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The effectives of indigenous soil conservation techniques on sustainable crop production

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Abstract

Soil and water conservation techniques remain an indispensable tool in sustaining crop production especially on farm lands under severe soil degradation. Six (6) village farm locations (Humbutode, Gella, Digil, Yewa, Hurida and Duda) within Mubi area that apply indigenous soil and water conservation techniques (Hillside-terraces, stone-bunds, stone-lines, sand-bag lines, trash-lines, vegetative-barriers, earth-contour bunds, rice-bran mulch and organic-manuring) were surveyed and assessed for effectiveness between April and November, 2006. Parameters related to soil degradation such as vegetation, topography, land slope, soil textural class and erosion types were equally noted and/or measured. Data collected were statistically analysed and compared using Likert scaling test. The result indicated that Hillside-Terraces (Gella and Duda), earth-contour bunds (Humbutode), vegetative-barriers (Digil, Yewa and Hurida), rice-bran mulch (Digil and Yewa) and organic-manuring (Digil) effectively conserved soils against erosion losses that characterize the Mubi undulating topography. The challenge to optimally sustain a timeless food crop returns through locally effective soil and water conservation methods feasible in Mubi area were equally addressed.

Keywords: Likert scaling test, Indigenous techniques, soil conservation, effectiveness, agrarian locations, and sustainable crop production.

Introduction

Over the centuries, intensive systems of soil and water conservation have been developed and practiced by local farmers settling around the adjacent plains of the Mandara Mountains of Northern Nigeria. Conservation farming techniques such as hillside terraces, stone-lines and bunds, trash-lines, sand-bag lines, earth-contour bunds, crop rotation, rice-bran mulch, vegetation-barriers and organic manuring utilize natural ecological processes to conserve moisture, improve soil structure, curtail soil erosion and enhance soil fertility (Morgan, 1986). Safe disposal of run-off water involves practices such as the physical manipulation of soils, which includes land shaping, construction of contour-bunds, terraces, waterways and ridges as measures to improve water infiltration and conservation (Ray, 2006).

However, in recent years, adaptation of incompatible technologies on some soil environments are noticed limitations that have put most arable lands into perpetual degradation (Anon, 1999). Thus, farming activities are adversely affected due to diminishing productive capacities of the soils (Lal, 1995). Consequently, crop returns often deplete sharply and reflected in prohibitive food dearth and starvation among human population (Olawoye, 2000).

Therefore, assessment of localized soil and water conservation practices in an erosion prone environment such as Mubi area is of paramount importance. In view of this need, the present study was conducted in order to assess the effectiveness of these practices on sustainable crop production in the study area.

Materials and Methods

Study Area

Mubi is situated in the Northeastern part of Adamawa State, and located between latitudes 9°26' and 10°10'N and between longitudes 13 °1' and 13° 44'E. It has a land area of 506.40km^2 with a population size of 759,045, with a density of 160.5 persons per square kilometer (Nwagboso and Uyanga, 1999). Its eastern boundary belts the Nigeria-Cameroon border by the Mandara mountain ranges. Mubi borders Michika Local Government Area to the North, Asikira–Uba to the West and Hong Local Government to the South. The climate of the area is characterized by alternating dry and wet seasons. The rains last from April to October with a mean annual rainfall ranging from 700mm to 1,050mm (Adebayo, 2004, Udo, 1970) and atimes ranging between 998mm and 1,262mm as documented by the Adamawa Agricultural Development Programme Mubi weather station in 1999. The vegetation is of typical Sudan Savannah, which connotes grassland interposed by shrubs and few trees mostly Acacia, Eucalyptus and Locust-bean trees amongst others (Tekwa and Usman, 2006; Adebayo, 2004). The dominant physical feature in the area is the Mandara Mountains, which runs along the Cameroon-Nigeria boarders with heights of up to 1200 to 1500m (Hiol, *et. al*., 1996). In the foothills, soils are made of colluvial deposits with regosols occurring in juxtapositions with rocky outcrops and lithosols. Soils on the adjacent plains are predominantly clayey sand mixed with gravels placed on a gentle to steep slopes with dissected surfaces. The land use types are mainly arable farming and livestock production threatened by soil erosion at varying devastations from sheet and rill erosion to the spectacular gully erosion known for colossal loss of soils and nutrients (Tekwa, *et al.,* 2006). Even though, structural degradation occurs combined with increasing impermeability and gully erosion, yet, the soils has been noted for high quality production of variety of crops including cotton, sorghum, millet and groundnut under strategize management (Hiol, *et. al*., 2006).

Field study

The research was carried out between April and November, 2006 in six (6) village farm locations namely; Humbutode, Hurida, Digil, Duda, Gella and Yewa, all within Mubi area. Field parameters such as vegetation, topography and land degradation types were observed and noted in each location. Slope angles were measured using an Abney level. Field data were purposively sampled through on-farm oral interviews (on farmers' perceptions) and using structured questionnaires (120 copies) administered (20 copies per location) among farmer population practicing local conservation methods in the six (6) sites studied. A total of 98 farmers' perceptions were sampled and analyzed for this study. Other information on the subject was sourced from existing relevant literatures.

Laboratory study

Composite soil samples consisting eight (8) samples from each site were collected (using bucket auger) as representative soil samples. The samples were labeled and prepared for laboratory analysis. The soil particle size distribution was determined using the Bouyocous hydrometer method (Trout, *et al.,* 1987) from where the soil textural classes were obtained through subjecting same data to soil textural triangle.

Data Analysis

The effectiveness of the techniques was analyzed using a 4-point Likert scaling test (Asika, 1991) expressed as: **ETV**=∑ (Scale-grade **x** Corresponding Responses/Total Number of Questionnaires)
where: ETV=effectiveness test value and ∑=summation. The scale-grades were; 1=Not effective; 2=less effective; 3=moderately effective and 4=highly effective. Effectiveness Test Value (ETV) of 2.5 was taken as the benchmark, below which any of the technologies was considered as not effective (NE) within a given effective period (EP).

Results and discussion

Results on field parameters such as vegetation, present land use, land slopes, degradation types and conservation practices alongside corresponding impacts are presented in Table I. Individual study of each location are presented as follows:

Digil location

The area appears on a gently slopping (0-4%) ground with few trees, grasses and shrubs. The devastating soil degradation agents are sheet erosion and gully landslides of mainly sandy clay loam soils. Present land uses are predominantly arable farming (mainly maize, guinea-corn, cowpea and beniseeds) and livestock production (Ekwue and Tashiwa, 1992; Tekwa and Usman, 2006). Localized soil and water conservation practices are largely the use of rice-bran mulch, trash-lines, sand bag lines, vegetative barriers and organic manuring, which were experienced as highly effective between 3 and 6 years. However, both Hill-side terraces and earth–contour ridges were perceived as not effective techniques, likely due to its less need on the area's level topography (Table 2). Even though, rice–bran mulching. The sites that seasonally experiences active gulling amongst other severe degradation activities, were largely conserved through use of the effective practices (Table 2) in maintaining crop production stably in the area. It is recommended that extension workers such as Agricultural Development Programme staff, should create farmer awareness in order to address the limited application of the soil enriching rice-bran mulches as a close alternative to the scarce mineral fertilizers in the area.

Duda location

The site is placed on a steeply slopping (20-22%) ground dominated by livestock production and arable farming of largely guinea-corn grown amidst rill and gully erosion devastations. The soils are predominantly silty clay loam textured with few tress and grass vegetation (Ekwue and Tashiwa, 1992). High erosion intensities due to site elevation (Table 1) are seasonally curtailed by application of durably strong barriers. Effective conservation techniques were Hillside terraces, stone bunds /lines, sand bag lines, vegetative barriers and organic manure applications over an effective period of between 2 and 10 years (Table 2). Both earth-contour ridges and rice-bran mulching practices were not used, possibly due to its perceived low impacts under the excessive erosion devastations, and thus, termed as not effective in the area (Table 2). Field observation showed that considerable soil and water were conserved against the menacing rill and gully erosion with only a low labour input, thereby enhancing yearly crop production success in the area.

Hurida location

The riverine area is sited on a moderately slopping (8-10%) field with considerable trees interposed by shrubs. The soil is mainly of sandy loam textures largely utilized for orchards. Gully landslides prove the most serious soil loss agent devastating the area (Ekwue and Tashiwa, 1992). All the conservation practices (Table 2) investigated recorded moderate to high effectiveness within 2 to 12 years periods, except for the less applicable earth-contour ridge technique. The effective conservation practices in place conserved moisture, retained earth and curtailed gully spreads (Table 1) with a contribution on sustainable crop production activities in the area.

Humbutode location

The site appears on a relatively flat topography (0-4%) and seasonally experiences impeded drainage as a major soil degradation faced by farmers. The soils are predominantly of clay loam textures covered by tall grasses and few trees. Earth-contour bunds have remained the most effective conservation practice amongst other techniques in the area (table 2). Similarly, vegetative barriers, rice-bran mulch and organic manuring were rated as moderately effective within 1 to 4 years, while stone bunds/lines, sand-bag lines and hillside terraces were low in soil conservation, and

Table 1. Field and conservation practice parameters

Farming location	C. F experience (years)	Present land use	Vegetation	Major crop grown	Land-slope (%)	Soil texture	Major degrada-Tion	Major conservation practices	Conservation practice Effectiveness
Digil	5-28	Arable farming and Animal grazing	Few trees, grasses and shrubs	Maize	0-4	SCL	Sheet Erosion gully-landslides	Rice-bran mulch, trash lines, sand-bag lines, vegetative-barriers and organic–manuring	Protects soil surface, retains earth and conserves moisture with longer conservation effectiveness
Duda	10-22	Arable farming and animal grazing	Few trees and grasses	Guinea-corn	20-22	SCL	Rill and gully Erosion	Stone bunds /lines Hillside Terraces and stone-lines.	Protect rill and gully erosion, Conserves soil moisture with longer conservation effectiveness
Hurida	5-30	Orchard	Trees and Shrubs	Vegeta.	8-10	SL	Gully-landslides	Stone-lines/bunds vegetative barriers, sand-bag lines and trash lines	Retains earth, checks gully erosion and conserves soil moisture. Enhances good drainage conditions. Reclaims degraded lands.
Humbu.	11-25	Arable farming	Tall grasses and few trees	Sweet potato	0-4	CL	Impeded drainage	Earth-contour bunds, vegetative barriers, rice-bran mulch and organic-manuring.	Redirect run-off water and enhances good drainage conditions
Gella	12-35	Arable farming and Animal grazing	Trees, shrubs and few grasses	Guinea-corn	20-22	SC	Sheet and gully Erosion.	Stone lines/bunds, Hillside terraces, vegetative barriers, organic manuring.	Protect sheet and gully erosion. Conserves soil and water. Retains earth and soil sediments Longer conservation effectiveness
Yewa	7-38	Arable farming and Animal grazing	Few trees, grasses and shrubs	Sugar-cane	4-6	SCL	Sheet and gully Erosion	Vegetative barriers, trash lines, sand-bag lines and stone bunds/lines and Rice-bran mulch.	Protects gully and sheet erosion spreads, Reduces slope lengths and flattens land slopes for arable use

Key: C.F=conservation farming, SCL= Sandy clay loam, Sicl=Silty clay loam, SL=sandy loam, CL=clay loam, SC=Sandy clay, Conserv.= Conservation, Humbu=Humbutode, Vegeta=vegetables
Source: Tekwa and Belel (2009)

Table 2. Likert Scaling Test for Conservation practice effectiveness

Conservation Practice	Village Farm Locations																	
	Digil			Duda			Hurida			Humbutode			Gella			Yewa		
	ETV	ER	EP (yrs)	ETV	ER	EP (yrs)	ETV	ER	EP (yrs)	ETV	ER	EP (yrs)	ETV	ER	EP (yrs)	ETV	ER	EP (yrs)
Rice-bran mulch	2.75	E	3	1.00	NE	-	3.05	E	2	3.32	E	3	1.20	NE	-	3.82	E	4
Organic manuring	3.43	E	3	3.21	E	2	3.65	E	3	3.36	E	1	3.70	E	3	3.70	E	2
Hillside terrace	1.00	NE	-	3.79	E	10	3.45	E	12	1.84	NE	-	3.75	E	12	3.88	E	14
Earth–contour ridge	1.52	NE	-	1.73	NE	-	1.90	NE	-	3.90	E	2	1.30	NE	-	1.59	NE	-
Sand-bag lines	3.53	E	3	3.58	E	4	3.45	E	5	1.90	NE	-	3.60	E	6	3.53	E	5
Vegetative barriers	3.36	E	6	3.53	E	5	3.65	E	8	3.53	E	4	3.15	E	7	3.53	E	5
Stone bunds/lines	1.90	NE	-	3.79	E	7	3.80	E	9	1.48	NE	-	3.50	E	8	3.37	E	10

Key: ETV = Effectiveness Test Value, ER = Effective Rate, EP = Effective Period, NE = Not Effective, E = Effective, yrs = years.**Source**: Field survey (2006) perceived as not effective techniques (Table 2) in the location. The established structures indicated effectiveness in redirecting run-off water and provision of well-drained soil conditions (Table 1). The collective contributions of the effective practices have indicated a considerable influence on crop production (sweet potato) cultures often with increased crop yields in the area.

Gella location

The site elevation (20-22% slope) seasonally contributes in run-off generation resulting into rill and gully erosion distributions with considerable devastation. Though, the soils (sandy clay) are relatively resistant to surface erosion and gully expansions (Tekwa and Usman, 2006), arable activities are still limited by the physical terrain (rock outcrops) of the area. Livestock production appears favourable on its shrub, trees and grassed vegetation. The investigation recorded the conservation practices (Table 2) as highly effective techniques within 3 to 8 years period, except for rice-bran mulch and earth-contour ridges that were uncommon practices in the area. The conservation practices effectively controlled sheet and gully erosion, trapped soil sediments, reclaimed degraded farmlands and conserved soil moisture. Seasonal sustainability of arable cropping (e.g. guinea-corn) is usually enhanced through correct use of these technologies in the area.

Yewa Location

The area occupies a moderate slopping (4-6%) ground covered by few trees, grasses and shrubs. The soils (sandy clay loam) are deep, well drained and suitable for cultivation of variety of crops, especially sugar-cane, which dominates farming activities in addition to animal rearing in the area (Ekwue and Tashiwa, 1992). Prevalence of sheet and gully erosion appears eminent in the area, thereby requiring durably strong barriers to curtail soil movements. It was observed that the conservation techniques investigated were highly effective between 2 and 14 years period, except for the uncommonly practiced earth-contour bunds which are not effective in the area. The effective practices protected sheet and gully erosion, trapped soil sediments and conserved soil moisture with relatively low labour inputs (Table 1). Sugar-cane farming successes are enhanced by periodic accumulation of fertile alluvial and colluvial soils deposited by run-off water seasonally.

Conclusion

Local technologies appeared viable and relevant in conserving soil and water required for sustainable crop production in this study. Even the techniques rated as not effective were likely due to their non-applications, other than the observed inefficiency of the technologies. Long-term effectiveness was recorded as direct functions of the stony conservation structures established in the areas studied. It is viewed that rice-bran mulching and organic manuring notably improved considerable soil physico-chemical properties for supportive plant growth.

Recommendation

It is recommended that the observed effective soil protecting and enriching practices should be extensively encouraged among farmer population to enable cheap soil conservation and fertilization as alternatives to the costly scarce mineral fertilizers.

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Appendix I: Field Questionnaire

1. Name/Age of farmer
2. Farming location
3. Years of conservation farming experience (a) 1-5 years (b) 5-10 years (c) 10-15 years (d) 15-20 years (e) above 20 years.
4. Type of crop(s) grown (a) Maize (b) Guinea-corn (c) Sweet potato (d) sugar-cane (e) Other (s) specify
5. Land degradation type experienced (a) Sheet/rill erosion (b) gully Erosion (c) impeded drainage (d) landslide erosion (e) other (s) specify
6. Type of conservation technique practiced (a) Rice-bran mulch (b) organic manure

(c) Hillside-terrace (e) earth-contour ridge (e) Sand-bag lines (f) vegetative barriers
(g) Stone-bunds/lines (h) other (s) specify

7. How long does your conservation structure resist degradation agent(s)? (a) 1 year (b) 2-5 years (c) 5-10 years (d) over 10 years
8. How effective is the conservation technique(s) practiced? (a) Highly effective (b) Moderately effective (c) Marginally effective (d) Not effective (e) other(s) specify
9. What is the level of land degradation experienced? (a) High devastation (b) Moderate devastation (c) Low devastation (d) No devastation (e) Other (s) specify
10. What conservation practice(s) enhances higher crop yields? (a) Rice-bran mulch (b) Organic-manure (c) Hillside Terraces (d) earth-contour ridge (e) sand bag lines (f) Vegetative barriers (g) Stone-bunds/line (h) Other(s) specify