addressing the situation. For now action plans are in place but the question remain as to when the state government will begin to implement them. Whether or not the erosion process will stop while we await government action is yet another matter.

Table 1: Measurements at 7 sites and estimated soil loss

	L	H	B	ESTIMATED VOL.
1.	38.59	15.6	16.3	9812.67
2	15.7	11.6	29.2	5317.9
3	16.44	13.19	20.5	4445.29
4	35.4	13.1	14.88	6900.45
5	35	13.03	14.99	6836.19
6	22.13	9.5	18	3784.23
7	40.16	16.35	28	18385.25
				55481.98m^3

Source: Usman and Abubakar (1994)

Table2: Dimensions of 7 erosion sites and estimated soil loss

Point	L_M	H_M	B_M	VOL M^3
1	87	17.8	27.5	425586.5
2	21.15	15.85	50.85	17046.32
3	21.15	15.85	25	8380.68
4	49.9	16.20	21.25	17178.05
5	46	16.11	2.10	15636.37
6	30.8	16.11	21.10	10469.57
7	58.10	17.10	39	38146.89
				149444.41m^3

Source: Field measurements (1999)

Table 3: Changes in erosion-scoop dimension (1994-1999)

1.	32773.83
2.	11728.42
3.	3935.39
4.	10277.63
5.	8800.18
6.	6685.34
7.	19761.64
	93962.43m^3

Plate 1:

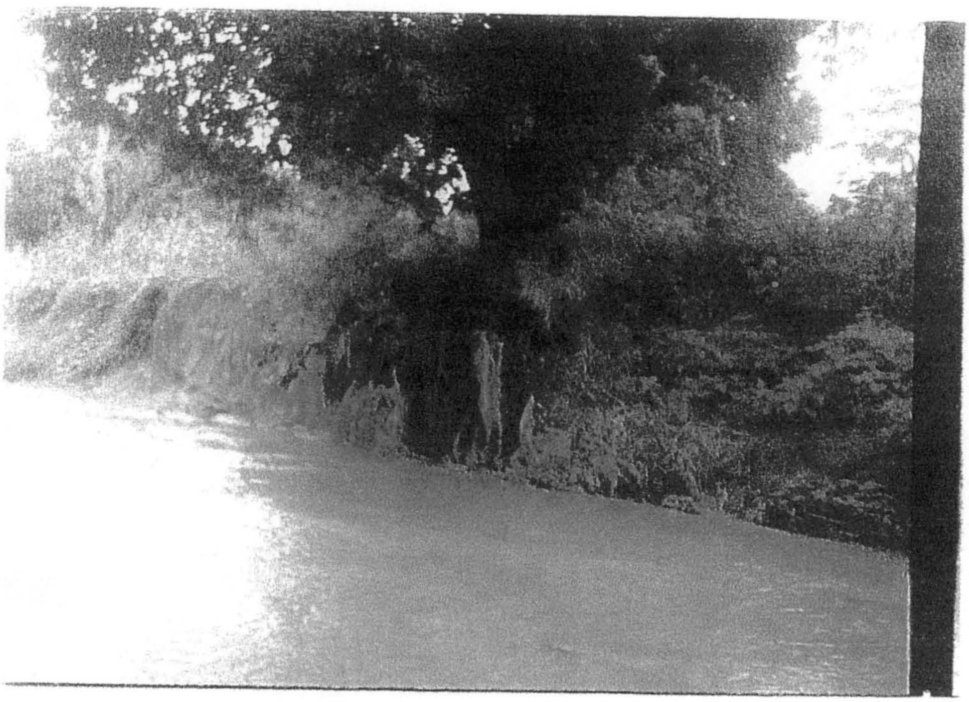

Plate 2:

Plate 1 and 2: Bank erosion threatering mango trees in an orchard.

Plate 3:

Plate 4:

Plate 3 and 4: River meanders which are associated with the dynamics of erosion and deposition.

Plate 5:

Plate 6:

Plate 5 and 6: Crops on the channel bed. They loosen the soil and are washed away.

Plate 7:

Plate 8:

Plate 7 and 8: Sand deposits and the excavations at work.

Plate 9:

Plate 10:

Plate 9 and 10: Structures on the bank threatened by erosion.

Plate 11: A section of erosion site 1 - the most extensive of 7 sites examined. Note the buildings in the background.

Plate 12: A fresh site downstream of site 1 already claiming victims.

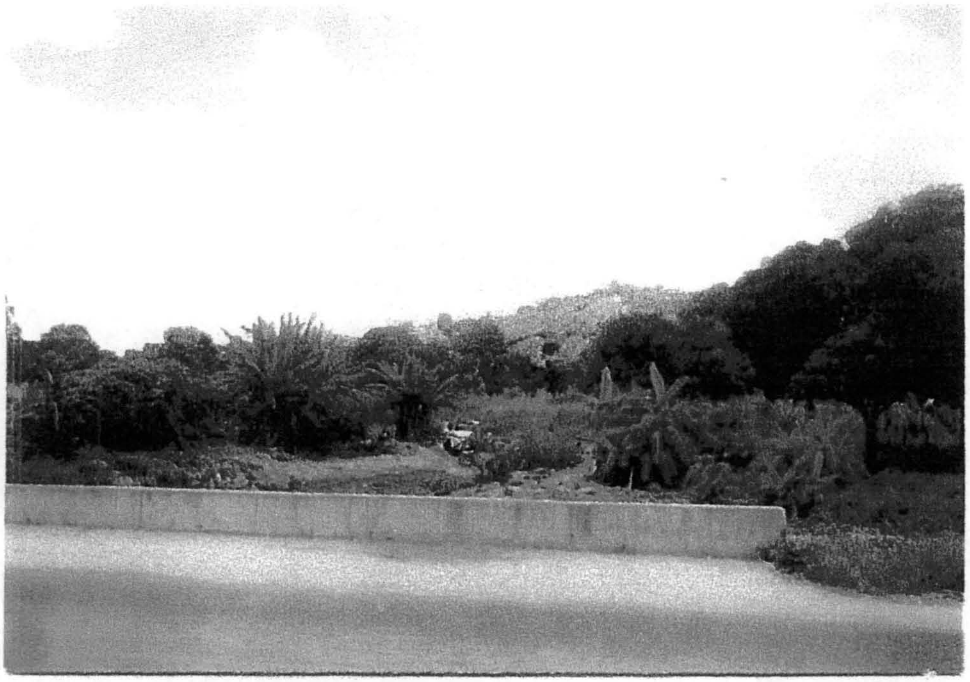

Plate 15: Sand excavators with their tipper truck right inside the channel.

CHAPTER FIVE

5.1 SUMMARY AND CONCLUSION

The Bosso river (or stream as some prefer to call it because of its present discharge levels) has been grossly abused). As some respondents did suggest, the water level in the channel has dwindled by more than 70% in the last 15 years. It is instructive to note that while the discharge has been on the decline, erosion has steadily increased such that by 1999 (during field survey), an estimated 150,000m^3 of soil had been removed from the banks at 7 sites only. This rapid rate of degradation of adjoining lands has been caused mainly by indiscriminate land use which destroys vegetal cover coupled with the selective channelisation work carried out in the late 80s.

The implication is that unless something concrete is done to stabilize these banks, the rates of erosion are likely to continues and all agricultural fields and buildings within 10 metres of the bank are likely to have become victims by the end of the year.

5.2 RECOMMENDATION

1. A massive enlightenment campaign should be embarked upon to educate all and sundry on the dangers of indiscriminate devegetation. This should be integrated into existing community level social welfare programmes.

Since agriculture off unprotected banks constitutes an important socio-economic pre-occupation stopping it shall not be an option. If that be the case, the extension of channelosation works will also not be scientifically viable since this will put a stop to irrigation. It is strongly recommended that simple but effective schemes for natural self-regeneration of the river should be pursued. Experts in this area should be contacted to draw up detailed plans.

3. Existing legislation which prohibits the excavation of from river/stream channels should be enforced. This presently exacerbates the erosion process.

4. Though it was not part of the objective of this study, it was saddening to note that the bulk of the discharge during the dry season was from effluents of domestic origin. Urgent research information needed (and should be sought) on the safety of the vegetables grown with such water.

5. Relevant government bodies responsible for land use planning ought to reverse this flood plain as a non-residential area. This is the most sensible thing to do.

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