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Effects of farmers' demographic and socio-economic characteristics on soil degradation in different physiographic units of Nyakach Sub-county, Kenya

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ABSTRACT

A number of scholars contend that demographic and socio-economic characteristics influence soil degradation. However, the nature and extent of the relationship varies spatially and temporally. Nyakach Sub-county in Kenya is characterized by high levels of soil erosion, low agricultural production and high poverty. This research aimed at establishing the relationship between soil degradation and: 1) demographic characteristics of the farmers, 2) social characteristics of the farmers, and 3) economic characteristics of the farmers in different physiographic units. Simple random sampling was used to select 388 homesteads out of about 13,300. Questionnaire and field measurements were used to collect primary data. Descriptive and non-parametric inferential statistics were used to determine the effects and associations. Kendall tau-b association test was used to test the associations of soil degradation and farmers' characteristics with physiographic units. Chi square test for independence was conducted to confirm whether farmers' characteristics and soil degradation were independent of the physiographic units. Results show that soil erosion depth had significant association with age, main occupation and income. A number of demographic and socio-economic characteristics of farmers were dependent on physiography. Agricultural policies based on demographic and socio-economic statuses of farmers must take into consideration site specific topographic conditions.

Keywords: Demographic, socio-economic, soil degradation, physiographic units.

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INTRODUCTION

FAO (2015) in its International Year of Soil notes that increasing degree and extent of soil degradation processes are threatening the survival of human race. This statement confirms the situation that is being witnessed in Nyakach Sub-county of Kisumu County in Kenya where severe soil erosion has reduced per capita food availability leading to high poverty levels among the local farming households. The problem of soil degradation highlighted by Sjors (2001) and Mwaura (2010) has placed a limit on the productivity of agriculture and hence high poverty in the sub-county.

Many studies have been conducted globally to establish the relationship between agricultural land use and land degradation (FAO, 2012; Palmer-Felgate et al., 2009; IFPRI, 2007; Pender et al., 2004). Tukur et al. (2004) and Ogunleye et al. (2004) did their studies in Africa and also concluded that there was a positive correlation between the two variables. Matsa and Muringania (2011), Tiffen et al. (1994), and conducted their research in Kenya and confirmed the same.

The relationship between agricultural land use and soil degradation has been extensively studied. What are yet to be explored are the effects of demographic and socio-economic factors on soil degradation and the role of physiographic units on this relationship.

The research provides new information to the farmers on demographic and socio-economic determinants that influence soil degradation in each physiographic unit. To the policy makers the study provides a new paradigm in agricultural planning – physiography-specific agricultural

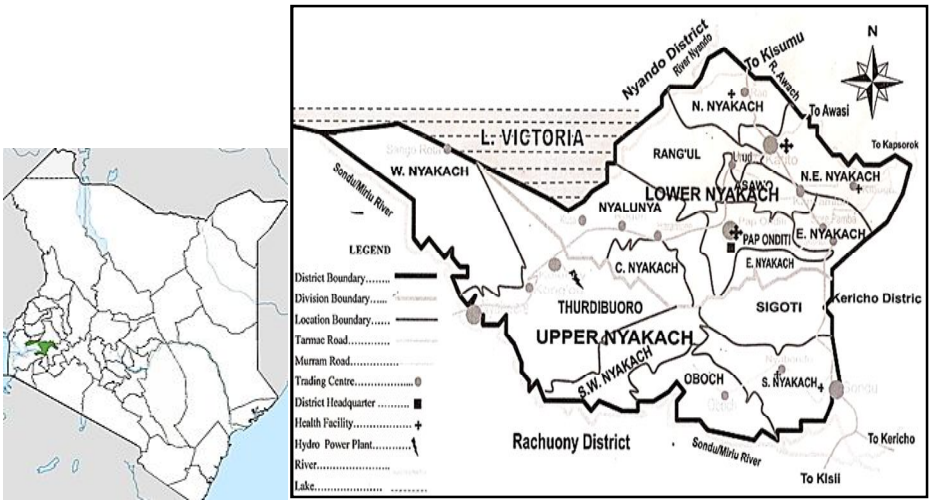

Figure 1. Map of the study area. Source: Nyakach Sub-county Development Office (2014).

planning and investment. To the scholars the study provides new knowledge and opens up a new frontier in the study of land degradation. The study also provides gaps such as physiographic determinants of spatio-temporal changes in agricultural land use. The research therefore purposed to establish the relationship between soil degradation and the demographic, social and economic characteristics of the farmers in different physiographic units.

MATERIALS AND METHODS

Study area

Nyakach Sub-county in Kisumu County, Kenya is located within longitudes 34°45′ E to 35°00′ E and latitudes 0°15′ S to 0° 30′ S (Republic of Kenya, 1982). It falls within the Lake Victoria Lowlands and Floodplains Region (Figure 1). The lowland area (Nyakach Plains) has a flat topography and gently changes to steep slopes in southern areas where it links with the steep Kisii Hills. The tableland of Upper region is called Nyabondo Plateau (Namirembe and Kung'u, 2012).

The sub-county has a population of about 133,041 and an average density of 319 persons per sq. km (KPHC, 2010) with a growth rate of about 3.4% (NDDP, 2009). Absolute poverty is 60.5% (CBS, 2003) with a crude death rate of 44.1 and infant mortality rate of 116, which is 50% higher than the national figure (NDDP, *ibid*). The main economic activity is subsistence agriculture which contributes 52% of the household incomes (NDDP, *ibid*). Unpredictable weather, high absolute poverty, non-performing agriculture, population pressure, and soil degradation are difficult challenges on the livelihood of the residents. Soil erosion is a major land degradation process in most parts of the sub-county.

Research design

The study employed a cross-sectional descriptive research design because it investigates the effects of various demographic and socio-economic factors in different population groups. Probability sampling, pre-planned design for analysis, structured instruments of data collection, and pre-determined operational procedures were used. Homesteads were used as the unit of analysis.

Study population and sampling design

A total sample size of 388 homesteads out of about 13,300 were selected using the formula given by Cochran (1963) as: $n = \frac{Z^2pq}{e^2}$; where n is the sample size, Z^2 is the abscissa of the normal curve that cuts off an area $\propto$ at the tails (1 - $\propto$ equals the desired confidence level), e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population, and q is 1 – p. Z is obtained from statistical tables which contain the area under the normal curve. To use the Cochran formula, a precision level of ±5 with a confidence level of 95%, and probability value of 0.5 were chosen. Probability sampling design based on the concept of random selection was adopted. Simple random sampling was used when choosing 97 samples from within each the Plateau, Scarp Slopes, Plains, and Valley Bottoms.

Data collection methods

Primary data was obtained using questionnaire, oral interviews, field observations and field measurement. Secondary data was sourced from agro-ecological zone maps, topographic map of the sub-county, and sub-county development office. Erosion depth (in metres) of three randomly selected cross-sections of the erosional features was measured for each homestead. Depth was determined from the deepest point to the level surface as shown in Figure 2. The average value for each homestead was computed and recorded.

Data analysis and results presentation

Data analysis began by coding the questionnaire responses. MS Excel was used to perform queries, filter, create different groups, and do simple calculate the mean. The data was inspected by obtaining frequency tables. Descriptive statistics was used to compute frequencies and percentages. Kendal tau-b association test and Chi square test of independence were used to determine

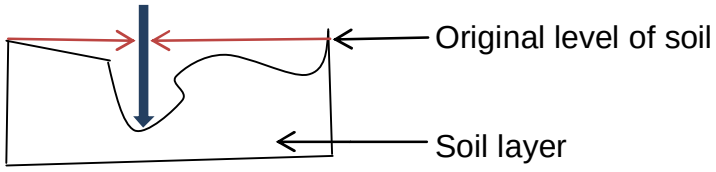

Figure 2. Measuring erosion depths.

the association between soil degradation and various demographic and socio-economic variables, and the influence of physiography. The results were presented using tables, pie charts and line graphs.

RESULTS AND DISCUSSIONS

Demographic characteristics and soil degradation in different physiographic units

Three demographic characteristics evaluated were sex and age of the household head, and the number of dependents in each household. All these characteristics were categorized into different variables. The results obtained are summarized in form of frequencies and percentages in Table 1.

Table 1 reveals that there were more male household heads (55.2%) than females (44.8%). This agrees with African Population and Health Research Centre (APHRC, 2013) which obtained 59.8 and 40% for males and females respectively in Nyanza. Gender disparity in household headship is due to traditional patriarchal ownership and inheritance patterns of land which dispossess women of the right to own land. About 20.7% of the female household heads interviewed were widows. This implies that most females took control of land only upon the demise of their spouses. Women in many parts of the world lag behind men in land ownership and other resources pertaining to land (Aoyagi et al., 2011; FAO, 2012).

Table 1 also reveals that the number of male-headed households was more than female-headed households in the Plateau, Scarp Slopes and Valley Bottoms. The percentage of male-headed households was higher in the Plateau (60.8%) followed by the Valley Bottoms (58.8%), and finally the Scarp slopes (52.6%). However, the ratio was 47:50 in the Plains. The unique ratio in the Plains was probably due to the fact that males take up full responsibilities in farming only where agriculture is more rewarding.

Male headed households had lower erosion depth (0.487 m) than female headed ones (0.505 m) probably because males had more resources at their disposal compared to females. Males also had more physical strength required to construct erosion control structures. Where both couples are alive and the woman is in charge, the final decision still rests with the man even when he stays in town. The local culture demands the man must be at home before planting begins. Where the widows have assumed full control of land, protracted land litigations have disrupting soil management and conservation.

Table 1 shows that 41.2% of the household heads were in the age-group 51 to 60 while those below 21 years were 0.3%. The percentage increased with increasing age-group except for those above 60 years. Younger people are locked out of household headship because the local culture prohibits them from taking charge of family affairs when their parents are still alive. Younger people may also be held up in education or may be out of the locality in search of employment. Civil servants move closer home to take full charge of farming as they approach retirement age of 60. Farming has remained in the hands of elderly, locking energetic age-groups out of farm management. This finding agrees with a study by Tahir et al. (2012) in West Pakistan in which 77% of the farmers were above 30 years. The dominant age-group (51 to 60 years) constituted 48.5% in the Plateau, 43.3% in the Scarp Slopes, 35% in the Plains, and 38.1% in the Valley Bottoms. Republic of Kenya (2013) confirms the average age of household heads in Nyanza region to be 44.5.

Lowest average erosion depth of 0.457 m was in 51 to 60 and the highest of 0.55 m was in 41 to 50 categories. Category of 51 to 60 bore a lot of family commitments and relied mostly on the farm as the main source of income. Those in formal employment at 51 to 60 were preparing for retirement by investing in farming. Category 41 to 50 had less family commitments and hence concentrated more on building their careers.

According to Table 1, 35.8% of households had 4 to 6 dependents, 22.4% had 7 to 9 dependents, 10.8% had over 9 dependents, 26.8% had 1 to 3 dependents, and 4.1% had no dependents. Households with 4 to 6 dependents constituted 39.2% in Plateau, 30.9% in Scarp Slopes and 50.5% in Valley Bottoms. About 32% of households in the Plains had 7 to 9 dependents. The distribution is shown in Figure 3.

Erosion depth of 0.434 and 0.549 m were recorded by households with 4 to 6 and 7 to 9 dependents, respectively. Having 4 to 6 dependents is high enough to instill hard work in the farm for family sustenance, but low enough to allow some investment on land. When the number of dependents goes beyond six it becomes unbearable and hence soil mining ensues. A large share of income goes into feeding, clothing and educating the

Table 1. Demographics of household heads in Nyakach Sub-county (n = 388).

Characteristics	Physiographic unit									
	Plateau		Scarp Slopes		Plains		Valley Bottoms		Nyakach	
	No.	%	No.	%	No.	%	No.	%	No.	%
Sex										
Male	59	60.8	51	52.6	47	48.5	57	58.8	214	55.2
Female	38	39.2	46	47.4	50	51.5	40	41.2	174	44.8
Age										
<21	0	0	0	0	0	0	1	1.0	1	0.3
21 - 30	4	4.1	5	5.2	5	5.2	8	8.2	22	5.5
31 - 40	9	9.3	14	14.4	18	18.6	17	17.5	58	14.9
41 - 50	24	24.7	27	27.8	25	25.8	24	24.7	100	25.8
51 - 60	47	48.5	42	43.3	34	35.0	37	38.1	160	41.2
>60	13	13.4	9	9.3	15	15.5	10	10.3	47	12.1
No. of dependents										
0	6	6.2	1	1.0	6	6.2	3	3.1	16	4.1
1-3	33	34.0	28	28.9	25	25.8	18	18.6	104	26.8
4-6	38	39.2	30	30.9	22	22.7	49	50.5	139	35.8
7-9	11	11.3	25	25.8	31	32.0	20	20.6	87	22.4
>9	9	9.3	13	13.4	13	13.4	7	7.2	42	10.8

Source: Field Data (2015).

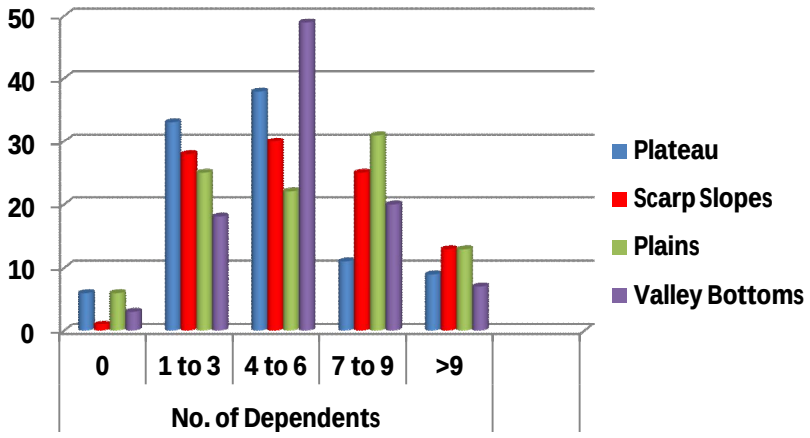

Figure 3. Distribution of number of dependents. Source: Field Data (2015).

children. High dependency ratio is associated with high poverty levels in many rural areas. Poor farmers cannot afford various soil supplements and therefore engage in soil mining.

According to Table 2, only age was significantly associated with erosion depth (r_b = -0.116) and was also dependent on physiography (r_b = -0.118). As the age of the farmer advanced, erosion depth decreased. A farmer gains more soil conservation skills as the age advances. Atnafe et al. (2015) and Adugna (2005) also found a significant relation between age and adoption of conservation methods. A general hypothesis: "Demographic characteristics and soil degradation are independent of the physiographic units" was tested using the Chi square test. The results are given in Table 3.

According to Table 3, the calculated Chi square statistic for number of dependents and erosion depth were 32.698 and 238.929 respectively at 12 degrees of freedom and 99% confidence level. Age and sex were not significantly associated with physiography. Number of dependents is related to poverty level which in turn depends on the agricultural potential of the physiographic unit. It was

Table 2. Kendal tau-b values for the demographics, erosion depth and physiography (n = 388).

Characteristic	Erosion depth		Physiography	
	r_b	sig	r_b	sig
Age	-0.116**	0.006	-0.118**	0.006
Sex	0.002	0.963	0.021	0.648
No. of dependents	0.008	0.854	0.064	0.130

* Correlation is significant at 0.05 level; ** Correlation is significant at 0.01 level. Source: Field Data (2015).

Table 3. Chi square test for independence of demographics and soil degradation (n = 388).

Parameter	X^2	df	Phi	Cramer's V	Sig
Age	7.401	6	.138	.098	.285
Sex	3.793	3	.099	.099	.285
No. of dependents	32.698	12	.250	.177	.001
Erosion depth	238.929	12	.785	.453	.000

Source: Field Data (2015).

therefore concluded that the number of dependents and the depth of soil erosion depends on physiography.

Social characteristics and soil degradation in different physiographic units

Table 4 gives a summary of the social characteristics of Nyakach farmers in different physiographic units.

According to Table 4, 34.3% of the respondents attained primary level of education, 25.3% had secondary level of education and 14.7% had no formal education. Post-secondary, elementary and Kenya Junior levels of education were attained by 13.9, 10.1 and 1.8%, respectively. Household heads with primary level of education dominated in all the four physiographic units. The Plains and Scarp Slopes had highest attainment of secondary level of education (26.8%). The finding on secondary level of education agrees with Nyakundi et al. (2010) who obtained 24.5% completion rate. However, their figures for other levels are substantially different due to area of coverage and difference in time when these two studies were conducted.

Complete lack of formal education confines the fate of a peasant farmer to soil and the struggle to survive. Those with post-secondary education do not take farming as their main occupation although they are best placed to adopt soil conservation measures (Pender et al., 2004). Those with Kenya Junior level of education had low average erosion depth of 0.462 m. Those with elementary education scored the highest average erosion depth of 0.617 m. Education significantly influenced how farmers interacted with land resource. The results showed that those with post-secondary education had average erosion depth of 0.547 m. This group had in the past alienated themselves from the farm by engaging in formal employment in the major cities.

Table 4 also reveals that 72.7% of the household heads were married, 16.8% were widowed, 9% were single and 1.5% was divorced. About 81.4% of the household heads in the Plains, 74.2% in the Scarp Slopes, 62.9% in the Valley Bottoms and 72.2% in the Plateau were married. The number of single household heads was 14.4% in the Plateau, 12.4% in the Valley Bottoms, 6.2% in the Plains and 3.1% in the Scarp Slopes. Marriage, although initially deemed to be a social obligation, has acquired strong economic links.

Agricultural potentiality of a region determines both economic and health progress of individuals. Poverty levels are higher in agriculturally poor regions. This leads to postponement of marriages and high mortality rates hence more cases of widows. In the local community marriage is still a social obligation and even the widowed are expected to re-marry ("inherited" if they are females). Females are expected to marry earlier than males. National Council of Population and Development (Republic of Kenya, 2013) found that in the age-group 15 to 19 about 15.4% of females and 3.2% of males were married. Amao et al. (2013) observe that being married reduces the probability of being poor and may lead to improvement in land quality.

Divorcees had the lowest average erosion depth of 0.395 m compared to the widowed (0.517 m). The divorced had less responsibility and hence could re-invest farm revenue by purchasing farm inputs. The widowed had to support the family and hence lacked capital to invest in agriculture. The widowed females stood the risk of being pushed out their land by the in-

Table 4. Social characteristics of household heads in Nyakach Sub-county (n = 388).

Characteristics	Physiographic unit									
	Plateau		Scarp Slopes		Plains		Valley Bottoms		Nyakach	
	No.	%	No.	%	No.	%	No.	%	No.	%
Level of education										
None	19	19.6	21	21.7	11	11.3	7	7.2	59	14.7
Elementary	10	10.3	7	7.2	10	10.3	14	14.4	39	10.1
Primary	31	32.0	29	29.9	37	38.1	32	33.0	133	34.3
Kenya Junior	1	1.0	3	3.1	1	1.0	2	2.1	7	1.8
Secondary	23	23.7	26	26.8	26	26.8	24	24.7	98	25.3
Post-secondary	13	13.4	11	11.3	12	12.4	18	18.6	54	13.9
Marital status										
Married	70	72.2	72	74.2	79	81.4	61	62.9	282	72.7
Single	14	14.4	3	3.1	6	6.2	12	12.4	35	9.0
Widowed	12	12.4	19	19.6	10	10.3	24	24.7	65	16.8
Divorced/separated	1	1.0	3	3.1	2	2.1	0	0	6	1.5
Years in place										
<10	11	11.3	8	8.2	5	5.2	26	26.8	50	12.9
10-19	13	13.4	12	12.4	22	22.7	31	32.0	78	20.1
20-29	14	14.4	13	13.4	12	12.4	12	12.4	51	13.1
>29	59	60.8	64	66.0	58	59.8	28	28.9	209	53.9
Land acquisition										
Inheritance	84	86.6	83	85.6	87	89.7	56	57.7	310	79.9
Purchase	13	13.4	7	7.2	9	9.3	21	21.6	50	12.9
Donation	0	0	1	1.0	0	0	0	0	1	0.3
Renting/leasing	0	0	0	0	0	0	20	20.6	20	5.2
Others	0	0	6	6.2	1	1.0	0	0	7	1.8

Source: Field Data (2015).

laws and were thus dissuaded from investing on land.

Table 4 also reveals that 53.9% of the household heads had occupied the same farms for over 29 years, 13.1% had occupied their farms for 20 to 29 years, 20.1% had occupied their farms for 10 to 19 years and 12.9% had occupied their farms for less than 10 years. Those who had occupied the land for more than 29 years were the majority in the Plateau (60.8%), the Scarp slopes (66%), and the Plains (59.8%). Those who had occupied their farms for less than 10 years were the minority in the Plateau (11.3%), the Scarp slopes (8.2%) and the Plains (5.2%). Patriarchal land inheritance system meant that most household heads were had stayed in the farms from their childhood. In the Valley Bottoms embracing leasehold had allowed more new entrants into commercial agriculture because entrepreneurs lease land that has the potential for maximum returns.

Those with 20 to 29 years occupancy had the lowest average erosion depth (0.463 m). Through experience, they had a better understanding of the forces at play. This is consistent with the finding of Adugna (2005). Those with less than 10 years occupancy also had a fairly low average erosion depth (0.471 m) because they were motivated to show a difference. Those with 10 to 19 years occupancy had the highest average erosion depth of 0.57 m. They became complacent as time went by. Those with over 29 years occupancy also had relatively low average erosion depth (0.48 m). Four groups were discernible on the basis of years of farm occupancy – 1st group were new entrants eager to prove their mettle; 2nd group were the complacent; 3rd group were those awakened by increasing family obligations; and the 4th were the twilight group with spent energy.

Table 4 shows that 79.9% of the household heads acquired land through inheritance, 12.9% through purchase, 1.8% through inheritance and purchase, and 5.2% through renting or leasing. Those who inherited land but still saw the need to buy more land had realized the significance of land in their livelihood. Those who rented land were mainly driven by profit maximization. Some of those who purchased land could have been land speculators whose main intension was to re-sell to

Table 5. Kendal tau-b values for the association between social characteristics, erosion depth and physiography (n = 388).

Characteristic	Erosion depth		Physiography	
	r_b	sig	r_b	sig
Level of education	0.023	0.578	0.086*	0.040
Marital status	0.045	0.307	-0.061	0.173
Years of farm occupancy	-0.076	0.072	-0.205**	0.000
Land acquisition	0.037	0.405	0.236**	0.000
Years of using the land	-0.058	0.161	-0.268**	0.000

* Correlation is significant at 0.05 level; ** Correlation is significant at 0.01 level. Source: Field Data (2015).

Table 6. Chi square test of social characteristics versus physiography (n = 388).

Parameter	X^2	df	Phi	Cramer's V	Sig
Level of education	18.763	15	.220	.127	.225
Marital status	17.991	6	.215	.152	.006
Years of farm occupancy	45.595	9	.343	.198	.000
Land acquisition	63.282	6	.404	.286	.000
Years of land use	67.671	6	.423	.299	.000

Source: Field Data (2015).

developers.

The proportion of those who acquired land through inheritance varied from one physiographic unit to another – they were 86.6% in the Plateau, 85.6% in the Scarp Slopes, 89.7% in the Plains, and 57.7% in the Valley Bottoms. There were no cases of leasing/renting except in the Valley Bottoms where 20.6% leaseholds were registered. Land acquisition through donation was only found in the Scarp Slopes (1%). Land acquisition through purchase was higher in the Valley Bottoms (21.6%) and the Plateau (13.4%), but was low in the Scarp Slopes (7.2%) and the Plains (9.3%).

More agriculturally productive land attracted more purchasers. Land purchase was thus higher in the Valley Bottoms which have fertile soils due to annual silt deposition. Valley Bottoms lie within proximity to major rivers and hence allow irrigation. Although the Plateau has fertile soils and fairly wet conditions, it did not attract many land purchasers due to high population density (522.3 persons per sq.km - NDDP, 2009) hence very small pieces of land.

Land renters/leasers had the lowest average erosion depth (0.405 m), land purchasers had the highest erosion depth (0.586 m), and land inheritors had erosion depth of 0.489 m. Those who rent land may not put up permanent soil erosion control structures but all the same they do soil amendments such as fertilizer use, green manuring and use of organic manure which in the long run help in reducing soil erosion. The long held belief that those who purchase land use of the resource more intensively than the heirs is not true. They do not always intend to use the land for agricultural purposes. Given that formal employment opportunities have become very scarce, heirs are turning their focus on long term utilization and management of land resource.

Table 5 indicates that all of the social characteristics except marital status were dependent upon physiography but none of them significantly related with erosion depth. This finding is supported by Atnafe et al. (2015) and Adugna (2005). However, Egbetokun et al. (2014) found a significant relation between technical efficiency with marital status and years of occupancy of land. Chi square test results for the independence of social characteristics are given in Table 6.

Table 6 shows that the calculated Chi square statistic was significant for all of the social characteristics except the level of education. This suggests that physiography has a significant influence on social characteristics except the level of education.

Economic characteristics and soil degradation in different physiographic units

Summaries of economic characteristics are given in Table 7a and b.

Table 7a reveals that 71.4% of the household heads chose farming as their main occupation while10.8% chose civil service. The proportion of full-time farmers

Table 7a. Economic characteristics of the household heads in Nyakach Sub-county (n = 388).

Characteristics	Physiographic unit									
	Plateau		Scarp Slopes		Plains		Valley Bottoms		Nyakach	
	No.	%	No.	%	No.	%	No.	%	No.	%
Main occupation										
Farming	73	75.3	71	73.2	57	58.8	76	78.4	271	71.4
Self-employed	8	8.2	1	1.0	3	3.1	0	0	12	3.1
Civil service	6	6.2	4	4.1	18	18.6	14	14.4	42	10.8
Business	10	10.3	21	21.6	18	18.6	7	7.2	56	14.4
Others	0	0.0	0	0.0	1	1.0	0	0.0	1	0.3
Farm size (acres)										
<1	6	6.2	6	6.2	13	13.4	32	33.0	57	14.7
1 - 5	90	92.8	87	89.7	70	72.2	65	67.0	312	80.4
6 - 10	1	1.0	4	4.1	14	14.4	0	0	19	4.9
Income sources										
Farming only	70	72.2	71	73.2	57	58.8	73	75.3	271	69.8
Farming-business	11	11.3	21	21.6	18	18.6	7	7.2	57	14.7
Farming-civil	7	7.2	4	4.1	18	18.6	14	13.4	43	11.1
Others	9	9.3	1	1.0	4	4.1	3	3.1	17	4.4

Conversion rate = KShs 85 per USD. Source: Field Data (2015).

Table 7b. Economic characteristics of the household heads in Nyakach Sub-county (n = 388).

Characteristics	Physiographic unit									
	Plateau		Scarp slopes		Plains		Valley bottoms		Nyakach	
	No.	%	No.	%	No.	%	No.	%	No.	%
Income (USD pm)										
<37.5	33	34.0	82	84.5	22	22.7	30	30.9	166	42.8
37.5 - 118	57	58.8	11	11.3	15	15.5	20	20.6	103	26.5
118.5 - 199	5	5.2	2	2.1	15	15.5	16	16.5	38	9.8
199.5 - 280	2	2.1	2	2.1	33	34.0	12	12.4	49	12.6
280.5 - 361	0	0	0	0	9	9.3	12	12.4	21	5.4
>361	0	0	0	0	3	3.1	7	7.2	11	2.8
Agricultural land use change										
Mixed to agroforestry	15	15.5	2	2.1	37	38.1	0	0	54	13.9
Agroforestry to mixed	12	12.4	32	33.0	0	0	0	0	44	11.4
Pure crop to mixed	4	4.1	7	7.2	2	2.1	3	3.1	16	4.1
Mixed to pure crop	5	5.2	6	6.2	1	1.0	25	25.8	37	9.5
Continuous agroforestry	39	40.2	29	29.9	4	4.1	0	0	72	18.6
Continuous mixed	22	22.7	21	21.6	53	54.6	69	71.1	165	42.5
Distance to market										
<1 km	34	35.1	28	28.9	27	27.8	60	61.9	149	38.4
1 - 3 km	61	62.9	69	71.1	37	38.1	33	34.0	200	51.5
4 - 6 km	2	2.1	0	0	33	34.0	4	4.1	39	10.1

Conversion rate = KShs 85 per USD. Source: Field Data (2015).

was 78.4% in the Valley Bottoms but 58.8% in the Plains. The results suggest that the higher the agricultural potential of the physiographic unit, the greater the number who embrace farming as the main occupation.

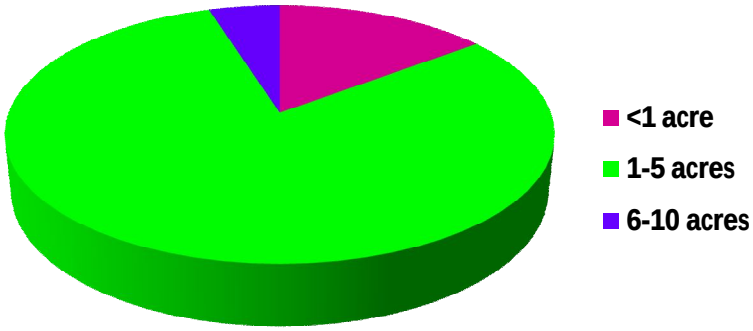

Figure 4. Farm size distribution in Nyakach Sub-county. Source: Field Data (2014).

Full-time farmers dedicate more resources to farming and hence engage in soil conservation.

Decline in farm sizes and falling farm productivity due to soil degradation have driven about 28.1% of household heads into off-farm economic activities. Demissie and Legesse (2013) and Ovwigho (2014) identify gender, education, age, farm size, and the number of economically active members of the household as some of the factors influencing involvement of rural farmers in off-farm activities.

Those whose main occupation was farming had a fairly low average erosion depth (0.455 m). Those who are self-employed recorded 0.345 m because have extra money which they used in purchasing essential farm inputs such as fertilizers. They engaged extra labour in construction of structures for controlling soil erosion and enjoyed the freedom to choose when to remain in their farms. Those who were full-time farmers did not have sufficient money to hire extra labour and purchase farm inputs because local agriculture did not yield good returns. Soil erosion situation was worse in households headed by civil servants (0.728 m) because they committed more time to their work stations. Farming requires close supervision even when hired labour is engaged to do the work.

According to Table 7a 80.4% of farmers owned 1 to 5 acres (0.4 to 2.0 ha) and 14.7% owned less than 1 acre (0.4 ha) of land. Almost 95.1% owned at most 5 acres (2 Ha) which was less than the critical farm size of 5.56 acres (2.25 ha) given by Senga et al. (1980) as the minimum size of farm on which an average family size can just survive. No farmer had more than 10 acres (4 ha) of land, implying that all were small scale farmers.

Spatial variation of farm sizes is indicative of population densities in the different physiographic units. The higher the population density the smaller the farm sizes. Zhou (2011) and COMESA (2010) observe that there has been a general decrease in farm sizes in Africa, Asia, Latin America, and Kenya since the 1950s. Salami et al. (2010) also support the view that land sizes among smallholder farmers in East Africa are usually small. This situation may also be attributed to the prevailing land tenure which requires the sub-division of the farm holding equally among all the sons (Maitima et al., 2009). The disproportionate distribution of farm sizes in the sub-county is shown in Figure 4.

Those who owned 1 to 5 acres had the lowest average erosion depth (0.442 m), those who owned 6 to 10 acres had the highest (0.811 m) and those who owned less than 1 acre had 0.681 m. The results suggest that when the land is very small (less than 1 acre) it tends to be over-exploited resulting in degradation. When it is too big much of it is ignored and hence degradation ensues. Small scale farmers operating under financial constraints require 1 to 5 acres as the optimum size that allows for good care of land resource.

According to Table 7a, 69.8% of the households depended on farming as the only source of income. This figure is just slightly more than the 52% given by NDDP (2009). Other sources of income were farming-business (14.7%), farming-civil service (11.1%), farming-pension (2.3%), farming-remittance (1.5%), and both farming-politics and non-farming (0.3% each).

Farming as the main source of income was 72.2% in the Plateau, 73.2% in the Scarp Slopes, 58.8% in the Plains, and 75.3% in the Valley Bottoms. The second main source of income in the Plateau, Scarp Slopes and Plains was farming-business which constituted 11.3, 21.7 and 18.6%, respectively. Remittances, politics and non-farming played minor roles in all the four physiographic units. Households with reliable sources of income are expected to invest more into farming and hence ensure high soil quality.

Table 7b shows that while 42.8% of the household heads earned less than USD 37.5 (KShs 3187.50) per month, only 2.8% earned over USD 361 per month. As 58.8% of the household heads in the Plateau earned USD 37.5 to 118 per month, 84.5% in the Scarp Slopes earned less than USD 37.5 per month. While 34% of the household heads in the Plains earned USD 199.5 to 280, 30.9% in the Valley Bottoms earned less than USD 37.5 per month. Income increased with increasing agricultural potentiality of the physiographic unit.

About 42.8% of the household heads live below the

Table 8. Kendal values for economic characteristics, erosion depth and physiography (n = 388).

Characteristics	Erosion depth		Physiography	
	r_b	sig	r_b	sig
Main occupation	-0.171**	0.000	0.008	0.851
Farm size	-0.059	0.185	-0.189**	0.000
Income sources	0.066	0.125	0.018	0.687
Income	0.227**	0.000	0.255**	0.000
Agricultural land use change	0.078	0.057	0.229**	0.000
Distance to market	0.056	0.197	-0.078	0.080

* Correlation is significant at 0.05 level; ** Correlation is significant at 0.01 level. Source: Field Data (2015).

poverty line (USD 1.25 per day; USD 37.5 per month). This poverty rate is close to the national rural figure of 49.7% obtained by Kenya (2013) and 43.37% quoted by Kiragu (2013). The high poverty may be a reason for soil degradation since poverty is associated with land degradation (Nkonya et al., 2008). Those with relatively low income had low erosion depths. Those with income USD 37.5 to 118 had the lowest erosion depth (0.367 m) while those with less than USD 37.5 had erosion depth of 0.43 m. Those with the highest erosion depth (0.728 m) were in the range of USD 199.1 to 280. This implies that there is no direct relationship between a farmer's income and investment in farming among small scale farmers. Farmers who live below poverty line spend a larger share of their income in meeting family obligations rather than investing in soil conservation practices. Those with high income do not look at farming as a good investment given the fact that repairing degraded land requires huge capital outlay yet the returns are low and are severely limited by weather vagaries. Such people choose to invest in non-agricultural enterprises.

It is shown in Table 7b that 42.5% of the farmers practised continuous mixed farming, 18.6% practised continuous agroforestry, and 13.9% changed from mixed farming to agroforestry, 11.4% changed from agroforestry to mixed farming, 9.5% from mixed farming to pure crop farming, and 4.1% from pure crop farming to mixed farming. The most prominent land use change that occurred between the 1950s and 2010s in the Plateau was continuous agroforestry (40.2%), in the Scarp Slopes agroforestry to mixed farming (33%), and in the Plains and Valley Bottoms it was continuous mixed farming (54.6 and 71.1%, respectively). Mixed farming is soil-friendly because of the organic remains from the animals (World Bank, 2009).

Farmers who changed from agroforestry to mixed farming had the lowest average erosion depth (0.29 m), mixed farming to agroforestry had the highest average erosion depth (0.595 m), continuous agroforestry gave 0.312 m, and continuous mixed farming had 0.592 m. These results highlight the significance of agricultural land use sequences in understanding the relationship between agricultural land use and soil degradation. Continuous mixed farming does have merits only where livestock numbers do not surpass the carrying capacity. Agroforestry is good in checking soil erosion over a long-term period. Introducing agroforestry in an area that has been overgrazed and hence highly degraded may not serve as a short-term measure to rectify the situation.

Table 7b also shows that while 51.5% of the household heads live within 1 to 3 km from a market, 38.4% live within less than 1km from a market. About 62.9, 71.1, 38.1 and 61.9% of households in the Plateau, Scarp Slopes, Plains and Valley Bottoms respectively lived within 1 to 3 km from a market centre. There was a relatively high erosion depth (0.492 m) observed among households staying less than 1 km to a market centre. Living very close to a market may instill fear concerning farm take-over as the urban expands. Urban sprawl not only consumes the surrounding agricultural land but also sets farmers against petty thefts by the urban poor. Such households are more likely to engage in soil mining than in soil conservation and improvement. Households living 1 to 3 km from market centres had the lowest erosion depth (0.448 m). Households whose farms were not under threat from urban expansion yet were fairly close to a market engaged more in sustainable farming so as to serve the market well. Proximity to a market encouraged investment on land because farm produce could be sold more profitably due to low cost of transportation. Those who lived 4 to 6 km away from a market had the highest erosion depth (0.71 m). This was due to reduced profit margin arising from higher cost of transporting farm produce to the market. There were three zones in terms of distance to a market – zone 1: Agricultural twilight zone, the zone within 1 km radius of a market; zone 2: Maximum agricultural returns zone 1 to 3 km from a market; and zone 3: Marginal agricultural returns zone 4 to 6 km radius away from a market.

Table 8 shows that main occupation and income were significantly related to erosion depth (r_b = -0.171 and 0.227, respectively). Only farm size, income and agricultural land use change were dependent upon physiography. The finding is consistent with that of

Table 9. Chi square test for independence of economic characteristics versus physiography (n = 388).

Parameter	X^2	df	Phi	Cramer's V	Sig
Main occupation	24.288	6	.250	.177	.000
Farm size	37.243	3	.310	.310	.000
Income sources	21.224	6	.234	.165	.002
Income	208.481	15	.733	.423	.000
Agricultural land use change	268.373	15	.832	.480	.000
Distance to market	112.839	6	.539	.381	.000

Source: Field Data (2015).

Table 10. Soil erosion depths between different physiographic units (n = 388).

Erosion depth	Sub-county		Plateau		Scarp Slopes		Plains		Valley Bottoms	
	No.	%	No.	%	No.	%	No.	%	No.	%
<0.20 m	71	18.3	36	37.1	18	18.6	0	0.0	17	17.5
0.20 - 0.39 m	132	34.0	61	62.9	45	46.4	6	6.2	20	20.6
0.40 - 0.59 m	69	17.8			21	21.6	20	20.6	28	28.9
0.60 - 0.79 m	43	11.1			13	13.4	23	23.7	7	7.2
0.80 - 0.99 m	31	8.0					25	25.8	6	6.2
1.00 - 1.19 m	17	4.4					12	12.4	5	5.2
1.20 - 1.39 m	14	3.6					9	9.3	5	5.2
1.40 - 1.59 m	6	1.5					2	2.1	4	4.1
1.60 - 1.79 m	3	0.8							3	3.1
>1.79 m	2	0.5							2	2.1

Adugna (2005). Atnafe et al. (2015) also found no significant correlation between farm size and soil conservation structures. Those with high income invest some money in soil conservation practices (Tiffen et al., 1994).

Table 9 shows that the calculated Chi square statistic was significant in all the economic characteristics. This finding suggests that physiography has a significant influence on the economic characteristics examined.

Various demographic and socio-economic characteristics discussed above and presented in Tables 1, 4, and 7 were examined against soil erosion depth. Table 10 shows the variations in soil erosion depths between the four physiographic units.

Table 10 shows that 34% households recorded erosion depths between 0.2 and 0.39 m. The frequency then progressively decreased with increasing erosion depth as illustrated in Figure 5.

Soil erosion depth was lowest in the Plateau (<0.2 to 0.39 m) but highest in the Plains where 49.6% recorded 0.8 to 1.59 m. The Plateau is relatively level and a lot of effort has been made to curb soil erosion. Contrary to the expectation that the Scarp Slopes should have the severest soil erosion, the erosion depth was <0.2 to 0.79 m. Farmers in the Scarp Slopes had embarked on erosion control measures. Agroforestry practices were spreading from the Plateau to the Scarp Slopes.

CONCLUSION

Male-headed households with the heads aged 51 to 60 and 4 to 6 dependents had relatively low soil erosion depths and hence soil degradation. The relationship between age and soil degradation was negative and statistically significant at 99% confidence level. The number of dependents in the household was dependent upon the physiographic unit.

Divorcees with Kenya Junior level of education who had leased land for 20 to 29 years had relatively low erosion depths and hence soil degradation. A positive relationship existed between erosion depth and level of education, marital status, and mode of land acquisition; a negative relationship occurred between erosion depth and years of farm occupancy years of land use. These relationships were statistically insignificant. Only education level was not dependent upon physiography.

Self-employed household heads owning 1 to 5 acres of land within a distance of 1 to 3 km from a market and earning USD 37.5 to 118 per month, and who had changed from agroforestry to mixed farming recorded relatively low erosion depths and hence soil degradation. The relationships between erosion depth and the main occupation as well as income were statistically significant. All the economic characteristics were dependent upon physiography.

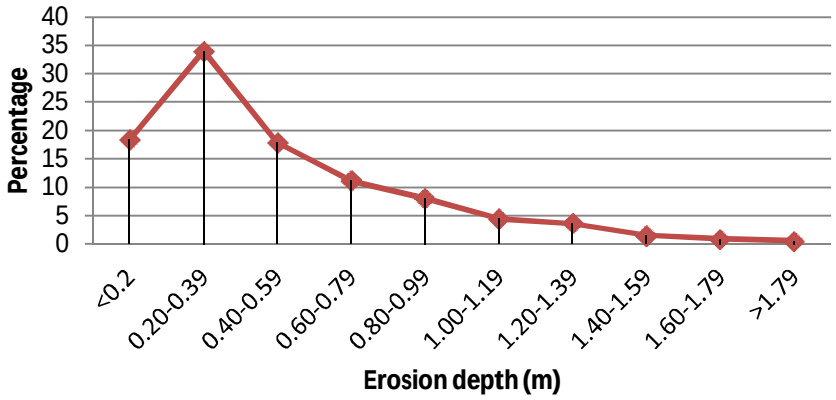

Figure 5. Variations in erosion depth across homesteads in Nyakach Sub-county. Source: Field Data (2015).

RECOMMENDATIONS

Policy actions geared towards minimizing soil degradation in Nyakach Sub-county must focus on the following: 1) Reduce household sizes to an average of five through family planning and delayed marriages; 2) Encourage the highly educated to embrace farming; 3) Encourage leasing of land by those who own over 5 acres; and 4) Reduce the number of household living below poverty line.

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