Available online at http://www.ajol.info/index.php/njbas/index
Nigerian Journal of Basic and Applied Science (June, 2012), 20(2): 134-141 ISSN 0794-5698

Full Length Research Article

Soil Resources Degradation and Conservation Techniques Adopted Among the Small Holder Farmers in Gusau, North-Western Nigeria

[1]S. Dalhatu and *[2]J. Garba
[1]Department of Geography, Zamfara State College of Education, Maru, Zamfara State, Nigeria
[2]Department of Agricultural Education, Zamfara State College of Education, Maru, Zamfara State, Nigeria
[*Corresponding author: email address; jamilunmaru@yahoo.com; ☎: +2348065691304]

ABSTRACT: Soil degradation is increasingly regarded as a major constraint to food production in the tropics. This problem is primarily caused by soil erosion, which particularly damages the soil surfaces. It is therefore the objectives of this paper to study the types of erosion in Gusau area as well as its effects on selected soil properties including particles size distribution, soil organic carbon, N, pH, P, Na, Ca, Mg and K, and CEC among others. The paper also attempts to unveil some anti-erosion measures practiced by small holder farmers for conserving the soils in the study area. Results showed that sheet erosion type is the most prevalent in the study area, and that erosion has declining effects on the above soil properties especially in bare land than in cultivated soils. Different techniques including mulching, contour farming, cover cropping, terracing and strip cropping are being practiced by the farmers as soil and water conservation techniques for improved crop production.
Keywords: Soil erosion, small holder farmers, Gusau area, soil properties, anti-erosion measures

INTRODUCTION

Soil degradation is increasingly regarded as a major constraint to food production in tropical environments of the world (Stoorvogel and Smaling 1998; Pimentel and Kounang 1998; Scherr 1999). These problems are primarily caused by soil erosion, which is particularly damaging the soil surfaces in the tropics (Lal 1987; 1995). The detachment of soil particles from the landmass and the transportation of the loosened material to another place are termed soil erosion (Hudson, 1965). As Babalola, *et al* (2009) observed, soil is a limited and an irreplaceable resource, and continues to face threats from erosion, which poses a great danger to agricultural production. Moreover, Morgan (1995) asserts that soil erosion is one manifestation of soil degrading process that results in reduced soil quality and productivity. And that it has been projected to become an even more severe constraint into the future (Vernon, 1999). Soil erosion commonly occur on farmlands though may not be noticed by farmers. Farmers often notice soil erosion when gullies developed in the farm and only then call for assistance (Kirchhoff and Odunze, 2003).

In some areas, the farmers' fields are severely affected by erosion that the top soils have been entirely dislodged, and some rills and gullies formed as a result, which have in some cases entrenched themselves to depth of a meter or more in the underlying soil material (Dalhatu, 2009). Other erosional features indicating soil loss in the area include among others: pedestals, armour layers and tree moulds which lead to the destruction of many arable and grazing lands, thereby posing vulnerability threats to environmental quality and food security. Urbanization and increasing population forces most of these farmers to continuously cultivate these eroded lands. thus, it is imperative to install serious anti-erosion measures on these lands for sustainable agriculture and environmental quality. It is therefore the objectives of this study to investigate the types of erosion and its effect on selected soil properties in Gusau area, and to unveil the different anti-erosion measures practiced by small holder farmers for conserving their soils

MATERIAL AND METHODS

Site location and Description

The study was carried out in Gusau (latitudes $12^0 13^1$ to $12^0 18^1$N and longitudes $6^0 29^1$ to $6^0 45^1$ E) with an altitude of 300 meters above sea level in the Sudan Savannah of Nigeria. The area is characterized by two climatic seasons; dry season (November – April) and rainy season (May – October). It also has mono-modal rainfall pattern ranging from 750-1000 mm with annual mean of 875 mm. The mean annual temperature is 30 ºC. The vegetation as observed by Kaltho *et al* (1997) consists of short grasses forming a matrix for thorny shrubs. Gusau area (Figure 1) is drained and influenced by River Sokoto and the uplands are traversed by some small streams and rivers. These are tributaries of Rima, Sokoto, and Niger rivers flowing westwards and southwards along the regional landscape of the Gusau area (Shear & Partners, 1991). According to Swindel *et al*, (1982)

the study area is undulating in nature and sloping gently to the river valley. Although dominated by plains, older types of granitic rocks occur all over the landscape, presenting a distinct feature in the form of inselbergs, The area equally occupies part of the extensive Northern Plains, otherwise known as 'High plains of Hausa land" which is underlain by rocks belonging to the Pre-Cambrian basement complex, and as such commonly found are hard, coarsely crystalline granites and gneiss (Swindel *et al*, 1982). Land use practices in the study area include continuous cultivation, grazing, and fuel wood extraction which have subsequently depleted the vegetation of the area.

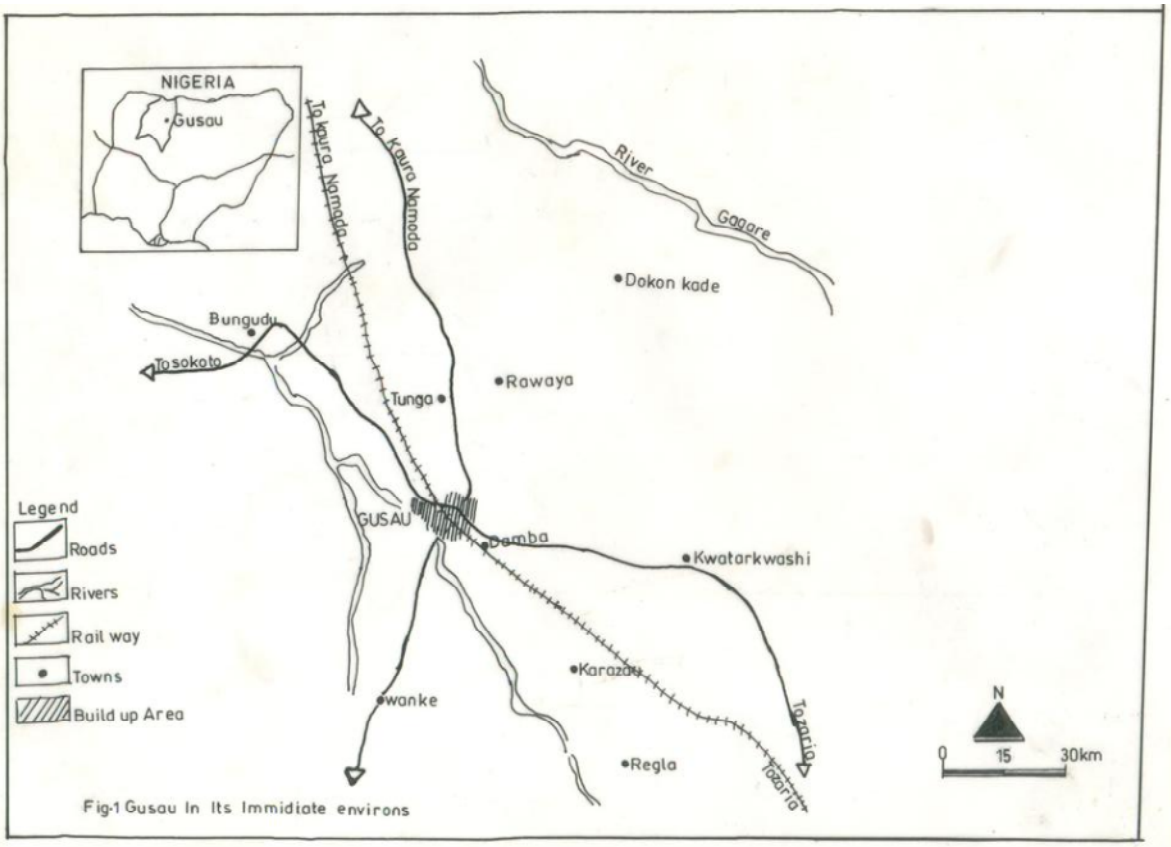

Figure 1: Map of the study area

Sources of Data

The data for this study were derived mainly from primary and secondary sources. Primary data were generated through field survey by observations of the soil management practices adopted by the farmers on the eroded lands as well as the laboratory analyses of the sample soils collected to monitor the effect of these practice on some soil properties. Similarly, responses from the questionnaires administered to farmers in the study area form another source of primary data. Secondary data were however obtained from publications/literature relevant to the research work; and also in form of maps/aerial photos which guided the delineation of the study area.

Sample size and Sampling techniques

Following a careful reconnaissance survey of Gusau area, special attention was made to six (6) districts (Mayana, T/ Wada, Rijiya, Damba, Galadima, and Madawaki) where there are critical erosion problems. Stratified random sampling technique was employed in selecting 12 villages (Kasha ruwa, Jaurin Rogo, Geba, Gidan Maidawa, Gidan Baushi, Bulunku, Unguwar Mangwaro Karazau, Hayin Karzau, Janyau, Madidi, and Abarma) from the six districts identified with erosion problem. Moreover, the same sampling method was adopted in selecting six rill and gully erosion sites from the villages for the observation of the soil management practices adopted by the farmers. In the administration of the research instrument – structured interview schedule to 350 farmers in the area, cluster (area) random sampling method was used to select the respondents from the 12 selected villages found to experience critical erosion problem within Gusau area. Finally, a purposive quota sampling technique was also adopted in collecting soil samples at a depth of (0 – 20 cm) for each of the land use types – Maize, Cotton, and Cowpea within the study area.

Soil Analysis

The soil samples collected were analyzed for the following properties using standard laboratory procedures: Particle size analysis was determined by using hydrometer method as described by Gee and Bauder (1986). Measurement of pH was done using a glass electrode pH meter or a ratio of 1:2.5 suspensions in water. Organic Carbon was determined by dichromate oxidation method (Nelson and Somners, 1982). Ca and Mg were measured using an atomic absorption spectrophotometer (AAS) while Na and K were measured with the aid of flame photometer. ECEC was determined by summation method following the extraction of exchangeable acidity in 1N KCl. Available phosphorus was extracted using dilute HCI/NH4F as described by Bray and Kurtz (1945), while total nitrogen was determined following the regular Kjeldahl method (Bremner and Mulvaney, 1982).

RESULT AND DISCUSSION

Socio-Economic Characteristics of the Farmers in the Study Area

From the data presented in Table 1 below, the sex distribution of the respondents reveals that 98.9% of the farmers interviewed were males, while 1.1% was females. This signifies that farming is a male dominated activity in Gusau area which is as a result of the purdah system that restricts women from some outdoor activities such as farming. In the same vein, the age distribution of the respondents shows that only 0.9% falls within the age bracket below 20 years. This may be due to the fact that children within this category are mostly in schools. 15.4% of the respondents are between the ages of 20 to 40, and with no female farmer in that category and farmers between the ages 41 to 60 years are 28%. The last group of farmers of ages 61 years and above is the dominant 54.6% males and 1.1% female farmers. This can be accounted for by the fact that most people within this age group have retired from civil service and are into full time farming activities. Again, the female farmers in this category are all widows who possibly inherited farms from their late husbands.

The educational qualification of the respondents (Table 2) ranged from Qur'anic education which is the most dominant among the farming population in the study area with 45.4%, to tertiary education which is the least having only 5.1% of the total respondents. Between these are adult education (10.3%), primary education (17.7%), and secondary education (21.4%).

Similarly, the occupational types engaged by the respondents in this study as presented in the same Table 2 shows that 34.9% of the respondents engaged in farming as the most dominant activity and the only source of their income, 33.1% of the respondents combine farming with local crafts, 19.4% combine farming with trading and civil servant has 12.6%. The data also reveals that those who attained tertiary education do not engage in farming as a primary economic activity because majority of them are civil servants.

Table 1: Age and sex distribution of the respondents

Age (years)	Male	%	female	%	Total	%
≤ 20	3	0.9	0	0	3	0.9
21 – 40	54	15.4	0	0	54	15.4
41 – 60	98	28.0	0	0	98	28.0
≥61	191	54.6	04	1.1	195	55.7
Total	346	98.9	04	1.1	350	100

Source: Field survey, 2009

Table 2: Educational status and occupation of the respondents

	Occupation of the respondents									
Educ. status	**Farming**	**%**	**Local craft**	**%**	**Trading**	**%**	**Civil Service**	**%**	**Total**	**%**
Qur'anic educ.	70	20	52	14.9	18	5.1	19	5.4	159	45.4
Adult educ.	14	4	7	2	12	3.4	3	0.9	36	10.3
Primary educ.	28	8	13	3.7	21	6	0	0	62	17.7
Secondary educ.	10	2.9	41	11.7	16	4.6	8	2.3	75	21.4
Tertiary educ.	0	0	3	0.9	1	0.3	14	4	18	5.1
Total	122	34.9	116	33.1	68	19.4	44	12.6	350	100

Source: Field survey, 2009

Table 3: Methods of land acquisition and years of farming experience

	Years of farming experience											
Land acquisition	**1-5**	**%**	**6-10**	**%**	**11-15**	**%**	**16-20**	**%**	**21above**	**%**	**Total**	**%**
Inheritance	6	1.7	9	2.6	23	6.6	56	18	67	19.1	161	46
Hiring	2	0.6	3	0.9	9	2.6	20	5.7	26	7.4	60	17.1
Purchase	3	0.9	2	0.6	25	7.1	39	11.1	18	5.1	87	24.9
Burrowing	1	0.3	7	2	14	4	3	0.9	0	0	25	7.1
Gift	0	0	6	1.7	2	0.6	5	1.4	1	0.3	14	4
Others	0	0	3	0.9	0	0	0	0	0	0	3	0.9
Total	12	3.4	30	8.6	73	20.9	123	35.1	112	32	350	100

Source: Field survey, 2009

Table 4: Agricultural land use practices and farmers' consistency over the years

	Consistency over the years					
Agricultural land use	**Yes**	**%**	**No**	**%**	**Total**	**%**
Rain-fed agriculture	171	48.9	36	10.3	207	59.1
Market gardening	46	13.1	8	2.3	54	15.4
Animal grazing	72	20.6	17	4.8	89	25.4
Total	289	82.6	61	17.4	350	100

Source: Field survey, 2009

Land acquisition through inheritance is the dominant method in the study area (Table 3) amounting to 46% of the respondents. This method leads to small land holdings due to fragmentation of the farm to the heirs, and consequently resulting to too much pressure on the land as well as its degradation. Hiring and purchase both as methods of land acquisition in the area have 17.1% and 24.9% respectively. 7.1% of the respondents use borrowed land for cultivation while gift land and other means of land acquisition have 4% and 0.9% respectively.

In a likewise manner, the years of farming experience as revealed by the same table show that respondents in the inheritance category totaling 67 (19.1%) have higher years of farming experience (21 years and above) compared to other groups.

Table 4 presents data on agricultural land uses engaged by the farmers and consistency over the years, from the data, it could be observed that rain fed agriculture appears to be the most dominant agricultural land use practiced by the farmers in Gusau area. This is evident from the data shown on table below where 59% of the farmers revealed that they engaged in rain fed agriculture while 15.4% are practicing market gardening on their farms. This is likely due to the proximity of the area to the city center and the state capital – Gusau. The last category of agricultural land use is animal grazing which is engaged by 25.4% farmers in the study area.

Furthermore, on the farmers' consistency with their land use practices over the years, 82.6% of the respondents attest that they have been consistent with their present land use over the years, while 17.4% of the farmers responded that they have not been consistent with the current land uses over the years.

Soil erosion Types and Severity in the Study Area

The data presented in Table 5 shows that 3.4% of the farmers interviewed do not experience soil erosion on their fields which could be attributed to their perception of erosion and its various forms. Sheet erosion (Plate 1) is prevalent on 67 (19.1%) of the farms sampled which is in contrast with rill and gully erosion having 168 (48%) and 103 (29.4%) respectively. Similarly, it could be deduced from the data that sheet erosion has the least occurrence in the study area which may be due to difficulty faced by farmers in noticing its prevalence on their fields. In the same vein, on the severity of erosion in the study area, low soil erosion accounts for 27.4% of the farms studied, moderate erosion constitutes 50.9%, while severe erosion (Plate 2) covers 18.3% of the farmers' responses. This signifies that moderate erosion is the dominant type.

Table 5: Soil erosion types and severity in the Study Area

	Severity of erosion							
Erosion types	**light**	**%**	**moderate**	**%**	**Severe**	**%**	**Total**	**%**
None	-	-	-	-	-	-	12	3.4
Sheet erosion	21	6	37	10.6	9	2.6	67	19.1
Rill erosion	67	19.1	84	24	17	4.8	168	48
Gully erosion	8	2.3	57	16.3	38	10.9	103	29.4
Total	96	27.4	178	50.9	64	18.3	350	100

Source: Field survey, 2009

Plate 1: Sheet Erosion in a farm within Gusau area

Plate 2: One of the severely eroded farmlands in Gusau area

Effects of erosion on selected soil properties in different agricultural land use

Particles size distribution (Table 6) of the soil samples in the different land use areas shows a decrease in clay content from the cultivated fields in comparison with the uncultivated eroded field but the silt contents is relatively similar from the entire fields with cultivated field recording high sand content. This finding is in agreement with Kowal and Kassam (1976) who reported that erosion of cultivated soils remove a proportionately greater amount of silt and clay than sand within the savanna regions of Nigeria. The pH values of the soils under the different land use types, were smallest while their exchangeable acidity values ($H^+ Al$) are the highest, which clearly indicates that soil erosion has decreased the soil pH. This outcome may have adversely affected crop yield as well as the productivity of the soils in the area. Similarly, the table depicts that eroded soils have the least values of organic carbon in both the surface and subsurface soils which again portrays that soil erosion has adversely affected the soil organic matter content in the soil in contrast with the relatively higher values obtained from other land use types in the study. The low values of organic matter content of the eroded surfaces leads to low porosity, decrease water infiltration, and low cations absorption capacity. The values of available phosphorus (AP) in the eroded field are far less only for the soil at the surface (because phosphorus is not a mobile element). This outcome also shows the effect of soil erosion which detaches the rich top soil layer containing most of the valuable soil nutrients including phosphorus. With regards to cations exchange capacity (CEC), the values are highest in the cowpea field and equally the lowest in the eroded surface. This shows that soil erosion has also affected the CEC, being one the most important chemical properties of soil usually related to fertility (USDA, 1999). Similarly, the result from the soil analysis clearly shows that the higher the values of CEC the more the values of organic matter content in all the land use types. This suggests the close positive relationship between CEC and organic carbon content of the soils in all the land use types because CEC represents the primary soil reservoir of available K, Ca, Mg, and several micronutrients, at the same time prevents nutrients leaching from soils. Moreover, the total Nitrogen content (N) of the eroded soils has the least values as could be seen from table 6 below, when compared with the values of the other land use types which again signifies the effect of soil erosion in the removal of this valuable soil nutrient. This finding agrees with Kowal and Kassam (1976) who observed that about 13.7 kg/ha of Nitrogen were lost within four years of rain splash.

Table 6: Mean values of soil data for different land uses in Gusau

	Crop/Land use			
	Cotton	**Cowpea**	**Maize**	**Eroded soil**
Particle size (g kg^{-1})				
Sand	600	460	590	500
Silt	250	310	260	250
Clay	150	230	150	250
pH (1:2.5)				
H_2O	7.2	6.85	7.10	6.60
$CaCl_2$	6.15	6.10	6.05	5.40
OC (g kg^{-1})	3.7	4.1	5.9	1.8
N (g kg^{-1})	0.35	0.44	0.44	0.27
P (mg kg^{-1})	10.53	17.09	46.40	1.78
H^+ AL(Cmol kg^{-1})	0.30	0.25	0.10	0.50
Ca(Cmol kg^{-1})	3.00	6.15	3.40	3.50
Mg(Cmol kg^{-1})	1.26	2.11	1.17	0.35
K(Cmol kg^{-1})	0.60	0.72	0.54	0.57
Na(Cmol kg^{-1})	0.88	0.90	1.35	1.35
CEC	7.40	11.60	7.55	7.30

OC= organic carbon; CEC = cations exchange capacity

Farm Level Anti-erosion Measures in the Study Area

The most notable erosion control practices adopted by farmers in Gusau area could be grouped into two depending on the prevailing type of erosion and its severity; the general terrain characteristics; and the farmers' knowledge of the varieties of appropriate erosion control measures. These include:

i. Agronomic practices which refer to cropping techniques used exclusively with a view to reducing runoff and erosion damage; and
ii. Mechanical erosion control techniques.

Broadly therefore, the following are some of the anti-erosion measures practice by the farmers in Gusau area

Mulching

This form of anti-erosion measure is practiced in Gusau area mostly with crop residues (such as Maize, Millet) etc. Although other mulch materials such as husks, straw and chaff are also used, their effectiveness in mulching in the area is limited largely due to their quality and most importantly, quantity. This practice reduces surface runoff and ensures protection of soil against raindrop impact by creating a protective layer between the raindrop and the soil surface. Similarly, mulching promotes the development of soil structure, and improves the physical conditions of the soil. Mulching supplies organic matter to the soil, which in the words of Wischmeier, *et al* (1971) "A 1% increase in the amount of organic matter in the soil brings a mere 5% reduction in soil erodibility."

Contour farming and tie ridging

This practice though not widely embraced, few farmers in the area make contour embankments and drainages in their fields and then make sure they make their ridges to follow the contour lines so that the eventual runoff is slowed as much as possible. Even though this method is effective only on gentle slopes, contour ridging as observed by Roose (1996) is twice as effective as simple contour tillage, reducing erosion to about 30% of that on the flat-tilled control plot for slopes of 1 to 8%. Similarly, tie ridging practice is also done by farmers in Gusau area to conserve water between ridges and to improve the lateral infiltration of water into the ridged soils. According to Odunze (2008), this technique also conserves soil eroded from the ridge within furrows in such a way that fertilizer materials are not readily lost from the tied-ridging zone.

Cover cropping

Provision of ground cover and high production of organic matter are two most important reasons of using cover crops in erosion control. In Gusau area, legumes such as Groundnuts and Cowpea are commonly grown in rotation with other crops for erosion control and restoration of the lost nutrients from the eroded soils. Similarly, a common leguminous plant in the area *Ipomoea asarifolia* is widely planted on eroded fields to prevent rain splash and runoff damages. This is because; the plant spreads all over the surface thereby decreasing the volume of soil loss from runoff, at the same time ensuring stability of the eroded surfaces.

Sand bagging and Land refilling

This involves using bags filled with sand aligned at some peak runoff areas with a view to diverting the water from entering a farmers' field. Farmers in Gusau area also use sand bags as land re-filling technique especially in the prevention and control of gully development. Moreover, re-filling the eroded lands is also done by the farmers of Gusau area so that the rills and or gullies developed could stabilize and heal. The common materials used for this practice include: Soil materials, solid wastes, corn stalks, and other crop residues.

Terracing

Although not commonly practiced in the area, this is a method employed by few farmers in the hill side areas of Gusau. It involves constructing series of levels, fairly narrow strips of ground on a hillside that would otherwise be too steep for cultivation. The practice controls soil erosion and conserves soil water for plant use.

Strip cropping

This is a cropping technique practiced by farmers in Gusau area when a slope is too steep or too long, or when other types of farming may not prevent soil erosion. In this method for instance, farmer plants maize and legumes (Groundnuts or Cowpea) in alternate strips on the same piece of land. This measure ensures that the strips of legumes would check erosion and also improves soil quality, while in the alternate strip of maize next to the legumes, some soil loss may be experienced which is also trapped by the next alternate strip of legumes following the Maize.

Deep ploughing

This practice is commonly done as erosion control measure by farmers whose fields are either naturally or mechanically compacted due to existence of a hard pan in the subsoil as a result of over cultivation and or other processes in the soil. Deep ploughing is done after crop harvest with a view to improving the infiltration capacity of the soil as well as reducing runoff.

Minimum or zero tillage

As part of recent technology of fighting erosion, very few farmers in Gusau area are now embracing this method. They employ minimum tillage practices and apply herbicides to control weeds in their fields which reduce the vulnerability of their farms to erosion.

CONCLUSION

This study revealed that sheet erosion type is the prevalent in the study area with moderate severity. Erosion also affects soil properties adversely in bared land than in cultivated soils. Different techniques including mulching, contour farming, cover cropping, terracing and strip cropping are being practice by the farmers in conserving their soils for sustainable crop production.

REFERENCE

Abdu, P.S. Boyd, J. Davis, G. Main, H.A.C. McCarthy, M. and Swindell, K. (1982). *Sokoto State in maps; An atlas of Physical and Human Resources.* University Press Limited.

Babalola, O. Jimba, S.C. Maduakolam, O. and Dada, O.A. (2009). Use of Vetiver Grass for Soil and Water Conservation in Nigeria. *Ecosystems* **1**:416-26

Bray, R.H. and Kurtz, L.T. (1945). Determination of total, organic and available forms of phosphorus in soils. *Soil Science*. **59**: 39-45.

Bremner, J.M. and Mulvaney, C.S. (1982). Nitrogen – Total". In: Page, A.L, Millar, R.H. and Keeney, D.R. (eds.) *Methods of Soil Analysis, Part 2. Chemical and Microbiological properties. Agronomy Monograph No. 9, 2nd Edition.* ASA SSSA, Madison, Wisconson, USA, p 1159.

Dalhatu, S. (2009). *Effects of Soil Erosion on Agricultural Land Uses in Gusau Area.* An unpublished M.Sc. Thesis, Department of Geography, Nigerian Defence Academy, Kaduna

Gee, G.W. and Bauder, J.W. (1986). Particle size analysis. In: A. Bluter (ed.) *Method of soil analysis* part 2 (2nd edition) No. 9 ASA Inc. Madison, Washington, D.C.

Hudson, N.W (1965). *The influence of rainfall on the mechanics of soil erosion*. M.Sc. Thesis University of Cape Town

Kaltho, J.B (ed.) (1997). *Gusau Master Plan:* Final Draft Report. Department of Urban and Regional Planning, A.B.U Zaria, Nigeria.

Kirchhoff, G. and Odunze, A.C. (2003). Soil Management Practices in northern Guinea savannah of Nigeria. International Soil Tillage Research Organization Conference, (ISTRO). In Soil Management for Sustainability, 16th Triennial Conference, Brisbane, Australia

Kowal, J.M. and Kassam, A.H. (1976). Energy load and instantaneous of rain intensity storms at Samaru, northern Nigeria. Trinidad, **(53)**

Lal, R. (1987). Effects of Soil Erosion on Crop Productivity, *CRC Critical Reviews in Plant Sciences* **5 (4)**: 303–67.

Lal, R. (1995). Erosion-Crop Productivity Relationships of Africa, *Soil Science Society of America Journal* **59 (3)**: 661–67.

Morgan, R.P.C (1995). *Soil erosion and Conservation*. Longman, Malaysia

Nelson, D.W. and Somners, L.E. (1982). Total carbon, organic carbon and organic matter. In: A.L. Page *et al.* (eds.). *Method of soil analysis.* Part 2 (2nd edition) Agron. Monograph 9. ASA and SSSA, Madison, W.I.

Odunze A.C. (2008). Soil Conservation and Management Practices. Department of Soil Science, IAR/ A.B.U Zaria

Pimentel, D. and Nadia, K. (1998). Ecology of Soil Erosion in Ecosystems.

Productivity Research in South America. *Advances in Geo Ecology* **31**: 335–62.

Roose, E. (1996). Land husbandry practices – Components and Strategies. 70 FAO Soils Bulletin, Rome: Food and Agriculture Organization (FAO).

Scherr, S.J. (1999). "Soil Degradation: A Threat to Developing-Country Food Security by 2020" Food, Agriculture, and the Environment Discussion Paper 27. Washington, DC: IFPRI.

Shear and Partners (1991). *Gusau Land use Development Plan 1990 – 2011*. Dar al Handasah Consultants

Stoorvogel, J.J. and Smaling, E.M.A. (1998). Research on Soil Fertility Decline in Tropical environments: Integration of Spatial Scales, *Nutrient Cycling in Agroecosystems* **50**:151–58.

USDA, Natural Resources Conservation Service (1999). *Soil quality test kit guide.* Retrieved on 30th May, 2009 from www.google.com /search?

USDA, Natural Resources Conservation Service (2004). Soil survey laboratory Methods manual. *Soil survey investigation report No. 42 version 4.0.* Natural Resources Conservation Service.

Vernon, W.R. (1999). The transition to Agricultural Sustainability. Retrieved from www.pnasorg/ search? On Saturday 30th May, 2009

Wischmeier W.H. Johnson, C.B. and Cross, B.V. (1971). A soil erodibility monograph for farmland and construction sites. *Journal of Soil and Water Conservation* **26 (5)**: 189-192.