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Factors Influencing Adoption of Pigeon Pea and its Impact on Household Food Security in Machakos County, Kenya

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A household survey was carried out in Kalama, Mwala and Yatta Sub-counties of Machakos County Kenya to obtain data on the current situation of pigeon pea value chain. A total of 414 households were interviewed in the month of October 2020. Data was analysed using descriptive statistics, Logit Model to determine factors that influence adoption of pigeon pea (*Cajanus cajan* L) using Statistical Package for Social Scientists (SPSS) version 20 Software. The HFIAS model was used to determine the impact of adoption of Pigeon Pea on household food security. The results of the descriptive statistics showed that there was low adoption of the Pigeon pea technologies and this implies that more needs to be done in creating awareness of the improved Pigeon pea varieties. The Logistic model results showed two factors that significantly influence adoption of

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Pigeon pea varieties by farmers. These were membership to a community group and access to credit. More needs to be done to increase adoption of the new/improved varieties in Machakos County, Kenya.

Keywords: Adoption; HFIAS model; pigeon pea; climate smart crops; impact; food security; Machakos county.

1. INTRODUCTION

Agricultural productivity growth is important in most African countries as agriculture is the backbone of the economies of most African countries. Despite this, many countries experience low productivity growth; and this has mainly been associated with low adoption and low use of improved technologies and innovations by end users. Understanding adoption of agricultural technologies is important if agricultural productivity is to be increased in Africa. In addition, smallholder farmers are vulnerable to climate change which further negatively impacts productivity in Sub-Saharan Africa [1]. Small holder farmers in Sub-Saharan Africa face many constraints that lead to low productivity and which in turn lead to hunger and malnutrition in the rural areas. Researchers in Africa have developed technologies which if adopted and used can lead to increased productivity at the farm level. However, a number of studies have reported low adoption of agricultural technologies in Africa [2].

Agriculture in East and Central Africa is the main source of livelihood for approximately 80% of its population, while contributing 40% of the GDP [3]. Various studies showed that in Kenya, agriculture contributes about 24% of GDP and supports livelihoods for approximately 80% of the small scale farmers in the rural areas. The region has high rainfall variability between and within seasons that lead to large fluctuations in farmers' yields and incomes [4]. Most of the small scale farmers in developing countries rely on rainfall and their agricultural production has highly declined, resulting to enhanced food insecurity and poverty [5, 6, 7]. As climate change effects increase resulting in erratic and unpredictable weather patterns, further decline in crop yields will occur in most tropical and sub-tropical regions [8].

As a result of climate change, rainfall has become more erratic in arid and semi-arid areas, and uncertain in high rainfall areas [9]. Further, studies have shown that there has been significant decrease in crop yields and livestock production [10], attributed to water and heat stress. This is likely to escalate the existing food insecurity, poverty and hence negate realization of development goals [11]. Climate smart agriculture is described by FAO as "agriculture that enhances productivity in a sustainable way, improves resilience, mitigates greenhouse gases, and boosts realization of national food security and development objectives", and involves utilization of farming practices such as adoption of drought tolerant crop varieties. According to FAO [12], climate smart practices are described as "practices adopted in farming systems under climate smart agriculture that enhances sustainable agricultural production while responding to climate change challenges". The main focus in adoption of such practices is to enhance sustainability and agricultural intensification, considered key for ensuring enhanced productivity and food security.

In Kenya, climate variability, coupled with changing climatic patterns has posed various risks that include crops and livestock losses [13]. In addition to this, there are adverse effects of climate change and variability on farming in Kenya affecting crop yields [14,15]. All these factors have disproportionately affected small scale farmers particularly in Kenya, due to the prevailing vulnerabilities. This was affirmed by [16] in a study in Yatta Sub-county in Machakos County on the effects of climate variability and change on food security which showed that there are severe and adverse effects in terms of access, availability and sufficiency of food among small scale farmers. It is also evident that effort towards combating climate change in Kenya remains low, with weak and inadequate policy and legal framework [17]. Despite this weakness, there is significant development towards climate change as is reflected in the development of National Climate Change Response Strategy (NCCRS) and National Climate Change Action Plan [18].

Further, the process of mainstreaming climate change is at its initial stages as recently evidenced by national adaptation meeting for agriculture [19]. Towards addressing issues related to climate change, the Kenya government with World Bank crafted a project "Kenya Climate Smart Project (KCSAP) to combat climate change on small holder farms in Kenya. KCSAP has established a competitive Grants System (CGS) to provide collaborative research grants (CRGs) that support implementation of agricultural research through the National Agricultural Research System (NARS) framework led by Kenya Agricultural and Livestock Research Organization (KALRO). The KCSAP-CGS is designed to achieve efficiency, synergy, and cost effectiveness by applying inter-disciplinary, multi-institutional and holistic collaborative research incorporating the agricultural product value chain approach and the public-private-partnership (PPP) strategy. This project was developed in response to a call made for research proposals under the competitive grants and it is being implemented in three counties: Busia, Machakos and West Pokot. This project was funded by the World Bank in collaboration with the Kenya Government, Project number GA03-1/2.

This paper is based on Objective 1, which was carried out in three Counties: Busia County, Machakos County and West Pokot County. The TIMPs examined in Machakos County were: Green gram, Pigeon Pea and Sorghum. This paper reports the results of Pigeon Pea value chain in the three sub-counties of Machakos County. The objective of the household survey was to determine the current adoption status, social acceptability and economic viability of TIMPs and their impact on household food security in various value chains across selected counties. The paper reports results for Machakos County on adoption of pigeon pea and its impact on household food security.

2. METHODOLOGY

2.1 Study Sites and Site Selection-Machakos County

The study was carried out in Machakos County. Machakos County was purposively selected as it was part of the counties covered in the KCSAP Project. The county has an area of 6208.2 Km^2 most of which is semi-arid. The county has eight Sub counties/ constituencies namely; Masinga, Yatta, Kangundo, Matungulu, Kathiani, Mavoko, Machakos Town/ Kalama and Mwala. The county has a total of 40 Wards and 69 Locations. It lies between latitudes 0º45´South and 1º31´South and longitudes 36º45´East and 37º45´East. Kalama, Mwala, and Yatta Sub-counties were selected for the study (these are shown in Fig. 1). The three sub-counties fall within agro-ecological zones UM2-UM4 and LM2-LM5 [20]. Rainfall is bimodal with short rains from October to December and long rains from March to May. Rainfall varies between 500-750mm per annum. The soils are mainly sandy loam with marrum. The slope of the land ranges from gentle to fairly steep. The major economic activities in the sub-counties include livestock production (dairy, local zebu animals, sheep, goats and indigenous poultry) and crop farming.

2.2 Sampling Frame and Sample Determination

The study used both secondary and primary data. For the purposes of ensuring the integrity of the data collected, focus group discussions and key informant interviews and on site observations were included to triangulate the data collected. A household survey was carried out in Machakos County. Three Sub-counties were selected. The sampling frame consisted all farmers in the three sub-counties; Kalama, Mwala and Yatta sub-counties. The three sub-counties each had two KCSAP Wards where the targeted TIMPs (Technologies, Innovations and Management practices) were disseminated and were being produced in the selected sub-counties. In Kalama there are two KCSAP Wards (Kalama Ward and Kola Ward). Kola Ward had two Locations (Lumbwa and Kola) and Kalama Ward had three Locations (Kimutwa, Kalama and Kyangala). Two Locations were randomly selected, these were: Kimutwa and Kyangala. From Kimutwa location Kyanzasu Sub-location was randomly selected and from Kyangala Location, Kakayuni Sub-location was selected. From these two sub-locations, 6 villages were randomly selected and farming household lists were compiled by Chiefs and Assistant Chiefs. A total sample of 414 households were interviewed.

2.2.1 Sample size determination

A multistage sampling procedure was used to get the sample. First, Machakos County was purposively selected because it was one of the Counties where the Kenya Climate Smart Agriculture Project (KCSAP) and the TIMPS of interest were disseminated. Then three sub-counties were also purposively selected with the help of the county agricultural officers. From each sub-county one ward was selected from which two locations were randomly selected. From each location a sub-location was randomly selected and from each sub-location 6 villages were randomly selected for the survey as shown in Table 1. A formula taking into account the population of the sub-county was applied to get a minimum sample of 384 households but the actual sample was 414 households as shown in Table 1.

2.2.2 Data sources and collection

Both secondary and primary data were used in the study. Data was collected using a structured questionnaire mounted on Open Data Kit (ODK) is a free open source tool that allows data collection using android mobile devices and data submission to an online server at the time of data collection. Data was collected in the months of September, October and November 2020. Data was collected by trained enumerators using smart phones and tablets. The enumerators were supervised by the research team.

2.3 Analytical Methods

Theoretical methods: Data was analysed using Descriptive statistics, Logit model and HFIAS for analysing impact of adoption on household food security.

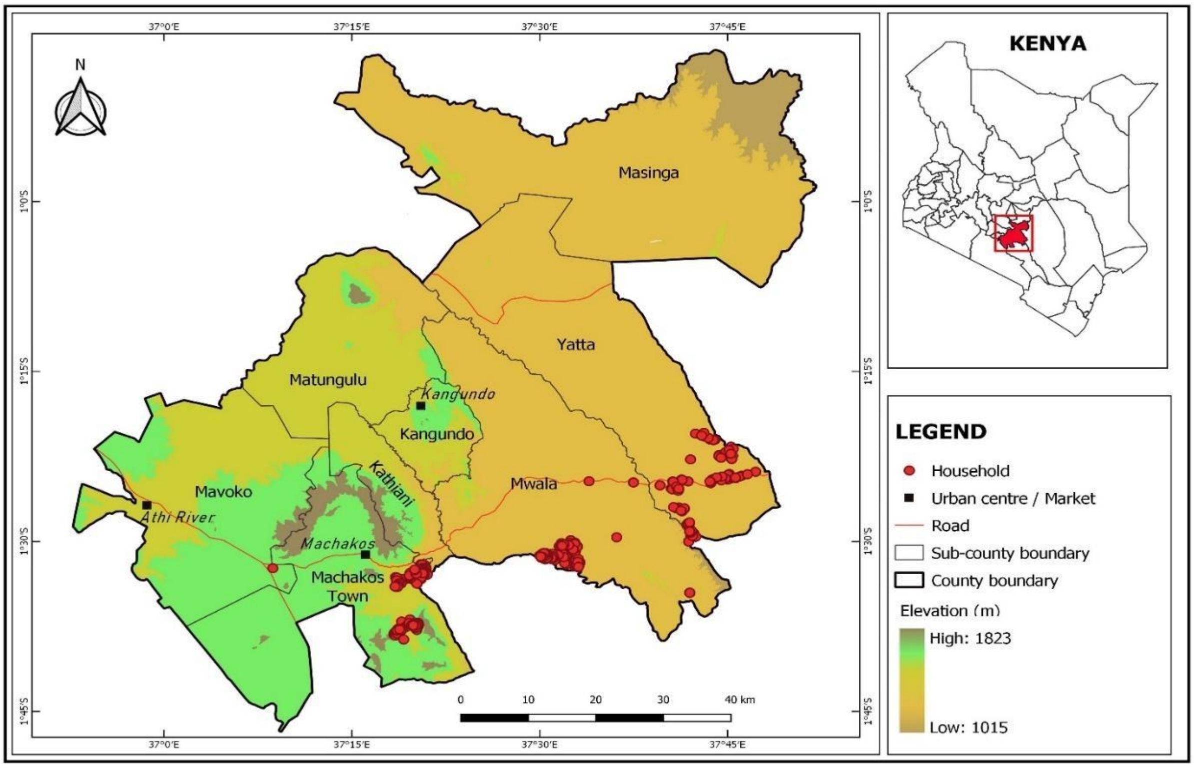

Fig. 1. Map of Machakos county showing the study sites
Source: Survey data. Map prepared by the KALRO Kabete GIS lab

Table 1. Sampled households in Kalama, Mwala and Yatta Sub-counties

Sub-county	Ward	Location	Sub-location	Number of households sampled
Machakos town/Kalama	Kalama	Kyangala	Kakayuni	65
		Kimutwa	Kimutwa	80
Mwala	Muthetheni	Miu	Utithini	63
		Muthetheni	Nthaani	69
Yatta	Katangi	Katangi	Mekilingi	73
		Kyua	Syokisinga	64
Total				414

2.3.1 Descriptive statistics

Descriptive statistics was generated using SPSS version 20. Data was analyzed to generate means and frequencies which gave the description of households in the study sites.

2.3.2 Logistic regression model

The Logistic regression model was used to determine the factors that influence adoption of the selected TIMPS (Green Gram, Pigeon Pea and Sorghum). A number of studies have investigated various socio-economic, cultural and political factors that influence the farmers' decision to adopt new technologies [21]. In this study the Logit model was used to analyze factors that influence farmer's choice to adopt Green Gram, Pigeon Pea and Sorghum technologies in Machakos County in Kenya. This paper is concerned with the adoption of Pigeon pea in the study sites of Machakos County
The Logistic equation is given as in [22],

$$\Pr(Y=1) = e^{\beta' X}/(1+e^{\beta' X}) \quad (1)$$

With the cumulative distribution function given by

$$F(\beta' X) = = 1/(1+e^{(\beta' X)}) \quad (2)$$

Where; β′ represents the vector of parameters associated with X

Definition of variables in the empirical model

The variables in the empirical model were as follows:

Dependent Variable: The dependent variable was a dummy variable which took a value of 1 if a household adopted Pigeon Pea, zero otherwise.

Independent Variables: The independent variables consisted of nine variables: household size (HHSIZE), gender of household head (GHHD), age of the household head (HHAGE), farm size (FARMSIZE), education level of household head HHDEDU) which was indicated by the number of years the household head had spent in school, Household labour (number of people in the household who can do farm work, access to credit (ACRDT), access to markets for the TIMPS (MKTAB), Income of the household (IHH), Distance to market (DMK), Distance to nearest all weather road (DNAR) recorded in Km, HHI which was recorded as total income of the household, Household source of income (a dummy variable representing whether income was from on-farm or off-farm sources). from various sources and Membership of Household head to community groups (MHHCG) a proxy for social capital which was touted as being critical in the adoption of new/improved technologies.

Assuming the probability that farmer will choose to use any of the technologies is equal to the proportion of smallholder farmers using the climate smart technology (Pigeon Peas), the empirical model was estimated using the maximum likelihood method using Stata version 12

2.3.3 Impact assessment model (HFIAS model)

The impact of TIMPs on household food security was determined by the Household Food Insecurity Access Scale (HFIAS). Originally developed to monitor food insecurity in the United States [23], the HFIAS tool has been further refined for developing countries contexts. It was validated in Bangladesh [24] and in Tanzania [25]. HFIAS is relatively easy and less cost-intensive to implement than most other measurement approaches since it captures the household's own perception of food insecurity. This study adopted the HFIAS model to determine the impact of adoption of Pigeon pea on household food security.

3. RESULTS AND DISCUSSION

3.1 Household Characteristics of the Study Sites

The mean land size was variable among the sub-counties. Mean land size in the sampled households was on average approximately 2.86 acres even though there were differences between female and male headed households as well as between sub counties as shown in Table 2. The land put under Pigeon pea production ranged from 0.21 Acres in Kalama with the highest 0.58 Acres across all sub-counties. The land put under Pigeon Pea production was much bigger in female headed households' probably because Pigeon Pea was a food security crop and perhaps women were more concerned to have sufficient food in their own households.

Generally, over 75% of the households in the study sites were male headed but approximately 58% of the respondents were female (Table 2).

The mean of the household head age was 52 years. Most the female headed households derived their income from on-farm activities such as sale of produce among others whereas male headed households earned more income mainly from off-farm activities as shown in Table 2.

3.1.2 Adoption of Pigeon pea and use of improved/New technologies

All the Sub-Counties grow both improved and local varieties of Pigeon pea, with majority of them growing local varieties across the three Sub-Counties as shown in Table 3. Generally, the adoption of new or improved Pigeon Pea varieties was about 6.8-18% in Kalama and Mwala but extremely low in Yatta at about 3.7%. This results were much lower than reported in [26] who reported an adoption rate of 36% in rural Kenya.

3.2 Factors Affecting Adoption of Pigeon pea in Machakos County

The results from the Logit Model for Pigeon pea indicate that all identified variables together contribute to determine the adoption of Pigeon pea technologies as the Model Chi^2 is significant at 1%. Farm Size, gender of the household head, age of the household head, education level of the household head, labour (people in the household who can do farm work), distance to the market, distance of homestead to all weather road, source of income (on-farm or off-farm) and total income of the household were not statistically significant as shown in Table 4. Pigeon pea is taken as food security crop and around 95% of the households grow Pigeon pea mainly for subsistence.

Table 2. Household characteristics in Kalama, Mwala and Yatta in Machakos county

Household Characteristics	Kalama		Mwala		Yatta		All	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Female**	**Male**
Land								
Mean land size (Acres)	2.40	2.05	3.19	2.58	3.81	3.18	2.62	3.10
Mean Size under Pigeon Pea (Acres)	0.21	0.37	0.17	0.23	0.50	1.10	0.58	0.29
Demographics								
Household gender (%)	78.8	21.2	25.0	75.0	74.6	25.4	23.8	76.2
Sample by respondent gender (%)	54.8	45.2	45.2	54.8	29.3	70.7	58.3	41.7
Mean Household age (years)	51.4	57.2	60.5	53.8	50.8	53.2	56.9	52.0
Main Income source								
On-farm	32699	37758	40582	32150	43160	50912	40433	38516
Off-farm	81017	24774	86826	28303	71490	10659	21065	79815
Education level (%)								
None	12.3		18.2		26.9		18.9	
Primary level	47.9		53.8		50.0		50.5	
Secondary level	28.1		23.5		17.2		23.1	
Tertiary level	11.6		4.5		6.0		7.5	
Total	100		100		100		100	

Table 3. Main varieties grown across the sub-counties

Pigeon pea type	Kalama	Mwala	Yatta
	%	**%**	**%**
Local variety	81.5	78.8	89.6
Improved variety	6.8	18.2	3.7
Both local and improved varieties	11.6	3.0	6.7
Total	100.0	100.0	100.0

Source: Survey data 2020

The Household head membership to a community group had a positive influence on the adoption of Pigeon pea technologies and was highly significant at 1% significance level. This result is plausible for Pigeon pea which was grown by most households in the study sites as food security crop and therefore farmers' could learn from each other if they were in community groups.

Access to credit was statistically significant at 5% significance level and positively influenced the adoption of Pigeon pea technologies in Machakos County. A study by [27] showed that access to credit was important and positively influenced adoption of agricultural technologies in Zanzibar. When farmers access credit, they are able to access funds that they can use to assist them to buy inputs and undertake agricultural activities. This will increase agricultural production as well as reduce poverty at the farm level especially if the resources are used on farm activities. This is the case for adoption of new/improved Pigeon Pea varieties in Machakos County.

3.3 Impact of Adoption on Household Food Security-HFIAS Model Results

Households were categorized into quartiles using the food insecurity indices. This resulted into food-secure, mildly food-insecure, moderately food-insecure, and severely food-insecure households. Comparisons were then made based on whether a household had adopted improved production technologies for Pigeon pea value chain or not. The results for Pigeon pea are presented in Fig. 2.

The proportion of food-secure and mildly food-insecure households was higher among improved pigeon pea technologies adopters, while the proportion of severely food-insecure households was higher among the non-adopters as shown in Fig. 2. From Fig. 2 the percentage of severely food insecure was more in the non-adopters at 13.6% compared to adopters' households at 10.1 %. The level of food secure households was slightly higher among the adopters at 46.4% compare to 45.5% among the non-adopters as shown in Fig. 2.

Table 4. Factors that influence the choice of pigeon pea technologies in Machakos county - logit analysis results

Variable	Coefficient	Std error	Z	p>|z|
Farm size (Ha)	0.017	0.0411	0.41	0.682
Gender of household head (male=1, 0 otherwise)	=0.222	0.331	-0.67	0.503
Household head age (number of years)	0.009	0.011	0.82	0.415
Education level (number of years spent in school)	-0.005	0.036	-0.14	0.891
Household labour (number of people in the household who can work on the farm)	0.0107	0.612	0.17	0.862
HH membership to community Group	1.186	0.312	3.71	0.001***
Access to credit	-0.622	0.303	-2.05	0.040**
Distance to market	0.0175	0.016	1.10	0.273
Distance to the nearest all weather road	-0.422	0.039	-1.08	0.280
Main source of income	-0.449	0.304	-1.48	0.140
Total Household income	-1.090	1.150	-0.95	0.344
Constant	-1.699	0.768	-2.21	0.027**
Number of observation = 414				
LR chi^2 (11) = 38.81				
Prob > chi^2 = 0.001***				
Pseudo R^2 = 0.0695				

** 10 % significance level, ** 5% significance level and *** 1% significance level*
Source: Survey results, 2021

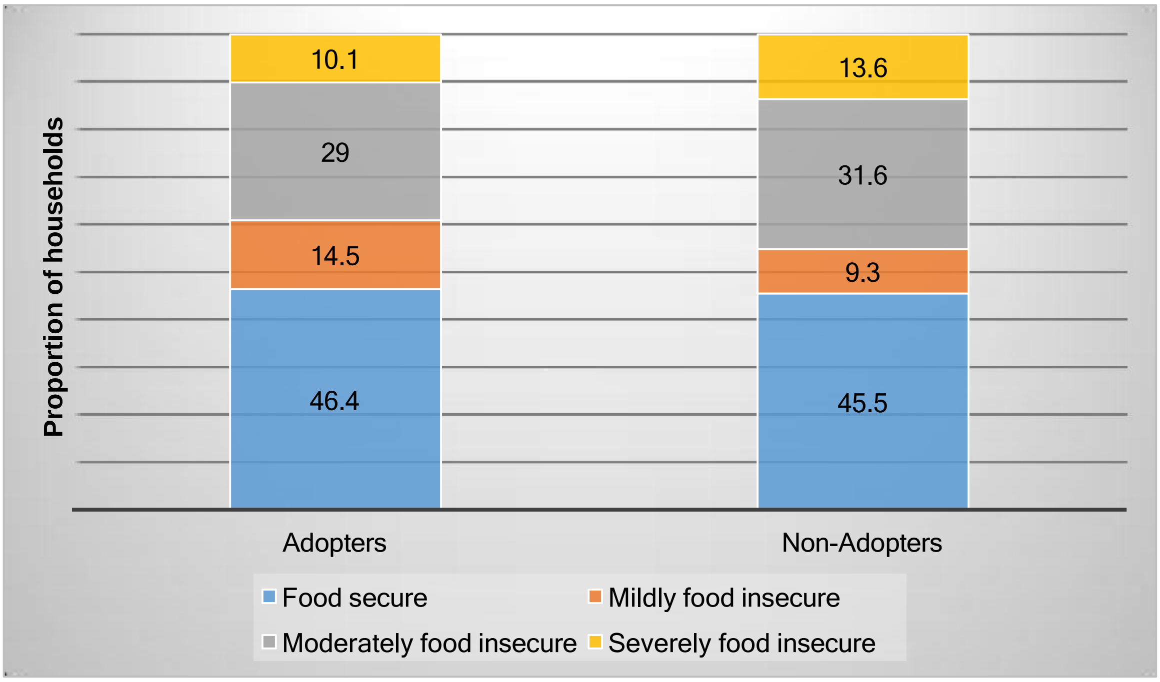

Fig. 2. Proportion of food-insecure households by adopter status for pigeon peas in Machakos County, Kenya

4. CONCLUSIONS AND IMPLICATIONS

The paper used household level data to examine the levels of adoption and factors that influence adoption of Pigeon pea and its impact on household food security in Machakos County. The study aimed at revealing factors that influence adoption of Pigeon pea and how the adoption of Pigeon pea technologies, innovations and management practices impacted on household food security. These results add to the body of knowledge which will help research scientists, policy makers and other stakeholders in the Pigeon pea value chain to take into consideration the revealed factors to improve the adoption between Pigeon pea by smallholder farmers which will result in increased productivity in the Pigeon pea value chain.

Our results from the descriptive statistics indicated that farmers had adopted some of the improved/new Pigeon pea varieties but it varied in different sites. The adoption of new or improved Pigeon Pea varieties was about 6.8-18 % in Machakos County and this was quite low. More efforts need to be put in awareness creation and capacity building farmers on the production Pigeon pea.

The Logit Model results which were efficient in explaining the adoption of pigeon pea technologies by smallholder farmers. These results were further corroborated by results from other developing countries such as Zanzibar, Ghana, Uganda and Tanzania. The study concluded that membership to a community group and access to credit were significant in the adoption of pigeon pea in the study sites. Making credit to be accessible to farmers is necessary to assist farmers if production of Pigeon pea which is a food security crop as well as climate smart crop is to be increased. Therefore, the factors that are significant in the adoption of pigeon pea should be reinforced and more information on the availability of the improved varieties be availed to smallholder farmers in the study area.

The adoption of improved Pigeon pea had a positive impact in reducing household food insecurity as households that had adopted had low cases of severe food insecurity compared to those that had not adopted improved /new pigeon pea varieties.

5. LIMITATIONS OF THE STUDY

The study used cross-sectional data that was collected in 2020 and also the data was specific to Machakos County conditions, therefore caution should be applied if the results of this study are to be applied in other parts of the world which do not have similar agro-ecological and socioeconomic conditions as in Machakos County, Kenya.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. IPCC. The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press; 2012.
2. Odame H, Kimenye L, Kabutha C, Dawit Alemu, Oduori LH. Why the low adoption of agricultural technologies in Eastern and Central Africa? ASARECA (Association for Strengthening Agricultural Research in Eastern and Central Africa), Entebbe; 2013.
3. IFPRI, Resilient Adaptation to Climate Change in African Agriculture. Bonn, Germany: Deutsches Institut fur Entwicklungspolitik/German Development Institute; 2004.
4. Fischer G, Shah M, Tubiello F, Van Velhuizen H. Smallholder Integrated Crop-Livestock Farming Systems: Scoping Study on Climate Smart Agriculture in Kenya. Mitigation of Climate change in Agriculture (MICCA) Programme. Background Report 8. Rome: FAO; 2005.
5. Mendelsohn R, Morrison W, Schlesinger M, Adronova N. Country Specific Market Impacts from Climate Change, Climatic Change. 2000a;45:553-569.
6. Boko MI, Niang A, Nyong Vogel C, Githeko A, Medany M. Principles of Soil Conservation and Management. New York: Springer. Principles of Soil Conservation and Management. New York: Springer; 2007.
7. Mburu B, Muriuki J, Kungu J. Climate Change Adaptation Strategies by Small - Scale Farmers in Yatta District, Kenya. African Journal of Environmental Science and Technology. 2014;9(9):712-722.
8. IPCC. Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press; 2007b.
9. Ogada M, Mwambu G, Muchai D. The Impacts of ENSO in Africa, In Low, P. S. (Ed.) Climate Change and Africa. Cambridge University Press, Cambridge. 2014;218-230.
10. Christensen J, Hewitson B, Busuicoc A, Chen A, Gao X, Held I, et al. Access to Climate Change Information and Support Services by Vulnerable groups in Semi-Arid Kenya for Adaptive Capacity Development. African Crop Sceince Journal. 2007;20(2):169-180.
11. FAO. Assessing the Role of Climate Smart Agriculture in Combating Climate Change, Desertification and Improving Rural Livelihood in Northern Nigeria. African Journal of Agricultural Research. 2010; 9(15):1180-1191.
12. FAO. Climate Smart Agriculture Policies, Practices and Financing for Food Security, Adaptation and Mitigation. United Nations. Rome Italy: Food and Agriculture Organisation; 2013.
13. Thornton PK, Jones PG, Alagarswamy G, Andresen J. Reducing subsistence farmers' vulnerability to climate change: The potential contributions of agroforestry in western Kenya, Occasional Paper 16. Nairobi: World Agroforestry Centre; 2009.
14. Schlenker W, Lobell D. Intergrated Soil Fertility Management in Africa:Principles, Practices and Development process, Nairobi: Tropical Soil Biology and Fertility Institute of the Internaional Centre for Tropical Agriculture; 2010.
15. Mburu K. Effects of Climate variability and Change on Household Food Sufficiency among Small Scale Farmers of Yatta District, Kenya. Journal of Environment. 2013;3(2):19-27.
16. Mburu B, Muriuki J, Kungu J. Climate Change Adaptation Strategies by Small - Scale Farmers in Yatta District, Kenya. African Journal of Environmental Science and Technology. 2014;9(9):712-722.

17. Mutinda S, Mayieko S, Peterson O, Wanyama K. Farmers Access to Climate and Weather Information and its Impact on Maize and Wheat Production in Uasin Gishu County, Kenya. Eldoret: Masters Thesis, University of Eldoret; 2010.
18. MENR. Country Specific Market Impacts from Climate Change. Climatic Change. 2010;45(3-4):553-569.
19. MOALFD. National Climate Change Action Plan Draft. Nairobi: Ministry of Agriculture, Livestock and Fisheries Development; 2014.
20. Jaetzold R, Shemidt H, Hornetz B, Shisanya C. Farm management handbook of Kenya. Vol II-Natural conditions and farm management information. 2nd Edition. Part c East Kenya, sub-part C1 Eastern Province; 2006.
21. Adesina A, Zinnah M. Technology Characteristics, Farmers' Perceptions and Adoption Decisions: A Tobit Model Application in Sierra Leone". Agricultural Economics. 1993;9(4):297-311.
22. Greene WH. Econometric analysis. Fourth edition. Englewood Cliffs, NJ: Prentice Hall; 2000.
23. Wolfe Wendy, Frongillo Edward. Building Household Food Security Measurement Tools From the Ground Up. Food & Nutrition Bulletin. 2001;22.
    DOI: 10.1177/156482650102200102
24. Coates Jennifer, Anne Swindale, Paula Bilinsky. Household Food Insecurity Access Scale (HFIAS) for measurement of Household Food Access: Indicator Guide (v.3). Washington D. C.; 2007.
25. Knueppel Danielle, Demment Montague, Kaiser Lucia. Validation of the Household Food Insecurity Access Scale in rural Tanzania. Public Health Nutrition. 2009;13:360-7.
    DOI: 10.1017/S1368980009991121.
26. Simtowe F, Muange E, Munyua B, Diagne A. Technology Awareness and Adoption: The case of Improved Pigeon pea varieties in Kenya. Selected paperprepared for presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Fozdo Iguacu, Brazil; 2012.
27. Mohamed KS, Andrew E Temu. Access to Credit and its Effect on the Adoption of Agricultural technologies: The Case of Zanzibar African Review of Money Finance and Banking. 2008;45-89. JSTOR.
    Available:www.jstor.org/stable/41410533
    Accessed 12 Mar. 2021.

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