An Empirical Survey on Damages Caused by Erosional Depositions on Farmlands along Jimeta-Yola Road, Adamawa State Nigeria

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Authors’ contributions

This work was carried out in collaboration among all authors. Authors AAS, MA and AB proposed designed, sourced literature, structured the methodology, conducted the original research work and presented the manuscript for contribution to knowledge development. All authors read and approved the final manuscript.

ABSTRACT

Aim: To empirically survey the damages caused by erosional deposition on farmlands along Jimeta-Yola road, Adamawa state Nigeria.

Place and Duration of Study: It was conducted in June-July 2020 rainy season due to the unprecedented depositions on three farmlands (Abattoir, Garage and Yola Bridge) in the area.

Methodology: Data was obtained in three phases which include on-farm interviews and questionnaires, direct measurement of depositions using simple bathymetric method and collection of three representative soil samples from the profiles for determination of some physico-chemical properties.

Results: The result indicated that rice was major crop grown in the area for about 30 years with an average yield ranges from 2000-8000 kg (20-80 bags). The number of farmlands damaged was 11 with total of 22 acres, at Abattoir, 5 farmlands at Garage having a total of 15 acres and 7 farmlands were also damaged with about 10 acres respectively. Fine sandy soil was deposited to an average depth of 55 cm with an estimated volume of 48.96 m³ at Abattoir area, debris and clay loam was

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depicted to an average of 20 cm at Garage having an estimated of 12.14 m$^2$ and at Yola Bridge farm location about 4.24 m$^2$ volume of loamy soils were also deposited to an average depth of 10 cm. The depositional soils have pH values ranges from 5.23-6.23, organic matter content of 0.43-2.33%, water holding capacity 35-55% with rapid to moderate permeability. **Conclusion:** To combat the damaged imposed by soil erosions on farmlands in the area both preventive and conservative measures should adopted by the government and the farmers with the aim of restoring and sustaining the good soil health that will support food production for growing population.

**Keywords:** Damages; deposition; empirical; erosion; farmlands; Jimeta-Yola; survey.

1. INTRODUCTION

Soil erosion, as a process of the detachment, transport and accumulation of soil materials from any part of the Earth’s surface, plays an important role in research since it assumes the most significant position among the individual degradation processes [1,2,3]. Soil erosion is widely recognized as a major environmental and agricultural problem affecting many parts of the world [4]. The importance of soil erosion research lies in the protection of soil as a fundamental resource for human food supplies [5]; therefore, the understanding of soil erosion processes has important practical implications over large areas of the Earth [6,7]. Estimates suggest that, each year, as much as 75 billion ton of soil are removed from the land by wind and soil erosion, with most of it coming from agricultural land [8]. Thus, among the devastating agent of soil erosion that imposed damages on agricultural lands water erosion is the utmost that affects farmlands in the study area through erosional decompositions of sediments. The amount of sediment in a catchment is heterogeneous in space and over time, depending on the land use, vegetation cover, climate, and landscape characteristics, i.e., the soil type, topography, any slopes, and the drainage conditions [8,9]. It was reported by [10] that averages of 41-80 hectares of land were destroyed by the flood in Yola South of which sediment depositions are quite among. Erosional deposition occurs when the amount of sediment becomes greater than the carrying capacity of the force that is moving it [11]. Therefore, erosional depositions can be considered as the solid materials which may includes soil particles

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Plate 1. Damages caused by erosional soil deposition at abattoir locations
(sand, silt, clay) pebbles, granules, debris and other alliums that are or have been carried away from its site of origin (erosional site) by the agent of either air or water gravity transported them (transportational site) and deposited them to a down or steep slope area (depositional site) causing positive or negative impact on the landforms process. Ref [12] described that erosion removed the substantial quantity of soils (on-site effects), which are transported to a far distance and deposited on another area which might be on the arable lands (off-site effects). However, off-site impacts of soil erosion are not always as apparent as the on-site effects. But it effects and cost management effectiveness are more vulnerable and high. According to the research conducted by [13] explained that the off-site costs for Java were estimated to be 26-91 million US dollars per year and off-site costs are highly visible and politically sensitive. Off-site cost of erosion is very high and can be considered is in form of sedimentation of reservoirs and irrigation systems, flooding of lowlands causing damage to crops and property as well as loss of lives [13]. Globally, soil erosion's most serious impact may be its threat to the long-term sustainability of agricultural productivity, which results from the 'on-site' damage which it causes Crops are particularly reliant on the upper horizons of the soil, which are the most vulnerable to erosion by water and wind [4]. There is great variety in soil conservation strategies, soil types, and physical environments: and the combinations of such factors of interest to land managers are too numerous, difficult and costly to investigate in all cases by direct measurement of soil loss and deposition [14]. It is a known fact that deposits of sediment have different physical characteristics than the older, buried soils upon which they were deposited. The buried soil is generally darker and more uniform in color. The sediment deposits are generally less dense, with a wider range in grain sizes. Sediment deposits often show distinct stratification or layering [11].

Plate 2. Damages caused by erosional soil deposition at garage locations
It is apparent that a substantial volume of depositions was placed on various farmlands along Jimeta-Yola road of Yola South caused by intensive soil erosion and flooding from Malkoi stream which eventually developed an increased process of soil detachment from the upper slopes and transported them to the down slopes of the study area. The damages caused by deposition on different farmlands in the study area were portrayed on Plates 1, 2 and 3 respectively. Therefore, it is imperative to survey the damages caused by the off-site depositions of soil erosions on farmland and proffer possible solution to the menace. Thus, this research work saddled to study the empirically survey on damages caused by erosional depositions on farmlands along Jimeta-Yola road, Adamawa state Nigeria.

Plate 3. Damages caused by erosional soil deposition at Yola bridge farm locations
2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Yola South LGA and Environs of Adamawa State, Nigeria which lies on latitude 09°14'N and 09°20'N of the equator and longitude 120°25'E and 120°28'E of the Greenwich meridian with an average annual rainfall of 850 mm-1000 mm with over 41% of rain falling in August and September. Temperature also has a significant temporal variation in the study area; with an average maximum temperature of 42°C with an average relative humidity of about 29% [15]. Like most areas in northern Nigeria, the soil of Yola-South are derived from the basement complex rock, however, The soil of the study area is loamy and it drains easily when it rains. [16] Ray (1999) identified the soil of the Yola South to belong to 213 unit of the F.A.O soil classification as Eutric Regosol soil type with sandstones geological formation. The study are is among the probable flood prone area which might be associated with anthropogenic activities and their proximity to the River Benue Plains coupled with some natural climatic phenomenon such as high rainfall or precipitation, River flow, Run-off, gauge height [17,10] Sadiq, and Hena, 2019; Sadiq, et al 2019). The study area is underlain by sedimentary deposit that is made up of two stratigraphic units, namely: the Quaternary river coarse alluvium deposit and the sandstone [18] (Festus, 2016). The Quaternary River coarse alluvium deposit occurs mainly along banks of River Benue at the north-eastern part of the area and its tributaries particularly river chochi along Yolde Pate area. It consist mainly sands, clays, silts, salty clays and pebbly sands.The Quaternary river alluvial deposit are recently deposited alluvium materials that mainly from the river bank materials as it is mainly found along the main course of river Karlahi and Malkoi at Yolde Pate and river Chochi along Anguwan Tabo and Wuro-chekke [19] (Sadiq, 2019).
2.2 Data Collection

This study was quantitative in nature which largely based on survey measurement and estimate of data from three selected farm locations (Abattoir; Garage and bridge farm locations) in the study area where sediment depositions are apparent. The research possessed three (3) phases of data collection. Firstly, it involves the verbal interview and use of well-defined and structured questionnaires on the number of farmlands destroyed by the depositions. The second phase is the application of simple bathymetric method which consists of direct field measurement of deposition depth, thickness; volume of soil deposited and estimated land covered by the sedimentation (Plate 4). Thus, the quantification of eroded material can be made by a variety of methods, objectives, size of the study area and the characteristics of the research group [20]. Ref [3] explained that the bathymetric measurement of sediment deposited in a reservoir is a suitable method for assessing the volume of eroded material in a study area. Hence, considering this fact simple bathymetric method was adopted for the purpose of this research work.

Volume of Erosional soil deposited (m$^3$) = Area of deposited farmland (m$^2$) × depth of profile deposition (m) equation 1

The last phase involves the physico-chemical analysis of the nine collected samples of the deposited soils from the three profiles at each farm location. Soil particle size distribution was determined using Bouyocous Hydrometer Method [21], organic carbon was quantify by the Walkley-Black wet dichromate oxidation [22], and converted to organic matter by multiplying it by 1.724, Soil reaction (pH) was determined using the pH meter method (soil/water ratio of 1:2.5), while the electrical conductivity (EC) was determined in a soil/water extract using an EC meter [23] water holding capacity was determined by gravimetric method [23], soil structure was obtained based on textural classification pyramid as described by Ontario Centre for Soil Resource Evaluation Manual [24] while Soil permeability was based on soil texture class described by [25] and [26] respectively. Additional relevant data such as journal, textbooks and maps were sourced as secondary sources from library, internets and other relevant agencies.

Plate 4. On-farm measurement of deposited soils in the study area
3. RESULTS AND DISCUSSION

Results on the damages imposed by erosional depositions soils on the various farm locations were presented on Table 1. The result revealed that rice farming was predominant among the farmers in the area. This could be connected to the clayey and loamy soils dominated the farms location with considerable waterlogged features suitable for rice cultivation. This finding agreed with the result of [27] who explained that farmers cultivate rice as a major crop grown. Similarly, the rice cultivation was assessed to have practiced for about 30 years farming experiences by the arable farmers in all the study areas. This finding expressed the valuable features of the lands towards providing substantial farm produce over that long period which consequently improved the socio-economic status of the farmers as they depend on farming as their primary activities. Average money spent on cultivation (in Naira) at Abattoir farm location was estimated to be 45, 000 Naira/ farm, 30, 000 Naira/ farm at Garage farm location and at Yola Bridge location was 20, 000 Naira/ farm respectively. This explained that the farmers are spending on farm operations almost more than the national minimum wage approved recently by the government of 30, 000 naira/ month. Thus, farmers usually sold their farm produce to carry out the farm operations with low or not assistance neither from government nor non-governmental organization. Similar statement was made by [10] expressed that majority of the farmers were leaving at poverty level of ≤ 10,000 monthly which is not up to the minimum wage benchmark of 18, 000 naira of the country. This is as a result of the nature of their occupation as mainly farming at a subsistence (hand to mouth) level and this perhaps suggests the different reasons they gave for their continuous farming in the area despite the annual threat of flood. For the average annual number of bags (100 kg/bag) harvested Abattoir farm locations possessed the highest yield harvested of about 50-80 bags/year (5,000-8,000 kg) then followed by Garage location with about 30-50 bags/year (3,000-5,000 kg) and the least farm output of 0-30 bags/year (0- 3,000 kg) was found at Yola Bridge which might be attributed to rapid urbanization emanating in the area such as filling stations, timber sheet, motor park among others which led to gross reduction of fertile agricultural land. This assertion is in conformity with the result of [27] reported that land use and urbanization was the utmost factor that caused devastating soil degradation in the study area with 23% of the respondent which might be largely due to increase in population density which prompted inhabitants in the area to occupy the fertile agricultural land under cropping to building of houses and industries. Similarly, this finding correlated and agreed with the report of [28] explained that people have been building and expanding their cities on the most fertile soils, thereby squandering such a valuable resources. Number of farmland damaged by the hazard was at Abattoir location was 11, while 5 at Garage and 7 farmlands at Yola Bridge respectively. Similarly, farmlands destroyed in the study area was also presented on Table 1, where 22 acres of farmlands were damaged by soil depositions while at Garage location 15 acres of arable lands were damaged and 10 acres of farmlands were also destroyed at Yola Bridge farm location. In essence, almost ¼ of the cultivated farmlands in the three locations under study were damaged by the erosion deposits which have subjected the farmlands less or unproductive. This result also conceived with the findings of [29], reported that in 2003, 3340 km² of deposited farmland soils (DFs) had been formed on the Loess Plateau of China (CLP), on which 1.67 billion kg crop yield per year was produce and the area of DFs and crop yield are expected to have doubled by 2020. The loss of land for cultivation is a serious social and economic consequence of soil erosion, given a situation where farming is the main occupation of majority of the people [4].

The results on the characteristics of erosional depositions were presented on Table 2. It was revealed that in all the farm locations flooded water was the main agent that has caused erosional depositions damaging cropping system. The water flooding was rejuvenated and sourced from the stream of Malkoi located at the southern part of the study area which flooded after intensive and long duration rainfall that carries much of sand and debris to the down slope areas where the study area is located. Thus, Ref [30] revealed that sediment transport is a direct function of water movement. Sediment flux is the product of overland water flux and sediment concentration [14]. The actions of water erosion on erosional depositions on various farm locations in the study area were presented on Plate 5.

The original soil type at Abattoir and Garage farm locations was clay soils and clay loam at Yola Bridge location. This is a clear evidence of rice domination on most of the location because clay
and clay loam is more suitable for rice production due to its high Cation Exchange Capacity (CEC) and moisture retention capacity respectively. Conversely, for the type of erosional deposits on the productive original soils identified fine sandy soils was predominantly deposited over the clay soils to an average depth of 55 cm at Abattoir farmlands while debris and clay loam were deposited at Garage farmlands to an average depth of 20 cm and debris and loamy soil was deposited at Yola Bridge location over clay loam original soils to a depth of 10 cm as depicted on plates respectively. At Abattoir farm location with presence of fine sandy soils over clayey soils was considered to be more devastating damaging the lands which subject it to unproductive, inhibiting seeds and seedlings than the Garage and Bridge locations. Hence, eroded soil deposited down slope can inhibit or delay the emergence of seeds, bury small seedling and necessitate replanting in the affected areas [31]. Results on estimated volume erosional soil deposited on farmlands was also presented on Table 2, where 48.96 m$^3$ of sandy soils were deposited over clay soils, 12.14 m$^3$ volume of clay loam and some debris were deposited on clay soils and 4.24 m$^3$ volume of loamy soils and debris over clay loam respectively. These values signify apparently the reduction of agricultural lands most especially along Abattoir areas. Ref [32] reported that losses in arable land have increased over the past ten years to a current rate of 7 to 10 million ha per year as a result of erosion.

Table 3 presented the physico-chemical properties of the erosional deposited soils of the three farm locations. The result indicated that the textural class of the deposited soils at Abattoir area was sandy soils having very fine granular structure with soil pH (5.23), organic matter (0.48%), water holding capacity (55%) with rapid permeability. These properties of deposited soils have seriously turned most of the farmlands in the area to lose it fertility while some farmlands were permanently out of cropping land particularly areas with more than 15 cm of deposited sandy soils that are beyond mitigation through mix plough or chisel plough techniques. Thus, Ref [29] reported that an increased erodibility of soils is high with sand fractions and low with clay and silt contents. Generally, information on particle size distribution (PSD) reinforces the important role of deposited farmlands in agricultural development and soil conservation.

Pei Z., [29]. The loss of soil fertility leads to steady decrease in crop yields and this make difficulties on the concern of the local farmers over their economic wellbeing [4]. At Garage farmlands Clay loam texture soils having a platy structure with soil pH (6.23), EC (0.012 dSm$^{-1}$) organic matter (1.98%) having water holding

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**Table 1. Estimated farmlands damaged by erosional depositions on farm locations**

| Farm Locations | Abattoir Location | Garage Location | Yola Bridge Location |
|----------------|-------------------|-----------------|---------------------|
| Types of Crop Grown | rice | Rice | rice |
| Years of Farming Experience | 30 | 30 | 30 |
| Average money Spent on Cultivation (in Naira) | 45,000 | 30,000 | 20,000 |
| Average annual number of bags (100 kg/ bag) harvested | 50-80 | 30-50 | 0-30 |
| Number of farmlands damaged | 11 | 5 | 7 |
| Total farmlands Destroyed (Acres) | 22 | 15 | 10 |

**Table 2. Characteristics of erosional soil depositions**

| Farm Locations | Abattoir Location | Garage Location | Yola Bridge Location |
|----------------|-------------------|-----------------|---------------------|
| Agent of erosional deposits | Flooded water | Flooded water | Flooded water |
| Original soil type before deposition | Clay | Clay | Clay loam |
| Type of erosional deposits | Fine sandy soils | Debris and clay loam | Debris and loamy soils |
| Average Depth of deposits (cm) | 55 | 20 | 10 |
| Estimated volume of erosional soil deposited on farmlands (m$^3$) | 48.96 | 12.14 | 4.24 |
capacity of (35%) with slow to moderate permeability were identified as depositional properties which relatively favors the production of rice as alluvial soils deposition. Thus, most farmers are still re-planting and sowing the deposited areas taking the advantage of clay loam deposit. The trend almost remain the same at Yola Bridge location where loam soils with medium to coarse granular soil structure was predominated the area with soil pH value of (5.45), EC (0.011 dSm$^{-1}$), organic matter (2.30%), water holding capacity of (38%) having moderate permeability. However, despite the glaring damages caused by the deposited soils and debris in the area, on the other hand there is obvious advantage of the fluvial loamy deposits having high amount of humus content where rice are cultivated in at Yola Bridge farm locations. This affirmation agreed with the recent findings of [12] in the area who described that sediment deposit may be of significant important most especially the alluvial and fluvial deposits with high amount of humus content particularly in areas around the river basin having seasonal flooding with gradual sedimentation of fluvial soils.

Plate 5. Water actions on erosional deposition during and after the flooding in the study area
Table 3. Physico-chemical properties of the erosional deposits

| Farm Locations | Abattoir Location | Garage Location | Yola Bridge location |
|----------------|-------------------|-----------------|---------------------|
| Soil Textural class | Sandy | Clay loam | Loam |
| Soil pH | 5.23 | 6.23 | 5.45 |
| Soil EC (dSm⁻¹) | 0.013 | 0.012 | 0.011 |
| Soil Organic Matter (%) | 0.48 | 1.98 | 2.33 |
| Soil Water holding capacity (%) | 55 | 35 | 38 |
| Soil Permeability (%) | Rapid | Slow to moderate | Moderate |
| Soil Structure | Very fine granular | Platy | Medium to coarse granular |

4. CONCLUSION

It is apparent that erosional deposition on farmlands is one of the major factors affecting agricultural production globally. The effects and damages caused by the process vary with the type, nature, depth and quality of the depositional materials. It result indicated that about 47 acres of farmlands were damaged by the erosional depositions of sandy particles, clay soils, debris and other sediment materials due to the action of flooded water caused by intensive rainfall which turned most of the affected land unproductive. However, few farmlands were benefited from the scenario where fluvial sediments were deposited where rice farming are carried by some of the farmers in the areas. Generally, farmers’ decisions to conserve natural resources in soil and water in particular are largely determined by their knowledge of the problems and perceived benefits of the conservation [33]. Therefore based on the findings obtained from this study it recommends the following:

I. There is need for holistic and ardent concern to mitigate the problems of erosional depositions in the study area through re-directing of the Malkoi stream to empty its water into the River Chochi by the governments at both the federal and state levels through the involvement of agencies concern such as national soil conservation committee, environmental protection and management agencies etc.

II. Similarly, as for the potential management practices described by USDA, (1996) the use of moldboard plowing to mix the surface and subsurface layers and chisel plowing, which causes a greater degree of mixing should be appropriately adopted in the affected areas.

III. Maintaining plant or crop residue cover, high infiltration rates improvement, and minimal runoff should also be adopted by the farmers in the study area with the aim of reducing soil detachments

IV. Conservation construction practices such as dikes, levees, and intercepting channels should be used to provide local protection from some flooding and sediment deposition

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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