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Study on Soil Erosion in Abandon Shifting Cultivations in Bago Yoma Watershed Areas

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ပဲခူးရိုးမတွင် တောင်ယာများနှင့် စွန့်ပစ်တောင်ယာများ၏ မြေဆီလွှာ အခြေအနေနှင့် မြေဆီလွှာထိန်းသိမ်းနိုင်မည့် နည်းလမ်းများနှင့် ဆည် အတွင်းနုန်းပို့ချမှုကို လေ့လာခြင်း

ဘီလီနေဝင်း၊ လက်ထောက်သုတေသနအရာရှိ
ဆွေဆွေထွန်း၊ လက်ထောက်သုတေသနအရာရှိ
ဖြူဖြူဆွေ၊ သုတေသနလက်ထောက် -၂
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သစ်တောသုတေသနဌာန

စာတမ်းအကျဉ်း

လွန်ခဲ့သောနှစ်များအတွင်း မြန်မာနိုင်ငံအတွင်း တောင်ယာများခုတ်ထွင်ခြင်း၊ လူဦးရေ တိုးပွားလာခြင်း၊ မြေများအား စနစ်တကျစီမံခန့်ခွဲမှုအားနည်းခြင်း တို့ကြောင့် ရေဝေရေလဲဧရိယာများ ပျက်ဆီးပြီး ဆည်အတွင်း နုန်းဝင်ရောက်မှုများခြင်း စသည်တို့ခံစားနေရပါသည်။ မြန်မာနိုင်ငံသည် စိုက်ပျိုးရေးကို အခြခံသောနိုင်ငံ တစ်ခုဖြစ်ခြင်းကြောင့် ဆည်များ၊ တာတမံများကို နိုင်ငံအဝှမ်း တည်ဆောက်ခဲ့ကြပါသည်။ ထိုနည်းတူ ပဲခူးရိုးမအတွင်းတွင်လည်း စိုက်ပျိုးရေရရှိရန်အတွက် ဆည်များ ဆောက်လုပ်ခဲ့ပါသည်။ ယခုလက်ရှိအချိန်တွင် မြန်မာနိုင်ငံအနေဖြင့် ဆည်ပေါင်း (၂၆၇) ခုတည်ဆောက်ထားပြီးဖြစ်ပါသည်။ ယခုစာတမ်းသည် ပဲခူးအရှေ့ခြမ်းနှင့် အနောက်ခြမ်း ဧရိယာ(၂) ခုကို ရွေးချယ်၍ တောင်ယာများအတွင်ရှိ မြေဆီလွှာအခြေအနေများ၊ နုန်းပို့ချမှုများ နှင့် ရေဝေရေလဲ ဧရိယာများအား ထိန်းသိမ်းနိုင်မည့် နည်းလမ်းများကို ရှာဖွေထားပါသည်။ လေ့လာတွေ့ရှိချက်များအရ တောင်ယာများတွင် နုန်းပို့ချမှုအများဆုံးတွေ့ရှိရပြီး၊ ဖုန်းဆိုးတောသည် ဒုတိယနေရာတွင်ရှိကာ တောပျက်များတွင် အနည်းဆုံးတွေ့ရှိရပါသည်။

Study on Soil Erosion in Abandon Shifting Cultivations in Bago Yoma Watershed Areas

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Abstract

In the past decades, many watersheds in Myanmar have undergone serious degradation due to shifting cultivation, population increase, encroachment, unsuitable land use practices. As Myanmar is an agricultural country, reservoirs and dams are implementing throughout the country. In the same way, dams are being constructed along the Bago Yoma region from which water resource can be available for Myanmar. Nowadays about 267 dams has been constructed.This paper tries to evaluate soil fertility level under shifting cultivation areas, to assess soil erosion and sedimentation rate of shifting cultivation in the watershed area and to provide adequate soil conservation measures for degraded watershed area. The effect of shifting cultivation on soil organic matter, permeability, texture, and structure indirectly affects the inherent susceptibility of the soil. The result of this study indicated that shifting cultivation area did affect the soil loss rate. Shifting Cultivation area in both sites fell in the highest soil loss rate according to the ratings of soil loss values. Fallow area has little profound effect on the inherent susceptibility of the soil to eroding forces. This may be related to the regeneration of the secondary growth that protects the soil from raindrops and facilitates accumulation of soil organic matter.

Content

Study on Soil Erosion in Abandon Shifting Cultivations in Bago Yoma Watershed Areas

1. Introduction

As Myanmar is an agricultural country, reservoirs and dams are implementing throughout the country. In the same way, dams are being constructed constructing and irrigation system, the Bago Yoma region from which water resource for irrigation and hydropower can be available for within Bago Region. Nowadays about 267 dams and reservoirs have been constructed in Myanmar. Watershed areas play a vital role for annual water flow into dams and reservoirs and their lifelong span.

The people in the uplands of Bago Yoma have been practicing shifting cultivation fromtime immemorial and it is closely related with theirsocio-cultural identity.However,in the past, they practiced shifting cultivation inthe same area with a fallow period of 15–20 years,which ensured the long-term sustainability of soilfertility, and ensured forest regrowth. With the rapidgrowth in population, the fallow period has beendramatically reduced to 3–4 years, allowing verylittle time for soil or vegetative regeneration. The decrease in fallow period has led to the deterioration of faunal and microbial organisms, top soil loss, and erosion during periods of heavy rainfall. Beside the degree, extent, causes and measures of soil fertility decline have not received adequate research attention.As people depend on this forestry practices traditionally shifting cultivation, it is not easy to prohibit.

Investigating soil physical and chemicals properties and soil conservation under shifting cultivation within watershed, could assist policy makers, researchers, extension workers and farmers to have baseline information to improve the soil fertility and productivity of acid soils of the Bago Yoma study area and elsewhere which have similar agro ecology. Research on this line is of paramount importance as the results obtained from east and west of Bago Yoma watersheds studies could also be as reference for soil conservation measures in watershed areas.

2. Objective

1. To evaluate soil fertility level under shifting cultivation areas in Bago Yoma
2. To assess soil erosion and sedimentation rate due to shifting cultivation in the watershed area
3. To provide adequate soil conservation measures for degraded watershed area

3. Literature Reviews

Land use and land-use changes have significant influence on the main soil quality parameters like organic matter, nutrient supply, soil vegetation cover, and soil compaction, which are critical for soilhealth (Dunjó et al. 2003). Shifting cultivation has been much condemned for forest destruction andderived environmental effects. Harvesting activities reduce surface cover and compact the soil, leadingto increased runoff and erosion. Erosion generally decreases the productivity of forests by reducingthe available soil water for forest growth and through the loss of nutrients in eroded sediment(Elliot et al., 1999).

Contrariwise, studies conducted in different countries have indicated the benefit of swidden agriculture (shifting cultivation) for soil productivity. Some studies reported that shifting cultivation is the only solution to the problem of soil erosion in the tropics (Lal, 1973). Soil erosion under shifting agriculture is not, therefore, a serious problem provided that the forest clearing is done on gentle slopes, that there is no extensive damage to forest litter by uncontrolled burning, and that a short period of cropping is followed by a long forest fallow. Under the increasing pressure of population on land, however, these conditions may never be realized (Lal, 1973).

A study conducted by Werner (1984) in Costa Rica also indicated that there was no significant change in clay content, bulk density, or water retention. Soil structure remains stable throughout the succession. Hansen (2001) concluded that some alternative land-use practices, especially permanent arable cropping, may be more prone to accelerated erosion and fertility decline in Laos than shifting cultivation. Shifting cultivation partially restores soil fertility during the fallow periods, and limits erosion through minimal tillage, maintenance of a favourable soil structure, and through the distribution of erosion over a larger area.

4. **Materials and Methods**

The study was conducted at SwaChaung dam watershed area in Yetashae Township in the East of Bago Yoma area and Taungnawin dam watershed area in Paukkong Township in the west of Bago Yoma area.

A simple checklist survey was made with 3 villages in each watershed area to collect soil samples and compare soil properties that directly matched with the experimental treatments. The treatments set for the research were three types under shifting cultivation areas including taung ya area, phone zoe areaand degraded forest (fallow area). Due emphasis was given to slope ranges and the sample sites lay between sloperanges of 20 to 30 percent.

Each treatment was replicated five times for precision considering eachshifting cultivations area as a replicate. The design was a completely randomized design (RCBD).Emphasis given to slope as the shifting cultivation preferred higher slopes to gentle ones to avoid sedimentdeposition. The sample spots in each field were selected by a simple criss-cross method to find thecentre, top, and bottom ends of the field diagonal. Representative auger samples were collected fromthree random points of each field to make composite soil samples for soil analysis.Ninety soil samples were collected   at the depth of 0-10 cm and 20-30 cm from each study area.

Thecomposite soil samples were transported to Forest Research Institute (FRI) and analyzed in Soil Laboratory. All measured soilproperties were analyzed using recognized standard procedures and methods. Details are given intable 1.

The result used the statistical package for social science (SPSS) and Excel® tools for the analysis of the data. A variance analysis was made using the two-way ANOVA to analyze the impact of shifting cultivation on soil properties. Descriptive statistics were also applied separately in each study area to compare the means of the different soil properties under the shifting cultivation areas.

Table 1. Methods used for analysis

Parameters	**Procedure/methods**	**Reference**
Physical analysis		
Soil texture	Pipette method	Prittchet (1983)
Chemical analysis		
Total N	Kjeldahl method	Nelson and Sommers (1996)
Available P	Blue method	Prittchet (1983)
Available K	Ammonium acetate extractable	Helmke and Sparks (1988)
Soil organic matter (SOM)	Walkley-Black method	Nelson and Sommers (1996)
pH	Water suspension method	McLean (1982)

5.Result

5.1.Soil properties

Soil physical and chemical properties are the most important factors that affect soil fertility and determine the nutrient supplying power of soil to the plants and microbes. In this study, the most important soil physical chemical properties were analyzed and presented in appendix I and appendix II (chemical properties).

Soil physical and chemical properties showed significantly difference under shifting cultivation areas but the interaction between shifting cultivation areas and soil depth were not difference in both sites.

5.1.1. Soilphysical properties at East Side of Bago Yoma

The soil texture ofsand % and silt % in Taung-ya area has no statistically significant different in Phone zoe area and Fallow area.

The lowest silt % was found under Fallow area but silt % has not statistically difference among the areas.

The soil texture ofClay % inTaung-ya area and Phone zoe area were not significantly different 5% level by LSD. Fallow area has the highest clay % .

5.1.2.Soil physical properties at west Side of Bago Yoma

Taung-ya area significantly showed the highest sand % and the lowest sand % in Phone zoe area.

The lowest silt % was found in Fallow area but silt % has not statistically difference among the areas.

According to LSD test , Phone zoe area has the highest clay % and followed by Taung-ya area and Fallow area.

5.1.3. Soil chemical properties at East Side of Bago Yoma

Soil pH was significantly affected by the effect of shifting cultivation where the highest pH (6.47) was found in Taung-ya area. But Soil pH was no statistically difference between Phone zoe area and fallow area.

Total N content in taung-ya area was not significantly different with fallow land.Phone zoe area has the lowest soil N content.

Available phosphorus and soil organic matter were significantly lower in Phone zoe area when compared to Fallow area.

Available K was highly significantly affected by shifting cultivation whereby the highest K (0.0028) was observed in Fallow area.

5.1.4. Soil chemical properties at West Side of Bago Yoma

Soil pH underfallow area was gave the lowest pH content. Taung-ya and Phone zoe area were not significantly different.

Shifting cultivation under fallow area have the highest Total N content and followed by Taung-ya and Phone zoe area.

According to LSD test, Available phosphorus under Phone zoe area has the lowest phosphorus content and soil under Taung-ya and Fallow area showed the highest phosphorus content and gave the same effect.

Fallow area was found to have the highest K but Shifting cultivation under other areas have not significantly different.

6.Discussion

6.1 Soil chemical properties and fertility status under shifting cultivation

6.1.1 pH

Shifting cultivation in east side had a pH value less than 7 indicating the acid character of soil and the west sideshowed thebasic character. Probably the pre-weathered parent materials and the intense leaching of basic cations are the reasons for these acidic conditions.(figure 1.)

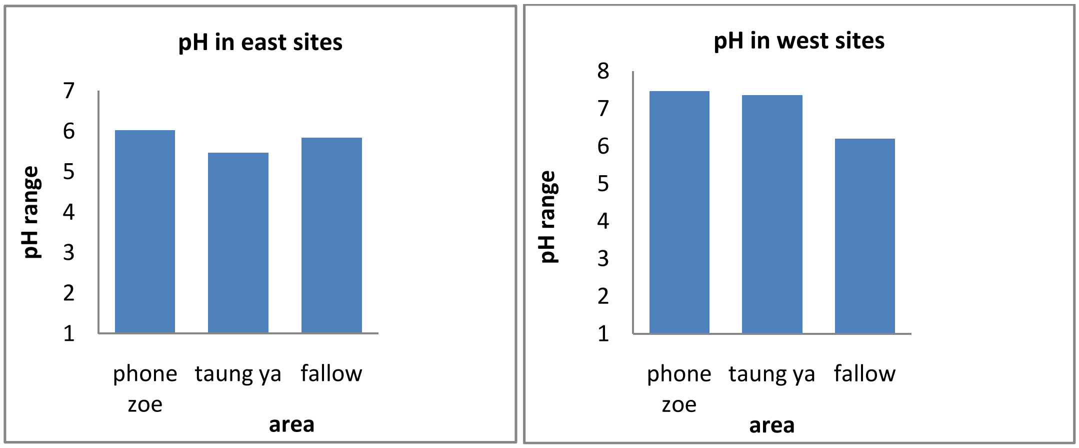

Figure1.average pH range under shifting cultivation area in east and west sites

6.1.2 Total N

The total N content of soils under in all areas was not significantly different in both soil depth regions. This indicated that high exploitation of the soil N reserved by shifting cultivation over time. Although Total N was different at both site , less than 1% of total N was available to the plant . (figure 2.)

In traditionally shifting cultivation, the nitrogen availability of soil is an important factor to sustain crop production since most N contained in aboveground biomass would be lost in the the atmosphere at the time of burning;(Giarndia et al2000) .

The lower N availability in shifting cultivation of Taung-Ya in east site and Phone zoe areas in both site could be ascribed to loss of nitrogen from soil ecosystems and the insufficient recovery of soil N pools under poor vegetation regrowth due to intensive land use in these areas.

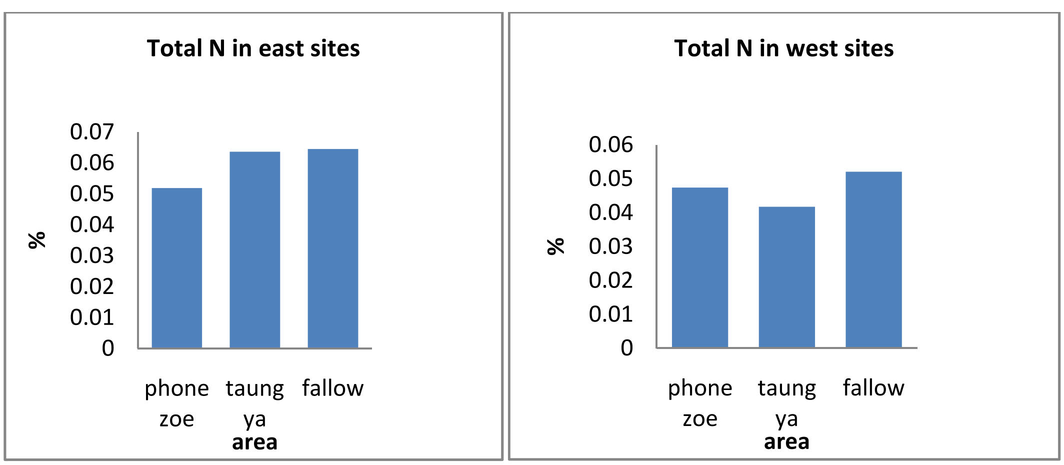

Figure2. Total N% under shifting cultivation area in east and west sites

6.1.3 Available Phosphorus

Many of the soils in Myanmar are deficient in phosphorous (FRI, 2001).Phosphorous concentration levels were significantly different in this study. The slight decrease was in available phosphorous in Phone zoe area in both sites. It may be due to the fixation and weed consumption. (figure 3.)

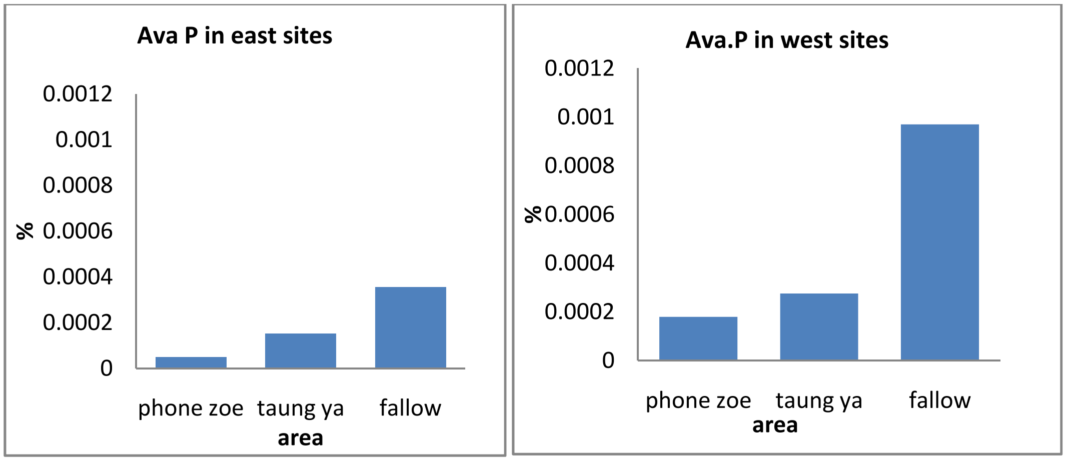

Figure3. Ava P % under shifting cultivation area in east and west sites

6.1.4 Available Potassium (K)

Fallow areas in both sites revealed relativity less acidity and higher contents of available potassium (K) compared with the other areas.This could be ascribed to the remaining effect of ash and fertilizer application at cropping time and nutrient uptake by vegetation regrowth during fallow. Tanaka et.al (2007) also described soil with less acidity and higher content of exchangeable base during fallow.

The low level of available potassium content was found in Phone zoe area (Figure4), This disappearance or decrease may be through the leaching loss since the soil type derivates from the sand stone. Presently the increasing weed may also use up extractable potassium.

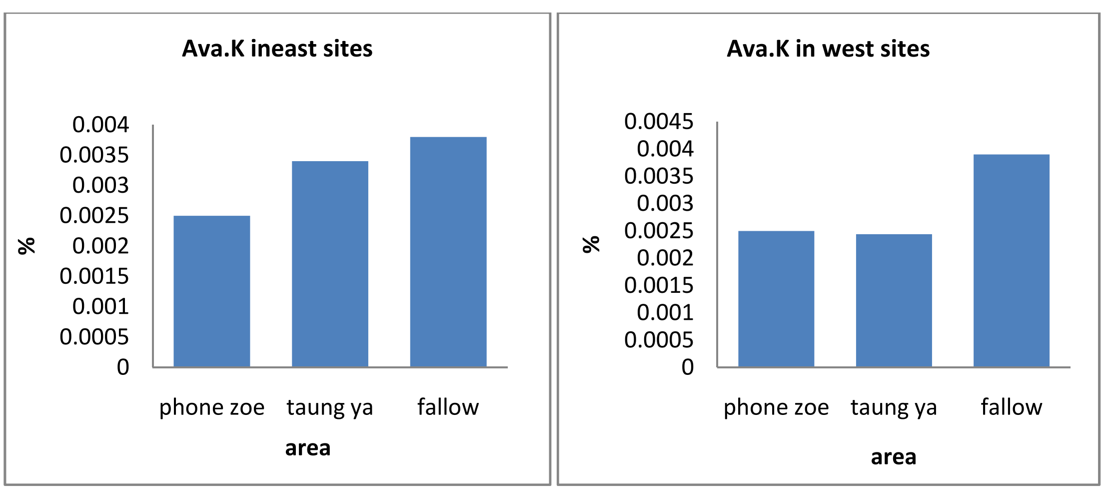

Figure 4. Ava K % under shifting cultivation area in east and west sites

6.1.5 Soil Organic matter

Phone zoe area generally have low organic matter compared to Taung ya area and Fallow areas (Figure5).It may be due to shorter fallow periods in the current shifting cultivation system in these areas lead to poor vegetation recovery, resulting biological decomposition of the organic matter and the loss of surface layer through the soil erosion.

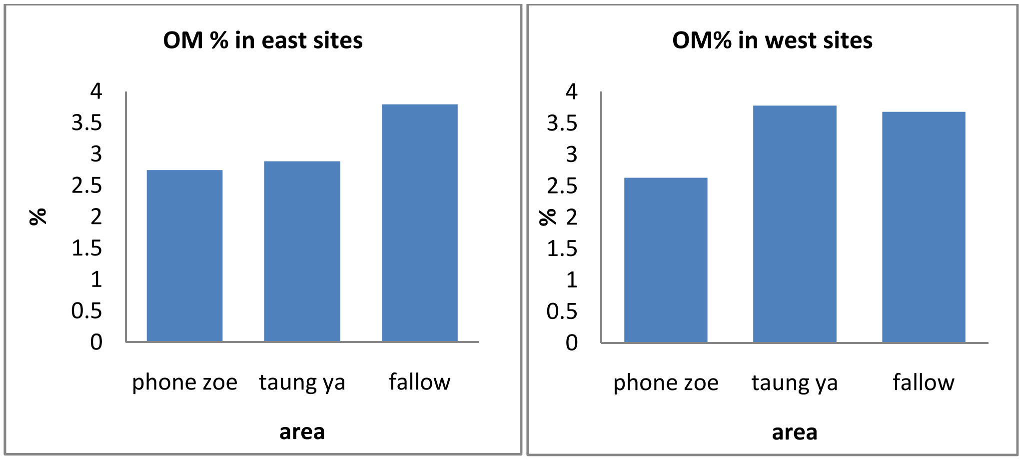

Figure5. Average OM % under shifting cultivation area in east and west sites

6.2 Soilerosion in shifting cultivation area

The effect of shifting cultivation on soil organic matter, permeability, texture, and structure indirectly affects the inherent susceptibility of the soil, ie. soil erodibility, represented by the soil loss rate. Erodibility varies with soil texture, aggregate stability, shear strength, infiltration capacity, and organic and chemical content (Morgan, 1995).The result of this study indicated that shifting cultivation area did affect the soil loss rate. Shifting Cultivation area in both sites fell in the highest soil loss rate according to the ratings of soil loss values (figure 6) . Fallow area has little profound effect on the inherent susceptilibility of the soil to eroding forces. This may be related to the regeneration of the secondary growth that protects the soil from raindrops and facilitates accumulation of soil organic matter.

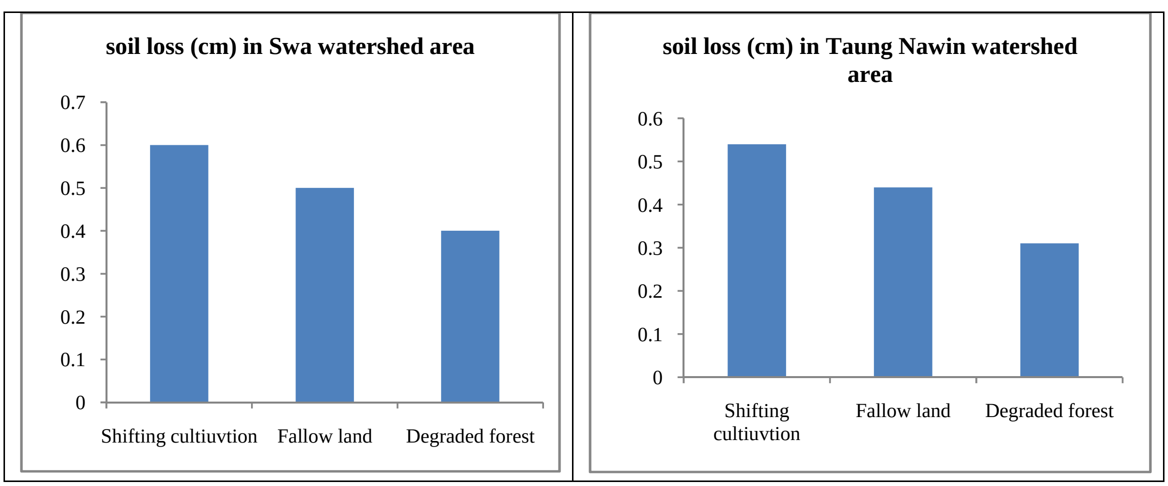

Figure.6 Soil loss rate (cm) in shifting cultivation area in east and west sites.

7. Conclusion

The use of fire and the exposure of the soil during in the shifting cultivation areais the most commonly reported causes of the negative impacts to physical and chemical properties of soil. The effects of the negative impacts were also similar in that they affected variables related to the three types of soil properties (physical, chemical, and biological). Soil physical and chemical properties showed significantly difference under shifting cultivation areas but the interaction between shifting cultivation areas and soil depth were not difference in both sites.

Even today, shifting cultivation is considered as a major source of rural economy in east and west of Bago yoma and will remain as important one as it is associated with socioeconomic and cultural systems of the people of this region. Because of this, degradation will continue in the years to come and may reach to the extent of out of control, if proper care is not taken right now. In this direction, community forestry and agroforestry system with some sound resource conservation techniques needs to be strengthened for long-term sustainable production and environmental conservations in fragile ecosystem which will contribute to improved food security and income generation for resource poor farmers and protect the environments.

The establishment of woody perennials and nitrogen-fixing trees close to, or intercropped with, agricultural crops maintains or improves the fertility of arable land. Trees increase the soil's ability to absorb and retain water, produce nutrients for plants, maintain high levels of organic matter in the soil, and moderate soil temperatures.Shifting cultivators and other farmers who depend on forest-fallow systems have long recognized the vital role that trees play in maintaining soil fertility. Traditional agroforestry techniques play a significant role in increasing household food security in many countries. In Nigeria, for example, the planting of alternate rows of *Leucaena leucocephala* with maize and cowpeas has resulted in a marked improvement in soil fertility.

When evaluating the environmental effects of shifting cultivation, it must be compared with alternative farming practices—not only with forestry or natural forest. Being a farming system that relies on field crop production, shifting cultivation cannot be expected to be more environmentally friendly than natural forest, but it would in most cases provide more and better environmental services than other more intensive farming systems. The forest and crop litter, combined with the minimal soil disturbance in the shifting cultivation systems, forms an almost continuous covering layer that protects the soil from erosion.

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Appendix I

ANOVA for sand % in East Site

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2249.067(a)	5	449.813	4.401	.001
Intercept	442681.600	1	442681.600	4331.253	.000
layer	211.600	1	211.600	2.070	.154
method	1582.467	2	791.233	7.742	.001
layer * method	455.000	2	227.500	2.226	.114
Error	8585.333	84	102.206		
Total	453516.000	90			
Corrected Total	10834.400	89			

Mean comparison for sand % in East Site

layer	method	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
0-10cm	phone zoe	72.067	2.610	66.876	77.258
	tyaung ya	74.200	2.610	69.009	79.391
	fallow	68.733	2.610	63.542	73.924
20-30cm	phone zoe	65.333	2.610	60.142	70.524
	tyaung ya	77.467	2.610	72.276	82.658
	fallow	63.000	2.610	57.809	68.191

* The mean difference is significant at the .05 level.

Appendix I cont.

ANOVA for sand % in West Site

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3827.256(a)	5	765.451	4.078	.002
Intercept	440300.278	1	440300.278	2345.667	.000
layer	253.344	1	253.344	1.350	.249
method	3544.956	2	1772.478	9.443	.000
layer * method	28.956	2	14.478	.077	.926
Error	15767.467	84	187.708		
Total	459895.000	90			
Corrected Total	19594.722	89			

Mean comparison Comparisonsfor sand % in West Site

	(I) method	(J) method	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	phone zoe	tyaung ya	15.03(*)	3.537	.000	8.00	22.07
		fallow	4.73	3.537	.184	2.30	11.77
	tyaung ya	phone zoe	15.03(*)	3.537	.000	22.07	8.00
		fallow	10.30(*)	3.537	.005	17.33	3.27
	fallow	phone zoe	4.73	3.537	.184	11.77	2.30
		tyaung ya	10.30(*)	3.537	.005	3.27	17.33

* The mean difference is significant at the .05 level.

Appendix I cont.

ANOVA for Silt % in East Site

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	225.467(a)	5	45.093	1.561	.180
Intercept	18835.600	1	18835.600	651.930	.000
layer	42.711	1	42.711	1.478	.227
method	135.467	2	67.733	2.344	.102
layer * method	47.289	2	23.644	.818	.445
Error	2426.933	84	28.892		
Total	21488.000	90			
Corrected Total	2652.400	89			

Mean comparison Comparisonsfor Silt % in East Site

	(I) method	(J) method	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	phone zoe	tyaung ya	2.53	1.388	.072	.23	5.29
		fallow	.13	1.388	.924	2.89	2.63
	tyaung ya	phone zoe	2.53	1.388	.072	5.29	.23
		fallow	2.67	1.388	.058	5.43	.09
	fallow	phone zoe	.13	1.388	.924	2.63	2.89
		tyaung ya	2.67	1.388	.058	.09	5.43

* The mean difference is significant at the .05 level.

Appendix I cont.

ANOVA for Silt % in West Site

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	878.367(a)	5	175.673	3.077	.013
Intercept	27772.900	1	27772.900	486.458	.000
layer	22.500	1	22.500	.394	.532
method	851.667	2	425.833	7.459	.001
layer * method	4.200	2	2.100	.037	.964
Error	4795.733	84	57.092		
Total	33447.000	90			
Corrected Total	5674.100	89			

Mean comparison Comparisonsfor Silt % in West Site

	(I) method	(J) method	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	phone zoe	tyaung ya	6.83(*)	1.951	.001	10.71	-2.95
		fallow	.67	1.951	.733	4.55	3.21
	tyaung ya	phone zoe	6.83(*)	1.951	.001	2.95	10.71
		fallow	6.17(*)	1.951	.002	2.29	10.05
	fallow	phone zoe	.67	1.951	.733	3.21	4.55
		tyaung ya	6.17(*)	1.951	.002	10.05	-2.29

* The mean difference is significant at the .05 level.

Appendix I cont.

ANOVA for Clay % in East Site

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1028.189(a)	5	205.638	4.650	.001
Intercept	17500.278	1	17500.278	395.749	.000
layer	162.678	1	162.678	3.679	.059
method	435.556	2	217.778	4.925	.009
layer * method	429.956	2	214.978	4.861	.010
Error	3714.533	84	44.221		
Total	22243.000	90			
Corrected Total	4742.722	89			

Mean comparison Comparisonsfor Clay % in East Site

	(I) method	(J) method	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	phone zoe	tyaung ya	2.00	1.717	.247	5.41	1.41
		fallow	5.33(*)	1.717	.003	8.75	1.92
	tyaung ya	phone zoe	2.00	1.717	.247	1.41	5.41
		fallow	3.33	1.717	.056	6.75	.08
	fallow	phone zoe	5.33(*)	1.717	.003	1.92	8.75
		tyaung ya	3.33	1.717	.056	.08	6.75

* The mean difference is significant at the .05 level.

Appendix I cont.

ANOVA for Clay % in West Site

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1372.989(a)	5	274.598	4.842	.001
Intercept	11994.678	1	11994.678	211.523	.000
layer	162.678	1	162.678	2.869	.094
method	1183.622	2	591.811	10.436	.000
layer * method	26.689	2	13.344	.235	.791
Error	4763.333	84	56.706		
Total	18131.000	90			
Corrected Total	6136.322	89			

a R Squared = .224 (Adjusted R Squared = .178)

Mean comparison Comparisonsfor Clay % in West Site

	(I) method	(J) method	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	phone zoe	tyaung ya	8.87(*)	1.944	.000	12.73	5.00
		fallow	3.97(*)	1.944	.044	7.83	.10
	tyaung ya	phone zoe	8.87(*)	1.944	.000	5.00	12.73
		fallow	4.90(*)	1.944	.014	1.03	8.77
	fallow	phone zoe	3.97(*)	1.944	.044	.10	7.83
		tyaung ya	4.90(*)	1.944	.014	8.77	1.03

* The mean difference is significant at the .05 level.

Appendix II

ANOVA for pH in East site

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5.561(a)	5	1.112	5.741	.000
Intercept	3012.539	1	3012.539	15552.728	.000
layers	.592	1	.592	3.057	.084
methods	4.967	2	2.483	12.821	.000
layers * methods	.002	2	.001	.004	.996
Error	16.271	84	.194		
Total	3034.370	90			
Corrected Total	21.831	89			

Mean comparison for pH

	(I) methods	(J) methods	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	phonezoe	taungya	.5633(*)	.11364	.000	.3374	.7893
		fallow	.1800	.11364	.117	.0460	.4060
	taungya	phonezoe	.5633(*)	.11364	.000	.7893	.3374
		fallow	.3833(*)	.11364	.001	.6093	.1574
	fallow	phonezoe	.1800	.11364	.117	.4060	.0460
		taungya	.3833(*)	.11364	.001	.1574	.6093

Appendix II cont.

ANOVA for Total N in East site

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.004(a)	5	.001	4.012	.003
Intercept	.199	1	.199	1006.126	.000
layers	.000	1	.000	.962	.330
methods	.002	2	.001	4.025	.021
layers * methods	.002	2	.001	5.524	.006
Error	.017	84	.000		
Total	.220	90			
Corrected Total	.021	89			

Mean comparison for Total N

	(I) methods	(J) methods	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	phonezoe	taungya	.00563	.003636	.125	.00160	.01286
		fallow	.00467	.003636	.203	.01190	.00256
	taungya	phonezoe	.00563	.003636	.125	.01286	.00160
		fallow	.01030(*)	.003636	.006	.01753	.00307
	fallow	phonezoe	.00467	.003636	.203	.00256	.01190
		taungya	.01030(*)	.003636	.006	.00307	.01753

Appendix II cont.

ANOVA for Ava P in East site

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.57E-006(a)	5	3.14E-007	3.981	.003
Intercept	3.09E-006	1	3.09E-006	39.123	.000
layers	2.96E-008	1	2.96E-008	.374	.542
methods	1.45E-006	2	7.25E-007	9.189	.000
layers * methods	9.08E-008	2	4.54E-008	.575	.565
Error	6.63E-006	84	7.89E-008		
Total	1.13E-005	90			
Corrected Total	8.20E-006	89			

Mean comparison for Ava P in East site

	(I) methods	(J) methods	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	phonezoe	taungya	.00010310	.000072549	.159	.00024737	.00004117
		fallow	.00030567(*)	.000072549	.000	.00044994	.00016140
	taungya	phonezoe	.00010310	.000072549	.159	.00004117	.00024737
		fallow	.00020257(*)	.000072549	.006	.00034684	.00005830
	fallow	phonezoe	.00030567(*)	.000072549	.000	.00016140	.00044994
		taungya	.00020257(*)	.000072549	.006	.00005830	.00034684

Appendix II cont.

ANOVA for Ava K in East site

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.37E-005(a)	5	6.74E-006	16.879	.000
Intercept	.001	1	.001	2343.240	.000
layers	2.18E-006	1	2.18E-006	5.454	.022
methods	2.71E-005	2	1.35E-005	33.895	.000
layers * methods	4.45E-006	2	2.23E-006	5.576	.005
Error	3.35E-005	84	3.99E-007		
Total	.001	90			
Corrected Total	6.72E-005	89			

Mean comparison for Ava K in East site

	(I) methods	(J) methods	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	phonezoe	taungya	.000943(*)	.0001632	.000	.001268	.000619
		fallow	.001300(*)	.0001632	.000	.001624	.000976
	taungya	phonezoe	.000943(*)	.0001632	.000	.000619	.001268
		fallow	.000357(*)	.0001632	.032	.000681	.000032
	fallow	phonezoe	.001300(*)	.0001632	.000	.000976	.001624
		taungya	.000357(*)	.0001632	.032	.000032	.000681

Appendix II cont.

ANOVA for OM in East site

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	22.446(a)	5	4.489	2.159	.066
Intercept	888.683	1	888.683	427.313	.000
layers	1.904	1	1.904	.915	.341
methods	19.590	2	9.795	4.710	.012
layers * methods	.952	2	.476	.229	.796
Error	174.695	84	2.080		
Total	1085.825	90			
Corrected Total	197.141	89			

Mean comparison for OM in East site

	(I) methods	(J) methods	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	phonezoe	taungya	0.13767	.372353	.713	.87813	.60280
		fallow	1.05133(*)	.372353	.006	1.79180	.31087
	taungya	phonezoe	.13767	.372353	.713	.60280	.87813
		fallow	.91367(*)	.372353	.016	1.65413	.17320
	fallow	phonezoe	1.05133(*)	.372353	.006	.31087	1.79180
		taungya	0.91367(*)	.372353	.016	.17320	1.65413

Appendix II cont.

ANOVA for pH in West site

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	30.536(a)	5	6.107	9.928	.000
Intercept	4424.011	1	4424.011	7191.658	.000
layers	.016	1	.016	.026	.872
methods	29.271	2	14.635	23.791	.000
layers * methods	1.249	2	.624	1.015	.367
Error	51.673	84	.615		
Total	4506.220	90			
Corrected Total	82.209	89			

Mean comparison for pH in West site

	(I) methods	(J) methods	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	phonezoe	taungya	.1000	.20251	.623	.3027	.5027
		fallow	1.2567(*)	.20251	.000	.8540	1.6594
	taungya	phonezoe	.1000	.20251	.623	.5027	.3027
		fallow	1.1567(*)	.20251	.000	.7540	1.5594
	fallow	phonezoe	1.2567(*)	.20251	.000	1.6594	.8540
		taungya	1.1567(*)	.20251	.000	1.5594	.7540

Appendix II cont.

ANOVA for Total N in West site

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.003(a)	5	.001	3.869	.003
Intercept	.324	1	.324	1912.426	.000
layers	.000	1	.000	.670	.415
methods	.003	2	.001	8.759	.000
layers * methods	.000	2	9.78E-005	.578	.563
Error	.014	84	.000		
Total	.341	90			
Corrected Total	.017	89			

Mean comparison for Total N in West site

	(I) methods	(J) methods	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	phonezoe	taungya	.01170(*)	.003359	.001	.01838	.00502
		fallow	.01260(*)	.003359	.000	.01928	.00592
	taungya	phonezoe	.01170(*)	.003359	.001	.00502	.01838
		fallow	.00090	.003359	.789	.00758	.00578
	fallow	phonezoe	.01260(*)	.003359	.000	.00592	.01928
		taungya	.00090	.003359	.789	.00578	.00758

Appendix II cont.

ANOVA for AvaP in West site

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.37E-005(a)	5	2.75E-006	6.647	.000
Intercept	2.02E-005	1	2.02E-005	48.803	.000
layers	7.00E-007	1	7.00E-007	1.695	.196
methods	1.11E-005	2	5.53E-006	13.385	.000
layers * methods	1.97E-006	2	9.85E-007	2.384	.098
Error	3.47E-005	84	4.13E-007		
Total	6.86E-005	90			
Corrected Total	4.84E-005	89			

Mean comparison for AvaP in West site

	(I) methods	(J) methods	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	phonezoe	taungya	.0006910(*)	.00016597	.000	.0003610	.0010210
		fallow	.0007870(*)	.00016597	.000	.0004570	.0011170
	taungya	phonezoe	.0006910(*)	.00016597	.000	.0010210	.0003610
		fallow	.0000960	.00016597	.565	.0002340	.0004260
	fallow	phonezoe	.0007870(*)	.00016597	.000	.0011170	.0004570
		taungya	-.0000960	.00016597	.565	.0004260	.0002340

Appendix II cont.

ANOVA for AvaK in West site

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.66E-005(a)	5	9.33E-006	56.965	.000
Intercept	.001	1	.001	4766.095	.000
layers	4.99E-006	1	4.99E-006	30.503	.000
methods	3.89E-005	2	1.95E-005	118.876	.000
layers * methods	2.71E-006	2	1.36E-006	8.285	.001
Error	1.38E-005	84	1.64E-007		
Total	.001	90			
Corrected Total	6.04E-005	89			

Mean comparison for Ava K in West site

	(I) methods	(J) methods	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	phonezoe	taungya	.000080	.0001045	.446	.000128	.000288
		fallow	.001353(*)	.0001045	.000	.001561	.001146
	taungya	phonezoe	.000080	.0001045	.446	.000288	.000128
		fallow	.001433(*)	.0001045	.000	.001641	.001226
	fallow	phonezoe	.001353(*)	.0001045	.000	.001146	.001561
		taungya	.001433(*)	.0001045	.000	.001226	.001641

Appendix II cont.

ANOVA for OM in West site

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	25.918(a)	5	5.184	3.275	.009
Intercept	1014.049	1	1014.049	640.703	.000
layers	.602	1	.602	.380	.539
methods	23.816	2	11.908	7.524	.001
layers * methods	1.500	2	.750	.474	.624
Error	132.948	84	1.583		
Total	1172.915	90			
Corrected Total	158.866	89			

Mean comparison for OM in West site

	(I) methods	(J) methods	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
LSD	phonezoe	taungya	1.1250(*)	.32483	.001	1.7710	.4790
		fallow	1.0540(*)	.32483	.002	1.7000	.4080
	taungya	phonezoe	1.1250(*)	.32483	.001	.4790	1.7710
		fallow	.0710	.32483	.828	.5750	.7170
	fallow	phonezoe	1.0540(*)	.32483	.002	.4080	1.7000
		taungya	-.0710	.32483	.828	.7170	.5750

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