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RESEARCH ARTICLE

Farmers' Knowledge and Adoption of Soil Conservation Practices in North Central Nigeria: An Index-based Approach

A.K. Daudu[1], F. O. Oladipo[1], W. O. Kareem[1], L. K. Olatinwo[2]

[1]*Department of Agricultural Extension and Rural Development, University of Ilorin, P.M.B. 1515, Ilorin, Nigeria,* [2]*Department of Agricultural Economics and Extension, Kwara State University, Malete, Nigeria*

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ABSTRACT

Soil is the most crucial resource on which agriculture is based. Proper management of this valuable resource is vital to sustain long-term agricultural productivity. Farmers' knowledge level and adoption of soil management practices have influenced agricultural productivity. This study therefore, investigated the farmers' knowledge gap and adoption of soil conservation practices in North Central Nigeria. A four-stage random sampling technique was adopted for selecting 960 respondents from all the six states for the study. Structured questionnaire and interview schedule were used to elicit information from the respondents. Data collected were analyzed with both descriptive and inferential statistics such as frequency counts, percentages, and mean, standard deviation, and knowledge gap and adoption indexes. The overall results for the six states showed that 45.3% had low knowledge gap, 43.4% had medium knowledge gap, and only 11.3% had high and wider knowledge gap of soil conservation practices. Benue have the largest (52.3%) number of farmers with the lowest knowledge gap on soil conservation practices. Results showed that 37.2 and 38.6% of respondents had low and moderate adoption rate, respectively, while only 24.2% had high adoption rate of soil conservation practices. State-wise, Benue (0.74) had the highest adoption rate while Kogi (0.33) had the lowest. Adoption rate of soil conservation practices is significantly influenced by farmers' knowledge level at varying degree. It is concluded that farmers' knowledge gap and adoption of soil conservation practices ranges between low and medium with wide knowledge gap were found mostly in the areas of terracing, contour farming, conservation tillage, and vegetative barriers. The study recommend that training with result demonstration through agricultural extension services should be organized for farmers on soil conservation practices to bridge their knowledge gap, especially in the areas where wider gap was found and increases its adoption.

Key words: Knowledge gap, index, adoption, soil conservation practices, depletion

INTRODUCTION

Soil fertility depletion and degradation are serious impediment to improve agricultural productivity especially in sub-Sahara Africa (SSA). This is because their soils are largely unhealthy due to years of nutrient mining and limited organic or inorganic resupply. The increased degradation and declining fertility of SSA soils contributes to food insecurity and poverty. The World Bank (2013) estimates that over 80% of Africa's agricultural lands are degraded, having either biophysical or chemical constraints that limit food production.

Nearly 15% of the 7 billion people alive today are classified as food insecure (Food and Agriculture Organization *et al*., 2017; FSIN, 2018). With the world population projected to hit 9 billion by 2050

Address for correspondence:
A. K. Daudu
E-mail: daudu.ak@unilorin.edu.ng

(Montpellier, 2013), the food insecurity challenge can be expected to become more severe, especially for SSA, where an estimated quarter of the people are already hungry. Current attempts to meet food and livelihood needs of sub-Saharan smallholder farms have often led to severe soil degradation. Without addressing soil degradation issues, smallholder farmers cannot benefit from yield gains offered by improved plant genetics and other associated agronomic practices. Limited by soil degradation, yield increases from improved crop varieties are estimated at only 28% in Africa as compared to 88% in Asia (International Fertilizer Development Center, 2013). Therefore, soil loss is not only a problem for the farmer, with the loss of organic matter and fertility but it is also an environmental problem. Sediment entering streams can destroy fish habitat and water quality, especially when soil particles contain contaminants such as pesticides or nutrients.[1,2]

One of the main causes of soil degradation identified in various parts of Africa by the Food and Agriculture Organization of the United Nations (FAO, 2013) is the practice of inappropriate methods of soil preparation and tillage. The soil naturally replenishes itself when used properly. The causes of soil degradation are complex and vary from place to place. The major drivers of soil degradation are generally grouped into two: Proximate and underlying causes (Belay *et al*., 2015; Pingali *et al*., 2014). The proximate causes are more or less natural factors such as biophysical conditions, topographic and climatic conditions, and inappropriate land management practices, whereas the underlying factors are mostly anthropogenic, which include population growth, land tenure, and other socioeconomic and policy-related factors.[3-5]

In Nigeria, where limited cultivable land and high population growth rates, fallow periods are no longer sufficient to allow soil fertility to be restored. Furthermore, poor soil and water management, including overgrazing and inappropriate irrigation and deforestation practices often undermines productivity of soil (World Overview of Conservation Approaches and Technologies, 2012). To reduce soil nutrient depletion and degradation especially due to inappropriate practices used among farmers and avert a subsequent decline in crop yield, there is a need to bridge the farmers' knowledge gaps and strengthen the adoption of sustainable agricultural practices, for example, soil conservation practices.

Soil conservation practices are those farming operations and management strategies conducted with the goal to control soil erosion by preventing or limiting soil particle detachment and transport in water or air. It is a combination of approaches which influence the physical, chemical, and biological status of the soil. Wall *et al*. (2013) defined soil conservation as a management system that excludes the degradative components existing in conventional management systems by; removing practices that destroy the soil structure and which break down soil organic matter, the insufficient return of organic matter to the soil and lack of protection of the surface soil, and monoculture. The practices conserve soil fertility and allow continuous soil regeneration for current and future cropping with the potential for achieving the highest agricultural yield through the most economic means. Experience from the past showed that the farmers practice according to their current knowledge and that it is an important factor relating to their decision-making in sustainable practices. Farmers' knowledge of soil conservation practices also differs, so farmers may practice different soil conservation techniques depending on their degree of perception and knowledge.[6-10]

In an effort to maintain optimum crop productivity, farmers are encouraged to adopt different production technologies that would conserve the soil. In relation to this, Onwudike *et al.* (2016) suggested adoption of many strategies aimed at improving soil productivity and crop yield. Despite the numerous benefits attributed to soil conservation practices, its adoption among smallholder arable crop farmers has received little attention. Low rates of adoption of soil conservation practices are documented, especially in SSA and in some cases zero uptake of soil conservation practices were observed in most countries (Arslan *et al*., 2014). In light of aforementioned scenario and however, in the study area, previous studies in the sphere of farmers' knowledge and adoption of sustainable soil management practices were limited in scope despite their importance in improving agricultural production. Therefore, an instant study was conducted with aim to assess the farmers' knowledge and adoption of soil conservation practices in North Central Nigeria.[11-15] The specific objectives are as follows:

i. Determine the farmers' knowledge gap in the use of soil conservation practices; and
ii. Examine the adoption level of soil conservation practices among smallholder crop farmers in the study area.

METHODOLOGY

Study area

This study was conducted in North Central region of Nigeria. This region, however, is made up of six states, namely, Benue, Kwara, Niger, Plateau, Nasarawa, and Kogi and Abuja the Federal Capital Territory and situated geographically in the middle belt region of the country, spanning from the west, around the confluence of the River Niger and the River Benue. It lies approximately between 3° and 14° E and latitude 7° and 10° N. It constitutes the food basket of Nigeria covering about 730,000 km^2 or about 78% of the total land mass of Nigeria. The region itself is rich in natural land features, and boasts some of Nigeria's most exciting scenery. The total population of North Central Nigeria is over 20 million (National Bureau of Statistic, 2012). The climate of the region is partly influenced by climates in the northern and southern region of Nigeria while the major vegetation is basically the Guinea Savannah Zone which occupies same 90% of the land mass. The tropical savannah climate characterized by wet and dry condition affects most parts of North Central Nigeria. Rainy seasons de-cline correspondingly in length as one move northward. Temperature is generally high in the region. This is mainly due to the fact that the region lies within the tropics where the apparent movement of the sun is limited. The major vegetation of the North Central region of Nigeria [Figure 1].[16-20]

Sampling procedure and sample

A four-stage random sampling technique was adopted for selecting 960 respondents from all the six states for the study. At stage one: Two agricultural zones were randomly sampled from each of the six states and making a total of 12 agricultural zones. Stage two; from each of the selected 12 agricultural zones, two local government areas (LGAs) were randomly selected making a total of 24 LGAs. Stage three: Involved a random sampling of three rural farming communities from each of the sampled 24 LGAs making 48 rural farming communities for the study. And in stage four: From each of the selected farming communities, 20 smallholder crop farmers were randomly selected giving a total of 960 respondents. However, out of 960 questionnaires administered responses from only 944 farmers were eventually used for the study. Structured questionnaire was used to elicit information on farmers' socioeconomic profile, their knowledge of and adoption of soil conservation practices.

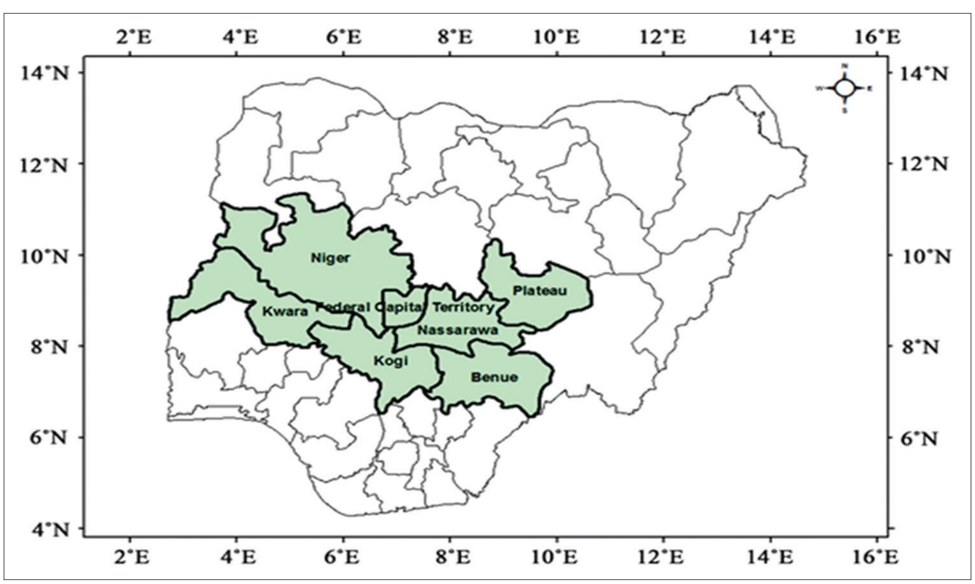

Figure 1: Map of Nigeria showing North Central region in color portion. Source: Author (2019)

Data collected were subjected to both descriptive and inferential statistics such as frequency counts, percentages, and mean, standard deviation, and knowledge gap and adoption indexes.

Knowledge gap

Knowledge gap refers to the difference in knowledge between the recommended practices and the knowledge possessed by farmers. To calculate the knowledge gap of smallholder crop farmers, a list of soil conservation practices were compiled during pilot studies carried out in research area [Table 1]. In determining knowledge gap, soil conservation practice wise score was assigned such as 0 = "no knowledge," 1= "partial knowledge," and 2 = "full knowledge" in the knowledge test. Overall score of the ten questions was 20 and each question carried two scores. The difference between obtainable score and obtained score indicated the knowledge gap of the respondents. This deviation was then expressed in percentage as the proportion to the farmer's maximum possible score. As used by Kundu *et al*. (2013) and Tomar *et al*. (2012), the knowledge gap index was computed as:

$$KGI = \frac{K_p - K_o}{K_p} \times 100 \qquad (1)$$

Where;
KGI = Knowledge gap index;
K_p = Maximum possible score of a crop farmer;
K_o = Obtained knowledge score by a crop farmer.
However, the value of knowledge gap index was therefore on-negative and lied between 0 and 100. The value of index closer to zero indicated the lower knowledge gap, while that closer to 100 indicated the larger knowledge gap.

Construction of adoption index (AI)

AI is an aggregation of adoption of different dimensions of agricultural technology. Here, the agricultural technology referred to is various soil conservation practices used by farmers in their respective states. For this study, an index was constructed for each state based on available data from farmers. This state-wise AI would be used in the identification of the states that required intervention to change the pattern of adoption. The method adopted here was based statistical background developed by Narain *et al.* (1991). A set of n points represented the states (1, 2,…,n) for a group of indicators (1,2,…,k) that was represented by a matrix $[V_{ij}]$; i = 1, 2,…,n and j = 1, 2,…,k. Since all the variables or indicators were normally in different units of measurement and the objective was to compute the single composite index

Table 1: Soil conservation practices used among the respondents in research area

Soil conservation practices	Description
Compost and mulching	Add important nutrients to soil, loosen soils, help conserve moisture, maintain or improve plant and soil health, reduce soil erosion, suppress weed growth, compost example is add leaves or straw
Cover crops	Improve soil structure, reduce soil erosion, help retain nitrogen, reduce rate and quantity of water that flows off the field, assists with weed and pest management
Crop rotation	Practice of growing dissimilar crops in same area successive seasons, help soil retain nitrogen, assist in plant disease and weed prevention
Contour farming	Growing crops across or perpendicular to a slope rather than up and down the slope
Conservation tillage	Any method of cultivation that leaves previous year crop residue on field before and after next crop, to reduce soil erosion and runoff; at least 30% of soil surface must be covered with residue after the next crop (includes mulch, ridge, strip, and no tillage)
Terracing	An earthen embankment, ridge or ridge and channel built across a slope (on the contour) to intercept runoff water and reduce soil erosion
Vegetative barrier	Growing of one or more rows of trees or shrubs so as to provide shelter from the wind and salt spray along the coast and it is also used to protect the soil from erosion
Intercropping	Cultivation of different crops in the same field. Through intercropping, the rooting systems of the various crops use different elements in the soil profile, ensuring better nutrient uptake.
Ridges and beds	Raising soil structure for the cultivation of root crops and vegetables. Ridges for tuber crops cultivation are normally while beds could be as wide as 1 m–2 m and 15 cm–30 cm high. 1 m wide and 40 cm high
Inorganic fertilizer	Different fertilizers are used to provide all nutrients required by plants and applied at various stages of the plant growth

Source: Field survey, 2019

relating to dimension in question, there was a need of standardization of these indicators. Each indicator/variable was then standardized to fit within the range 0–1 using non-weighted averages of estimated normalized variables either linear normalization or Z-score, depending on the type of data. In this study, the normalized scores for each indicator were computed using MS-Excel's MAX () and MIN () functions. Thus, the normalized value of an indicator (Y) for a state (*i*) is given by:

$$Z_{ij} = \frac{V_{ij} - V_{min}}{V_{max} - V_{min}} \quad (2)$$

Where,

Z_{ij} = Normalized value of indicator for farmers in state *i*

V_{ij} = Observed value of indicator for farmers in state *i*

V_{max} = Highest value

V_{max} = Lowest value within sample range.

Moreover, the AI for a given state (*i*) is expressed as average of normalized score for all indicators of soil conservation practices used by farmers in state (*i*) and mathematically computed as:

$$S_i = \sum_{i=1}^{n} \frac{Z_{ij}}{n} \quad (3)$$

for (*i* = 1,2,…,*n*) and (*j* = 1,2,….,*k*)

Where,

S_i = Adoption index for farmers in state *i*

Z_{ij} = Normalized value of indicator for farmers in state *i*

n = Number of indicators of soil conservation practice in state *i.*

However, the overall AI for all the six states is therefore computed as composite index, estimated using simple non-weighted average of all indices of soil conservation practices adopted by farmers in the selected states and expressed as:

$$AI_c = \frac{1}{n}\left[S_1 + S_2 + S_3 + \ldots + S_6\right] \quad (4)$$

Where,

AI_c = Composite index of adoption for farmers in all selected states

n = Number of states

Si = Adoption index for farmers in each state.

The value of status index was non-negative and lied between 0 and 1. The value of index closer to zero indicated the lower level of adoption, while that closer to 1 indicated the higher level of adoption. Similarly, for classificatory purposes, a simple ranking of the states based on the indices, namely, $\overline{y_i}$ would be enough. Moreover, for a meaningful characterization of the different stages of adoption, suitable fractile categorization from an assumed probability distribution is therefore needed. A probability distribution which is appropriate for this study is beta distribution, and takes the values in the interval (0 and 1), has thus been applied by Iyengar and Sudarshan (1982). This distribution is given by

$$f(z) = \frac{z^{a-1}(1-z)^{b-1}}{\beta(a,b)}, 0 < z < 1 \text{ and } a, b > 0 \quad (5)$$

Where $\beta(a,b)$ is the beta function defined by

$$\beta(a,b) = \int_0^1 x^{a-1}(1-x)^{b-1} \quad (6)$$

The beta distribution is skewed. Assuming $(0,z_1)$, (z_1z_2), (z_2z_2), (z_3z_4), and (z_4z_1) be the linear intervals such that each interval the same probability weight of 20%. Therefore, the fractile intervals can be used to categorize the various level of adoption of soil conservation practices in the study area.

Very low adoption (if $0<(\overline{y_i}<z_1)$, low adoption (if $z_1<(\overline{y_i}<z_2)$, moderate adoption (if $z_2<\overline{y_i}<z_3)$, high adoption (if $z_3<\overline{y_i}<z_4)$, and very high adoption (if $z_4<\overline{y_i}<1)$.

RESULTS AND DISCUSSION

Socioeconomic characteristics of respondents

Results in Table 2 show some socioeconomic characteristics of respondents measured in the study area. The results reveal that the average age of respondents was 49.58 years and standard deviation of 19.43 years old suggesting most of respondents are still in their active and productive age. Most (68.4%) of them were male, more than female which may be due to the socio-cultural structure of the region and majority (76.1%) of them are married. The distribution of respondents' education level shows that only 6.0% of the respondents had tertiary education with higher percent (44.0%) had no formal education. Almost half (49.6%) of respondents cultivate between 3 and

6 ha of farmland, and in terms of farming experience, about (47.6%) of the smallholder farmers had over 20 years of farming experience and the average of that was about 27.75 years.

Farmers' knowledge level and gap of soil conservation practices

Results in Table 3 show the respondents level of knowledge and gap of soil conservation practices. Ten soil conservation practices were identified and believed to be practicing by farmers in the researcher area. These conservation practices include: Compost and mulching, cover cropping, crop rotation, contour farming, conservation tillage, terracing, vegetative barrier, intercropping, ridges and beds, and application of inorganic fertilizers. Table 3 shows that overwhelming majority (92.6%) of the respondents had full knowledge of compost and mulching practices with knowledge of 7%. This implies that lesser percent of respondents required training on the preparation of compost and mulching

Table 2: Distribution of respondents by socioeconomic characteristics (n=944)

Variable	Group	Frequency	Percentage	Explanation
Age (years)	≤30	102	10.8	Minimum: 21; Maximum: 76; Average: 49.58; Standard deviation: 19.43
	31–40	247	26.2	
	41–50	369	39.1	
	51–60	158	16.7	
	>60	68	7.2	
Sex	Male	646	68.4	Mode: Male
	Female	298	31.6	
Marital status	Single	114	12.1	Mode: Married
	Married	718	76.1	
	Separated	34	3.6	
	Widowed	78	8.2	
Education level	No formal	415	44.0	Mode: No formal education
	Primary	278	29.4	
	Secondary	194	20.6	
	Tertiary	57	6.0	
Farm size (ha)	≤3	284	30.1	Maximum: 19.6; Minimum: 0.5; Average: 3.92; Standard deviation: 4.31
	3–6	468	49.6	
	>6	192	20.3	
Farming experience (years)	≤10	162	17.1	Maximum: 48; Minimum: 9; Average: 27.75; Standard deviation: 6.18
	11–20	333	35.3	
	21–0	367	38.9	
	>30	82	8.7	

Source: Field survey, 2019

Table 3: Distribution of respondents by knowledge level and knowledge gap

Soil conservation practices	No knowledge f (%)	Partial knowledge f (%)	Full knowledge f (%)	KG index (%)
Compost and mulching	22 (2.3)	48 (5.1)	874 (92.6)	7
Cover crops	0 (0)	0 (0)	944 (100)	0
Crop rotation	0 (0)	205 (21.7)	739 (78.3)	11
Contour farming	553 (58.6)	329 (34.9)	62 (6.6)	83
Conservation tillage	0 (0)	818 (86.7)	126 (13.3)	44
Terracing	581 (61.5)	338 (35.8)	25 (2.6)	88
Vegetative barrier	84 (8.9)	134 (14.2)	726 (76.9)	17
Intercropping	0 (0)	0 (0)	944 (100)	0
Ridges and beds	39 (4.1)	108 (11.4)	797 (84.4)	14
Inorganic fertilizer	0 (0)	147 (15.6)	797 (84.4)	8

Source: Field survey, 2019

with the aim of improving soil. This is because well-decomposed organic matter will release the necessary nutrients for crop plant growth and will also help improve the soil structure, and hence improve aeration and water retention. The results show that all the respondents had full knowledge of cover crop practices regarding soil conservation. Hence, no knowledge gap was observed among the farmers in the study area. This suggests that all the respondents are knowledgeable and understand the importance of cover crops for erosion control when principal crops produce insufficient or unsuitable residue for more conventional residue management-based erosion control. The knowledge gap concerning the practice of crop rotation among respondents revealed that majority (78.3%) of them had full knowledge and 21.7% had partial knowledge where the knowledge index showed 11% gap. Table 3 depicts that more than half (58.6%) of the respondents had no knowledge of contour farming, followed by partial knowledge (34.9%) with only very few (6.6%) hand complete knowledge. The knowledge index is however revealed that 83% gap existed in contour farming practices among the farmers in the study area. These findings suggest that farmers are aware of contour farming to reduce run-off on land but they lack required technicality to carry out the practice. Duncan and Burns (2012) opined that erosion control benefits of terraces and the related contour tillage and cropping practices expand overall crop grain and residue productivity by controlling runoff for increased water storage in the soil. Furthermore, results showed that majority (86.7%) of farmers had partial knowledge of soil conservation tillage and 13.3% of them had full knowledge while knowledge index revealed 44% gap. This implies that farmers are aware of conservation tillage but the knowledge of effectiveness of conservation farming varies across regions, crops, and over time which may be lacking among the respondents. Further findings showed that most (76.9%) of farmers had full knowledge of vegetative barrier practice, followed by partial knowledge (14.2%) and 8.9% had no knowledge. The knowledge index depict 17% gap of vegetative barrier practice among the respondents. The reason for relative knowledge of vegetative barrier among the respondents may be due to communication gap within farmers group and soil extension expert. The study revealed that all (100%) the respondents had full knowledge and no knowledge gap of intercropping. The full knowledge of respondents regarding intercropping may be due to their informed benefit of intercropping plant with another. This agreed with Himanen *et al*. (2016) who found out that intercropping can help in the regulation of water dynamics in addition to enhancing soil nutrient. The results in Table 3 showed that majority (84.4%) of the respondents had full knowledge, 11.4% had partial knowledge, and few (4.1%) had no knowledge while knowledge index showed 14% gap in the practice of ridges and beds. Moreover, concerning the use of inorganic fertilizer, the results showed that about 15.6% of farmers had partial knowledge and majority of 84.4% had full knowledge with 8% knowledge gap. The reason for low gap in knowledge might be due to the level of awareness and continuous usage of inorganic fertilizer among the farmers in the study area.[21-25]

Categorization of knowledge gap of respondents on soil conservation practices

Results in Table 4 show the state-wise distribution of farmers' knowledge gap on the use of soil conservation practices. The total scores from the knowledge test ranging from 2 to 20 were categorized into three levels: Low knowledge, medium knowledge, and high knowledge. All of the farmers undergone knowledge test had

Table 4: State-wise categorization of knowledge gap of the respondents on soil conservation practices

Level knowledge	Categorization	Benue		Nasarawa		Niger		Kogi		Kwara		Plateau		Overall	
		f	%	f	%	f	%	f	%	f	%	f	%	f	% (Gap)
Low	≥13.35 score	81	52.3	73	46.2	79	50.3	66	42.3	61	38.1	67	42.4	427	45.3
Medium	6.68–13.34	54	34.8	69	43.7	65	41.4	71	45.5	78	48.8	73	46.2	410	43.4
High	≤6.67 score	20	12.9	16	10.1	13	8.3	19	12.2	21	13.1	18	11.4	107	11.3
Total		155	100	158	100	157	100	156	100	160	100	158	100	944	100

Source: Field survey, 2019

knowledge of soil conservation practices for their respective farms but at varying levels. Table 4 shows that in Benue state more than half (52.3%) had low knowledge gap, 34.8% and 12.9% had medium and high knowledge gap, respectively, of soil conservation practices. In Nasarawa state, about 46.2% had low knowledge gap with 43.7% moderate knowledge gap and 10.1% had high knowledge gap in the use of soil conservation practices. Half (50.3%) of farmers in Niger state had low knowledge gap, followed by 41.4% medium knowledge gap and 8.3% high knowledge gap on soil conservation practices. Furthermore, in Kogi state, 42.3 and 45.5% of farmers had low and medium knowledge gap, respectively, and some 12.2% had high knowledge gap of SCPs. Findings in Table 4 revealed that in Kwara state almost half (48.8%) of farmers had medium knowledge gap while 38.1 and 13.1% had low and high knowledge gap of SCPs. In Plateau state, 42.4% had knowledge gap, followed by 46.2% medium knowledge gap and 11.4% high knowledge gap of soil conservation practices. However, the overall results for the six states showed that 45.3% had low knowledge gap, 43.4% had medium knowledge gap, and only 11.3% had high and wider knowledge gap of soil conservation practices. Therefore, the overall knowledge gap of farmers regarding ten soil conservation practices adopted in this study showed that farmers with a low level of soil conservation practices knowledge gap might had a good understanding of the advantages and disadvantages of SCPs. This group of farmers knew the importance of SCPs methods for maintaining and improving soil fertility. Farmers with a medium level of knowledge gap might understood the benefits of SCPs but most of them did not know much in terms of the necessary steps to practice SCPs, so they only practiced the methods that they knew well while, those with a high level of knowledge gap were accustomed to traditional methods which they continued to practice. These set of farmers had an understanding of only a few of the benefits of SCPs and believed the practices are tedious and labor intensive. Hence, this existed knowledge must be closed for better soil conditions and improved agricultural production. Birner and Resnick (2010) opined that gaps in knowledge must be closed so that nations, especially in Africa would be able to implement policies that favor development.

Adoption of soil conservation practices among the farmers

Results in Table 5 showed the state-wise distribution of AI of soil conservation practices among the respondents. AI was constructed and standardized to fit within the range 0–1 using non-weighted averages of estimated normalized variables. It is expressed as an average of normalized score for all indicators of soil conservation practices used by farmers in the research area. The value of index closer to zero

Table 5: State-wise distribution of adoption of soil conservation practices by respondents

Soil conservation practices	Benue		Nasarawa		Niger		Kogi		Kwara		Plateau	
	%	Z	%	Z	%	Z	%	Z	%	Z	%	Z
Compost and mulching	88.2	0.78	89.6	0.88	76.9	0	79.5	0.18	91.3	1	83.1	0.43
Cover crops	96.5	1	86.2	0	88.6	0.23	93.2	0.68	89.5	0.32	92.4	0.60
Crop rotation	98.7	0.99	96.1	0.71	98.8	1	89.5	0	91.9	0.26	90.6	0.12
Contour farming	24.1	0.38	32.4	0.66	20.2	0.25	16.6	0.13	12.8	0	42.3	1
Conservation tillage	75.4	0.30	85.6	0.83	88.9	1	71.3	0.08	69.7	0	82.4	0.66
Terracing	19.6	0.56	25.3	0.80	28.9	0.95	14.1	0.33	6.30	0	30.1	1
Vegetative barrier	59.4	0.55	51.5	0.12	49.2	0	64.7	0.83	67.9	1	52.8	0.19
Intercropping	98.8	1	95.8	0.72	87.9	0	88.3	0.04	90.1	0.20	94.3	0.59
Ridges and beds	95.9	0.91	63.8	0.2	54.9	0	98.9	0.98	99.8	1	77.8	0.51
Inorganic fertilizer	98.8	0.9	99.6	1	95.7	0.49	91.9	0	94.6	0.35	95.5	0.47
Σ of normalized scores		7.37		5.92		3.92		3.25		4		5.57
Adoption index (S)		0.74		0.59		0.39		0.33		0.40		0.56

Source: Field survey, 2019. %: Percentage of adopters, Z: Normalized value of adoption scores indicated the lower level of adoption, while that closer to 1 indicated the higher level of adoption. As shown in Table 5, farmers in Benue state with AI (0.74) appeared to have higher adoption rate, closely followed by Nasarawa state (0.59), Plateau state (0.56), Kwara state (0.40), Niger state (0.39), and the least is Kogi state (0.33). This finding suggests that farmers in these states embraces soil conservation practices but at different scales. This might be due to the fact that adoption of soil conservation practices tends to be more complex and knowledge intensive, especially the factors that contribute to adoption constraints. This statement agreed with Giller *et al*. (2009) that adoption of complex management practices is a gradual and incremental process where farmers experiment on small areas first and only expand when they are convinced of the benefits.

Table 6: Level of adoption of soil conservation practices by respondents

Level of adoption	Adoption index fractile	Frequency	Percentage
Very low adoption	0.0–0.20	0	0
Low adoption	0.21–0.40	351	37.2
Moderate adoption	0.41– 0.60	364	38.6
High adoption	0.61–0.80	229	24.2
Very high adoption	0.81–1.00	0	0
Total		944	100

Source: Field survey, 2019

Farmers' level of adoption of soil conservation practices

Table 6 shows the distribution of farmers by their level of adoption of soil conservation practices in the research area. The AI so computed lies between 0 and 1, with index closer to zero indicated the lower level of adoption, while that closer to 1 indicated the higher level of adoption. Results in Table 6 showed that 37.2% and 38.6% of respondents had low and moderate adoption rate, respectively, while only 24.2% had high adoption rate of soil conservation practices. None of the respondents were classified into very low and very high adoption levels. This implies that farmers' level of adoption of soil conservation practices ranging from low to high and with most were within the medium level. Low rates of adoption are documented in SSA (Giller *et al*., 2009; Arslan *et al*., 2014), especially SSA where zero uptake of conservation agriculture is observed in most countries. Results in Table 7 showed the Chi-square analysis estimated the relationship between the respondents' levels of knowledge and the adoption of soil conservation practices in the study area. The results showed that there was a significant and positive relationship between farmers' knowledge level and the practices of compost and mulching ($\chi^2 = 16.459$), contour farming ($\chi^2 = 56.682$), conservation tillage ($\chi^2 = 135.647$), intercropping ($\chi^2 = 642.573$), and ridges and beds ($\chi^2 = 728.281$) at different levels of significant in the study area.

Furthermore, there was a significant relationship between the farmers' level of adoption and the

Table 7: Chi-square showing association between respondents' knowledge level and adoption of soil conservation practices

Soil conservation practices	Pearson Chi-square			
	Farmers' level of knowledge		Farmers' level of adoption	
	Value	*P*-value	Value	*P*-value
Compost and mulching	16.459*	0.016	4.851	0.369
Cover crops	0.419	0.862	0.972*	0.051
Crop rotation	7.687	0.953	0.558**	0.021
Contour farming	56.682*	0.025	2.641	0.179
Conservation tillage	135.647**	0.016	11.108	0.512
Terracing	24.281	0.894	2.993	0.146
Vegetative barrier	13.629	0.451	0.517	0.182
Intercropping	642.573**	0.031	0.985**	0.032
Ridges and beds	728.281*	0.040	0.649	0.154
Inorganic fertilizer	0.365	0.379	0.688***	0.001

*, **, ***Statistically significant at 10%, 5%, 1%. Source: Field survey (2019)

practices of cover crops (χ^2 = 0.972), crop rotation (χ^2 = 0.558), intercropping (χ^2 = 985), and inorganic fertilizer (χ^2 = 0.688) at 10%, 5%, and 1%, respectively, while the practice of compost and mulching, contour farming, conservation tillage, terracing, vegetative barrier, and ridges and beds was positive and not significantly relating to the farmers' level of adoption. This implies that an increase in the farmers' knowledge level of these practices would likely increases their adoption rate Okobi and Barungi (2012) in their research stated that lack of knowledge, lack of market information, and limited access to fertilizer-specific extension services were determining factors influencing the adoption of fertilizer. Furthermore, Teklewold *et al.* (2013) observed that adoption of conservation practices impacts significantly and positively on profits.

CONCLUSION

Despite the wide range of knowledge exhibited by the farmers on soil conservation practices, farmers had between low and medium knowledge gap on soil conservation practices with wide knowledge gap was found mostly in the areas of terracing, contour farming, conservation tillage, and vegetative barriers. State-wise, Benue appeared to have the lowest knowledge gap closely followed by Niger while Kwara had the highest knowledge gap on soil conservation practices. In general, adoption of soil conservation practices among the smallholder farmers was moderate, and state wisely Benue had the highest adoption rate while Kogi had the lowest. The adoption rate of soil conservation practices is significantly influenced by farmers' knowledge level. The study recommend that training with result demonstration through agricultural extension services should be organized for farmers on soil conservation practices to bridge their knowledge gap especially in the areas where wider gap was found. Furthermore, stakeholders and extension should provide more technical support especially in the area of enlightenment campaign on the many benefit derivable from soil conservation practices to increase its adoption, improve soil conditions, and boost agricultural productivity. The procedure used in measuring the adoption in this study could be recommended to other researchers for future use.

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