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The Effect of Carbon Sequestration on Farmers' Income:

A Case Study of Kenya Agricultural Carbon Project

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Abstract

Purpose - The purpose of the study was to assess the effect carbon sequestration has on farmers' income. This objective was achieved by comparing how the carbon value, crop and livestock farming influence farmers' income for smallholder farmers working under Kenya Agricultural Carbon Project (KACP) and those of the control group, that is, farmers practicing traditional methods. The study also compared margins from crop farming between the two groups of smallholder farmers to assess their level of agricultural productivity.

Methodology - The study followed a descriptive statistics approach and more specifically a case study research design. Stratified random sampling was used to select thirty one participants for purposes of the study. In addition, the study employed more of quantitative than qualitative research approaches for data collection and analyses; correlation and multi linear regression analyses so as to complement the validity and reliability of the results.

Findings - The results confirmed that indeed carbon sequestration does have an impact on farmers' income. Farmers practicing sustainable agricultural land management practices are able to maximise their output using cost efficient means and are able to fetch higher margins compared to their counterparts using traditional means.

Implications - Governmental agencies need to strengthen their environmental policies to encourage sustainable agricultural practices. This will aid alleviate poverty from increased agricultural productivity, strengthen food security and enable farmers become resilient to climate change. The policies will also enhance capacity building, research and community development in incorporating carbon sequestration projects into the carbon markets. This will create a socio-economic transformation that will create more jobs and scale up the agro-sector.

Value - Carbon sequestration through agro forestry among other sustainable agricultural practices is an untapped potential to realize in part the country's vision 2030; poverty elimination and achievement of 10% forest cover. Farmers are urged to take advantage of climate smart agricultural practices that reduce environmental degradation and conserve resources while boosting income through improved crop yields and profitable systems such as carbon revenue and indirect income from carbon. In the process, farmers become food secure and resilient to climate change. This will in turn create more jobs and scale up the agro-sector which is the main driver of our country's economy.

Key Words: *Carbon Sequestration, Kenya Agricultural Carbon Project (KACP), Farmer's Income*

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Introduction

The phenomenon of greenhouse gases (GHG) emissions has had a severe impact on climate change in the recent past. We now witness more frequent and intense drought, storms, heat waves, rising sea levels and melting glaciers that directly harm animals, tear down infrastructure and homes and directly affects people's livelihoods. Scientists around the world agree that human activities are the main causes of climate change and only human intervention can bring us out of this quagmire (WMO & UNEP, 1990).

In 1997, the United Nations Framework Convention on Climate Change (UNFCCC) convened in Kyoto, Japan to come up with a lasting solution to reduce such emissions to combat the formidable effects of climate change. Developed nations are urged to invest in projects that seek to reduce carbon in developing nations since they often find themselves emitting beyond their stipulated quota. This pioneered the emergence of the carbon market from where green investors earn carbon revenue from carbon credit trading. Carbon credits represent units of carbon emissions reduced at source or units of carbon sunk underground by trees and other plantations from the atmosphere that can be traded in the carbon markets (UNFCCC, 2002).

According to Rohit and Swallow (2006), Africa's participation in carbon projects including carbon sequestration is marginalised yet these projects have the potential to uplift investments and alleviate poverty**.** Closer home, the Kenya Agricultural Carbon Project (KACP) aims to improve farmers' livelihood from increased crop production, increased income from carbon revenue and resilience to climate change through climate smart agricultural practices that sequester carbon.

Carbon Sequestration

Carbon sequestration refers to the process of transferring carbon from the atmosphere and depositing it in pools such as vegetation and soil pools for long term storage (UNFCCC, 2007). Member states of the UN adopted the Kyoto Protocol in 2005 with a binding aim for developed countries to reduce their carbon footprint to levels below their 1990 levels by 2008-2012 (UNEP, 2011). Carbon sequestration is one of the viable means through which the Kyoto Protocol allows member states to mitigate global warming (UNFCCC, 2002). The targets set out for the developed countries can be achieved through carbon sequestration projects which cost lower in tropical countries as compared to the developed nations based on a study by the Inter-Governmental Panel on Climate Change (IPCC). Besides mitigating effects of climate change, carbon sequestration also presents an opportunity through which the participants can generate alternative sources of income in addition to improved crop yield.

Nearly 37% of Africa's carbon sequestration projects are in East Africa. The World Bank remains the largest carbon financier in the continent. Unfortunately, many carbon sequestration projects in Africa are not undertaken for commercial reasons but for research purposes **(**Rohit and Swallow, 2006).

Farmers' Income

Farmers' income is pegged on their agricultural productivity which can be viewed as function of agricultural input and agricultural output. Malthus, an English economist in the 18th Century, argued that population growth would at one time outstrip agricultural production. Farmers would therefore result into intensive cultivation to maximize production from their pieces of land which would lead to land degradation over the years as is the case presently. With the pressures of population growth comes about forest conversions to pave way for more farming practices to increase agricultural production. As more trees are cut down, carbon that was once sunk in the ground become released into the atmosphere and contributes further to climate change. In addition, few improved agricultural practices and technologies were used resulting to diminished agricultural production (de Steiguer, 1995).

Poor smallholder farmers especially in developing countries are worst hit by the effects of climate change. The cost of climate change may present itself in numerous ways including but not limited to capital intensive repair of infrastructure damaged by floods, wild fires, storms and the need to irrigate previously rain-fed areas which directly affects not only the farmers' output but their livelihoods as well (Rohit and Swallow, 2006).

Carbon Sequestration and Farmers' Income

According to Atela (2012), farmers' food security has been an issue to grapple with after years of land dilapidation. Improved sustainable farming practices that sequester carbon also referred to as climate smart agriculture, can increase soil's organic matter, nutrients, biodiversity and water absorption. It is from these practices that farmers are in a position to maximize their productivity and enjoy food security and become resilient to the effects of climate change. Carbon sequestration opens farmers up to the carbon market from where they can earn an extra stream of income after carbon credits are traded.

A carbon credit is tradable and represents a right to emit or offset a ton of carbon. The objective of the carbon credit is to price emissions and incentivize parties to trim down their carbon footprint. Green projects undergo a thorough independent validation and verification process to ascertain the volume of carbon aimed to be offset in order to attain carbon credits. This process also determines the quality of the credits and has a bearing on its price (Rohit and Swallow, 2006: Capoor, 2007).

Carbon Sequestration and Farmers' Income in Kenya

Kenya has been dubbed as the regional economic hub in Eastern Africa yet nearly half of the country's population live below the poverty line in rural areas. The backbone of the country's economy has largely been agriculture. About 80% of Kenya's population lives in rural areas and mainly depend on agriculture for food and income. Smallholder agriculture thus remains a major engine of rural growth and livelihood improvement and a pathway out of poverty. Nonetheless, Kenya becomes food insecure during the perennial drought seasons witnessed in the recent past. It would therefore be prudent to investigate ways to not only make the country resilient to climate change and food secure but also alleviate poverty amongst the smallholder farmers.

KACP is Africa's inaugural project on Agricultural Carbon Finance having being commissioned in 2008 with backing from The World Bank. The World Bank, Government of Kenya and the Swedish based NGO, VI Agroforestry, later entered into the Emission Reduction Purchase Agreement (ERPA) in 2010 to purchase the first 150,000 tons of CO_2 equivalent emission reduction at US$4 each in support of the KACP. VI Agroforestry has the authorization of SALM implementation working alongside French Development Agency and the Syngenta Foundation. Other proponents include Unique Forestry Land Use Ltd that offer technical support and Sida Vi Planterar who are the project donors. It is through SALM methodology that the 30,000 farmers under KACP can acclimatize themselves to the brunt of climate change and also become more resilient to it. An average smallholder farmer household owns about one hectare of land, most of which, if not all, is under crop farming (Atela, 2012; World Bank, 2014).

KACP is under implementation in three counties which contribute significantly to the country's national poverty index. These are Kisumu, Siaya and Bungoma. According to the 'Socio-Economic Atlas of Kenya' — which is based on the 2009 Kenya Population and Housing Census data – Bungoma is among the top five counties that contribute highly to national poverty. Vi Agroforestry is among the donor funded agencies and NGOs with the aim of alleviating poverty and simultaneously conserving the environment (Atela, 2012; Kiteme et al, 2016).

The project has so far verified approximately 184 thousand tons of CO_2 equivalents and paid out proceeds from sale of carbon credits to the farmer groups. The Western Kenya's smallholder farmers are now enjoying the benefits of the carbon credits beyond higher crop yields from the SALM methodology. The carbon revenue received by the farmers is 65% of total carbon revenue from the sale of carbon credits to facilitate part payment of transaction costs associated with the project. Mitigation strategies in agriculture and adaption to climate change have a synergetic relationship between them. An increase in farm yields brings focus to farm enterprise development and accessibility to financing options. Vi Agroforestry endorses rural community savings and loaning to farmers who are unable to access official banking services (Carbon Finance Unit, 2014; World Bank, 2014).

Research Objective

To determine the impact of carbon sequestration on farmers' income.

Methodology

The study followed a descriptive statistics approach and more specifically a case study research design. This is in reference to an empirical foray to establish the particulars of a subject under scrutiny in a real-world setting, in cases where the fringes of phenomena and context overlap, especially where a diverse set of sources of evidence exist. Case study research is an indication of the unravelling of the intimate aspects of a given phenomenon, thereby setting a significant foundation for understanding of the said phenomenon. This fosters the investigation of a select number of phenomena, their context, and the relevant relationships among them (Yin, 2014)

A total of thirty thousand smallholder farmers in Western Kenya are working under KACP. Stratified random sampling was used to select thirty one participants for purposes of the study. Nearly 80% of the population is comprised of women. Men and youth account for the remaining 20% (Atela, 2012). The approach of sampling is intended to avert any likelihood of bias in selection of respondents.

Data Analysis

This section addresses the following aspects: conceptual and analytical models, measurement and parameterization and diagnostic test.

Conceptual Model

A conceptual model can be defined as a composition of variables of interest. Mathematically, the conceptual model can be expressed in the following equation.

$$Y = f(X_1, X_2, X_3) \quad (1)$$

Where

Y is farmer's income

X_1 is the carbon value

X_2 is income crop farming

X_3 is income livestock farming

Analytical Model

The analytical model of choice was the Multiple Linear Regression (MLR) model. It incorporates one or more predictor variables in comparison to the simple regression model.

$$Y = A_0 + B_1X_1 + B_2X_2 + B_3X_3 + e_t \quad (2)$$

Where

Y is farmer's income

A is the intercept

B_1 is the coefficient for the carbon value

B_2 is the coefficient for income from crop farming

B_3 is the coefficient for income from livestock keeping

X_1 is the carbon value

X_2 is the income from crop farming

X3 is the income from livestock

e_t is the residual or the error term

Summary Statistics

Generally, average income for the control group was lower compared to that of the experimental group. The latter groups of farmers have been able to achieve significant improvement in crop yield using the sustainable agricultural practices that seek to sequester carbon. Farmers in the region have, on average, one hectare of land which is predominantly used for crop farming. Both groups of farmers largely depend on crop farming as a source of their livelihood. From table 1 below, majority of the farmers were able to earn more from crop farming than livestock farming. Those who practiced livestock farming were few and produce was mainly for subsistence use with exception of a few farmers. This can be seen from the lower median values compared to the mean values.

High standard deviations noted save for carbon value indicates data is widely spread from the mean. This is an indication that the data is skewed to the right. This could be as a result of unusual values especially from the first data set where higher standard deviations were computed compared to the second data set.

Table 1: Summary Statistics

Summary Statistics For Farmers Working Under KACP			
	Mean	**Standard Deviation**	**Median**
Carbon Value	195.10	47.43	203.92

Crop Farming	208,361	113,195.10	181,263.10
Livestock Farming	51,513.35	70,613.23	18,900
Farmer's Income	403,592.10	295,906	290,570.60
Summary Statistics For Farmers Not For Control Group			
	Mean	**Standard Deviation**	**Median**
Crop Farming	173,166.40	96,513.59	153,970.50
Livestock Farming	45,772.26	55,611.92	11,880
Farmer's Income	300,724.50	214,406.10	239,295.20

Source: This study

Correlation Analysis

Table 2: Results of Correlation Analysis

Correlation Analysis For Farmers Working Under KACP				
	Farmer's Income	**Carbon Value**	**Crop Farming**	**Livestock Farming**
Farmer's Income	1.0000			
Carbon Value	0.2363	1.0000		
Crop Farming	0.7181	0.1824	1.0000	
Livestock Farming	0.7050	0.1724	0.3011	1.0000
Correlation Analysis For Control Group				
	Farmer's Income	**Carbon Value**	**Crop Farming**	**Livestock Farming**
Farmer's Income	1.000	N/A		
Crop Farming	0.7452	N/A	1.0000	
Livestock Farming	0.7377	N/A	0.3446	1.0000

Source: This study

Predictor variables in both data sets had a positive correlation with their respective dependent variables. Unlike carbon value, income from crop and livestock farming exhibited a strong linear relationship with farmer's income in the first data set. Similarly, income from crop and livestock farming were highly correlated to farmer's income in the second data set.

Predictor variables across board exhibited non multi-collinearity. This implies that there is a random linear relationship among the regressors. This is in conformity with one of the assumptions of MLR which requires there be no multi-collinearity among predictor variables.

Results of ANOVA

The R^2 is 0.7803 and the adjusted R^2 is 0.7558 for the farmers working under Vi Agroforestry's KACP which means that the independent variable explains 75.58% of the variability of the dependent variable, farmer's income, in the population. This is also evidenced by a higher sum of squares of the model compared of that of the residual.

We fail to accept the null hypothesis that the regression coefficients are equal to 0 since p-value is less than the significance level of 0.05. A linear regression, therefore established that independent variables could statistically predict farmers income, F (3, 27) = 31.96 where p = 0.0001 and the predictor variables accounted for 75.58% of the explained variability in farmers income.

The R^2 is 0.8178 and the adjusted R^2 is 0.8048 for the control group which means that the independent variable explains 80.48% of the variability of the dependent variable, farmer's income, in the population. This is can observed from a higher sum of squares of the model compared of that of the residual.

We fail to accept the null hypothesis that the regression coefficients are equal to 0 since p-value is less than the significance level of 0.05. A linear regression established that independent variables could statistically predict farmers income, F (2, 28) = 62.83 where p = 0.0001 and the predictor variables accounted for 80.48% of the explained variability in farmers income.

Table 3: Results of ANOVA

ANOVA Results For Farmers Working Under KACP					
Source	**Sum of Squares**	**Degrees of Freedom**	**Mean Square**	**F**	**Prob > F**
Model	2.0496e+12	3	6.8319e+11	31.96	0.0000
Residual	5.7723e+11	27	2.1379e+10		

Total	2.6268e+12	30	8.7560e+10		
ANOVA Results For Control Group					
Source	**Sum of Squares**	**Degrees of Freedom**	**Mean Square**	**F**	**Prob > F**
Model	1.1278e+12	2	5.6390e+11	62.83	0.0000
Residual	2.5129e+11	28	8.9746e+09		
Total	1.3791e+12	30	4.5970e+10		

Source: This study

Just like the farmers working under KACP, residuals from the control group's model could arise from variables not included in the model such as age, gender, size of land, number of members of household actively engaged in farming and level of education.

Estimated or Empirical Model

In the case of the farmers sequestering carbon through SALM, there is a 276.22 increase in farmer's annual income for every unit increase in carbon revenue, holding other variables constant. The coefficient for carbon value (276.22) is not statistically significantly different from 0 using alpha of 0.05 because its p-value is greater than 0.05.

There is a 1.4 increase in farmer's annual income for every unit increase in crop farming, holding other variables constant. The coefficient for crop farming is significantly different from 0 using alpha of 0.05 because its p-value is smaller than 0.05.

There is a 2.2 increase in farmer's annual income for every unit increase in livestock farming, holding other variables constant. The coefficient for crop farming is significantly different from 0 using alpha of 0.05 because its p-value is smaller than 0.05.

The constant is not statistically significantly different from 0 using alpha of 0.05 because its p-value is greater than 0.05

$$\textbf{Predicted Farmer's Income}_1 = \textbf{-64,234.96} + \textbf{276.22*Carbon Value}_1 + \textbf{1.4*Crop Farming}_1 + \textbf{2.2*Livestock Farming}_1 \qquad (3)$$

Table 4: Regression Output

Regression Output For Farmers Working Under KACP				
Farmer's Income	**Coefficient**	**Standard Error**	**t**	**P > | t |**
Carbon Value	276.2238	576.9253	0.48	0.636
Crop Farming	1.437378	0.249733	5.76	0
Livestock Farming	2.228599	0.399603	5.58	0
Constant	-64,235	116,987.9	-0.55	0.587
Regression Output For Control Group				
Farmer's Income	**Coefficient**	**Standard Error**	**t**	**P > | t |**
Crop Farming	1.237624	0.1909	6.48	0
Livestock Farming	2.104201	0.331303	6.35	0
Constant	-9,904.53	35,592.01	-0.28	0.783

Source: This study

In the case of the control group, there is a 1.2 increase in farmer's annual income for every unit increase in crop farming, holding other variables constant. The coefficient for crop farming is significantly different from 0 using alpha of 0.05 because its p-value is smaller than 0.05.

There is a 2.1 increase in farmer's annual income for every unit increase in livestock farming, holding other variables constant. The coefficient for crop farming is significantly different from 0 using alpha of 0.05 because its p-value is smaller than 0.05.

The constant is not statistically significantly different from 0 using alpha of 0.05 because its p-value is greater than 0.05.

$$\textbf{Predicted Farmer's Income}_2 = \textbf{-9,904.53 + 1.2*Crop Farming}_2 + \textbf{2.1*Livestock Farming}_2 \quad (4)$$

Discussion

The Malthusian scarcity theory argues that food supply could not be sustained in the long run since population growth rate would be higher than agricultural production rate (de Steiguer, 1995). Farmers have been practicing intensive farming to maximize output which has brought about environmental dilapidation and shrinking resources when forests are converted into farm lands, thereby emitting carbon into the atmosphere. Climate change which is mainly attributed to human activities has made it compulsory for farmers to adapt from practicing rain fed irrigation due to reduced rainfall and to adopt sustainable agricultural practices in order to improve agricultural production. This has been illustrated clearly by comparing the impact carbon sequestration has on farmers income between the two groups of farmers. Farmers working under KACP are able to improve their livelihood by increasing their crop yield using cost efficient means that sequester carbon.

Herman Daly's contribution to the steady state theory championed by John Stuart Mill is evidenced by the sustainable development aimed at balancing economic progress and environmental wellbeing through farmers' participation under Vi Agroforestry's KACP. Farmers are taken through capacity buildings to help them nurture sustainable farming practices so that they are food secure and resilient to the effects climate change. In the process, farmers can earn an additional stream of carbon income when they are rewarded for their environmental service of sequestering carbon. However, as per the findings, carbon revenue is not be statistically significant in predicting their income but the effect can be magnified when carbon revenue from farmers in a certain locale is used to set up community projects that are of much importance; health care facilities, boreholes.

Summary

The study finds that carbon sequestration has a positive impact on farmers' income. Farmers adopting SALM practices to sequester carbon are able to maximize their output using less costly inputs compared to the control group. The KACP farmers had higher incomes on average compared to their counterparts. The predictor variables for both farmer groups had a strong positive correlation with the response variable and were also statistically significant in predicting farmers' income with the exception of carbon value. Furthermore, the models were statistically significant in explaining most of variations. The model for KACP farmers explained 75.58% of the variations in the outcome variable whereas that of the control group explained 80.48%.

Conclusion

Farmers working under the carbon project practice climate smart agriculture which lessens production costs and increase agricultural productivity. There is a synergetic effect of cultivating crops and rearing livestock such as cows. One's output can be used as the other's input. In general, margin from the climate smart farmers is higher than that of farmers using traditional farming practices.

Vi Agroforestry, the project implementers of SALM under KACP have recognized that carbon revenue per farmer is not material is improving the livelihoods of the smallholder farmers. They intend to channel carbon revenue proceeds from the project to set up community projects that magnify the benefits to be enjoyed by the farmers providing environmental services

Recommendations

Fitting policies on climate change are a prerequisite to unlock the enormous potential for pro-poor mitigation in countries south of the Sahara. These policies should be aimed at increasing profitability of practices that are sustainable environmentally. This translates to higher income and increased investment opportunities for small producers and local communities. With aid from the intermediaries and supporters, pro-poor investments, capacity building, research and community development can lend a hand in incorporating carbon sequestration projects of developing nations into the carbon markets. This generates income gains and also achieves advancement in environmental security (Rohit and Swallow, 2006).

The study can be improved further by randomly sampling farmers from different farmer groups from the three counties where KACP is engaged with farmers to obtain a more representative result. This will also help reduce any instance of sampling error.

The models explain 75.58% and 80.48% of the variations in the predicted variables in data set one and two respectively. The unexplained variations could be from off farm income generating activities which can be incorporated in the model to predict farmer's income.

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