Conservation Agriculture Land Productivity on Livelihood Outcomes in ASAL Areas in Kenya

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Abstract

Most economies in sub-Saharan Africa and Kenya are agriculturally based, hence the importance to boost agricultural development for poverty reduction. This can be achieved by promoting conservation agriculture which has been shown to increase productivity while conserving the environment at the same time. The study sought to assess conservation agriculture practices and their impact on livelihood outcomes focusing on Makueni and Machakos Counties. Specifically, the study investigated the effect of land productivity on livelihood outcomes of conservation agriculture farmers in Makueni and Machakos Counties. The study employed cross-sectional survey as a research design. The Cochran formula was used with a 5% level of significance to obtain sample size of 384 respondents. The study relied on stratified random sampling to achieve a high degree of representation from groups with the desired characteristics. Sample size for each stratum was determined proportionately by dividing the population in each stratum by the sample size. Qualitative data was be subjected to content analysis while quantitative data was analyzed using both descriptive and inferential statistics. Findings show that land productivity has a positive influence on livelihood outcomes which include availability of food and catering for education and healthcare. The study concluded that Conservation Agriculture enhances land productivity which ultimately increases crop yield and hence, better livelihood outcomes.

Keywords: Livelihood Outcomes, Conservation Agriculture, Land Productivity, Output Quality, Output Level, Intercropping

Introduction

Background of Study

Several researchers have argued that Conservation Agriculture attempts to restore soil fertility and mitigate against the effects of soil degradation and therefore, increase crop yields (Guto et al., 2011; Govaerts et al., 2009). The conservation agriculture principles of minimum tillage, maintenance of soil cover and crop rotation enable farmers to reduce crop production costs, hence higher returns resulting into more spending on various aspects which promote quality life.

Smallholder farmers in sub-Saharan Africa have practiced conventional farming for several years. This type of farming comprises one or a mixture of activities including harrowing, plowing, and hoeing. These practices are normally associated with soil disturbances leading to erosion and sedimentation of streams and waterways (Mashingaidze and Mudahara, 2006). According to Knowler and Bradshaw (2007), conventional farming compacts soil, depletes soil organic matter and soil nutrients leading to major soil losses of up to 150 tons annually in Africa. Giller et al., (2009) conducted a study on conservation agriculture and smallholder farming in Africa. They found out that conventional norms of farming are still evident in many communities despite farmers acknowledging that conventional farming aggravates depletion of resources.

Conservation agriculture evolved as a response to concerns of sustainability of agriculture globally, has steadily increased worldwide to cover about 8% of the world arable land (124.8 M ha) (FAO, 2012). Conservation Agriculture aims to increase crop yields while reducing production costs (for example labour and inputs), improving and maintaining soil fertility (e.g. plant nutrients, organic matter, micro-organisms and structure), and water holding capacities and preventing soil erosion and land degradation. Conservation Agriculture comprises a package of crop production technologies and practices that can achieve sustainable agriculture and improve livelihoods (that is food security, nutrition and income generation) for vulnerable farming populations. Conservation agriculture can be applied to any crop whether cereal, pulse, fruit or vegetable. The practice is based on three core principles which are minimal tillage or soil disturbance, maintenance of soil cover and crop rotation (Fao, 2018).

Research Objective

The study sought to assess conservation agriculture land productivity on livelihood outcomes of farmers in Makueni and Machakos Counties, Kenya.

Research Hypothesis

$H0_1$: There is no significant effect of conservation agriculture land productivity on livelihood outcomes of farmers in Makueni and Machakos Counties, Kenya.

Literature Review

Michler et al., (2019) conducted a study on Conservation agriculture and climate resilience and considered yields during rainfall shocks. The study reported that yields tend to be more resilient under CA cultivation then under traditional cultivation practices. The study also found out that CA can be effective in mitigating yield loss in environments with increased weather-related risks. Climate change threatens to disrupt normal

rainfall patterns by reducing the duration and frequency of rainfall (prolonged droughts) and also by increasing the intensity of rainfall. The study revealed that in both cases (abnormally low rainfall and abnormally high rainfall) yields tend to be more resilient under CA then under traditional cultivation.

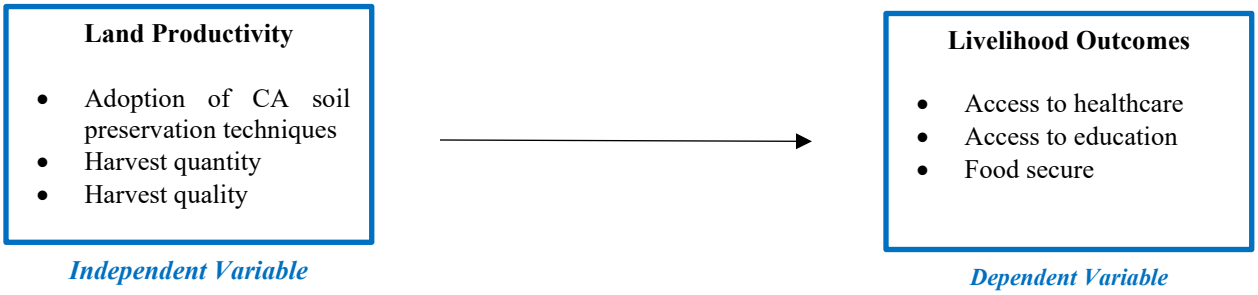
According to Devkota et al., (2022a, 2022b) and Kassam et al., (2019) economic incentives, yield stability, and resilience to varying weather are the fundamental driving forces for the wider adoption of CA. Bahri et al., (2019) conducted a simulation study and reported that conservation agriculture is more effective than conventional practices for boosting wheat yield and water use efficiency under semi-arid and sub-humid conditions in Tunisia. Devkota and Kumar (2022) conducted a study on Conservation agriculture, agronomic, economic, and soil fertility indicators for a clay soil in a rainfed Mediterranean climate in Morocco and observed that the average yield was significantly higher for the CA than the conventional practices by 24%, 38%, 48%, and 32% for wheat, barley, chickpea, and lentil, respectively.

According to Pittelkow et al., (2015) applying all the three conservation agriculture principles (minimum tillage, cover crop and crop rotation) minimizes yield losses in the first two years of implementation. CA is projected to result in a rise in food production while the negative effects of tillage in Africa reduce (FAO, 2012). According to Silici et al., (2011) the embracing of CA by farmers in many African countries has revealed potential to enhance rural livelihoods through sustainable but strengthened production. A long-term study of smallholder farmers embracing CA in Paraguay found significant changes in farmers' livelihoods. Farmers with 7 to 10 years' experience practicing CA were compared with conventional farmers and also with their situation before embracing CA. There was a rise in crop yields after adopting CA and this is due to the rapidly improved soil fertility (Lange, 2005).

Theoretical Framework

The study was guided by Sustainable Livelihood Approach.

Conceptual Framework



Research Methodology

The research design adopted for this study was cross-sectional survey design. The target population for this study was 5091 CA farmers Makueni and Machakos Counties out of which a sample of 384 CA farmers were selected based on the Cochran (1963) formula. Key informants were also selected, and they included 55 group leaders of farmer group. Stratified sampling was employed to identify the CA farmers by dividing the population into strata or homogenous subgroups and then using systematic sampling to select the nth item by dividing the population in each strata by the sample size. Primary data was collected using a face-to face questionnaire survey. Data was analyzed using descriptive and inferential statistics with the help of Statistical Package for Social Sciences.

The study employed descriptive statistics to measure the effects of the land productivity associated with conservation agriculture. This study relied on multi regression analysis to examine the effect of the independent variable on the dependent variable.

Results and Discussion

The questionnaire achieved a response rate of 70.29 % which statistically is considered more than sufficient for data analysis and was thus used for making inferences regarding the effect of land productivity on livelihood outcomes of conservation agriculture farmers in Makueni and Machakos counties. In addition to questionnaire, 34 out 55 targeted leaders of the groups were interviewed.

Land Productivity and Livelihood Outcomes

The second objective sought to examine the effect of land productivity on livelihood outcomes in ASAL areas. Various aspects of land productivity were investigated. These included CA principles being practiced by farmers, the number of seasons cultivated under a CA principle and the crops cultivated. The study started by asking the respondents the number of seasons they had so far planted crops under CA practices and the crops they had planted. Summary statistics are presented in Table 1 below.

Table 1: CA Principles and Crops Cultivated

Variable	Median
Seasons per CA principle	
Minimum tillage	3
Mulching	3
Crop rotation	3
Main crops cultivated under CA	Frequency
Maize	72
Beans	195
Cowpeas	2
Total	**269**
Was the CA crop rotated with another one?	
Yes	173
No	96
Total	**269**
Which crops were rotated with the CA crop?	

Maize	230
Beans	39
Total	**269**

Statistics indicate a median number of three (3) seasons under minimum tillage practice, mulching as well as crop rotation. This implies that on average, farmers in Machakos and Makueni counties have three seasons under CA principles per year. With regard to the main crops cultivated under CA practices, the study reports beans at 72.5%, followed by maize and cowpeas at 26.8% and 0.7% respectively. The study results also indicate that most CA farmers' practice rotational farming with CA crops and that maize is the most widely rotated crop. In addition, farmers were asked to indicate the extent to which they agreed or disagreed with arguments related to land productivity on a scale of 1-5. Descriptive results are presented in Table 2 below.

Table 2: Descriptive Statistics on Land Productivity (N=269)

Variable	**SA**	**A**	**N**	**D**	**SD**	**Mean**	**Std. Deviation**
	%	**%**	**%**	**%**	**%**		
Crop rotation/intercropping has led to application of fewer fertilizers;	63.6	36.4	0.00	0.00	0.00	1.36	0.48
Crop rotation/intercropping has led to improved water retention of the soil;	58.4	41.6	0.00	0.00	0.00	1.42	0.49
Crop rotation/intercropping has led to reduced soil erosion.	60.6	39.4	0.00	0.00	0.00	1.39	0.49
The output levels have remained the same since adopting CA	0.00	0.00	0.00	91.4	8.6	4.09	0.28
The output levels have improved since adopting CA	71.7	28.3	0.00	0.00	0.00	1.28	0.45
I am always assured of output every season since adopting CA	94.4	5.6	0.00	0.00	0.00	1.06	0.23
The output from my farm has been affected by pests since adopting CA	25.7	74.3	0.00	0.00	0.00	1.74	0.44
The output from my farm has been affected by diseases since adopting CA	25.7	74.3	0.00	0.00	0.00	1.74	0.44
The output from my farm has been mature since adopting CA	61.7	38.3	0.00	0.00	0.00	1.38	0.49
Mean: Strongly Agreed=1.00-1.80, Agreed=1.81-2.60, Neither Agree nor Disagree=2.61-3.40, Disagree=3.41.4-20, Strongly Disagree=4.21-5.00							

The mean response indicates that farmers strongly agreed on the arguments regarding land productivity which included intercropping, improved output level and quality. These results mean that the practice of CA enhances soil fertility which ultimately improves the productivity of the farms in terms of output, quantity and quality. Evidence shows that the adoption of CA practices including crop rotation, crop diversification and residue retention improves infiltration and soil moisture conservation (Thierfelder et al., 2017). Differences in crop rotation between CA and conventional agricultural systems also have the potential to impact soil organic carbon (SOC) values. The elimination of monocultures and incorporation of plant species into rotations that return greater amounts of residue to the soil are often associated with greater SOC stock in CA systems (Conceição et al., 2013).

Factor Analysis

The study conducted factor analysis for land productivity. Table 3 below presents results for variance explained which shows that three components were extracted from the process which had a total of 9 statements. The first component accounts for 28. 23 % of the total variance while the second component accounts for 13.24 % of the variance. The third component accounted for 24.56%. Thus, the three extracted components explain 65.67 % of the variance in the observed variables. The remaining variance (34.33) can be explained by omitted or unobserved factors. The 6-9 components were found not significant and hence discarded in the process. Table 3: Variance Explained for Land Productivity

Table 3: Variance Explained for Land Productivity

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.604	28.933	28.933	2.604	28.933	28.933	2.544	28.267	28.267
2	1.206	13.403	42.336	1.206	13.403	42.336	1.191	13.238	41.506
3	1.072	11.908	65.665	1.072	11.608	65.665	1.130	24.551	65.665
4	.028	11.422	65.665						
5	.995	11.061	76.726						
6	.887	9.857	86.583						
7	.551	6.119	92.702						
8	.499	5.549	98.251						
9	.157	1.749	100.000						
Extraction Method: Principal Component Analysis.									

Table 4 below indicated that the first three variables were loaded on the first component associated with intercropping while the next three variables were loaded on the third component which is related to output level. The last three variables were adequately loaded on the second component which is related to quality of the output.

Table 4: Rotated Component Matrix on Land Productivity

Variable	Component		
	Intercropping	Quality of output	Output level
Crop rotation/intercropping has led to application of fewer fertilizers	.804	.051	-.010
Crop rotation/intercropping has led to improved water retention of the soil	.751	.003	.109
Crop rotation/intercropping has led to reduced soil erosion	.949	.017	.039
The output levels have remained the same since adopting CA	.014	.208	.561
The output levels have improved since adopting CA	.142	.230	.861

I am always assured of output every season since adopting CA	.008	.063	.562
The output from my farm has been affected by pests since adopting CA	.013	.782	.028
The output from my farm has been affected by diseases since adopting CA	.111	842	.091
The output from my farm has been good since adopting CA	.182	.963	.170
Extraction Method: Principal Component Analysis.			

Descriptive statistics for extracted components are presented in Table 5 below

Table 5: Descriptive Statistics on Land Productivity Components

Component	**Mean**	**Std. Deviation**	**Cronbach Alpha**
Intercropping	1.40	.401	0.77
Output level	1.12	0.30	0.80
Quality of output	1.5	0.67	0.90

Mean: Strongly Agreed=1.00-1.80, Agreed=1.81-2.60, Neither Agree nor Disagree=2.61-3.40, Disagree=3.41.4-20, Strongly Disagree=4.21-5.00

The mean responses show that the study participants strongly agreed on the argument that intercropping enhances productivity, which is demonstrated by more output. Similarly, study participants strongly agreed to the arguments that CA practices improve both the output levels and quality of the produce. Several studies support these arguments. For instance, Thierfelder et al., (2017) argue that the adoption of CA practices including crop rotation, crop diversification and residue retention improves infiltration and soil moisture conservation. Similarly, Bassi, (2000), Saturnino & Landers (2002) argue that crop rotation or intercropping adds nutrients to the soil which enhances the quality of output harvested.

The same arguments were advanced by farmer group leaders during in-depth interviews. For example, a large majority of the leaders who were interviewed said that the practice of intercropping regenerates nutrients into the soil which improves the fertility of the soil. This in turn leads to more production which could potentially enhance livelihood outcomes. For instance, a leader argued that.

"The act of intercropping is very beneficial in the sense that it reduces the amount of fertilizer." (L004).

Regression on Land Productivity and Livelihood Outcomes

The study regressed livelihood variables on the land productivity variables (intercropping, output level and quality of output) which were constructed from the Likert scales. The estimated results are presented in Table 6 below.

Table 6: Regression Results on the Effect of Land Productivity on Livelihood Outcomes

	Model 1					Model 2				
	B	**Std. Error**	**Beta**	**T**	**Sig.**	**B**	**Std. Error**	**Beta**	**T**	**Sig.**
Independent										
(Constant)	-6.28	.451		-13.92	.000	-6.903	.563		-12.260	.000
Intercropping	1.628	.150	.499	10.86	.000	2.140	.238	.452	8.994	.000
Output level	1.183	.217	.250	5.440	.000	1.181	.200	.297	5.903	.000
Quality of output	.913	.170	.229	5.364	.000	.280	.115	.118	2.425	.016
Dependent	Availability of food					Catering for education and healthcare				
R – squared	0.555					0.326				
Adj. R squared	0.490					0.3101				
Std. Error	.938					.761				
F – ratio (2, 263)	5.031					4.312				
Prob. > F	0.000					0.026				

The probability of the ANOVA test shows that findings are statistically significant given the probability value of less 0.05 in both the models. The R squared statistics indicate that the explanatory variable (land productivity) accounts for 55.5% variation in the CA farmer's availability of food and 32.6% variations in catering for education and healthcare.

Findings show that land productivity has a positive and statistically significant relationship with availability of food among the CA farmers. This means that conservation of agricultural practices like mulching, crop rotation and minimum tillage enhances the fertility of the soil which in turn leads to more production and hence, availability of food and better livelihood outcomes of the farmer's households in general.

Similarly, the study established a positive and statistically significant relationship between land productivity variables such as intercropping, output level, quality of output and catering for education and healthcare. This means that CA practices lead to increased land production. Higher production means more income for the farmers to take care of health care and education needs of the family. The practice of conservation agriculture enhances the quality of the farm produce and ultimately, the quality of livelihood outcomes.

These findings are supported by other previous studies. For instance, Lange (2005) study in Paraguay reported that the majority of farmers came up with new crops and diversified their crop through rotation which resulted in increased farm productivity which once combined with the minimized production costs led to significantly more net income and hence, enhanced livelihood outcome of the farmers. Similarly, previous studies have linked practice of CA with higher output (Dumanski et al., 2006; Mazvimavi et al., 2010; Stewart et al., 2008). There have been positive impacts of CA adoption on maize/crop yield in Zambia (Ng'ombe et al., 2017; Ngoma, 2018), Tanzania (Arslan et al., 2017) and Ethiopia (Jaleta et al., 2016).

An in-depth interview with CA farmer group leaders has revealed that practice of conservation agriculture leads to increase in output levels. This was argued by a vast majority of leaders who were interviewed. In addition, the leaders also argued that CA practices such as mulching, and minimum tillage reduces input

costs which in turn enhances revenues. In addition, the majority of the leaders argued that crop rotation improves output, then revenues and hence, better livelihood outcomes. For example, one leader stated that;

"That rotating crops like legumes for maize increases soil fertility for the next maize planting season. This in turn provides more revenue to the farmer." (L012).

Hypothesis Testing

The study conducted Hypothesis testing based on regression analysis output. Rejection or acceptance of a hypothesis depends on the p-values. In this study, the null hypothesis was rejected when p <0.05, otherwise accepted. Table 7 shows that the null hypotheses was rejected. This means that there is a significant influence of land productivity.

Table 7: Summary of Hypothesis Testing

No	Hypothesis	P value	Verdict
$H0_1$	There is no significant effect of land productivity on livelihood outcomes in ASAL areas in Kenya.	0.000<0.05	Reject

Summary, Conclusion and Recommendation

Summary of the Findings

The productivity of the soil has a direct relationship with crop production. Findings of the study show that CA practices enhance soil fertility which enhances farm production. It has been found that on average, there are three seasons of crop production in the two counties (Makueni and Machakos). In addition, Maize, Beans and Cowpeas are the commonly grown crops under CA practices. The study has also established that most farmers practice rotational farming and maize as the most widely rotated crops. Furthermore, descriptive results have demonstrated that CA practices enhance both quantity and quality of farm produce.

Regression results indicate that all land productivity indicators (intercropping, output level & quality) have a positive influence on the livelihood outcome indicators (catering for education and healthcare). This was demonstrated by positive and statistically significant coefficients for all the variables. This means that practices such as minimum land tillage, mulching, crop rotation as well as intercropping improve soil fertility which in turn leads to more farm produce, income and hence, better livelihood outcomes. Furthermore, the study rejected a null hypothesis that land productivity has no effect on livelihood outcomes in Makueni and Machakos counties. This implies consistency with regression findings.

Conclusion

The study concludes that all land productivity indicators (intercropping, output level & quality) have a positive influence on the livelihood outcome indicators (catering for education and healthcare). This means that practices such as minimum land tillage, mulching, crop rotation as well as intercropping improve soil fertility which in turn leads to more farm produce, income and hence, better livelihood outcomes.

Recommendations

For a long time, agriculture in the country has been associated with poverty, a myth which should be demystified as a matter of agency to attract these youthful people to this lucrative enterprise. This could also resolve the perennial youth unemployment problems. Measures such as provision of cheap credit for farming and equipping the youths with modern farming techniques will be very instrumental in attracting this critical mass into the agricultural sector.

The national government, county governments and various development partners such as NGOs and CBOs need to support farmers to market their produce especially through contract farming. This would encourage most of them to venture into commercial farming as opposed to practicing subsistence farming. Such initiatives could go a long way in improving their livelihood outcomes since they would be in a position to cater for education needs for their children and also healthcare. The extra income earned from sale of produce would enable them to purchase food varieties that they do not grow.

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