Spotting Specific Agricultural Practices Impacting Desertification in Zamfara State, Nigeria

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Abstract
Agricultural practices are among anthropogenic factors impacting the desertification process. However, it is necessary to determine which of the practices that most affect the process. Eleven of the nineteen Nigeria's northern states bear the characteristics of the Sudano-Sahelian region. One of them (Zamfara State) was randomly selected for the study. A structured questionnaire was administered on 500 farmers out of which 497 of them responded. Data extracted were subjected to Pearson's correlation and stepwise regression analyses. The Pearson's correlation showed positive association between desertification and slash and burn, (r=0.074; p=0.05) and free-range farming (r = 0.103; p = 0.011 and negative association between desertification and organic manuring (r = -0.100; p = 0.013). The stepwise regression analysis showed that there was a significant relationship between desertification and free-range farming and organic manuring at p = 0.035 and p = 0.040 respectively. It was therefore concluded that slash and burn as well as free range farming were some of the agricultural practices employed in Zamfara State that most exacerbated desertification process in the region.
Keywords: Desertification, Agricultural practices, Free range farming, Organic manuring.
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1. Introduction

Agriculture, or farming, is one of the activities through which man has been blamed for his role in land degradation. According to Ezeh and Omotayo (2020), in a typical farm setting, there are identifiable activities such as land clearing, bush burning, tillage, organic manuring, irrigation, rain-fed farming, inorganic fertilization and, depending on adopted farming system, we could have crop rotation, shifting cultivation, zero grazing and free-range farming. Medugu *et al.*, (2007); Ceylan, (2009); Guo, *et al.*, (2011) and Ezeh and Omotayo (2020) all suggested that farming activities have deleterious effects on land and in fact do lead to desertification. According to Olarenwaju (2006), growing practices of slash-and-burn and other methods of subsistence farming necessitated by famines in less developed countries, are other causes of desertification. In some instances, it has been suggested that, nomads, moving to less arid areas disrupt the local ecosystem and increase the rate of erosion of such areas. Okorie (2003) suggested that nomads, typically, try to escape the desert but, because of their land use practices, they bring the desert with them.

Desertification, as a terminology, was first used by a French Botanist, Andre Aubreville, in his book, Climate, Forest et Desertification de l'Afrique Tropicale (1949) where he described desertification as the changing of a once productive land into a desert as a result of ruination of land by man-made soil erosion. Since then, desertification has taken prominence and has been acknowledged as a major environmental malady. Glantz, (1994) described desertification as a process that has a series of incremental or step-wise changes in biological productivity in arid, semi-arid and dry sub-humid ecosystems. It is a process of land degradation in arid, semi-arid and dry sub-humid areas caused by changes in climatic factors, human and animal activities (UNCCD 2004). This UNCCD definition seems to have been adopted as the operational definition as it commands huge acceptability.

In Nigeria, desertification is manifested by the visible presence of active sand dunes as found in Yobe, Borno and the Northern parts of Sokoto and Kebbi States. The critical desert-states (often referred to as the 11 frontline States) of Nigeria include: Adamawa, Bauchi, Borno, Gombe, Jigawa, Kano, Katsina, Kebbi, Sokoto, Yobe and Zamfara. The population of these frontline states put together is 46.4 million representing 31% of Nigeria's total population and occupying over 40% of Nigeria's total land mass (Fawusi, 2011). Dry lands in Nigeria extend from Sudan-Sahel Savannah to the Northern Guinea Savannah. With its huge population, there is a lot of human pressure on land particularly the marginal areas. This has continued to take its toll on the environment thereby leading to desertification (Usman, 2007). Desertification is believed to have depleted the nation's forest area by up to 10% leading to a threat of extinction of 11% plant species out of its 4,600 recorded species (Fawusi, 2011). In the same process, Olagunju (2015) and Emodi (2013) reported that as much as 63.83% of Nigeria's total land is encroached upon by desertification and that as much as 15% is already taking-on desert characteristics, thus, making the encroachment a life-threatening phenomenon and therefore, give serious reasons for concern.

Eleven of the nineteen Nigerian northern states are designated as front-line states by the Federal Government of Nigeria on account of their proximity to the Sahara Desert. These are Kebbi, Sokoto, Zamfara, Katsina, Kano, Jigawa, Bauchi, Gombe, Yobe, Borno and Adamawa states.. These states are sandwiched between the Sahel and the Guinea Savannas. The area features low rainfall and sparse vegetation with average annual rainfall varying from 250 mm in the extreme northern areas to 750 mm in the southern parts and can be highly erratic. Incidentally, this semi-arid zone of Nigeria, which is characterized as susceptible to desertification process, constitutes the country's largest grain producing area as well as the largest concentration of livestock (Ezeh and Omotayo, 2020). One of these states, Zamfara state, was randomly selected for this study.

Desertification is considered to be one of the major challenges facing development in Africa. A number of factors have been identified as being responsible for these (UNEP, 2006). Schematically, the concept diagram (fig.1) below shows the inter-relationship between the various processes that could lead to desertification. The diagram shows the two major factors that cause desertification. These are the anthropogenic and natural factors. Under anthropogenic factors, we have agricultural practices, industrialization/infrastructural expansion, mining and demographic factors each leaving, in its trail, processes that eventually lead to erosion and land degradation. The same could be noticed under natural factors where drought, climate change and wind/water erosion trigger processes that lead to land degradation.

Usually, for agriculture, the first visible sign of a degraded land is loss in crop and animal yield. This loss leads to food crisis. Food crisis in itself has dual effects of hunger (lack of food to eat) and lack of purchasing power as, with a depleted stock, the farmer probably has nothing to sell to raise cash. He inevitably becomes poor. Faced with poverty, the farmer struggles to survive. Thus, he intensifies farming on an already depleted land or extends to marginal lands. The same applies to an animal farmer who causes the only available rangeland to be overgrazed or extends to marginal lands. Each has the effect of turning in poor yields and further degradation of the soil; and the vicious cycle continues. In the face of increasing population and dwindling available farm land the farmer tends to over crop/over graze, added to his traditional slash and burn and tillage practices, the result of these anthropogenic factors manifests as desertification which is a form of land degradation (Nasiru, 2007). A degraded soil has a destroyed structure, low organic matter content, poor water and nutrient holding capacity amongst others. Such a soil can neither support crop growth nor forage for animal grazing (Olagunju, 2015). In essence, aggregated farming activities, could, and indeed do play a role in land degradation (Medugu *et al.*, 2007). As already noted, farming, as a profession, encompasses a gamut of activities. The objective is therefore to ascertain if each and all of these activities contribute to the desertification process? Furthermore, is it not possible that some of these activities do, indeed, enhance land conservation? It therefore becomes necessary to identify which of these activities that actually exacerbates, or indeed, mitigates the desertification phenomenon.

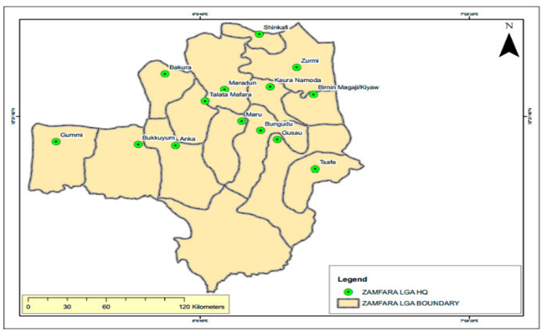
This study therefore seeks to disaggregate the agricultural practices with a view to determining which amongst them really causes the problem and then suggest solutions to the issue.

2. Research Methodology

2.1. The study area.

2.1.1 The Sudano-Sahelien Region

The Sudan Sahel region of Africa stretches in a West-East direction from Senegal by the Atlantic Ocean in the West through Mali, Guinea, Burkina-Faso, Niger, Nigeria and Chad to West Sudan, by the Red Sea in the east (Omijeh, 2008). In Nigeria, twelve of the nineteen northern states are either completely or partially in the Sudano-Sahelian region, and include Kebbi, Sokoto, Zamfara, Katsina, Kano, Jigawa, Bauchi, Gombe, Yobe, Borno, Adamawa and Kaduna states. Zamfara state was randomly selected for the study.



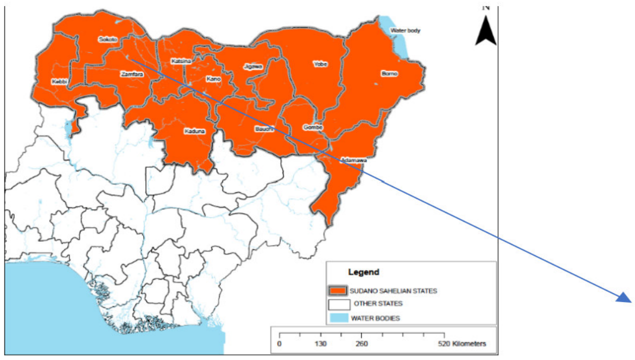


Figure 2: Sudano-Sahelian Nigerian States
Source: Ezeh and Omotayo, 2022.

Figure 2a: Map of Zamfara Local Government Areas

2.1.2. Zamfara state of Nigeria

The State is located between latitude 12°10N and longitude 6°15E and bounded by Katsina state to the east, Niger Republic to the north, Sokoto and Kebbi states to the west and Niger and Kaduna states to the south. The area is characterized by scanty rainfall averaging 200-750 mm annually with great variation from year to year (Omijeh, 2008).

2.2 Research design.

Correlational, ex-post factor and survey designs were employed for this study. Correlational design was used to examine the relationship between causes (agricultural activities) and effect (desertification). Ex-post factor design was used to determine to what extent the extant situation has been brought about by agricultural activities in the study area. The study employed the survey research design since it seeks to examine the status of only a cross section of farmers.

2.2.1Population of the study

The population for the study consisted of all farmers registered with the Zamfara state ministry of Agriculture. This was made up of both the large and small-scale farmers distributed across each local government area of the state. The farmers, in their daily routines, encounter the direct effects of desertification and so are better placed to assess its impact.

2.2.2 Sample and Sampling Techniques

A total of forty thousand, six hundred and forty-eight (40,648) large scale and small-scale farmers registered in Zamfara state constituted the sampling frame. The stratified sampling technique was used to select 500 farmers from both categories in the fourteen local government areas of the state using the formula developed by Taro Yamen in 1946.

3. Research instrument

A structured questionnaire comprising two main sections was administered to the farmers. Section A of the instrument provided the personal data of the farmers while section B, provided information on the impact of desertification. Focus group interview of the farmers was also used to complement and clarify responses from the farmers.

3.1 Data analysis

Data from the survey were analyzed using both descriptive and inferential test statistics. The descriptive statistics analyzed for the mean, standard deviation, percentages, tables and charts. Inferential statistics of Simple/Stepwise Regression and Pearson's Product Moment Correlation Coefficient Analyses were used to test the results of the study. The regression equation used was of the form:

$$Y = a + b_1x_1 + b_2x_2 + \ldots + b_nx_n \quad \text{(equation 1)}$$

Where Y = Dependent variable (Desertification)
a = regression constant (the intercept).
b = regression coefficient.
x = Independent variables.

4. Results

Distribution of farmers according to the local government areas in Zamfara state is presented in Table 1.

Table 1: Distribution of Farmers by Local government areas

LGA	LARGE-SCALE FARMERS SAMPLE		SMALL-SCALE FARMERS SAMPLE		TOTAL SAMPLE		TOTAL FARMER POPULATION
	GIVEN	RETURNED	GIVEN	RETURNED	GIVEN	RETURED	
ANKA	1	1	13	13	14	14	997
BAKURA	3	3	26	26	29	29	2338
B/MAGAJI	4	4	33	32	37	36	3156
BUKKUYUM	4	4	38	38	42	42	3472
BUNGUDUN	6	6	59	58	65	64	5387
GUMMI	4	4	32	32	36	36	2939
GUSAU	6	5	50	50	56	55	4656
K/NAMODA	4	4	35	35	39	39	3195
MARADUN	2	2	18	18	20	20	1495

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LGA	LARGE-SCALE FARMERS SAMPLE		SMALL-SCALE FARMERS SAMPLE		TOTAL SAMPLE		TOTAL FARMER POPULATION
	GIVEN	RETURNED	GIVEN	RETURNED	GIVEN	RETURED	
MARU	4	4	40	40	44	44	3644
SHINKAFI	1	1	12	12	13	13	900
T/MAFARA	3	3	27	27	30	30	2390
TSAFE	6	6	50	50	56	56	4658
ZURMI	2	2	17	17	19	19	1441
TOTAL	50	49	450	448	500	497	40648

Source: Ezeh and Omotayo, 2022

4.1 Socio-economic background of Farmers

The socio-economic data of the farmers are shown in the figures 1-4 below.

4.1.1 Age Distribution of farmers

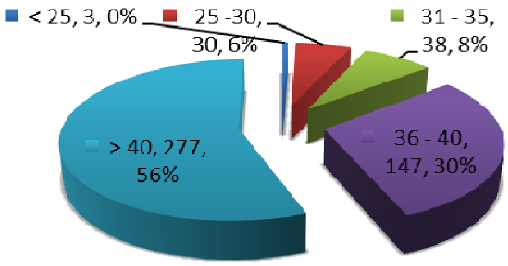

Fig 1: Age Distribution of farmers

The study showed that over 50% of the farmers are above forty while 30% were between 36 and 40 years of age. This shows that about 90% of the farmers are above 36 years of age.

4.1.2 Education and qualifications of farmers.

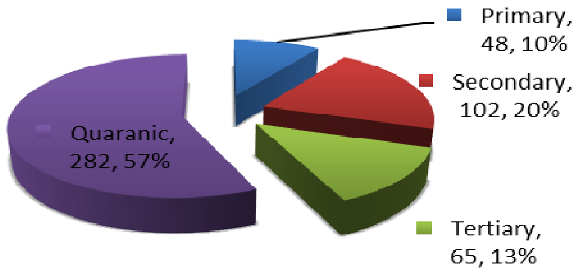

Fig 2: Educational Qualification of farmers

The report shows that 57% of farmers had studied qur'anic education while 20% has secondary education and 13% has tertiary education. 10% had formal primary education. There was no stark illiterate among the farmers implying that the farmers had good communication among themselves.

4.1.3 Occupations of farmers

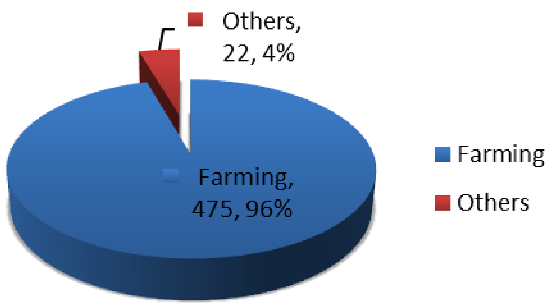

Fig 3: Farmers' Occupation

Ninety-six percent of the farmers took farming as their full-time occupation and 4% only as secondary occupation. However, no farmer had only one occupation. each had a main occupation as well as a secondary part time job. The implication here is that the future of farming is bleak and land degradation will continue unabated soon except things are done differently.

4.1.4 Household of farmers.

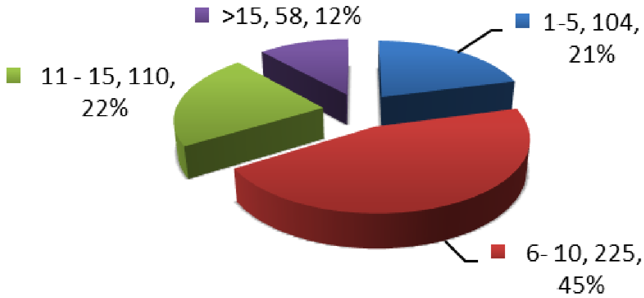

Fig 4: Household membership of Farmers

21% of the farmers had 1-5 people in the household while 45% had large families consisting of 6-10 people in their households. 22% had 11-15 people and 12% had more than 15 members in their household. Clearly, the socio-economic characteristics of the farmers indicate a continuum in their occupation and lifestyle. Therefore, present agricultural practices would continue to influence the land use patterns. Invariably, degradation of land and eventual desertification would continue, perhaps, unabated.

4. 2 Disaggregating Agricultural Practices

Agricultural practices consist of numerous activities. Disaggregating agricultural practices into individual components was to ascertain which of them most impact desertification. Table 2 shows the descriptive statistics for the disaggregated agricultural variables.

Table 2: Descriptive Statistics of disaggregated Agricultural practices.

	x	Range	Minimum	Maximum	Sum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
DESERTIFICATION	497	44.00	43.00	87.00	34454.00	69.3239	.42292	9.42830
ROTATION	497	50.00	25.00	75.00	26625.00	53.5714	.46927	10.46169
SHIFTING	497	50.00	25.00	75.00	25200.00	50.7042	.82062	18.29438
SLASHBURN	497	50.00	25.00	75.00	25525.00	51.3581	.62391	13.90914
TILLAGE	497	50.00	25.00	75.00	21385.00	43.0282	.61279	13.66119
FERTILIZATION	497	50.00	25.00	75.00	20024.00	40.2897	.67824	15.12024
ORGANICMANURING	497	50.00	25.00	75.00	17925.00	36.0664	.58853	13.12047
RAINFED	497	50.00	25.00	75.00	21100.00	42.4547	.60576	13.50442
IRRIGATION	497	50.00	25.00	75.00	21385.00	43.0282	.61279	13.66119
ZEROGRAZING	497	50.00	25.00	75.00	21605.00	43.4708	.69036	15.39060
FREERANGE	497	50.00	25.00	75.00	25750.00	51.8109	.63968	14.26069
Valid N (listwise)	497							

The table shows the mean, maximum, minimum as well as standard deviations for the disaggregated variables. The highest score of 87% was recorded for desertification. Scores for other variables ranged from 25% to 75%. Standard deviation ranged from 9.428 for desertification to 18.294 for shifting cultivation while the mean score ranged from 36.066 for organic manuring to 69.324 for desertification.

4.2.1 Correlation analysis for disaggregated agricultural activities.

The correlation analysis for disaggregated agricultural activities is presented in table 3.

Table 3: Pearson's Correlations Result for disaggregated Agricultural Practices

		DESERTIFICATION	ROTATION	SHIFTING	SLASH/BURN	TILLAGE	FERTILIZATION	ORGANIC MANURING	RAINFED	IRRIGATION	ZERO-GRAZING	FREE-RANGE
Pearson Correlation	DESERTIFICATION	1.000	-.008	-.042	.074	.015	-.028	-.100	-.001	.015	-.045	.103
	ROTATION	-.008	1.000	.007	.140	-.086	.013	.024	.100	-.086	-.007	.075
	SHIFTING	-.042	.007	1.000	.016	.002	-.004	.088	.006	.002	.036	.010
	SLASHBURN	.074	.140	.016	1.000	.037	.033	-.110	.009	.037	-.043	.852
	TILLAGE	.015	-.086	.002	.037	1.000	.069	.000	-.007	1.000	-.051	.052
	FERTILIZATION	-.028	.013	-.004	.033	.069	1.000	-.060	.018	.069	-.022	.017
	ORGANICMANURING	-.100	.024	.088	-.110	.000	-.060	1.000	.000	.000	.094	-.087
	RAINFED	-.001	.100	.006	.009	-.007	.018	.000	1.000	-.007	.021	-.006
	IRRIGATION	.015	-.086	.002	.037	1.000	.069	.000	-.007	1.000	-.051	.052
	ZEROGRAZING	-.045	-.007	.036	-.043	-.051	-.022	.094	.021	-.051	1.000	-.092
	FREERANGE	.103	.075	.010	.852	.052	.017	-.087	-.006	.052	-.092	1.000
Sig. (1-tailed)	DESERTIFICATION	.	.432	.174	.050	.369	.267	.013	.487	.369	.159	.011
	ROTATION	.432	.	.442	.001	.027	.390	.300	.013	.027	.441	.048
	SHIFTING	.174	.442	.	.361	.486	.464	.025	.445	.486	.211	.416
	SLASHBURN	.050	.001	.361	.	.207	.232	.007	.420	.207	.168	.000
	TILLAGE	.369	.027	.486	.207	.	.061	.497	.438	.000	.129	.124
	FERTILIZATION	.267	.390	.464	.232	.061	.	.090	.347	.061	.314	.349
	ORGANICMANURING	.013	.300	.025	.007	.497	.090	.	.500	.497	.018	.026
	RAINFED	.487	.013	.445	.420	.438	.347	.500	.	.438	.322	.446
	IRRIGATION	.369	.027	.486	.207	.000	.061	.497	.438	.	.129	.124
	ZEROGRAZING	.159	.441	.211	.168	.129	.314	.018	.322	.129	.	.020
	FREERANGE	.011	.048	.416	.000	.124	.349	.026	.446	.124	.020	.
N	DESERTIFICATION	497	497	497	497	497	497	497	497	497	497	497
	ROTATION	497	497	497	497	497	497	497	497	497	497	497
	SHIFTING	497	497	497	497	497	497	497	497	497	497	497
	SLASHBURN	497	497	497	497	497	497	497	497	497	497	497
	TILLAGE	497	497	497	497	497	497	497	497	497	497	497
	FERTILIZATION	497	497	497	497	497	497	497	497	497	497	497
	ORGANICMANURING	497	497	497	497	497	497	497	497	497	497	497
	RAINFED	497	497	497	497	497	497	497	497	497	497	497
	IRRIGATION	497	497	497	497	497	497	497	497	497	497	497
	ZEROGRAZING	497	497	497	497	497	497	497	497	497	497	497
	FREERANGE	497	497	497	497	497	497	497	497	497	497	497

The Pearson correlation analysis shows a significant positive correlation between desertification and, slash/burn ($r = 0.074$; $p = 0.05$), and free range ($r = 0.103$; $p = 0.011$). A positive but insignificant relationship was shown for desertification and, tillage ($r = 0.015$; $p = 0.369$) and irrigation ($r = 0.011$; $p = 0.369$) and. A significant negative correlation was noticed between desertification and organic manuring ($r = -0.100$; $p = 0.013$) while a negative but insignificant correlation was noticed between desertification and, rotation ($r = 0.008$; $p = 0.432$), shifting cultivation ($r = 0.042$; $p = 0.174$), fertilization ($r = -0.028$; $p = 0.267$) and rain-fed agriculture ($r = -0.001$; $p = 0.497$ and zero grazing ($r = 0.045$; $p = 0.159$).

The general implication is that desertification increases with increase in slash and burn, tillage, uncontrolled irrigation and free-range activities. On the other hand, the process of desertification decreases as there is an increase in rotation, shifting cultivation, fertilization, organic manuring, and zero grazing activities. Specifically, variables of significant association with desertification are slash and burn $r = 0.074$; $p < 0.05$; organic manuring $r = -0.100$; $p < 0.05$ and free-range $r = 0.103$; $p < 0.05$

4.2.2 Stepwise regression analysis

Table 4: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.103[a]	.011	.009	9.38778	.011	5.291	1	495	.022
2	.138[b]	.019	.015	9.35723	.008	4.237	1	494	.040

Following a stepwise regression analysis, the model summary shows the multiple correlation coefficient to be 0.138 as shown in table 4. This implies that, generally, there was a positive, significant relationship between desertification and the disaggregated practices. It also showed that the variation in desertification accounted for by the disaggregated practices of 1.9% is significant.

4.2.3 Analysis of Variance

Table 5: Analysis of Variance (ANOVA[c])

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	466.325	1	466.325	5.291	.022[a]
	Residual	43624.520	495	88.130		
	Total	44090.845	496			
2	Regression	837.336	2	418.668	4.782	.009[b]
	Residual	43253.509	494	87.558		
	Total	44090.845	496			

a. Predictors: (Constant), FREERANGE

b. Predictors: (Constant), FREERANGE, ORGANICMANURING

c. Dependent Variable: DESERTIFICATION

The ANOVA, Table 5, at F (1, 495) = 4.782; p = 0.009 shows that the model is adequate for further analysis. It implies that the information accounted for by the independent variables about the dependent variable is appropriate for result utilization and further analysis. It also shows that there are significant differences of the impact on desertification of disaggregated agricultural activities as scored by the farmers. The specific effects, on desertification, of the disaggregated agricultural activities are highlighted in the stepwise regression analysis coefficients in table 6.

Table 6: Stepwise Regression Analysis Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	65.801	1.588		41.429	.000					
	FREERANGE	.068	.030	.103	2.300	.022	.103	.103	.103	1.000	1.000
2	(Constant)	68.462	2.044		33.495	.000					
	FREERANGE	.063	.030	.095	2.120	.035	.103	.095	.094	.992	1.008
	ORGANICMANURING	-.066	.032	-.092	-2.058	.040	-.100	-.092	-.092	.992	1.008

The result of the analysis reveals that Free range farming and Organic manuring are significant at p = 0.035 and p = 0.040 respectively. This means that only organic manuring and free-range farming were found to impact desertification significantly. While organic manuring has an indirect effect on desertification, free range farming has a direct effect. While organic manuring reduces desertification, free range increases it. These results are supported by the Partial correlations obtained. The validity of the results is supported by Variance inflation factor (VIF), which shows no significant multi-collinearity since the values are all below 1.5.

4.2.4 The collinearity diagnostics

The collinearity diagnostics in table 7 shows that the condition index is below 15. This significantly solves the problem of heteroscedasticity.

Table 7: Collinearity Diagnostics

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions		
				(Constant)	FRRRANGE	ORGANICMANURING
1	1	1.964	1.000	.02	.02	
	2	.036	7.409	.98	.98	
2	1	2.869	1.000	.01	.01	.01
	2	.104	5.246	.01	.25	.66
	3	.027	10.267	.99	.74	.32

a. Dependent Variable: DESERTIFICATION

4.2.5 The residuals statistics

The residual statistics is presented in table 8.

Table 8: Residuals Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	66.63	71.51	69.32	1.299	497
Residual	-23.634	19.279	.000	9.338	497
Std. Predicted Value	-2.070	1.682	.000	1.000	497
Std. Residual	-2.526	2.060	.000	.998	497

a. Dependent Variable: DESERTIFICATION

The residuals statistics in Table 8 shows the mean error term to be zero (0) with constant standard deviation = 9.338. These conveniently satisfy the regression assumptions.

4.2.6 Excluded variables

Table 9 shows the excluded variables from the stepwise regression analysis.

Table 9: Excluded Variables

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	ROTATION	-.015[b]	-.344	.731	-.015	.994	1.006	.994
	SHIFTING	-.043[b]	-.967	.334	-.043	1.000	1.000	1.000
	SLASHBURN	-.050[b]	-.583	.560	-.026	.275	3.638	.275
	TILLAGE	.010[b]	.216	.829	.010	.997	1.003	.997
	FERTILIZATION	-.030[b]	-.664	.507	-.030	1.000	1.000	1.000
	ORGANICMANURING	-.092[b]	-2.058	.040	-.092	.992	1.008	.992
	RAINFED	-.001[b]	-.018	.986	-.001	1.000	1.000	1.000
	IRRIGATION	.010[b]	.216	.829	.010	.997	1.003	.997
	ZEROGRAZING	-.036[b]	-.795	.427	-.036	.992	1.009	.992
2	ROTATION	-.013[c]	-.283	.777	-.013	.993	1.007	.986
	SHIFTING	-.035[c]	-.789	.431	-.036	.992	1.008	.984
	SLASHBURN	-.062[c]	-.729	.467	-.033	.274	3.655	.274
	TILLAGE	.010[c]	.225	.822	.010	.997	1.003	.990
	FERTILIZATION	-.035[c]	-.789	.431	-.035	.996	1.004	.989
	RAINFED	-.001[c]	-.019	.985	-.001	1.000	1.000	.992
	IRRIGATION	.010[c]	.225	.822	.010	.997	1.003	.990
	ZEROGRAZING	-.028[c]	-.622	.534	-.028	.984	1.016	.984

a. Dependent Variable: DESERTIFICATION

b. Predictors in the Model: (Constant), FRRRANGE

c. Predictors in the Model: (Constant), FRRRANGE, ORGANICMANURING

4. 3 Discussion of Findings.

The Pearson's correlation analysis showed significant positive relationships between desertification and slash and burn and free-range farming, on the one hand, and significant negative relationships between desertification and organic manuring, on the other hand. These have implications on the desertification process. However, the stepwise regression analysis highlighted free-range farming and organic manuring as the most impactful factors on desertification in the region.

The negative but significant correlation between desertification and organic manuring implies that as organic manuring increases, the impact of desertification decreases in the study area. Organic manuring is a soil conservation practice and refers to the enrichment of the soil fertility through the application of organic materials. Such organic materials could be in the form of mulch or compost or green manuring. They help to conserve soil moisture. They also help enrich soil nutrient and enhance the crop canopy as well as intercept direct rainfall and sunrays and their resultant impact on the soil.

Like inorganic materials they enhance the soils' fertility. But, unlike the inorganic fertilizers, they enhance the soil structure by helping to cement the soil particles together. This singular quality enhances soil porosity/stability, thereby ensuring water-soil infiltration and, therefore, a reduction in soil erodibility. Organic matter application to the soil, also, has the mechanical effect of reducing water erosivity. According to Edeh and Kefas (2016), organic manure contributes in restoration and conservation of soil through three aspects of soil properties, namely, biological, chemical and physical properties. The combined effects of increased plant nutrients in the soil, enhanced soil water holding capacity and reduced soil erodibility/water erosivity will stem the tide of desertification by slowing down wind and water erosion.

A significant positive correlation between desertification and free-range farming portends that those free-range activities compound the encroachment and impact of desertification in the area. This agrees with the submission of the United Nations Convention on Desertification (UNCCD, 2011). According to the World body, free-ranging removes the vegetation cover that protects soil from erosion and degrades natural vegetation resulting to desertification. Similarly, direct impact of sunrays heats up the uncovered soil and aggravates evapotranspiration that depletes soil moisture, weakens soil structure and makes the soil more vulnerable to water and wind erosion. Nwokocha (2015) also in his submission affirmed that overgrazing, which is free range farming, is the major cause of desertification in Northern Nigeria. Lyu et al., (2020) stated in their, desertification control practices in China, that one of the major objectives of their programs is to mitigate over cultivation, overgrazing, and overcutting, which are the main factors triggering the desertification processes in China. In free range/overgrazing, animals are allowed to wander in the open field and graze freely. The sheer pressure the animals apply to the soil as they move about increases the bulk density of the soil. An increased soil bulk density reduces soil porosity, rate of water infiltration and water-holding capacity which in turn increases surface run off and exacerbates land degradation/desertification.

From Table 6, we can fit the regression model by transforming the equation from:

$$Y = a + b_1X_1 + b_2X_2$$

to:

$$DES = 68.46 + 0.063FRF - 0.066OM \quad \text{(Equation 2)}$$

Where DES - Desertification
FRF - Free Range Farming
OM - Organic Manuring

Equation (2) therefore implies that a unit increase in the current free-range farming would result to a 6.3% increase in desertification while a unit increase in organic manuring would result in a 6.6% decrease in desertification in the Sudano-sahelian region. The strategy to effectively control desertification in the study area should focus on the reduction in free range farming practice and an increasing organic manuring technique.

5. Conclusion.

Several literatures have suggested that farming activities have deleterious effects on land and contribute significantly to the desertification process. This study has unbundled agricultural practices into its major components in order to determine which among them most affect the desertification process. Five hundred farmers were selected from the list of registered farmers with a response of 99.4%. Desertification was measured as it affected the various farmers and juxtaposed against the disaggregated components of the agricultural practices. The Pearson's correlation analysis showed that slash and burn, organic manuring and free-range had a significant association with desertification at $r = 0.074$; $p < 0.05$; organic manuring $r = -0.100$; $p < 0.05$ and free-range $r = 0.103$; $p < 0.05$ respectively. However, stepwise regression analysis showed that Free range farming and Organic manuring are significant at $p = 0.035$ and $p = 0.040$ respectively. In other words, free-range and organic manuring most impact the desertification process.

Author Contributions:

F.E. and H.A. designed the study. F.E. conducted the experiment. F. E. and H.A. wrote the paper. Both authors read and approved the final manuscript.

Conflict of interests:

The authors did not declare any conflict of interest.

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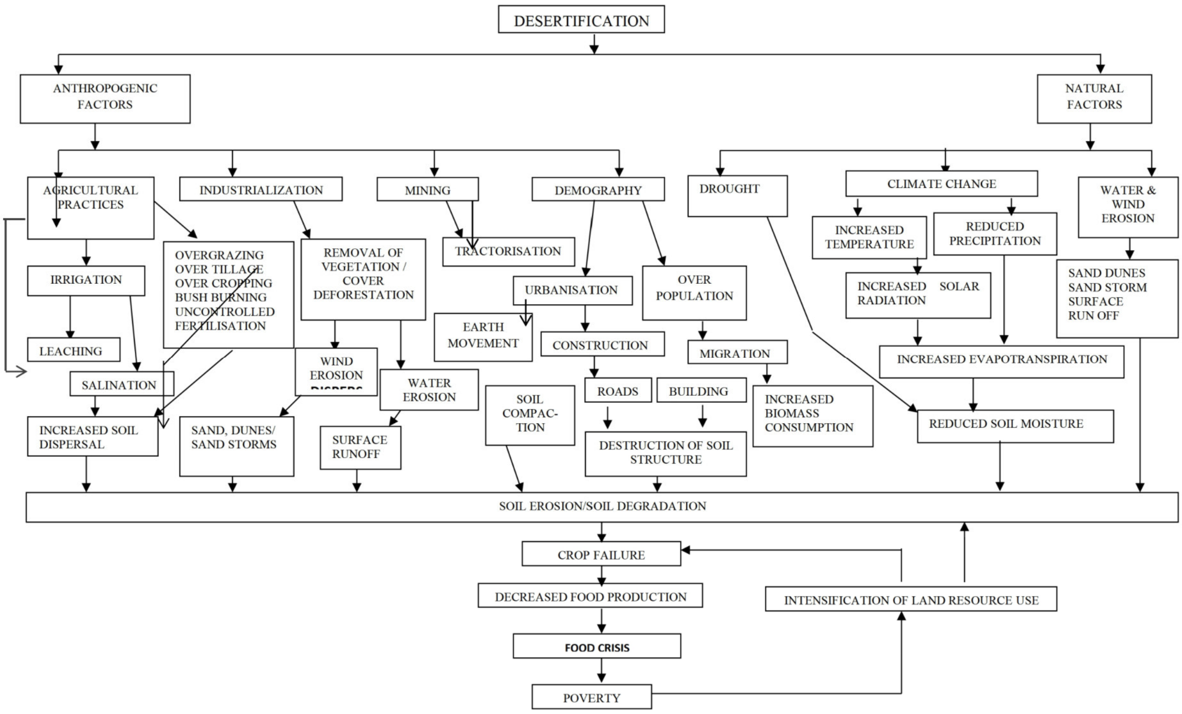

Figure 1. Schematic flow of the desertification process