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Effect of Different Crops and Crop Farming Practices on Soil Degradation in Nyakach Sub-county, Kenya

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ABSTRACT: Soil has influenced progression of civilization in many regions because it supports food production. Growth in world population has been met by intensification of soil utilization which in turn has caused diverse changes in physical, biological and chemical properties of soil resource. In Nyakach Sub-county in western Kenya intensified agricultural production and soil degradation have proceeded hand-in-hand. This area portrays a mismatch between agricultural production and soil quality. Efforts to curb soil degradation in the area have not yielded the desired results. Therefore this study was purposed to find out the effect of local crops on physical soil degradation; and how local crop farming practices impact soil quality. Data collected from 384 farmers using questionnaire, interviews, observation and measurements were analyzed using descriptive statistics and paired samples t-test. Results showed that crops that registered low physical soil degradation included sunflower (0.107m), cow peas (0.1303m), cassava (0.1313m), bananas (0.0907m), sugarcane (0.0875m) and rice (0.0988m). Crops that caused high physical soil degradation were beans (0.1819m), maize (0.1684m), sorghum (0.152m), sweet potatoes (0.1075m) and vegetables (0.1276m). Intercropping, fallowing and grazing on fallow land generally led to high soil degradation (0.1532m, 0.1443m and 0.1621m respectively).The researchers concluded that different crops and crop farming practices influenced soil degradation in Nyakach Sub-county. It is recommended that bananas, sunflower, cassava, sugarcane, rice and cow peas be given more prominence in Nyakach Sub-county.

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I. INTRODUCTION

Socio-economic development in Kenya like the rest of African countries is greatly dependent on soil productive capacity (Kenya, 2016a). This is because many people depend on soil either directly or indirectly for their livelihood (Ighodaro, Lategan & Mupindu, 2016). For this reason, soilhas influenced civilizations in many regions of the Earth (Parikh & James, 2012). Despite its significance, soil resource base is being threatened by rapid soil degradation (Tully, Sullivan, Weil & Sanchez, 2015).

Soil conservation in Kenya started by the colonial government and later on continued by the independent government through NSWCP and other agencies has been extended by the county government of Kisumu. There are many government agencies and non-governmental organizations working in Nyakach Sub-county to conserve soil. These include Friends of Lake Victoria, Lake Victoria Environment Management Programme, Climate Change, Agriculture and Food Security, CARE Kenya and SCC VI-Agro forestry. Community Based Organizations that focus on soil degradation include Nyadek, Friends of Katuk Odeyo, and Katuk Farmers.

Despite all these efforts soil degradation in Nyakach Sub-county has persisted over the years. Continued soil degradation has led to serious food shortages, malnutrition, high mortality rates, high poverty levels, unprecedented rate of rural-urban migration and increased sediment load in Lake Victoria. Emerging literature point out that some agricultural practices contribute to soil degradation. Therefore, the main question is: to what extent have agricultural practicescontributed to soil degradation in Nyakach Sub-county?

II. STUDY AREA, MATERIALS AND METHODLOGY

The study was conducted in Nyakach Sub-county, Kisumu County in western Kenya between longitudes 34^{o}45'E and 35^{o}00' E and latitudes 0^{o}15'S and 0^{o}30'S. Across-sectional survey design was used to collect data from 384 household heads out of a target population of 27,988 households using questionnaire, interviews, observation and measurements. Vector grids were created using UTM zone of East Africa to provide sampling units. A list of homesteads in each vector grid was prepared and simple random sampling used to select 384 households. Figure 1 shows the study area.

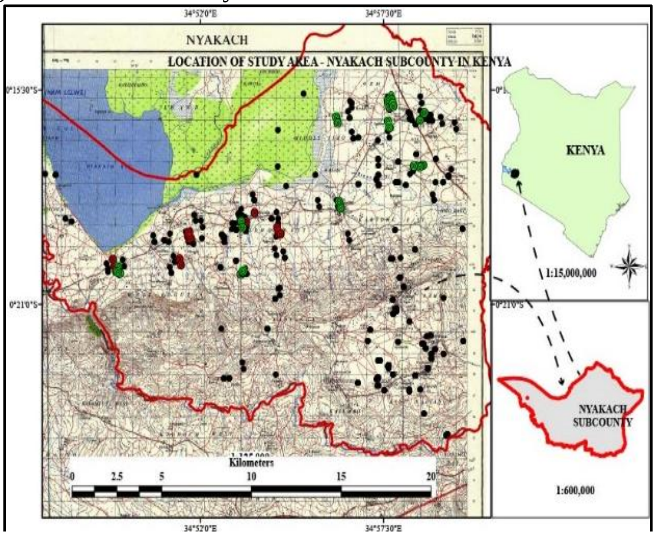

Figure 1: Location of the Study Area – Nyakach Sub-county in Kenya

Source: Modified from Kenya (1982)

III. RESULTS AND DISCUSSIONS

Descriptive statistics and paired samples t-test were used to analyze the data Paired samples t-test was used to assess the significance of the differences in soil degradation levels for households that planted sunflower, cow peas, and cassava against those who did not plant these crops. The results are presented in Table 1.

Table 1: Paired Samples t-test for Soil Degradation Levels of Different Crops (n = 384)

CROP	**PLAIN**		**PLATEAU**		**SCARP**	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**
Sunflower %	3.07	96.03	3.85	96.17	1.56	98.44
Degradation levels	.0440	.2020	.1180	.1380	.1600	.1800
t-value	-2.586		-.943		-.667	
df	4		4		1	
$t_{c\ 0.05}$	2.132		2.132		6.314	
Cow peas %	6.35	93.65	13.85	86.15	-	-
Degradation levels	.1438	.1738	.1167	.1328	-	-
t-value	-.659		-1.132		-	
df	7		17		-	
$t_{c\ 0.05}$	1.895		1.740		-	
Cassava %	10.32	89.68	50	50	19.53	80.47
Degradation levels	.1600	.1723	.0991	.1105	.1348	.1696
t-value	.357		1.327		-2.533	
df	12		64		24	
$t_{c\ 0.05}$	1.782		1.67		1.711	
Main crops	**%**	**Degradation**	**%**	**Degradation**	**%**	**Degradation**
Beans	11.9	.1740	14.61	.1995	14.06	.1722
Bananas	-	-	76.15	.0949	3.91	.0864
Maize	60.32	.1641	54.61	.1987	50.0	.1425
Rice	2.38	.0988	-	-	-	-
Sorghum	8.73	.1518	7.69	.1720	3.91	.1322
Sweet potato	5.56	.1094	9.23	.1120	3.91	.1010
Sugarcane	3.17	.0950	1.54	.0800	-	-
Vegetable	4.76	.1317	7.69	.1280	20.31	.1231

Source: Researcher (2017)

Sunflower was grown in the Plain by 3.07% of farmers who registered 0.044m of soil degradation compared to those who did not (mean = 0.202m; Table 1). It was grown by 3.85% of farmers in the Plateau who in turn registered soil degradation of 0.118m compared with 0.138m for those who did not grow sunflower. Only 1.56% of the households in the Scarp planted sunflower and registered a degradation of 0.16m compared to 0.18m for those who did not grow sunflower.

Households that planted sunflower registered lower soil degradation compared to non-growers. The t-test for differences in degradation level between growers and non-growers of sunflower was significant in the Plain ($t_{(4)} = -2.586 > t_{c\ 0.05} = 2.132$) but insignificant in the Plateau ($t_{(4)} = -.943 < t_{c\ 0.05} = 2.132$) and the Scarp ($t_{(1)} = -.667 < t_{c\ 0.05} = 6.314$). This finding is in agreement with that of Petcu *et al*. (2014) whose study established that sunflower did not have any obvious effect on soil property in south eastern Romania. However, the current study established that the effect of sun flower on soil quality was dependent on physiography.

Rough hairy stem, broad coarsely toothed rough leaves, and circular broad head with many flowers increase the potential of sunflower to intercept rainfall and hence reduce runoff (Ailincai, Jitareanu, Bukur & Ailincai, 2011). Additionally, finely branched and laterally spread surface roots of sunflower bind soil particles together thereby reducing soil loss by erosion. The role of physiography was evident since the relationship was significant only in the Plain. The Plain is made up of clay soil which is preferred by sunflower (Department of Plant Production, 2010).

Only 6.35% of farmers in the Plain planted cow peas and had soil degradation level of 0.1438m compared to 0.1738m for those who did not (Table 1). Only 13.85% of the households in the Plateau planted cow peas and registered degradation level of 0.1167m which was less than 0.1328m recorded by those who did not grow the crop. Generally, those who grew cow peas registered lower soil degradation compared to the non-growers.

The t-test analysis revealed that differences in soil degradation between growers and non-growers of cow peas were not significant in both the Plain ($t_{(7)} = -.659 < t_{c\ 0.05} = 1.895$) and the Plateau ($t_{(17)} = -1.132 < t_{c\ 0.05} = 1.740$). Cow peas was intercropped in the Plain and Plateau hence differences could not be separately determined. Although Lupwayi *et al*. (2012) suggests that the effect of peas on soil is mainly noted in monoculture systems, their opinion is not supported by any empirical evidence.

Only 10.32% of farmers in the Plain planted cassava and registered soil degradation of 0.16m which was less than 0.1723m observed among non-growers of cassava (Table 1). The number of farmers in the Plateau who planted cassava was equal to the number of those who did not. In the Scarp only 19.53% of the farmers planted cassava and registered soil degradation level of 0.1348m compared to 0.1696m observed among farmers who did not.

Differences between growers and non-growers of cassava was significant only in the Scarp ($t_{(24)} = -2.533 > t_{c\ 0.05} = 1.711$). This finding implied that cassava was more effective in soil conservation under steeply sloping land. Although Wayan *et al*. (2001) who did their study in South Sumatra found that planting cassava reduced soil erosion, they did not consider physiographic differences.

Farmers who planted sugarcane registered the lowest degradation in the Plain and Plateau (0.05m and 0.08m respectively). This is in complete contrast to the findings of a study conducted by Dominy *et al*. (2001) in Kwazulu-Natal which identified sugarcane farming as a major cause of soil degradation. This difference arises from the fact that Dominy and his colleagues considered chemical degradation as opposed to physical degradation adopted in this study.

The current study established that the contribution of each crop to soil degradation is a function of the type of soil degradation being considered. For instance a crop that causes physical degradation may not necessarily cause chemical degradation. Sugarcane reduces soil erosion through dense root network and interlocking leaves, although continuous cultivation may deplete soil nutrients (Gravois, LeBlanc, Sheffield & Nix, nd).

While banana farmers recorded relatively low degradation in the Scarp (0.0864m), rice farmers recorded low degradation in the Plain (0.0988m). Banana trees reduce surface runoff and their roots bind soil particles together (Plate 1). Banana trees reduce surface runoff thereby reducing erosivity of flowing water. The large banana leaves intercept a lot of rain drops before they can strike the soil. The only negative impact of banana cultivation on the environment indirectly arises from the agronomic practices such as use of herbicides (Tita, 2006).

Plate 1: Banana Farm at Sigoti Village in the Plateau showing dense soil cover
Source: Researcher (18/6/2018)

Rice cultivators in Nyakach registered fairly low soil degradation levels averaging 0.0988m. Since water in paddy rice cultivation does not flow, its erosivity is greatly reduced. This is corroborated by Salahin et al. (2013) who found low erosion in rice fields of Bangladesh because rice cultivation caused minimal disturbance to the soil. However, chemical degradation may show totally different results.

Soil degradation levels for farmers who employed intercropping, fallowing and those who used fallow land for grazing were compared with those who did not engage in these activities. Analysis was done using paired samples t-test. The results are displayed in Table 2. Table 2 reveals that households who practised intercropping were 34.13% in the Plain, 57.69% in the Plateau and 92.97% in the Scarp. Farmers who practised intercropping in the Plain had a higher soil degradation of 0.1777m compared with 0.1674m for those who did not intercrop. Nutrient depletion due to intercropping made the soil vulnerable to various forms of soil degradation. Intercropping in the Plateau recorded a lower degradation of 0.102m compared with 0.114m for those who did not. Soil stability in the Plain was sustained by the more favourable flat terrain. Those who practised intercropping in the Scarp recorded a higher degradation of 0.18m compared with 0.1567m for those who did not. Nutrient depletion enhanced soil degradation in the steep slopes of the Scarp. The differences in soil degradation were not significant since calculated t values were less than critical t values at 0.05 significance level (Table 2). Physiographic determinism came into play to influence these relationships.

Table 2: T-test for Soil Degradation Levels of Different Crop Farming Practices (n = 384)

CROP FARMING PRACTICE	**PLAIN**		**PLATEAU**		**SCARP**	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**
Intercropping %	34.13	65.87	57.69	42.31	92.97	7.03
Degradation	.1777	.1674	.1020	.1140	.1800	.1567
t-value	.362		-1.443		1.083	
df	42		54		8	
$t_{c\ 0.05}$	1.684		1.673		1.860	
Fallowing %	47.62	52.38	23.85	76.15	52.34	47.66
Degradation	.1575	.1575	.1177	.1255	.1577	.1518
t-value	.000		-.645		.583	
df	59		30		60	
$t_{c\ 0.05}$	1.671		1.697		1.671	
Grazing on fallow land %	25.40	22.22	21.54	2.31	51.96	48.03
Degradation	.1861	.1368	.1433	.1567	.1569	.1518
t-value	1.963		1.347		.601	
df	27		2		60	
$t_{c\ 0.05}$	1.703		2.920		1.671	

Source: Researcher (2017)

Farmers had various component crops in their intercrops including grains, legumes and tree crops. Interviews revealed that this was done to spread out risks of crop failure. Different crops had different effects on soil quality due to different foliage densities and mineral requirements. The number of intercropped crops also has an impact on soil quality as each crop extracts specific nutrients from the soil (Regehr, 2014). Lack of significant differences in soil degradation levels for different crop combinations was attributed to variations in soil management practices and component crops in the intercrop (Wayan *et al*., 2001).

Slightly less than half of the farmers in the Plain (47.62%) practiced fallow and registered degradation level of 0.1575m which was similar to those who did not practice fallow (Table 2). This was because of the heavy grazing of fallow and non-fallow plots. Only 23.85% of households in the Plateau practiced fallow and registered degradation level of 0.1177m compared to 0.1255m for those who did not. Livestock density in the Plateau was comparatively low and grazing was controlled thus minimizing overgrazing. Slightly over half (52.34%) of farmers in the Scarp practiced fallow and recorded degradation level of 0.1577m, which was more than 0.1518m registered by those who did not practice fallow. Like the Plain, livestock numbers in the Scarp were high thus leading to overgrazing of fallow land.

The t-test revealed that all the mean differences for fallow were not statistically significant since the calculated t values were less than critical t values (Table 2). Merely leaving land fallow did not have much effect on soil degradation in Nyakach Sub-county. This finding is corroborated by Benjamin, Mikha, Nielsen, Vigil, Calderon and Henry (2007) who found no effect of fallow on key soil properties in Colorado. The effectiveness of fallow in Nyakach Sub-county could have depended on residue cover, vegetation cover, length of fallow, and how the fallow land is used. Erosion was substantially reduced where the fallow comprised standing stalks (Plate 2).

Plate 2: Standing Maize Stalks in a Fallow in Asao Village in the Plain
Source: Researcher (20/8/2017)

Farmers who used fallow land for grazing comprised 25.4% of the households in the Plain and registered a higher soil degradation level of 0.1861m compared to 0.1368m registered by farmers who did not graze livestock on fallow land (Table 2). This was because grazing livestock on fallow land enhanced soil erosion in the Plain.

Households in the Plateau who grazed livestock on fallow land comprised 21.54% and recorded soil degradation of 0.1433m compared with 0.1567m for those who did not (Table 2). Grazing livestock on fallow land in the Plateau reduced soil degradation, but not significantly. This was because livestock density was low in the Plateau. Livestock grazing in the Plateau was controlled thus eliminating cases of overgrazing. Slightly over half (51.96%) of the households in the Scrap grazed livestock on fallow land and registered soil degradation of 0.1569m as opposed to 0.1518m for farmers who did not (Table 2). Like in the Plain, overgrazing livestock on fallow land raised soil degradation in the Scarp. The influence of livestock grazing played a major role in the relationship between fallow practice and soil degradation.

The difference in soil degradation was significant in the Plain where calculated t value of 1.963 was greater than critical t value of 1.703 (Table 2). However, it was insignificant in both the Plateau ($t = 1.347$) and the Scarp ($t = .601$) where calculated t values were less than critical values (2.92 and 1.671 respectively). These results implied that farmers who did not graze livestock on fallow land recorded lower soil degradation than those who grazed on fallow land. Compaction of soil by livestock movement caused soil degradation.

The finding on grazed fallow land deviates from Nunes (2011) who found that soil loss from grazed plots was about four times lower than that of fallow land in Portugal. It should be noted that Nunes did not compare grazed and non-grazed fallow plots. However, the finding of the current study concords with other studies (USAID, 2012) which record negative effects of livestock grazing and point out that it leads to changes in soil structure as a result of compaction, reduces infiltration and increases erosion. Interviews revealed that standing stalks (Plate 2) reduced the impact of grazing on fallow land. This further complicated the relationship between grazed fallow land and soil degradation in Nyakach Sub-county. These results also implied that physiography influences the relationship between crop farming practices and soil degradation.

IV. CONCLUSION AND RECOMMENDATIONS

Crops that registered low physical soil degradation were sunflower (0.107m), cow peas (0.1303m), cassava (0.1313m), bananas (0.0907m), sugarcane (0.0875m) and rice (0.0988m). High physical soil degradation was caused by beans (0.1819m), maize (0.1684m), sorghum (0.152m), sweet potatoes (0.1075m) and vegetables (0.1276m). Intercropping, fallowing and grazing on fallow land led to high soil degradation (0.1532m, 0.1443m and 0.1621m respectively). Different crops and crop farming practices influenced soil degradation in Nyakach Sub-county. Growing of bananas, sunflower, cassava, sugarcane, rice and cow peas should be encouraged in Nyakach Sub-county.

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