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IMPACT EVALUATION OF SEDIMENT DEPOSITION ON ARABLE LANDS OF YOLA AND ENVIRONS OF ADAMAWA STATE, NIGERIA

A.A Sadiq[1] and B.A Faruk[2]

[1]Department of Agricultural Technology, Adamawa State Polytechnic, Yola, P.M.B 2146

[2]Department of Crop Production, Federal Polytechnic Bali, Jalingo Taraba State. P.M.B 05

ABSTRACT: *Sediment depositions on farmlands are among the contemporary hydrogeo-phyiscal process affecting arable lands in most flood prone areas of the world which is receiving ardent attention of research. Arable lands in Yola are seriously receiving continuous sediment depositions which have affected the farming activities. Thus, the study saddled to evaluate the impact sediment deposition on arable lands of Yola and environs. The research consists of three phases. Used of structured questionnaires administered to the farmers, second phase involved direct on-field measurement of depth and width of sediment deposition and the third phase consist of textural class determination of soil samples in the laboratory. The results obtained from the five selected areas shown that Yolde pate, Wuro-chekke and Anguwan Tabo farm locations loamy clay sediments were deposited to an average depth ranges from 25cm-75cm over period of 10-19 years covering about 15-60 hectares of land where irrigation farming are intensively carried out which has positive impact on their farming activities. Conversely, Mbamba and Bole farm locations were assessed having coarse sandy sediment depositions over fertile clayey soil to an average depth of 35-40 cm for a period of 5-7 years wrapping a range of 2-9 hectares of fertile land with a negative impact of 60 % damaged of their productivity. For the infertile deposit of sediment on farm land, it is therefore recommending the potential management practices (chisel and moldboard ploughs), preventive management (improving infiltration rate and minimizing runoff) and conservation practices (dikes, levees, channels constructions) respectively.*

KEYWORDS: Arable Lands, Deposition, Evaluation, Impact, Sedimentation, Yola, Nigeria

INTRODUCTION

Despite the global demand of food for the growing population the food production still remains inadequate in African countries which associated with natural disasters such as flood, drought sedimentation and fertility degradation. (Sadiq et al.,2019a). In West Africa, soil erosion gulps about 10-21 tons of top soils per ha on nearly gentle slopes of 0.4 -0.8% and up to 30 -35 tons on 1-2% slopes (Serageldin, 1987). In Nigeria, it has been reported that over 25 million tons of valuable top soils are lost annually to erosion (Ezidinma, 1982). Similarly, agricultural land in Nigeria is often results in the degradation of natural soil fertility and reduced productivity (Sadiq et al., 2019b). In Adamawa state, soil degradation is quite glaring and felt through on field observation caused by various factors. (Sadiq et al.,2019c). Among these factors, farmers in the area are seriously facing reduction in farm output annually due to the accelerated loss of topsoil through erosion from agricultural land which recognized as an important threat to their profitable farming as depicted in palates 1 below (Sadiq et al.,2019d). Similarly, the study area is experiencing rapid development of extended gully erosion from its all farmland axis which carries organic soil from the top soil and sediment on farmlands (Sadiq et al., 2019 e).

Plates 1: Devastating Effect of Soil Erosion on Agricultural Lands in the Study Area (Adopted from Sadiq et al., 2019d).

Conversely, as the erosion removed the substantial quantity of soils (on-site effects), the soils are transported to a far distance and deposited on another area which might be on the arable lands (off-site effects). Sediment deposit is a solid material that is or has been transported from its site of origin by air, water, gravity, or ice to a field or low landscape position. According to United Nations Environment Programme and the World Health Organization (UNEP/WHO, 1996) explained that sediment transport is a direct function of water movement. During transport in a water body, sediment particles become separated into three categories: suspended material, bedload and the saltation load.

- Suspended load comprises sand + silt + clay-sized particles that are held in suspension because of the turbulence of the water.
- Bedload is stony material, such as gravel and cobbles that moves by rolling along the bed of a river because it is too heavy to be lifted into suspension by the current of the river. Bedload is especially important during periods of extremely high discharge and in landscapes of large topographical relief, where the river gradient is steep (such as in mountains). It is rarely important in low-lying areas.
- Saltation load is a term used by sedimentologists to describe material that is transitional between bedload and suspended load. Saltation means “bouncing” and refers to particles that are light enough to be picked off the river bed by turbulence but too heavy to remain in suspension and, therefore, sink back to the river bed

Deposition occurs when the amount of sediment becomes greater than the carrying capacity of the force that is moving it (United State Department of Agriculture [USDA]; Natural

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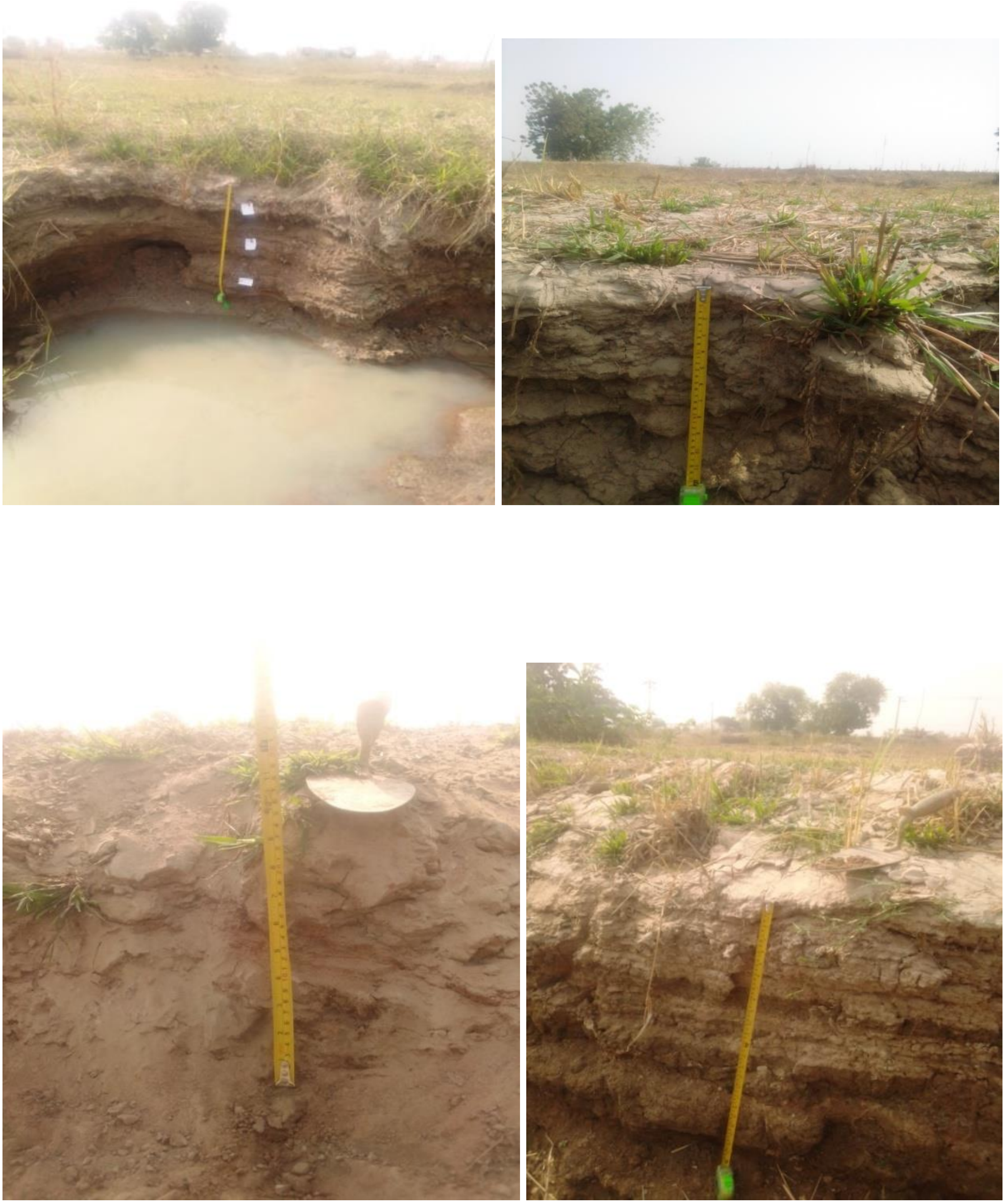
Resources Conservation Service [NRCS], 1996). Sedimentation effects are also known as off-site effects of soil erosion. Off-site is an addition of unwanted sediments in the depositional sites (Sadiq and Tekwa, 2018).

Off-site cost in the form of sedimentation of reservoirs and irrigation systems, flooding of lowlands causing damage to crops and property as well as loss of lives (Howeler, 2012). The off-site costs for Java were estimated to be 26-91 million US dollars per year. Thus, off-site costs are highly visible and politically sensitive (Howeler, 2012). However, off-site impacts of soil erosion are not always as apparent as the on-site effects. Eroded soil deposited down slope can inhibit or delay the emergence of seeds, bury small seedling and necessitate replanting in the affected areas. Sediment which reaches streams or watercourses can accelerate ban erosion, clog drainage ditches and stream channels, silt in reservoirs, cover fish spawning grounds and reduce downstream water quality (Wall, 2019).

Analysis of sediments provides environmentally significant information. Sediments will contain materials precipitated from chemical and biological processes. Natural processes responsible for the formation of bottom sediments can be altered by anthropogenic activities (International Atomic Energy Agency [IAEA], 2003). Modern 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 (USDA, NRCS, 1996). The clear examples are depicted below in plates 2 below and 3 accordingly.

Plates 2. Original Buried Soils (Paleosoils) and Deposited Sediments on Some Farm Location in the Study Area.



Plates 3: Stratification of Sediment Deposits at Anguwan Tabo farm Location in the Study Area.

Sediment Deposits often show Distinct Stratification or Layering

Impact of Sediment Deposition on Farmland

The impact of sediment deposition depends on the characteristics of the original soil, rate of deposition, type of material, and depth of deposition (USDA, 1996). However, sediment deposit can either improve or degrade the soils upon which it is deposited. The impact may be positive or negative. Positive impact entails the fertile sediment that support both rainy season and irrigation farming activities while negative impact when the infertile sediments are deposited on fertile productive arable land which impaired farming activities.

Positive Impact: occurs when fine-grained soil particles deposited on sandy soils generally improve soil quality with incremental deposits become incorporated with the surface layer and improve with organic matter accumulation,

Negative Impact: occurs when coarser material is deposited on fine-textured soils there is a more delicate balance, but coarser material generally results in degraded soil structure and physical characteristics and decreased soil fertility. Deposits of infertile sand on a highly productive silt loam that is high in organic matter and nutrients can significantly decrease the quality of the silt loam as depicted in plates 4 below at Mbamba farm location of the study area.

Plates 4: Deposition of Infertile Coarse Sandy Soils Over Fertile Clay Loam Soil Which Significantly Decreased the Soil Fertility of the Farmlands at Mbamba Farm Location in the Study Area.

The rate of deposition also affects soil quality. If an inch of sand is deposited on a fertile soil every year for 16 years, the effects would be much less than if eight inches of sand were deposited in one year (USDA, NRCS, 1996). Thus, soil quality may improve over a short period if the rates of depositions are not that much.

However, soil quality would change little if similar deposits occurred on a sandy soil that had a low content of organic matter, and low levels of nitrogen, phosphorus, and potash.

The Relationships between the depth and type of sediment deposit and damage to soils on flood plains relative to crop yield are shown in the table 1 below adopted from The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), 1996.

Table 1. Relationships Between the Depth and Type of Sediment Deposit and Damage on Crop Yield.

Depth	SOIL TEXTURE	Damage (%)	Recovery Period (yrs)*	Damage Remaining after Recovery (%)
4-8”	Fine sand and silt coarse sand and silt	20	5	0
4-8”	Medium sand coarse sand	40	10	10
8-12”	Fine sand coarse sand	40	10	10
12-14”	Coarse sand	60	20	30
12-24”	Coarse sand and gravel	90	30	50

*Source: (USDA, NRCS, 1996) *An estimate of the amount of recovery and the length of time required are made with the assumption that the flooding was a one-time event and would not reoccur.*

Most researches were (e.g Sadiq et al., 2019 a,b, c, d and e) focused on the on-site effects of soil erosion in the area having less concern on the depositional effects (off-site effects) of the removed sediments. As for the off-site effects, eroded soil, deposited down slope can inhibit or delay the emergence of seeds, bury small seedling and necessitate replanting in the affected areas (Wall, 2019).

It was reported by Sadiq et al., (2019a) that averages of 41-80 hectares of land were destroyed by the flood in the study area of which sediment depositions are quite among. This damaged was associated with deposition effects on the farm as depicted in the plates 5 below. However, 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. Apparent example occurred on some farm locations near river Benue in the study area as shown in the plates 6.

Therefore, there is ardent need to assess the sediment deposit and its impact on arable lands activities in the study area. Thus, farmers’ decisions to conserve natural resources in general, and soil and water in particular are largely determined by their knowledge of the problems and perceived benefits of conservation (Amsalu and Graff, 2007).

Plates 5: Shows the Apparent Effects of Sedimentation Caused by River Flooding at Anguwan Tabo in the Study Area. (Adopted from Sadiq et al., 2019a)


(A) **(B)**

Plates 6: (A) Seasonal Flooding on Farm Lands in August 2019 and (B) Farmlands after Flooding in December 2019

Study Area

The study was conducted in Yola South LGA and Environs of Adamawa State, Nigeria which lies on latitude 090 14'N and 090 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 ^{0}C with an average relative humidity of about 29% (Upper Benue River Basin Authority, Yola, Nigeria. 2018).

Materials and Method

This study was quantitative in nature which largely based on survey measurement and estimate of data from five selected farm locations (namely; Yolde pate, Mbamba, Bole, Wuro-chekke and Anguwan Tabo) in the study area where sediment depositions are apparent. The research possessed three (3) phases of data collection. Firstly, it involves the use of well-defined and structured questionnaires on the duration of sediment deposition, land use and other field parameters. The second phase consists of direct field measurement of deposition depth, thickness and estimated land coverage by the sedimentation (plates 7). The last phase was the laboratory analysis of soil textural class using textural class triangle of the collected soil samples from the deposited sediments farmlands using purposive sampling method and estimation of percentage damage and recovery period was made using USDA, NRCS, (1966). Additional relevant data such as journal, textbooks and maps were sourced as secondary sources from library, internets and other relevant agencies respectively.

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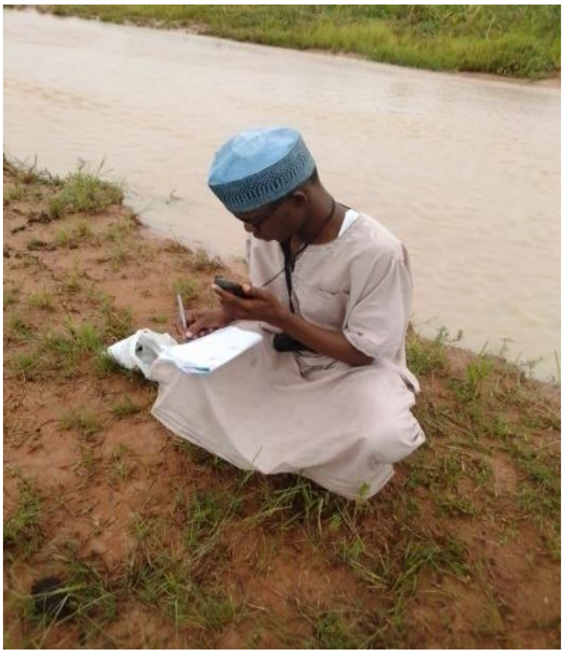

Plates. 7: On-field Measurement of Sediment Deposit in the Study Area

Table 2: Field Parameters

Farm Location	C.F Experience (years)	Present Land Use	Vegetative	Major Crop Grown	Erosion Type	Slope Type
Mbamba	5-35	Arable farming and animal grazing	Few tress and grasses	Rice, maize and cassava	Gully	Steep
Namtari	10-45	Arable farming and animal grazing	Trees, shrubs and grasses	Rice, cassava and maize	Rill	Moderate to steep
Bole	5-20	Arable farming, animal grazing and Orchards	Tall grasses, trees and shrubs	Maize, groundnu, beans and rice	Rill to gully	Steep
Yolde pate	10-25	Arable farming and animal grazing	Few trees, grasses and shrubs	Maize and rice	Sheet to gully	Gentle to moderate
Wuro-chekke	5-15	Arable farming and irrigation/ orchards	Tall grasses and few trees	Rice and cocoyam	Gully	Steep

C.F; Conservation Farming. Source: (Sadiq and Shuwa, 2019)

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Table 3: Impact Evaluation of Sedimentation Deposits on Arable Lands of Yola and Environs

Arable Lands	Type of Original Soil	Texture of Deposited Material	Average Depth of Deposition (cm)	Average Years of Sedimentation	Average Farmland Covered (ha)	Present Land use	Damage (%)	Recovery period (yrs)	Damage Remaining After Recovery (%)	Impact Remark
Yolde-pate	Clayey	Loamy clay	75	12	15-21	Irrigation	0	0	0	Positive
Wuroche-kke	Clayey	Silty clay loam	45	19	22-60	Irrigation	0	0	0	Positive
Mbamba	Loamy	fine/Coarse Sand	35	5	5-9	Uncultivated	60	20	30	Negative
Bole	Loamy	Coarse Sandy	40	7	2-7	Uncultivated	60	20	30	Negative
Anguwan Tabo	Clayey	Silty loam	25	10	15-30	Irrigation	0	0	0	Positive

Source: Field Survey, (2020)

Yolde Pate Farm Location

The area occupies a gentle to moderate slope rejuvenating rill to gully erosion having considerable effects on the arable farmlands dominated with maize and rice as major crops grown over 10- 25 years of farming respectively (Table 2). Few tress, grasses and shrubs made the vegetation of the area (Sadiq and Shuwa, 2019). From table 3 above, the original soil type on the farm location was clayey soils which eventually deposited with loamy soil sediments with about 75 cm average depth over a period of 12 years covering about 15-21 hectares of farmlands (see plates 8). Due to the gradual deposition of loamy clay soils with substantive quantity of soil humus ignited the farmers in the area to take advantage of the deposition engaging in irrigation farming practices during dry season and rice farming on some areas in rainy season respectively. There is no damage assessed during this study on the farm location and the impact of sedimentation deposit was positive on the arable land.

Plates 8: Loamy Soil Sediments at Yolde Pate Farm Location

Mbamba Farmlocation

The area is located at the eastern part of Yola south LGA characterized by few tall trees and grasses (Table 2). The farmers engaged dominantly in arable farming where rice and maize been the major crop grown for about 5-35 years conservation experience (Sadiq and Shuwa, 2019). Result from table 3 shows that Mbamba farm location was predominated with loamy soils as original soil which about 5-9 hectares of land in the area were deposited with coarse-fine sandy soils (plates 9) of about 5 years of sediment deposition to about 35 cm soil depth which presently imposed the arable land to an uncultivated land with damaged level of 60 % while an expected recovery period of 20 years with the projected damage remaining after recovery of 30 % estimated from (USDA, NRCS, 1966) respectively. The impact level of the deposition in the deposited areas was assessed to be negative as its impaired arable land uncultivated and unsuitable due to the presence of coarse sandy deposition over loamy soils.

Plates 9: Coarse Sandy Soils Deposited on Fertile Loamy and Clayey Soils at Mbamba Farm Location in the Study Area

Bole Farm Location

The riverine area is sited on steeply (of about 20-22%) slope gradient with well rejuvenated rill to gully erosion having considerable devastation on farmlands. The vegetation is characterized by tall grasses, tall trees and shrubs dominated with arable farming with about 5-20 years conservation experience mostly maize, groundnut and cowpea along the hilly areas while rice is cultivated at swampy syncline (Table 2), (Sadiq and Shuwa, 2019). Table 3 described the original soils of Bole farm location as loamy which was deposited with coarse sandy texture soils to an average depth of 40 cm covering about 2-7 hectares of arable farmlands over a period of 7 years consequently turned the areas unsuitable for cultivation neither rainy nor dry season as depicted on plates 10 below. Using the USDA, NRCS, rating (1966) the damage level was assessed to 60 (%) with an expected recovery period of 20 years and damage remaining after recovery of 30 (%). Negative impact on agricultural cultivation was assessed for the farm location accordingly.

Plates 10: Coarse Sandy Soils Deposited on Arable Lands in the Study Area

Wuro-Chekke Farm Location

The flood plain area is situated along river Benue basin at North-western part of the study area dominated with tall grasses and few trees, practicing arable farming, irrigation and orchards farming. The area has noticeable rill to gully erosion with notable steep topography having sediments and depositional materials spread over the low-lying adjacent areas. Rice and cocoyam were the major crops grown in the area for over 5-15 years conservation farming experience (Table 2) (sadiq and shuwa,2019). The result on table 3 shown that clayey soils are the original predominated before it fluvially deposited with silt clay loam to an average depth of 55 cm over a period of 19 years covering about 22-60 hectares of arable lands. The perennial flooding of river Benue is mainly responsible for the deposition of fluvial fine textured forming an extensive organically rich soil forming floodplains (fluvisols)

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which farmers intensively engaged in irrigation farming most especially the cultivation of local specie of Guinea corn known as "***MUSKUWA***" and it has no any damaged effects assessed for the period of this study as adopted from USDA, NRCS, (1966) accordingly.

Plates 11: Fertile Fluvial Deposits at Wuro-chekke Farm Location where Irrigation Activities are Intensively Carried Out

Anguwan Tabo farm location

Anguwan Tabo farm location is having similar features with that of Wuro-chekke farm location. The area is situated along river Chochi flood plain from the western area of Yola where farmers practicing arable farming of rice and maize respectively (Sadiq and Shuwa, 2019). Table 3 depicted the original soil type of Anguwan Tabo clayey which was deposited by silt loam alluvial soils covering about 15-30 hectares of arable lands to a depth of 25 cm over an estimated period of 10 years respectively. Due to the fluvial deposit from river Chochi in the area farmers engaged intensively in dry season farming cultivating different types of crops such as practices cassava, groundnut, sweet potatoes and sorghum (see plates 12 below) which have a positive impact on farmers socio-economic status with no damage and recovery period using USDA, NRCS, (1966) accordingly. The alluvial soil is suitable for irrigation farming due to high organic matter content in the alluvial materials deposited after the recession of seasonal floods and the retentions of the soil moisture content which supplement the moisture requirement of irrigated crops.

Plates 12: Cultivation of Sweet Potato, Cassava and Groundnuts on Sediment Deposit at Anguwan Tabo Farm Location of the Study Area

Possible Mitigation Strategies on the Negative Impact of Sediment Deposition

Management response to sediment deposition is generally determined by the depth of deposition and the quality of the underlying soil. Generally, as the depth of sediment deposition increases, less mixing is possible. USDA, (1996) highlighted the substantive possible mitigation strategies on negative impact of sediment deposit degradation on farmlands. They classified the techniques into three namely; potential management practices, preventive methods and conservation practices respectively.

i. **Potential Management Practices:** Potential management practices include the following;

- ❖ Use of moldboard plowing, which generally turns 6 to 8 inches of soil over but causes a minimum amount of mixing between the surface and subsurface layers.
- ❖ Chisel plowing, which causes a greater degree of mixing but generally disturbs the soil to a shallower depth of only 4 to 6 inches.
- ❖ Deep chiseling, which disturbs the soil to the greatest depth (12 to 24 inches) but generally results in a minimal amount of mixing.

ii. **Preventive Methods:** The best method for addressing sedimentation is prevention, since soil quality generally decreases as the depth of sediment deposition increases. Prevent soil erosion in upstream landscape positions by one of the following methods;

- ❖ Maintaining plant or crop residue cover.
- ❖ High infiltration rates improvement, and minimal runoff.

iii. **Conservation Practices:** Conservation practices on upstream watersheds reduce the risk of high-volume flooding and damaging sediment deposition. Dikes, levees, and intercepting channels are used to provide local protection from some flooding and sediment deposition.

CONCLUSION

Sedimentation and deposition are among the erosion processes which can be describe as off-site effects affecting agricultural productivity. Several studies have been conducted in Yola and environs on on-site effects of soil erosion which has to do with removal of surface and sub-surface soil particles and nutrients and deposited them to a given distance as sedimentation. This study aimed at evaluating the impact of sediment on arable lands of Yola as it affects both rainy and irrigation farming practices. It was revealed from the study that sediment deposition possessed positive impact of most of the arable lands especially those along the river Benue flood plains where alluvial deposits (silt, loamy and clayey soils) with predominated high content of humus. Farmers in those areas intensively participated in both irrigation and rainy season farming. Conversely, negative impact of sediment deposit was evaluated at Bole and Mbamba farm locations reducing about 60 % of their productivity due to overlying of infertile soils deposit (coarse sandy soils) on clayey fertile soils predisposing the arable land unproductive. Preventive and conservative measures on coarse sandy or infertile soils are recommended for recovering the land in to productive one but depending on the quantity, depth, and type of sediment respectively.

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