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Soil Erodibility Estimation under Different Tillage Systems Assessment in the Rain Forest Climate of Osun State, Nigeria

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Authors' contributions

This work was carried out by the two authors. Author JTF designed the study, managed the experimental process, wrote the protocol, and wrote the first draft of the manuscript. Author IEO managed the literature searches, and performed the statistical analysis of the study. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

This research was aimed at assessing the different tillage systems adopted in rural communities of Osun state with a view to estimating soil erodibility and to determine the prevalence of erosion in the sampled communities. Nine communities were selected and fifty questionnaires administered to farmers from the twelve LGA sampled, making a total of 5400 questionnaires. Ayedaade, Aiyedire, Atakunmosa west, Ede south, Ilesa west, Ife north, Ife south, Irewole, Oriade, Odo-Otin, Ejigbo and Ife central LGA.were used for this study. Result indicated that the slash and burn technique of land preparation is found to be predominantly adopted by the Farmers. Also, farmers percentage with erosion problems from the use of both conventional and traditional tillage techniques was highest in Ilesha west with a value of 44.56% (±8.12) and least in Irewole (12.11% ±1.45). Soils of Ife central and Ife south were highest in erodibility with values 0.65 and 0.53, respectively, while Oriade and Ede south had lowest erodibility with values 0.07 and 0.12, respectively. The practical implication of these findings is in the area of soil erodibility estimation for soil conservation planning.

Keywords: Soil tillage; soil erodibility; rain forest climate; organic matter; soil erosion.

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1. INTRODUCTION

Soil tillage practice and its consequences on soil erosion are of major concern in many parts of the world. Tillage has been described as the agricultural preparation or manipulation of soil for crop production [1]. It is the physical and mechanical manipulation of soils for the purposes of management of previous crop residues, control of competing vegetation, incorporation of amendments and preparation of a seedbed [2]. The main objectives of tillage includes, manipulation of soil for better contact between seeds and soil moisture, production of a suitable medium for plant growth, control of weed, moisture conservation and the infiltration of surplus rainwater [3].

However tillage, if practiced in excess may have damaging and destructive effects on soil and crops. These effects of tillage on soil processes and properties, and crop growth can be easily seen in its implications on the ecological system of the immediate environment. Among these effects are soil erosion and degradation, compaction of soil below the depth of tillage (i.e., formation of a tillage pan), increased susceptibility to water and wind erosion (erodibility) [1], disruption of soil aggregates and organisms, and increased susceptibility to breakdown of inorganic matter [4].

Tillage and cultivation practices that move soil are also among the major causes of surface runoff and soil erosion. Soil erosion is a function of such factors as surface residue, aggregation, surface sealing, infiltration, and resistance to wind and water movement. Excessive tillage destroys structure and increases the susceptible of soil to erosion [5]. Erosion results in the degradation of soil productivity in a number of ways: reduction in the efficiency of nutrient use by crops, damage to seedlings, decrease in plant rooting depth, decreased soil water-holding capacity and permeability, increases runoff, and reduced infiltration rate [6]. Soil erosion and accompanying sedimentation in the downstream areas are continuing threat to land and water resources around the world. The degree of environmental degradation from soil erosion varies from one location to the other depending on the soil type, climate, and the flora and fauna. Soil erosion is a global problem. Since 1950, one - third of the world arable land has been lost to erosion mostly in Asia, Africa and South America [2,7]. Soil loss to erosion is one of the causes of soil infertility that result to productivity decline. Soil removed by erosion carries nutrient, pesticides and other harmful agrochemicals into rivers, streams, and ground water resources [8-10], thus causing significant impact on environmental quality and agricultural sustainability [11]. In order to reduce these effects of soil erosion on water quality and soil resources, adequate conservation practices must be employed and part of these practices is to prevent bush burning, which reduces the number of trees and often times result to soil desertification [12].

In Nigeria and other developing economies of the world, Land preparation for agricultural practices involves bush burning and felling of trees. These two activities terminate useful micro-organisms that enormously contribute to nutrient recycling within the soil system and as well enhance soil degradation/loss via erosion processes. Today soil degradation is the single most destructive force diminishing the world's soil resource base [13]. Soil degradation is the most serious crisis facing the agricultural industry in the long term. Brown and Wolf [14] reported that worldwide, the mean annual loss of topsoil is estimated at 0.7 percent. Studies have shown that when the topsoil is removed, or where it has been severely eroded, crop yields are from 20 to 65 percent lower compared with non-eroded soils [13,15]. Soils that are rich in organic matter, with improved structure and moderate infiltration rate have greater resistance to erosion [16]. According to Nyakatawa et al. [8], a soil with relatively low erodibility factor may show signs of serious erosion, though a highly erodible soil may surfer little erosion. This is because erodibility is a function of many factors, some of which are soil texture, aggregate stability, shear strength, infiltration capacity, organic, and chemical contents [17]. Soil erodibility is an important index used in evaluating the soil sensitivity to erosion, and its precise study and evaluation is important in understanding soil erosion regularity and in the prediction and evaluation of soil loss and land productivity, respectively. Soil conservationists around the world use the Universal Soil Loss Equation (USLE) and regression equation describing the relationship between K (the soil erodibility factor) and soil physical and chemical properties to estimate soil erosion rates by water [18]. The equation provides an estimate of the Soil Loss Rate in tonnes/hectare/year and soil erodibility factor. This estimate can be used for soil conservation planning.

To be able to properly manage and conserve soil resources, principles of soil conservation such as maintaining permanent soil cover and promoting minimal mechanical disturbance of soil through zero tillage systems should be encouraged. This practice will enhance soil and water conservation, thus, controlling erosion and promote healthy soil environment. Soil productivity can be increased through crop rotations, cover crops, use of integrated pest management technologies, promoting legume fallows (including herbaceous and tree fallows where suitable), composting and the use of manures and other organic soil amendments, and enhanced agroforestry practice. Many rural farmers in the study area and many other parts of the developing world hitherto engage in bush clearing and burning, and in some cases employ frequent use of heavy machineries such as tractor for ploughing and other farm operations. These activities reduce the soil carbon stock and promote widespread erosion in cropped lands. Therefore, this research was aimed at determining and performing a quantitative assessment of the soil tillage practices, erosion characteristics and erodibility of some selected local government areas of Osun state, in the rainforest climate of Nigeria.

2. MATERIALS AND METHODS

2.1 Location of the Study

The research was conducted in 12 selected local government areas of Osun state namely Ayedaade, Aiyedire, Atakunmosa west, Ede south, Ilesa west, Ife north, Ife south, Irewole, Oriade, Odo-Otin, Ejigbo and Ife central LGA. Osun State is located in the South-Western part of Nigeria (Fig. 1). It covers an area of approximately 14,875 square kilometres and lies between longitude 04^{o} 00''E and latitude 05^{o} 55N". Osun state, which primarily is an agrarian community [19], is bounded by Ogun, Kwara, Oyo and Ondo States in the South, North, West and East, respectively. The major crops cultivated by an estimated 256,000 farming families are maize, cassava, yam, rice and cocoyam [19]. Others are minor food crops such as cowpea, okro, pepper, tomato and leafy vegetables. Tree crops such as oil palm, cashew, citrus (orange and lemon), cocoa and kolanut are grown in large quantity in the state. There are also large forest reserves with a variety of trees. The climate of Osun state is broadly of two seasons: rainy season (April-October) and dry season (November – March). The mean air temperature throughout the year ranges between 21ºC to 29ºC and humidity is relatively high [19]. The annual rainfall varies from 2000 mm in the southern areas to 1,150 mm in the northern axis of the state. Osun state enjoys luxuriant vegetation in the rain forest parts of the south and sub-savannah forest of the northern part [19]. The map of Nigeria and the study areas is presented in Figs. 1 and 2.

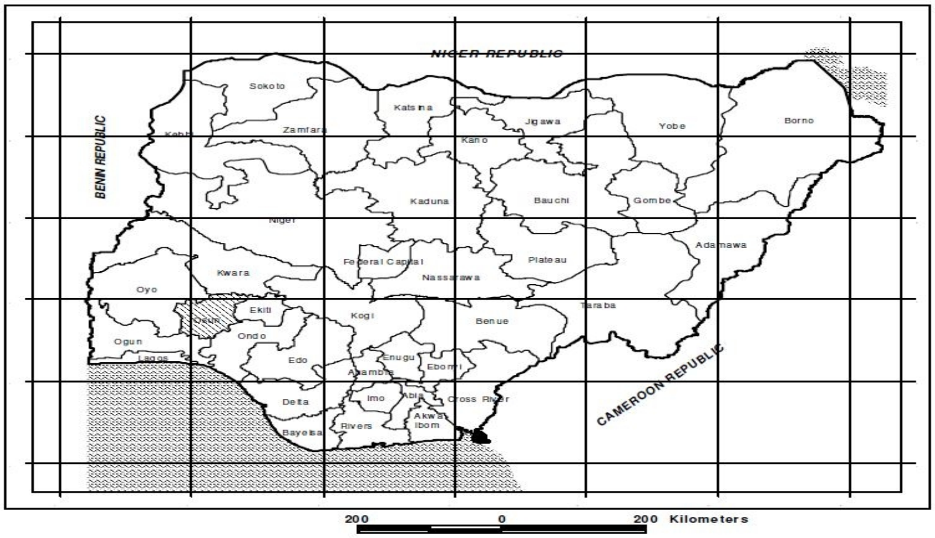

Fig. 1. Map of Nigeria showing Osun State (source: Sanni, [20])

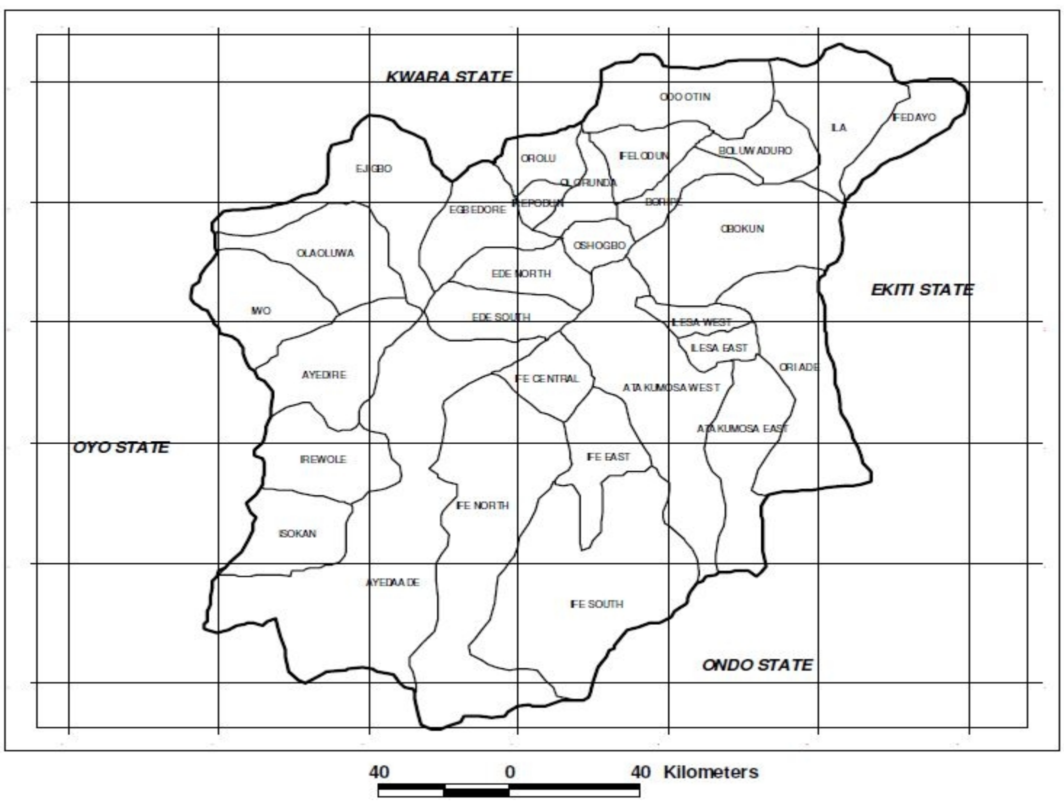

Fig. 2. Map of Osun State showing the Study Areas (source: Sanni, [20])

2.2 Field Investigation and Measurements

Nine communities were visited in each of the twelve sampled local government areas of Osun state and 50 farmers were randomly chosen from each of the visited communities making a total numbers of 5400 administered questionnaires. The questionnaires provided the following information about the communities and local government areas sampled: Land area under cultivation (ha), soil type, percentage of farmers that use the slash and burn technique in land cultivation, tillage systems adopted by farmers, percentage of farmers that retain trees within or around farm, percentage of farmers with formal knowledge of zero-tillage system, percentage of farmers with or without access to tractor mounted sprayers and percentage of farmers with erosion problem on farm. Land area measurement was conducted with the aid of a planimeter, which was moved around the perimeters of all farms in each of the farming communities. Soil types were identified through particle size analysis of samples collected from each of the study site. Particle size analysis was determined by the hydrometer method using the ASTM D 422 - Standard Test Method for Particle-Size Analysis of Soils [21]. Textural classification was carried out using the USDA classification system. The percentage organic matter (%OM) was determined using ASTM D 2974 – Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Organic Soils [22]. Investigation about the tillage system adopted by farmers involves the categorization of tillage into the followings: Traditional heaps and mounds, Tied ridges and Tilled-flat. Verbal discussions and questions were held with farmers to determine their knowledge of the advantages of zero tillage and the number of farmers that adopt the system determined.

Soil samples were collected from the visited communities for the determination of erosion characteristics, specifically erodibility factors of soils of the sampled communities. Soil samples were collected in soil profiles at depth up to 40 cm. The samples were packed in plastic bags, transferred to the laboratory and were air dried until reaching friability. The equation of Wischmeier et al. [18] was used for the estimation of soil erodibility K values for sampled soils (equation 1).

$$100\,k = 2.1(\%silt \times (100-\%clay)^{1.14}(10^{-4})(12 - \%organic\ matter) + 3.23(b - 2) + 2.5(c - 3) \quad (1)$$

where b is the soil structure code used in soil classification (very fine granular, 1; fine granular, 2; medium or coarse granular, 3; blocky, platy, or massive, 4), and c is the profile permeability class (rapid, 1; moderate to rapid, 2; moderate, 3; slow to moderate, 4; slow, 5; very slow, 6). Sampled soils were air-dried and analysed following the standard procedures described by Wischmeier and Smith [23]. Using the soil structure code described by Wishmeier and Smith [23], soil structure of the visited sites were determined by careful examination of column of undisturbed soil through profile trench of up to 50 cm depth. The Permeability class test was done to determine the permeability of soils of the various communities. Soil samples from the nine communities were put in separate measuring cylinders and 100 ml of water was added to each of the cylinders containing soil. Observation was then made on the time taken for the measured quantity of water to reach a particular level in the cylinder as it infiltrates down through the soil sample. The time was recorded and this was used for soil permeability classification according to the following codes: Fast – 1, Moderate to Fast – 2, Moderate – 3, Slow to Moderate – 4, Slow – 5, and Very Slow – 6 as described by Wischmeier and Smith [23].

All questionnaires were collated and subjected to statistical analysis to determine the influence of all measured variables on the farming system and erosion characteristics of soils of the sampled communities (a copy of the questionnaire can be seen in the appendix section).

3. RESULTS AND DISCUSSION

3.1 Land Areas and Clearing Techniques

The percentage land areas under cultivation in all communities of the sampled local government areas (LGA) are presented in Table 1. Atakunmosa west and Ife central had the highest and lowest land areas under cultivation with values 358.9 ha (11.44%) and 130.8 ha (4.16%), respectively. Large expanse of land is used for crop production most especially in Ayedaade, Ede south, Odo-otin and Ejigbo LGA of Osun state. These are rural communities where most inhabitants are peasant farmers. Despite the large area put under crop cultivation in all the sampled communities, the slash and burn technique of land preparation is predominantly adopted (Table 2). Slash and burn technique of land preparation were highest (> 99%) in Odo-otin, Ejigbo and Irewole LGA, while Ayedire was least (95.4%) in the use of slash and burn method of land clearing. This method of soil preparation is known to expose the soil to agents of erosion, reduce soil organic matter and organic carbon, and destroy soil micro-organisms that help create better aeration and incorporation of humus in soil [24]. Ayedire which was least in the use of slash and burn method (95.4%) had the highest percentage organic matter content (1.36), while in Irewole where the technique of land preparation is predominantly slash and burn (>99%), the percentage organic matter content was 1.18. Slash and burn method decreases the supply of fresh organic material and thus results in decreased level of organic matter in the soil which affects the soil fertility negatively [25]. Ife south, Ayedire and Ilesha west are characterized with reduced land areas been put to agricultural use due to alternative land uses such as building of houses, roads, schools and industries.

Burning leads to loss of forest cover which removes the natural protection of soils against the sun’s rays and the direct impacts of rainfall and reduced soil organic matter content (OM). There is a reduction in the infiltration of water into the soil and a simultaneous increase in surface runoff and Burning destroys trees and also damages the flora and fauna, and affects water availability [26]. Fig. 3 shows how the slash and burn method of land preparation affects the percentage of organic matter (%OM) in the soils of the different areas. The effect of burning on the total soil OM content varies depending on several factors such as fire type, intensity, and even slope [26]. Ejigbo with the highest prevalence of slash and burn method (99.4) had the least %OM (1.12) while Ayedire with the least percentage of respondents that uses the slash and burn land clearing technique in the sampled communities had the highest %OM of 1.36. Chandler et al. [27] reported that the bush burning effects may range from total destruction of the soil OM that may reach 30% in the surface layers, which often is caused by external inputs such as dried leaves and partially burnt plant materials in fires, affecting tree canopy. This in effect could result to temporal removal of the herbaceous layer, with effective loss of soil to erosion. However, increases in soil OM content was also adduced to an increased deposition of dry leaves and charred plant materials in fires that affect the tree canopy [28].

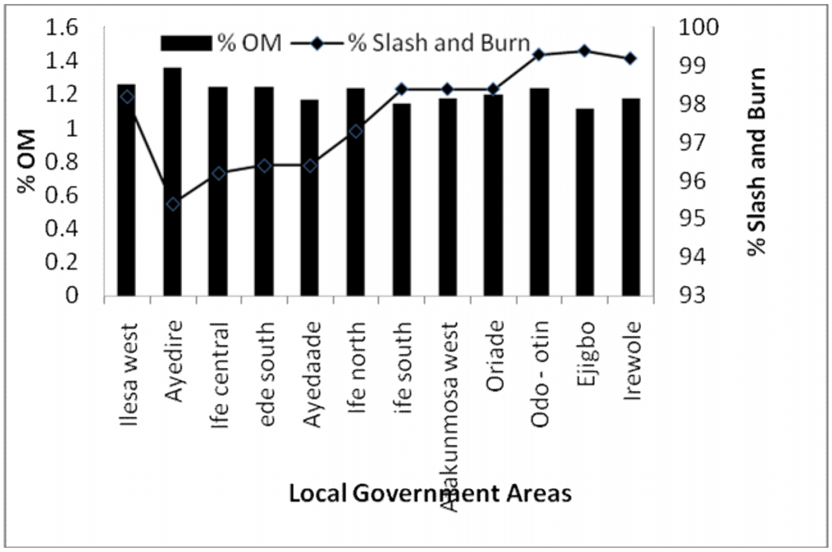

Fig. 3. Relationship between slash and burn method and %OM

Fig. 4 shows the trend of the relationship between percentage erosion problems and %OM. This trend shows that organic matter, together with micro-organisms (especially fungi) are involved in binding soil particles into larger aggregates and aggregation is important for good soil structure, aeration, water infiltration and resistance to erosion and crusting [29]. Wall et al. [16] also reported that soils rich in organic matter, and having improved structure and faster rates of water infiltration have greater resistance to erosion. Organic matter reduces the susceptibility of the soil to detachment, and it increases infiltration, which reduce runoff and thus erosion [30].

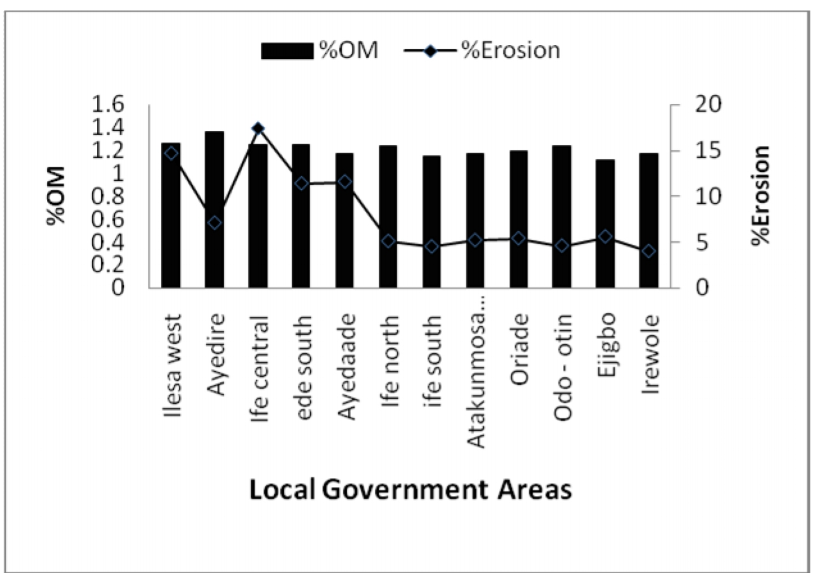

Fig. 4. Relationship between % erosion and %OM

3.2 Soil Tillage Systems in Sampled Communities

The statistics of tillage systems adopted by farmers in the sampled communities is presented in Tables 3, 4 and 5. Traditional heaps and mounds is mostly adopted by farmers in sampled rural communities of Ilesa west, Ife central, Ayedaade, Ife north, Ife south, and Atakunmosa west LGA. The popular use of this system may probably be due to high prevalence of erosion in these communities. Erosion is significant in these areas and the scenario can be linked to the removal of tree, which protects the soil against accelerated erosion and flooding for reasons such as building of other infrastructures around farmers' communities. The adoption of tilled flat system was highest in Ede south, Oriade and Odo-otin when compared with other sampled communities. The reason for use of tilled flat according to the farmers was the relatively flat terrain of their communities, which makes unnecessary the use of heaps and mounds or ridges to control erosion [31]. The use of tilled-flat was least in Irewole farmers' community with about an average of 14.5 (±3.50) respondents using the tilled-flat system. The adoption of tied-ridges was least comparatively with farmers that use of heaps and mounds and tilled-flat in all the sampled communities. Less than 10 respondents on the average actually practiced the tied ridges system in most of the sampled communities.

3.3 Canopy Cover and Erosion Problems in the Sampled Communities

Many of the respondents in the sampled communities cut down trees in their farm for domestic energy purposes and building works. On the average, approximately 13 out of the 50 respondents from Atakunmosa and Irewole retained trees within farmlands, while only about 8 respondents in Ife central retained trees on farm (Table 6); the purpose for which they confirmed is wind break. Canopy cover is known to protect the soil against the various agents of erosion such as wind and water by reducing their impacts on the soil [32]. Erosion potential is increased if the soil has very little or no vegetative cover and/or crop residues. Plant residue cover protects the soil from raindrop impact and splash, which slows down the movement of surface runoff and allows excess surface water to infiltrate [5]. Canopy cover is also very critical in the removal of atmospheric CO_2 (greenhouse gas), a process otherwise known as carbon sequestration. From this research, it was generally observed that only few among the respondents are aware of leaving scattered canopies on farm lands.

From the foregoing, it is obvious that many of the rural farmers are unaware of the importance of trees in the mitigation of erosion and carbon sequestration for plant use. It was also observed that very few farmers from the sampled community engaged in zero-tillage. Some of the farmers are aware of zero-tillage but are put off by the cost of obtaining chemicals for the purpose of weed crushing. Only less than 10 respondents on the average out of the 50 respondents from each community have adequate knowledge of zero- tillage (Table 7) but often do not use the method because of their innate interest on ash from bush burning, which, many among the farmers claimed it compliment the soil nutrient. Over 90% of farmers in all communities reported no access to tractor for the purpose of chemical application to crush weeds (Table 8).

The percentage of farmers with erosion problems is presented in Table 9. Farmers' percentage with highest erosion problems are from Ife central and Ilesha west LGA with values 17.4% and 14.7%, respectively. The least erosion problem was observed in Irewole LGA with value of 4%, where the highest percentage of farmers (10.3%) retained trees on farm. Ife central and Ilesha west LGA with high erosion problems had least percentage of farmers that retained trees on farm. This agrees with Isikwue and Adakole, [5] who reported in their work that the removal of vegetation cover and cultivation for two or more seasons reduces the inherent fertility drastically and accelerate erosion. This is because vegetative cover is the greatest deterrent to soil erosion and runoff [5]. Also Tree cover on farm land serves as shelter belt for crop protection during heavy winds and periods of rainstorms with high intensity, which breaks soil aggregates into fractions that are easily transported by overland flow [16]. Nevertheless, soil erosion is a function of many factors as mentioned in the universal soil loss equation (USLE) [33].

Fig. 5 shows the relationship between percentages of farmers that retains trees within and around farm lands and percentage of farmers with erosion problems. Ife central that had the lowest percentage of tree retention on farm (6.1) had the highest % erosion problems (17.4), while Irewole site with the highest tree retention (10.3) had the least erosion problem. This agrees with works of Roose, [34] and Lal, [35], who confirmed that in stable forest ecosystem where soil is protected by vegetation, erosion rates are relatively low, ranging from 0.004 to .05 t/ha per year. This showed that the presence of trees and cover crops protect the soil against erosion. The absence of trees and cover crops expose the soil to rain or wind energy which leads to erosion. This is also collaborated by the findings of other researches that worked on soils of coastal areas such as in Vietnam [36-37], Malaysia [38], Indonesia [39- 42], India [43-44], China [45] and Thailand [46]. These researchers provided evidence that coastal forests and trees provide some coastal protection and that clearing of coastal forests and trees leads to increased vulnerability of coasts to erosion. Leaves of trees prevent erosion of soil by the reduced impact of raindrops. Tree roots absorb water from the soil for its evapotranspiration purposes, making the soil drier and able to store more rainwater and also hold the soil in place, reducing the movement of sediment that can shrink river channels downstream [47].

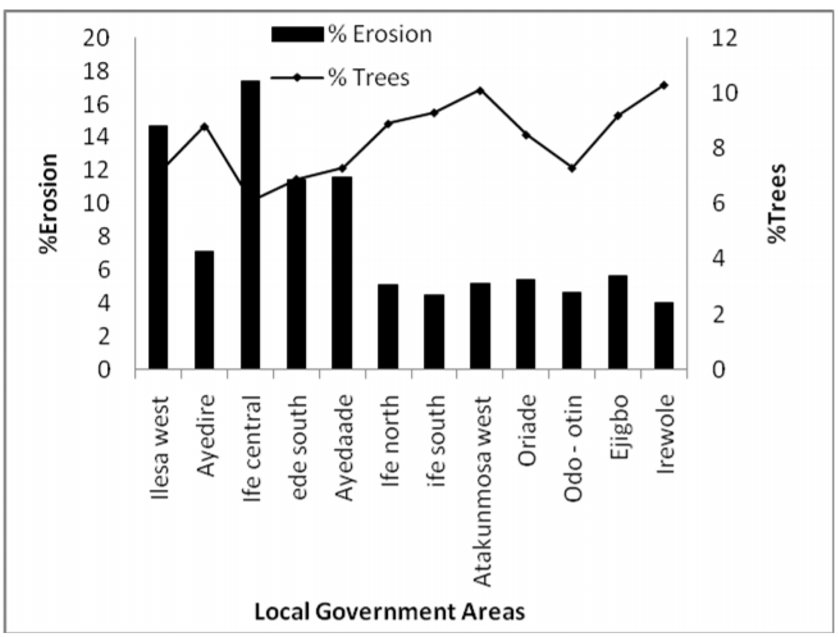

Fig. 5. Relationship between the % of trees retained and % erosion

Table 1. Total land area (ha) under cultivation in sampled local government areas

Community	Ilesa west	Ayedire	Ife-central	Ede south	Ayedaade	Ife north	Ife south	Atakunmosa west	Oriade	Odo-Otin	Ejigbo	Irewole
1	16.8	20.5	15.8	35.8	38.4	32.8	20.5	45.3	33.7	34.6	34.6	32.6
2	13.2	21.7	23.4	25.5	28.6	23.7	24.4	23.5	24.6	33.7	21.8	18.3
3	15.6	37.2	15.5	18.8	23.8	44.2	22.9	47.4	32.6	33.2	20.4	15.9
4	10	29.4	14.7	23.6	31.9	23.7	34.3	53.6	22.7	23.4	30.6	27.5
5	13.5	41.9	10.6	42.1	32.4	33.2	49.8	33.7	28.7	21.7	26.4	22.6
6	11.5	43.7	12.6	36.4	56.3	50.3	37.5	20.7	55.3	22.8	30.4	27.4
7	22	38.4	13.7	37.2	44.7	34.5	33.1	44.3	36.4	17.9	34.2	15.7
8	15.8	33.7	12.8	26.9	30.7	56.4	34.2	45.7	33.7	20.5	31.7	13.8
9	19.3	43.8	11.7	12.6	26.5	34.3	46.4	44.7	32.9	32.6	21.5	24.6
Total	137.7	310.3	130.8	258.9	313.3	333.1	303.1	358.9	300.6	240.4	251.6	198.4
Percent	4.4	9.9	4.2	8.3	9.9	10.6	9.6	11.4	9.6	7.7	8.02	6.4

Table 2. Respondents that use the slash and burn land clearing technique in sampled communities

Community	Ilesa west	Ayedire	Ife-central	Ede south	Ayedaade	Ife north	Ife south	Atakunmosa west	Oriade	Odo-otin	Ejigbo	Irewole
1	97	95	96	98	100	96	99	100	99	100	99	98
2	96	94	97	97	98	98	98	99	96	99	98	100
3	98	93	94	99	94	94	99	100	95	100	100	100
4	97	97	94	97	96	100	100	98	99	98	100	99
5	98	100	98	94	98	98	97	97	100	100	100	100
6	99	92	96	93	99	99	99	99	100	99	99	99
7	100	95	94	95	95	97	98	96	99	99	99	99
8	98	98	99	96	93	98	96	99	98	98	100	100
9	100	94	97	99	95	95	99	97	99	100	99	98
Mean	98.2	95.4	96.2	96.4	96.4	97.3	98.4	98.4	98.4	99.3	99.4	99.2
SD	1.36	2.55	1.83	2.13	2.40	1.92	1.22	1.41	1.73	0.83	0.71	0.83

Table 3. Respondents that adopt the traditional heaps and mound system of soil tillage in the sampled communities

Community	Ilesa west	Ayedire	Ife central	Ede south	Ayedaade	Ife north	Ife south	Atakunmosa west	Oriade	Odo-otin	Ejigbo	Irewole
1	21	10	20	14	21	28	21	23	15	10	14	23
2	25	9	17	12	24	20	25	20	9	9	20	26
3	23	11	10	10	20	22	24	19	10	9	24	30
4	12	12	13	20	12	21	20	21	14	12	26	27
5	22	13	15	14	13	31	17	20	13	14	23	25
6	18	11	14	15	10	22	30	25	15	10	21	24
7	16	12	17	11	22	23	22	17	13	9	27	22
8	23	10	22	10	16	18	24	18	11	11	21	28
9	10	8	17	9	13	22	21	16	14	10	22	23
Mean	18.89	10.67	16.11	12.78	16.78	23	22.67	19.89	12.67	10.44	22	25.33
SD	5.25	1.58	3.62	3.42	5.07	4.03	3.67	2.85	2.18	1.67	3.81	2.65

Table 4. Respondents that adopt the tied-ridges system of soil tillage in the sampled communities

Community	Ilesa west	Ayedire	Ife central	Ede south	Ayedaade	Ife north	Ife south	Atakunmosa west	Oriade	Odo-otin	Ejigbo	Irewole
1	6	12	6	4	9	5	6	7	9	7	5	10
2	10	13	7	5	7	4	5	7	6	6	6	12
3	8	13	5	6	8	5	6	8	10	7	6	12
4	6	11	4	8	6	6	4	5	6	8	8	10
5	4	7	6	7	9	5	5	6	7	4	6	9
6	8	9	4	6	8	4	4	6	4	5	7	9
7	9	10	5	8	9	6	3	4	3	10	2	11
8	4	12	3	8	7	5	3	5	7	10	10	10
9	6	8	6	10	6	7	6	5	8	4	8	8
Mean	6.8	10.5	5.1	6.9	7.7	5.2	4.7	5.9	6.7	6.8	6.4	10.1
SD	2.1	2.1	1.2	1.8	1.2	0.9	1.2	1.2	2.2	2.2	2.2	1.45

Table 5. Respondents that adopt the tilled-flat without residues system in the sampled communities

Community	Ilesa west	Ayedire	Ife central	Ede south	Ayedaade	Ife north	Ife south	Atakunmosa west	Oriade	Odo-otin	Ejigbo	Irewole
1	23	28	24	32	20	17	23	20	26	33	31	17
2	15	28	26	33	19	26	20	23	35	35	24	12
3	19	26	35	34	22	23	20	23	30	34	20	8
4	32	27	33	22	32	23	26	24	30	30	16	13
5	24	30	29	29	28	14	28	24	30	32	21	16
6	24	30	32	29	32	24	16	19	31	35	22	17
7	25	28	28	31	19	21	25	29	34	31	21	17
8	23	28	25	32	27	27	23	27	32	29	19	12
9	34	34	27	31	31	21	23	29	28	36	20	19
Mean	24.33	28.78	28.78	30.33	25.55	21.78	22.67	24.22	30.67	32.78	21.55	14.56
SD	5.83	2.33	3.80	3.54	5.59	4.15	3.61	3.56	2.78	2.44	4.16	3.50

Table 6. Percentage of farmers that retains trees within and around farm lands

Community	Ilesa west	Ayedire	Ife central	Ede south	Ayedaade	Ife north	Ife south	Atakunmosa west	Oriade	Odo-otin	Ejigbo	Irewole
1	8	12	5	7	10	14	12	15	10	7	9	10
2	10	10	7	8	9	10	11	12	11	11	12	19
3	7	13	10	10	10	11	14	13	9	9	11	13
4	12	14	9	8	8	16	12	10	12	8	13	12
5	9	10	7	9	7	11	13	14	8	10	12	14
6	10	9	8	7	9	10	11	13	14	7	14	15
7	8	11	10	8	10	12	9	12	12	11	10	10
8	6	8	5	10	10	9	12	11	10	10	9	12
9	10	12	7	11	9	8	10	14	10	9	13	11
Mean	8.89	11.00	7.56	8.67	9.11	11.22	11.56	12.67	10.67	9.11	11.44	12.89
SD	1.8	1.9	1.8	1.4	1.1	2.5	1.5	1.6	1.8	1.5	1.8	2.8
%	7.1	8.8	6.1	6.9	7.3	8.9	9.3	10.1	8.5	7.3	9.2	10.3

Table 7. Farmers with adequate knowledge of no-tillage

community	Ilesa west	Ayedire	Ife central	Ede south	Ayedaade	Ife north	Ife south	Atakunmosa west	Oriade	Odo-otin	Ejigbo	Irewole
1	9	5	13	9	7	9	5	7	8	8	6	7
2	7	7	12	8	10	8	4	9	7	6	7	7
3	3	7	10	9	7	7	8	4	9	9	4	5
4	7	9	11	10	11	5	6	7	5	5	6	7
5	10	6	10	7	7	5	5	3	6	7	7	6
6	8	9	12	8	8	7	4	8	8	6	4	4
7	6	8	9	5	8	9	7	8	5	4	5	8
8	9	8	9	7	8	10	4	7	6	7	4	6
9	7	6	10	8	6	4	5	6	9	5	8	7
Mean	7.3	7.2	10.7	7.9	8	7.1	5.3	6.5	7	6.3	5.7	6.3
SD	2.1	1.4	1.4	1.4	1.6	2.1	1.4	1.9	1.5	1.6	1.5	1.2

Table 8. Farmers without access to tractor and implements

community	Ilesa west	Ayedire	Ife central	Ede south	Ayedaade	Ife north	Ife south	Atakunmosa west	Oriade	Odo-otin	Ejigbo	Irewole
1	92	100	90	94	99	99	100	100	98	98	100	98
2	98	98	97	98	97	99	98	100	100	97	99	100
3	95	100	94	96	96	100	100	99	100	98	100	100
4	97	97	95	97	98	99	99	100	100	99	99	100
5	95	100	97	95	100	100	99	100	100	99	100	100
6	96	99	98	99	95	99	100	99	99	96	100	100
7	100	99	96	97	98	100	98	99	98	100	100	99
8	100	98	98	96	96	97	98	98	100	95	100	100
9	98	100	94	97	99	99	100	100	99	96	98	98
Mean	96.7	99	95.4	96.5	97.5	99.1	99.1	99.4	99.3	97.5	99.5	99.4
SD	2.5	1.1	2.5	1.5	1.7	0.9	0.9	0.7	0.87	1.6	0.7	0.9

Table 9. Percentage of farmers with erosion problems

community	Ilesa west	Ayedire	Ife central	Ede south	Ayedaade	Ife north	Ife south	Atakunmosa west	Oriade	Odo-otin	Ejigbo	Irewole
1	42	22	65	36	29	15	13	20	13	15	16	10
2	30	21	62	41	38	20	10	18	10	14	20	13
3	50	20	58	37	30	18	16	12	13	16	15	12
4	48	19	51	30	35	12	12	15	14	22	18	14
5	52	18	49	27	40	15	14	13	27	17	17	12
6	55	13	56	55	40	17	17	12	13	21	16	10
7	35	31	40	20	37	12	12	14	24	15	15	12
8	47	21	50	20	35	10	15	13	21	20	20	14
9	42	30	45	45	32	21	13	24	14	11	17	12
Mean	44.6	21.7	52.9	34.6	35.1	15.6	13.6	15.7	16.6	14.0	17.1	12.1
SD	8.1	5.6	8.1	11.6	4.1	3.8	2.2	4.2	5.8	3.5	1.9	1.4
Percentage	14.7	7.1	17.4	11.4	11.6	5.1	4.5	5.2	5.4	4.6	5.6	4.0

3.4 Soil Erosion and Erodibility Factor of Selected LGA in Osun State

The mean soil erodibility factor (k) of visited communities is presented in Table 10. Erodibility factor values of the soils in the various communities' show that the visited farm in Ife central was had the highest erodibility value of 0.65, an indication that the soil of the community is highly prone to erosion. It was closely followed by soils in Ife south with erodibility value of 0.53. Soil erodibilty was also high in Atakunmosa and Ilesha west local communities with values 0.48 and 0.41, respectively. However, soil vulnerability to erosion was lowest in Oriade and Ede south local communities with values 0.07 and 0.12, respectively. The particle size composition of soil of the various communities, which is predominantly sandy clay loam, indicated that most of the particles obtained from the study area belong to the category of sand and clay fractions. The high value of sand fraction showed that the soils were well sorted and the transportability of the sand fraction is low, which consequently may result to carrying away of the lighter particles of silt, clay and other colloidal material [48] and leaving behind sand fractions. Ife central with the least sand particle percentage (59%) was characterized with the highest erodibility value (0.65), while Oriade with highest percentage of sand particles (69%) had the least erodibility value (0.07).

Table 10. Mean soil erodibility of sampled communities in Osun state

Sampled LGA	%clay	%silt	%sand	%OM	Structure	permeability	erodibility(K)
Ilesha west	27	12	61	1.26	2	3	0.41
Ayedire	30	10	60	1.36	2	4	0.34
Ife central	28	13	59	1.25	2	3	0.65
Ede south	26	12	62	1.25	2	2	0.12
Ayedaade	24	11	65	1.17	3	3	0.25
Ife north	23	12	65	1.24	3	3	0.27
Ife south	27	10	63	1.15	2	2	0.53
Atakunmosa	28	11	61	1.18	2	2	0.48
Oriade	23	8	69	1.20	3	2	0.07
Odo-otin	25	12	63	1.24	2	3	0.29
Ejigbo	26	9	65	1.12	3	3	0.28
Irewole	24	10	66	1.18	3	2	0.31

4. CONCLUSION

Quantitative assessment of the methods of soil tillage, soil management techniques, erodibility and erosion characteristics of some selected local government areas of Osun state, in humid tropical climate of Nigeria had been conducted. Soil eodibility factor (K) was highest in Ife central while Oriade has the least one. This makes Oriade the least susceptible to detachment and transportability of the sediment and Ife central the most susceptible. The slash and burn technique of land preparation is found to be predominantly adopted by the Farmers. The practice of this method of soil preparation exposes the soils of the study areas to agents of erosion, reduce soil organic matter and organic carbon, and destroy soil micro-organisms that help create better aeration and incorporation of humus in soil. Practicing slash and burn method of land clearing increased the erodibility of the soils. Also, the absence of trees and cover crops also expose the soil to rain or wind energy which leads to reduction in the amount of organic matter in the soil and subsequently erosion problems. The least erosion problem was observed in Irewole LGA where the highest percentage of farmers retained trees on farm while the reverse occurred in Ife central and Ilesha west LGA with high erosion problems due to low percentage trees on farms. Traditional heaps and mounds, tilled flat system, and tied-ridges are the tillage systems adopted by farmers. The adoption of tied-ridges by farmers is least comparatively with the use of heaps and mounds and the use of tilled-flat in all the sampled communities. The different land preparation system and mechanical makeup of the soils determine their response and susceptibility to erosion problems. In order to reduce these effects of soil erosion on soil resources, adequate conservation practices such as maintaining permanent soil cover, avoiding the use of slash and burn methods and promoting minimal mechanical disturbance of soil through zero tillage systems to enhance soil and water conservation and control soil erosion and other practices that minimize soil disturbance must be employed.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

QUESTIONNAIRE

FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE, ONDO STATE DEPARTMENT OF AGRICULTURAL ENGINEERING

Date...

Sample No. .... Field Identification.............................. Field Size............. hectares

This questionnaire is for academic purpose, kindly fill or tick (√) in the spaces provided as it applies to you. Your response will be treated confidentially.

Name..

Community...

LGA...

1. What is your age? (in years) ....
2. What is your marital status? (a) Single( ), (b) Married ( ), (c) Divorced ( ),(d) Widow ( )
3. What is your family size?

   (i) No of Wives / Husband..........
   (ii) No of Children....................
   (iii) No of other dependants..........
   (iv) Total......................................

4. What is your highest educational level? (a) No formal education ( ), (b) Adult literacy ( ), (c) Others, specify.....................
5. How long have you been involved in farm activities? (in years) ....
6. How many hectares of land area do you cultivate? ....
7. Soil types......................... (a) Sandy ( ), (b) Loamy ( ), (c) Clayey ( )
8. What type of clearing technique do you employ in land cultivation? ....
9. What type of tillage systems do you adopt? (a) traditional heaps and mound system ( ), (b) tied-ridges system ( ), (c) tilled-flat without residues system ( )
10. Do you retain trees within or around farm? .... (a) Yes ( ), (b) No ( )
11. Do you have formal knowledge of zero-tillage farming system? ..... (a) Yes ( ), (b) No ( )
12. Do you have access to tractor and implements....................? (a) Yes ( ), (b) No ( )
13. If yes to question (12), how often do you use tractors and farm implements for your farm operations? Very often............... often ....not at all.......................
14. Do you have erosion problem on farm? (a) Yes ( ), (b) No ( )
15. Do you encounter any problem in obtaining the farm implements/seedlings used for farming? (a) Yes ( ), (b) No ( )
16. Which of the following do you consider as your needs:

    (i) Adequate credit ( )
    (ii) Storage facility ( )
    (iii) Market information ( )

(iv) Sourcing for raw materials ( )
(v) Availability of workers ( )
(vi) Farm Implements ( )
(vii) Record keeping ( )

17. How do you obtain information on your farming activities? (a) Radio / Television ( ), (b) Extension workers/Research Officers ( ), (c) Others, specify.......................
18. Have you ever been visited by Extension workers? (a) Yes ( ), (b) No ( )
19. What are other challenges faced by you in your farming activities?

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