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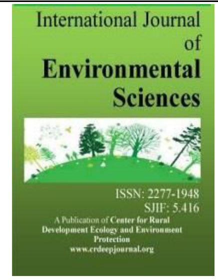

Full Length Research Article

Influence of Farm's Characteristics on Adoption of Eco-Friendly Farming Practices in Agroecosystems of Embu County, Kenya

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ABSTRACT

There is a close association between agriculture and the environment. Agriculture is one of the main economic activities that depends on and influences a number of environmental resources including water, land and biodiversity as well as production technologies and management skills. In the pursuit of feeding the rapidly increasing world population, some widespread agricultural practices have contributed to loss of biodiversity, acidification, soil erosion, unsustainable production and salinization. To simultaneously address these environmental challenges and ensure sustainable production, environmentalists have recommended a paradigm shift. This has led to promotion of Eco-Friendly Farming Practices (EFFPs) among farmers. EFFPs are farming activities that ensure optimum farm production and simultaneously maintain the environmental integrity of the agroecosystems within which they occur. However, despite the effort made in promoting EFFPs among farming households in Kenya, the adoption rates have varied greatly. This study was conducted in the agroecosystems of Embu County in Kenya to evaluate the Eco-Friendly Farming Practices (EFFPs). The purpose of the study was to find out the influence of farm's characteristics on adoption of the EFFPs. Ex post facto research design was used and through a multi-stage random sampling technique, 240 household farms were selected for the study. Soil pH, Farms' slopes, soil moisture and carbon content were determined and their relationship with EFFPs established. Slope of the farm had a statistically significant relationship with adoption of EFFPs. Levels of soil moisture were positively influencing adoption of EFFPs. Therefore the farms' biophysical characteristics need to be evaluated as EFFPs and related technologies are introduced on farms.

Introduction

There exists a close association between environment and agriculture. The green agricultural revolution involved intensified mechanization, intensified use of pesticides and excess inorganic fertilizers, expansion of irrigated land, specialization and breeding of high yielding crops. While the green revolution led to a sudden increase in production, the increase in production was not sustainable. This is because intensification of conventional agriculture has stretched environmental resources to limits thus weakening their natural processes (United Nations Environment Programme [UNEP], 2008). For instance these conventional agricultural practices have been associated with acute soil degradation (Ngetich, *et al.,* 2012), environmental pollution, soil acidification, unsustainable production, biodiversity loss and salinization (Hurni, 2000; Rasul & Thapa, 2004; Roling, 2005).

To address the environmental challenges associated with agriculture and simultaneously provide agroecosystem services, environmentalists have supported a paradigm shift by encouraging adoption of EFFPs. Success stories of EFFPs have been recorded in South Africa, Zimbabwe and Zambia (Yadate, 2007). Despite the environmental benefits associated with EFFPs, their adoption rates in many African countries remain low (Giller, *et al.,* 2009; International Assessment of Agricultural Knowledge, Science and Technology for Development [IAASTD], 2009). In Kenya, very low (0-6%) adoption rates of EFFPs have been reported (Republic of Kenya, 2007; Chomba, 2016). However, despite the low adoption, some households had been reported to have high adoption intensity of EFFPs (Olwande, Sikei & Mathenge, 2009; Suri, 2011). The study therefore sought to examine the influence of farms' characteristics on adoption of EFFPs in Embu County, Kenya. This is because appropriate and effective intervention measures would be better developed after examining the farms' characteristics influencing adoption of EFFPs through which environmental conservation would be realised.

Materials and Methods

The study was carried out in Embu County in Eastern part of Kenya. The choice of a study location was determined by existence of a knowledge gap (Singleton, 1993). In this case, intensive and often inappropriate use of environmental resources for agricultural production had led to environmental challenges in Embu County. The Nyandarua ranges and Mt. Kenya have influenced the soil types and the agroecology of Embu County. The highlands have humic nitosols that are well drained and very deep.

The study was conducted using ex post facto research design to determine the influence of farms' characteristics on adoption of EFFPs. There were 80,138 households in Embu County involved directly or indirectly in farming activities. The sampled farms chosen for the study were selected through a multistage sampling technique. A sample size of 240 household farms was selected for the study. Data was collected from household heads using structured questionnaire, observation schedule and direct field measurements on slope. The collected soil was taken to the laboratory for analysis on the pH, moisture content and carbon content. Data was cleaned and entered into a Statistical Package for Social Sciences (SPSS) version22 for windows. Chi square was used to test for statistically significant relationships. Percentages and Tables have been used to present information.

Results and Discussions

The study examined farms' characteristics including slope, soil pH, soil water content, soil carbon; and their relationship with adoption of Eco-Friendly Farming Practices.

Slope of Farms

A land's incline gives the slope of that farm which in turn may affect the farming practices to be adopted. The slope of the farms was determined by use of a clinometer and two ranging rods. The percentage slope was then obtained. The obtained slopes of the farms were classified into three groups: 0-10% (very flat), 10-20% (gentle slope) and beyond 20% (steep slope). The results obtained are presented in Table 1.

Table 1: Slope of Household Farms (N=402)

Slope	Percent
0-10%	4.7
10-20%	83.6
>20%	11.7
Total	100.0

The study found that majority (83.6%) of the farms had slopes ranging between six to twenty degrees. Very few (4.7%) of the respondents' farms had slopes less than 5%. These farms (with slopes of 5% and below) may not be as prone to agents of soil erosion because the slopes were very gentle. Slightly more than a tenth (11.7%) of the farms had steep slopes exceeding 20% (Table 1). Some farms recorded slopes of 48% especially in the UM1 zone. Farms with slopes exceeding 15% are considered to be prone to agents of soil erosion. Angima, *et al*., (2000) has shown that soil losses increase as the slope angle increases, up to 30%. To establish if a relationship exists between a farm's slope and adoption of EFFPs a chi-square test was conducted and results are presented in Table 2.

Table 2: Relationship between Slopes of Farms and Adoption of Eco-Friendly Farming Practices (N=402)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	404.4[a]	6	0.0001
Likelihood Ratio	272.056	6	0.0001
Linear-by-Linear Association	174.319	1	0.000

From the tests between farm slope and EFFPs adopted, a chi square value 404.4 with a corresponding p value of 0.0001 was realised. Since the p value obtained was less than 0.05, it implies that a statistically significant relationship exists between farm's slope and EFFPs adopted at 5% significance level. In particular, more soil and water conservation structures were adopted to counter the effects of soil erosion associated with steep slopes. A combination of biological and physical soil and water conservation measures were adopted based on the extent of the slope. These included cover cropping, contour tilling, *fanya juu* and *fanya chini* approaches.

Hucket (2010) and Cramb, *et al*., (1999) had found a positive influence of slope on adoption of conservation measures on farms. They observed that adoption of soil and water conservation measures was faster on steep slopes than on more gentle slopes. Therefore, failure to mitigate the effects of soil erosion (by way of soil and water conservation measures) would imply more top soil would be carried away. The eroded soil would find its way into nearby streams and rivers. So serious is the effect of soil erosion that about 200t/ha/year are lost on cultivated land (Angima, 2000) in the central highlands of Kenya. This washing away of top soil and surface run off rich in nutrients (phosphates and nitrates) especially from the farming lands cause eutrophication of water ecosystems within the catchment area. When these excess phosphates and nitrates find their way into aquatic ecosystems, they not cause ecological imbalance but health problems to human beings. Nitrate concentrations in drinking water that exceed 50mg/L reduce haemoglobin by converting it to methemoglobin. This in effect interferes with oxygen supply in the body thereby causing adverse physiological effects (WHO, 2008).

Other effects associated with soil erosion include dam water siltation, bottom water hypoxia and food insecurity (Justic, *et al*., 1995). Therefore a combination of EFFPs (agroforestry, minimum tillage, contour farming, mulching, *fanya juu* and *fanya chini*) addressing soil and water loss from farms must be adopted. Soil and water conservation programmes in Embu County were started by colonial government and emphasized by the Kenyan government. At that time, the office of the local administration would lead soil water conservation programmes even at household level. Therefore the common occurrence of these soil and water conservation practices was as long standing and concerted effort by stakeholders to address the challenge of soil erosion.

Soil pH

Soil pH influences the management practices on land (Tully, *et al*., 2015). The results for the sampled soils are presented in Table 3.

Table 3: Soil pH of Household Farms (N=239)

pH Range	Percent	Maximum	Minimum	Mean	Std. Deviation
< 4.5	22.8	3.30	8.10	5.1556	0.98991
4.5-5.0	40.3				
5.1-5.5	7.47				
5.6-6.0	8.2				
6.1-6.5	7.4				
6.6-7.2	12.6				

More than 60% of the sampled farms had their soils classified as acidic (pH less than 5). About a fifth of the sampled farms had their soil pH near neutral. The minimum soil pH on the farms of the respondents was 3.3 and the maximum soil pH was 7.2. The mean pH for all the farms was 5.2, with a standard deviation of 0.9899 (Table 3). This implies that most of the sampled farms were acidic. Soil pH is influenced by various biochemical and physical processes occurring within a farm. The soil pH in turn affects availability of major elements that subsequently affect the performance of vegetation or crops on that land. Farming lands in Kenya are worst hit by declining cation exchange capacity, low pH and cation imbalance. This low pH is closely linked with aluminum toxicity (Tully, *et al*., 2015). Tully, *et al*., (2015) further states that secondary soil acidification can be caused by continuous use of excess ammonium-based fertilizers, and this can, according to Juo, *et al.,* (1995) be exacerbated by failure to use of organic amendments. Application of basic material like calcium carbonate (agricultural lime) and wood ashes can increase soil pH. Wood ashes, which are locally available, have high amounts of calcium and potassium. Small amounts of phosphate and boron are also found in wood ashes (Njoroge, 1999; Njoroge, 2000). However if one were to use ashes in place of lime, to achieve a similar effect as agricultural lime, one needs to use more wood ash and over a longer period of time.

Since a pH range of 6 to 7.5 is ideal for availability of plant nutrients and ideal for optimal crop growth, very low soil pH limits availability and uptake of most key plant nutrients. Many nutrients become less available with increasing acidity while others become more available (Lucas & Davis, 1961). For example in high acidic soils manganese and aluminum become more available and toxic, whereas phosphorus, magnesium and calcium will become less available to crops. Potassium, nitrogen and phosphorus are the primary macro nutrients required by plants in relatively larger quantities. Sulphur, magnesium and calcium are the secondary macro nutrients required by plants in large amounts, but not as high as macroelements; while manganese and zinc are microelements required by plants in minute quantities (KIOF, 1999). Most crops in the study area do well in near neutral soil pH levels. Therefore the relatively acidic soils Embu County would limit availability of nutrients in such an agroecosystem thereby reducing crop yield and subsequently endangers food security within the area (Lampkin, 1994; KIOF, 1999; Njoroge, 2000).

If there is uncontrolled soil erosion or runoff from agricultural farms, these acidic soils can easily be swept to nearby rivers thereby accelerating water pollution. It is expected that with accurate information on soil pH, households would be motivated to adopt more EFFPs.

The study sought to establish if a significant relationship exists between soil pH and adoption of EFFPs.

Table 4: Relationship between Soil pH and Adoption of Eco-Friendly Farming Practices (N=243)

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	84.060[a]	84	.478
Likelihood Ratio	85.137	84	.445
Linear-by-Linear Association	1.590	1	.207

A p value of 0.478 with a corresponding chi square value of 84.06 was obtained after a chi- square test was run for the relationship between adoption of EFFPs and soil pH. Since the obtained p value is greater than 0.05 at 5% significance level, it implies that no statistically significant relationship exists between adoption of EFFPs and soil pH in Embu County, Kenya.

Table 5: Frequency of Soil Testing by Households (N=402)

Frequency of Testing	Percent
Never	44.5
Only Once	13.7
More than Once	41.8

According to results on Table 5, less than half (41.8%) of the respondents took their soils for testing regularly. About 45% of the respondents had never taken their soils for testing and a further 13.7% had their soils tested only once. This lack of soil testing was also noted by Chomba (2016). High costs involved in soil analysis prohibited households from taking their soils for testing. The soil testing laboratories are few and far apart. Lack of knowledge on the importance of soil testing could also be contributing to low testing among households in Embu County. If only households carried out soil testing often, they would adopt more EFFPs and especially after confirming the low pH of their soils. So, how do these households get to apply soil amendments without a clear diagnosis? Soil fertilization for optimal production is applied after understanding the nutrient status of soils. Majority of households relied on crop performance to predict the state of the soils which may not adequate or it could be misleading altogether. Without accurate soil analysis, the risk of households causing land degradation and eventually water pollution is high. Even with use of strict adoption of EFFPs on farms, their effect to soils and fertility can only be ascertained through soil testing. Accurate and efficient corrective measures can only be added to soils with proper soil analysis. Soil testing therefore should be carried out on all farms irrespective of whether they are under EFFPs or not.

Moisture Content of the Soils

The study determined the moisture content in the sampled farms. The results are presented in Table 6.

Table 6: Moisture Content for Sampled Soils (N=378)

	N	Minimum	Maximum	Mean	Std. Deviation
Moisture content	378	3.60	32.20	10.2071	4.72405
Valid N (listwise)	378				

The minimum soil moisture content on the respondents' farm is 3.60 and the maximum soil moisture content was 32.20 with a mean of 10.21. To test on whether a significant relationship exists between moisture content and adopted EFFP, a chi square test was carried out. The results are presented in Table 7.

Table 7: Relationship between Moisture Content and Mulching

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	234.636[a]	188	.012
Likelihood Ratio	145.637	188	.990
Linear-by-Linear Association	13.696	1	.000
N of Valid Cases	378		

A chi square value of 234.636 with a corresponding p value of 0.012 was obtained on testing the relationship between moisture content and mulching. The obtained p value of 0.012 is less than 0.05 at 5% significance level. This indicated a significant relationship exists between soil moisture content and mulching. This implies that more mulching gave soils more moisture content. Mulching confers more benefits to the soil environment including modification of the hydrothermal regime, improving soil aggregation and reduced soil erosion (Chalker-Scott, 2007; Telkar, Kant & Solanki, 2017). Therefore, farmers who realised that soils were low on soil moisture would adopt more of conservation measures like mulching. In times of reduced rainfall, farms that carry out mulching or have cover crops have their crops withstand the harsh conditions. That is when some immediate neighbouring households appreciate the importance of mulching.

Effect of Composting Level on Soil Carbon

Soil degradation can be monitored through estimates of soil organic matter. The study determined the amount of organic matter in the sampled soils. The amount of organic matter was tested for significant relationship with adoption of composting as an EFFP. The chi square test was conducted and results presented in Table 8. The results on Table 8 show that the chi square value between carbon/organic matter and level of composting was 214.0 with a p value of 0.0001. Since the p value is less than 0.05, there is a significant relationship between carbon/organic matter and adoption of composting as an EFFP. This implies that increase in composting had a significant effect on levels of organic matter content of the sampled soils at 5% significance level. This is quite significant environmentally because higher levels of organic matter content is associated with higher levels of carbon. This implies that in such soils with high organic matter content, more carbon sinks are provided.

In conclusion, no statistically significant relationship was found between soil pH and adoption of EFFPs. Slope of the farm had a statistically significant relationship with adoption of EFFPs. Levels of soil moisture were positively influencing adoption of EFFPs.

Table 8: Relationship between Organic Matter and Adoption of Eco-Friendly Farming Practices

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	214.0[a]	102	0.0001
Likelihood Ratio	119.996	102	0.108
Linear-by-Linear Association	71.820	1	0.000
N of Valid Cases	107		

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