

## Review Article

### **Effectiveness of Extension Services for Food and Nutrition Security through Integrated Crop-Livestock Farming Systems: A Case Study of Smallholder Farmers in Rarieda Sub-County, Kenya**

#### **ABSTRACT**

Integrated Crop-Livestock Farming Systems (ICLFS) are globally recognized for their contributions to improving agricultural sustainability. These systems also play a big role in conservation and Climate-Smart Agriculture (CSA) since they reduce greenhouse gas (GHG) emissions, thus assisting in coping with the effects of climate change. This study aimed at evaluating the effectiveness of extension services in achieving food and nutrition security by farmers practicing integrated crop-livestock farming systems. The data were analysed using both descriptive statistics and inferential statistics. The frequency over which farmers receive their extension services indicated that the majority never received them, followed by farmers who annually received extension service. From the findings, mass media and village meetings were statistically significant in extension delivery modes. The results indicated a strong and positive correlation ~~of~~ between the extension service provision and performance. The standardized regression coefficients revealed that for every unit increase of extension service increases performance and was statistically significant. Therefore, this study recommends a refinement and improvement of extension services to impact ~~on~~ integrated farming system positively.

**Keywords:** *Integrated, sustainability, Climate-Smart Agriculture, extension services, food and nutrition security.*

#### **INTRODUCTION**

The importance of agriculture in the socio-economic development of countries, especially those in Sub-Saharan Africa (SSA), has long been recognized. Agriculture is the dominant contributor to the Gross Domestic Product (GDP) of developing countries and their exports (FAO, 2003; Cervantes-Godoy & Dewbre, 2010). In addition, the bulk of job creation in the rural areas of the majority of countries in sub-Saharan Africa, as is the case with many other developing countries,

**Comment [HJH1]:** Marked in RED through paper: Not reported in ref list??? Must add

**Formatted:** Font color: Red

occurs in the agricultural sector, which is believed to account for generally more than half of the active labour force (FAO, 2003; Cervantes-Godoy & Dewbre, 2010).

Formatted: Font color: Red

Smallholder crop-livestock systems play an important role in sub-Saharan African agriculture because of their real extent, livelihood provision, and impact on ecosystem services (Thornton; Herrero, 2015). In Kenya, the government has promoted several programs to enhance the productivity of small farms where cereals, vegetables, and legumes are grown on the same farm as other enterprises. With regards to the benefits of benefits of integrated farming systems, a previous study by Frederic et al. (2014) reported that in Western Kenya, the importance of two functions of crop-livestock farming practices (integrated crop-cows farming system) have shown that the number of dairy cows and the quantity of manure used in the farm have a significant influence on crop production (Frederic et al., 2014). The Integrated Crop and Livestock Farming Systems (ICLFS) is the most practiced in Rarieda Sub-County, with sorghum and maize being the main staple food crops in the system. Still, proper documentation on the status of the farming system is lacking.

Comment [HJH2]: Not reported in ref list???  
Must add

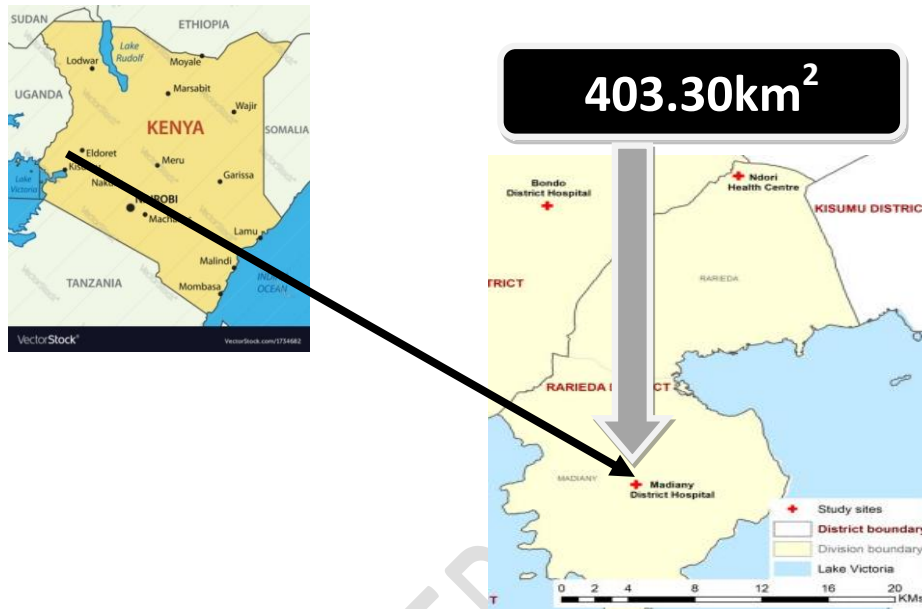
Formatted: Font color: Red

There is a lack of information and data on the types of ICLFS being practiced in Rarieda sub-County. Moreover, information on factors and obstacles that policy makers need to be aware of to ensure interventions on adoption and efficient management of ICLFS are also limited. This results in food insecurity, despite most households engaging in ICLFS. Based on this, the study aimed at evaluating the effectiveness of ICLFS in contributing to sustainable food security and the challenges faced by ICLFS-smallholder farmers in Rarieda sub-County. Furthermore, the performance of crops and livestock in an integrated farming system was assessed in this study.

## METHODOLOGY

The study was conducted in Rarieda Sub-County, in Siaya County, which is one of the 47 counties in Kenya. Rarieda sub-County is located in the western part of Kenya, at latitude 0° 12' 6" S and longitude 34° 20' 18" E. It is comprised of five administrative units, namely, East Asembo, West Asembo, West Uyoma, North Uyoma, and South Uyoma wards in what was formerly known as Rarieda and Madiany divisions (Asembo and Uyoma, respectively), with a total area covering 403.30 km<sup>2</sup>. The sub-County borders Lake Victoria to the South.

Formatted: Font: Bold



Formatted: Normal (Web), Left, Tab stops: Not at 0.91"

Figure 1. Map of the study area

Formatted: Font: Italic

The economic activities in the sub-County are mainly small-scale subsistence farming, including the rearing of livestock (cattle, sheep, goats, and poultry) and production of crops like maize, sorghum, cassava, potatoes, beans, green grams, groundnuts, cowpeas, and fruits like mangoes and oranges. Other economic activities include fishing and small-scale trade in agricultural produce.

### Sampling procedure

The study targeted farmers engaged in integrated crop and livestock systems in Rarieda sub-County. The sub-County has an estimated population of 75,779, with 710 as the target population for the study, according to the [Kenya National Bureau of Statistics \(2019\)](#). A representation of smallholder farmers within the administrative units was sampled.

Formatted: Font color: Red

A stratified simple random sampling technique based on sub-sector was used. A pre-specified size in each stratum was drawn independently in different strata to make up a stratified sample.

Then an Independent Simple Random selection was made in each stratum Nassiuma (2001). This sampling method was used because data needed to be collected from the selected zone representation. The study employed the Causal Research Design, an informal investigation into an issue or topic that looks at the effect of one variable on another (Dudovisky, 2018). The study helped analyse the influence of extension services on the performance of integrated crop and livestock farming systems for food and nutrition security.

#### Sample Size determination-

The sample size was determined using Cochran's formula according to Mugenda and Mugenda (2003) and Hejase & Hejase (2013) as follows:

$$n = (z^2 \cdot p \cdot q) / e^2$$

Where:

$n$ : is the minimum sample size required

$z$ : the standard normal deviate that is, 1.96 for 95% confidence level

$p$ : is the proportion in the target population estimated to have the characteristic, recommended to be 50% if there is no estimate available of the proportion in the target population assumed to have the characteristic of interest.

$q$ : is the proportion not having the characteristic (that is,  $1-p$ )

$e$ : is the level of significance or margin of error (set at 5% in this study).

Substituting the data in the formula gave a sample size of 384.

Since the target population of 710 is less than 10,000, a smaller sample size called adjusted minimum sample size was used without affecting the study's accuracy (Mugenda & Mugenda, 2003; Hejase & Hejase, 2013). This was calculated using the following formula:

$$n' = n / (1 + n/N)$$

Where:

$n'$  is the adjusted minimum sample size

$n$  is the minimum sample size, as calculated above, that is, 384

$N$  is the total population, that is, 710

Substituting these figures into the formula gave a minimum sample size of 249

Simple Random Sampling was employed in the study to avoid bias and ensure representativeness. The stratified Random Sampling technique categorizes smallholder farmers

into different subgroups or strata based on the type of integrated crop and livestock farming, their farm acreage, and administrative area. Then subjects were selected randomly and proportionately. Purposive sampling was used to determine the other stakeholders, including administrators, farmers' representatives, officers from the sub-County agricultural offices, Non-Governmental Organizations, and officers from the National Government. Qualitative and quantitative data were collected through self-administered, structured, and unstructured questionnaires. The questionnaires were validated by pre-testing the questionnaires.

### **Instrumentation**

Data were collected through interviews through one-on-one oral engagement schedules with farmers, agricultural extension officers, and other stakeholders. Questionnaires of both open and close-ended questions were used to capture data on production, challenges, and factors that influence the integration of crops and livestock. Descriptive design and Survey methods were used for collecting data. The study used test-retest reliability to assess how test scores are consistent from one test to the next. Secondary data was collected using published literature.

### **Data Analysis**

Data were processed and analysed using the Statistical ~~Package for Social Sciences~~ Product and Service Solutions, (SPSS) version 20, an IBM product since 2009 (Hejase & Hejase, 2013, p. 58). The analysis was done using both descriptive and inferential approaches. Frequency counts and measures of central tendency, including mean and dispersion using standard deviation, were used for descriptive statistics. On the other hand, chi-square and simple linear regression were applied for inferential statistics. The degree of association and cause-effect influence between the variables was determined. ~~Descriptive and inferential statistics were used in analysing the data.~~ Inferential statistics were used to draw implications from the data. Objectives were achieved by calculating the Pearson's product-moment correlation coefficient of the variables to establish a relationship between and among findings. The Pearson's correlation coefficient "r" was calculated using the formula;

$$r = \frac{\sum xy^2}{\sqrt{\sum x^2 \cdot \sum y^2}}$$

(Bagchi & Khamrui, 2012)

Formatted: Font: 12 pt

Comment [HJH3]: SPSS name was changed since it was acquired by IBM in 2009.

Comment [HJH4]: Not reported

## RESULTS AND DISCUSSION

### Evaluating Effectiveness of Extension Services in Enhancing Food and Nutrition Security

The effectiveness of extension services in achieving food and nutritional security was assessed in this study.

#### Source of Agricultural Extension Service to Respondents

From the findings, the main sources of agricultural extension services to most farmers are agricultural seminars and workshops with a proportion of 43.0%, followed by the Ministry of Agriculture (MoA) and NGOs, respectively, as shown in Table 1. These were found to have a significant relationship with the integrated crop-livestock farming system. Aker (2011) also found that agricultural seminars and workshops mainly provide information and technological knowledge and skills.

Table 1: Source of extension service to your farm

	Frequency	Percent	Value	Level of Significance (P-value)
Ministry of agriculture	31	20.5	27.8	0.000****
NGOs	26	17.2	17.3	0.001***
Valid Agricultural seminars and workshops	65	43.0	44.6	0.000****
Shows and Demonstration	19	12.6	13.7	0.002***
Other	10	6.6		
Total	151	100.0		

NS = not significant; \* =  $p < 0.1$ ; \*\* =  $p < 0.05$ ; \*\*\* =  $p < 0.01$ ; \*\*\*\* =  $p < 0.001$

#### Frequency of Agricultural Extension Service

The frequency over which the farmers receive their extension services was also examined. The analysis in Table 2 shows that majority of the respondents never received extension services (31.1%), followed by 29.1% who say they have been receiving the services annually. According to Maoba (2016), most of the farmers in sub-Saharan Africa had not received any agricultural extension services in their region.

Comment [HJH5]: Not reported??? Must add

Formatted: Font color: Red

Formatted: Space After: 0 pt, Line spacing: single

Formatted: Font: Times New Roman, 12 pt

Formatted: Font: Times New Roman, 12 pt

**Table 2: Frequency of extension services**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Weekly	9	6.0	6.0
	Monthly	28	18.5	24.5
	Yearly	44	29.1	53.6
	Every two years	23	15.2	68.9
	Never	47	31.1	100.0
	Total	151	100.0	100.0

Formatted: Space After: 0 pt, Line spacing: single

Formatted: Font: Bold

Formatted: Space After: 0 pt, Line spacing: single

**Methods of Extension Service used:**

Method most commonly used by extension workers to deliver their content was through gatherings organized by the area chief with a proportion of 42.4% followed by mass media (20.5%). All these methods of extension services were found to be statistically significant hence having a great influence on integrated crop livestock farming system (Table 3). [Guatam, \(2000\)](#) found out that majority of farmers in the sub-Saharan Africa mainly gain their knowledge and skills and information through public gatherings and other forms with more of physical contact.

Comment [HJH6]: Not reported????? Must add

Formatted: Font color: Red

**Table 3: Methods of Content Delivery**

	Frequency	Percent	Value	Significance Level(p-value)	
Valid	On-farm visit	30	19.9	122.7	0.000****
	Demonstrations	22	14.6	126.3	0.000****
	Chiefs Meetings	64	42.4	87.7	0.002***
	Mass Media	31	20.5	99.6	0.001***
	Other	4	2.6	96.7	0.001***
	Total	151	100.0		

Formatted: Font: Bold

NS = not significant; \* = p < 0.1; \*\* = p < 0.05; \*\*\* = p < 0.01; \*\*\*\* p < 0.001

**Effect of Extension Services on Performance of ICLFS**

As shown in Table 4, the R Squared for Model 1 is 0.691, indicating that 69.1% of the variation in performance is explained by variation in the independent variable extension service. The

results indicated that there is a strong and positive correlation between the extension service provision and performance. This corroborates previous report by Carrer, (2021) who found that agricultural extension services greatly affect performance of the farmers.

Formatted: Font color: Red

**Table 4: Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.263 <sup>a</sup>	.691	.063	.72235

a. Predictors: (Constant), Extension Services

Formatted: Font: Bold

Comment [HJH7]: Cannot be so small????  
Check  
Usually we report Adjusted R Square

**Table 5: ANOVA**

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	5.777	1	5.777	11.071	.001 <sup>b</sup>
	Residual	77.747	149	.522		
	Total	83.523	150			

a. Dependent Variable: Performance of ICLFS  
b. Predictors: (Constant), Extension Services

Formatted: Font: Bold

Formatted: Centered, Space After: 0 pt, Line spacing: single

Formatted: Space Before: 0 pt, After: 0 pt

The ANOVA results in Table 5 indicated that the effect of extension services on the performance of ICLFS was statistically significant ( $F=11.071$ ,  $p=0.001$ ,  $p < 0.05$ ). Moreover, the standardized regression coefficients shown in Table 6 revealed that for every unit increase of extension service, the performance of ICLFS ( $\beta=0.199$ ) increases; and was statistically significant ( $p=0.001$ ,  $p < 0.05$ ). This shows that extension services were statistically positively correlated with the performance of an integrated crop-livestock farming system.

**Table 6: Coefficients**

Model		Unstandardized Coefficients		Standardized Coefficients	t	P-value
		B	Std. Error	Beta		
1	(Constant)	1.698	.154		11.001	.000****
	Extension	.199	.060	.263	3.327	.001***

a. Dependent Variable: Performance of ICLFS

Formatted: Font: Bold

Formatted Table

Formatted: Centered

NS = not significant; \* =  $p < 0.1$ ; \*\* =  $p < 0.05$ ; \*\*\* =  $p < 0.01$ ; \*\*\*\* =  $p < 0.001$

## **CONCLUSION** [Validate with reported literature](#)

According to the findings, farmers mainly receive their agricultural extension services through agricultural seminars and workshops, the Ministry of Agriculture, and Non-Governmental Organizations in that order. The major problem here is the frequency of the extension services, which the farmers rarely receive. Those who have had the privilege to access these extension services are mainly through gatherings organized by the local area chiefs and mass media.

According to the findings of this research, there is a significant association between the ICLFS and food security among the smallholder farmers in the study site. The ANOVA supported this, which indicated a strong and positive correlation between the extension service provision and performance.

Extension services should be provided extensively and often since most of these extension services are rarely offered; therefore, the extension service providers should develop new strategies for reaching farmers apart from workshops and seminars. This will lead to an increase in performance as farmers will be aware of the activities entailing ICLFS. Agricultural and veterinary services have been devolved to the counties in Kenya, agrarian research funding and training on modern agricultural technologies need to be enhanced and evolved. This would improve the farmers practicing ICLFS access to irrigation facilities, enhanced access to extension services, and provision and training on modern agricultural technologies. These interventions would enhance the performance of ICLFS and mitigate food insecurity in the study area and Lake Victoria Crescent at large, as well as motivate the perception of farmers in adopting these farming systems.

## **COMPETING INTERESTS DISCLAIMER:**

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

Formatted: Not Highlight

Formatted: Not Highlight

## References

**Major problem here. Almost all references are not used in the text [Marked in RED] leading to Unethical Inflation of References.... Must add all citations to the list!!![Marked within the text in RED as well]**

Amann, A., Herrnegger, M., Karungi, J., Komakech, A. J., Mwanake, H., Schneider, L., ... & Lederer, J. (2021). Can local nutrient-circularity and erosion control increase yields of resource-constraint smallholder farmers? A case study in Kenya and Uganda. *Journal of Cleaner Production*, 318, 128510.

Formatted: Font color: Red

Formatted: Font: Not Italic, Font color: Red

Formatted: Font color: Red

Formatted: Font: Not Italic, Font color: Red

Formatted: Font color: Red

Cervantes-Godoy, D., & Dewbre, J. (2010). Economic Importance of Agriculture for Poverty Reduction. OECD Food, Agriculture and Fisheries Working Papers, No. 23, OECD Publishing. <http://dx.doi.org/10.1787/5kmmv9s20944-en>

Christiaensen, L., Demery, L. & Kuhl, J. (2010). The (Evolving) Role of Agriculture in Poverty Reduction. UNU-WIDER, Working Paper No. 2010/36.

Formatted: Font: Not Italic, Font color: Red

Formatted: Font color: Red

Thorton, P.K., Kruska, R.L., Henninger, N., Krisjanson, P. M., Reid, R. S., Atieno, F., Odero, A.N. and Ndegwa, T. (2002). Mapping Poverty and Livestock in the Developing World. ILRI (International Livestock Research Institute), Nairobi, Kenya

Formatted: Font: Not Italic, Font color: Red

Carvalho, P. C. F., Anghinoni, I.; Moraes, A., Souza, E. D.; Sulc, R. M., Lang, C. R.; Flores, J. P. C.; Lopes, M. L. T.; Silva, J. L. S.; Conte, O.; Wesp, C. L.; Levien, R.; Fontanelli, R. S.; Bayer, C. (2010). Managing grazing animals to achieve nutrient cycling and soil improvement in no-till integrated systems. *Nutrient Cycling in Agroecosystems*, v. 88, n. 2, p. 259–273, 30 abr.

Formatted: Font color: Red

Formatted: Font: Not Italic, Font color: Red, French (France)

Formatted: Font: Not Italic, Font color: Red

Formatted: Font color: Red

Powell, J. M.; Pearson, R. A.; Hiernaux, P. H. (2004). Crop-Livestock Interactions in the West African Drylands. *Agronomy Journal*, v. 483, n. March 2003, p. 469–483.

Formatted: Font: Not Italic, Font color: Red

Formatted: Font color: Red

Sanderson, M. A., Archer D., Hendrickson J., Kronberg S., Liebig M., Nichols K., Schmer, M., Tanaka D., Aguilar J. (2013). Diversification and ecosystem services for conservation agriculture: Outcomes from pastures and integrated crop-livestock systems. *Renewable Agriculture and Food Systems*, v. 28, n. 02, p. 129–144.

Formatted: Font: Not Italic, Font color: Red

Formatted: Font color: Red

Mercer, D. E. (2004). Adoption of agroforestry innovations in the tropics: A review. *Agroforestry Systems*, v. 61-62, n. 1-3, p. 311–328.

Formatted: Font: Not Italic, Font color: Red

Formatted: Font color: Red

Herrero, M., Thornton, P.K., Notenbaert, A. Msangi, S., Wood, S., Kruska, Bossio, D., Van de Steeg, J., Freeman, H.A., Li, X., Parthasarathy, Rao. (2009). Drivers of change in crop-livestock systems and their impacts on agro-ecosystems services and human well-being

Rapsomanikis, G. (2015). The economic lives of smallholder farmers; An analysis based on household data from nine countries.FAO. Rome, Italy. **Formatted: Font: Not Italic, Font color: Red**

Biaxin,B,Sterk,G.,Temesgen,M.,Abdulkedir, A. andStroosnijder, L.(2012).Rainwater harvesting and management in rain-fed agricultural systems in sub –Saharan Africa-A review. Physics and Chemistry of the Earth Parts A/B/C,47-48:139-151. **Formatted: Font color: Red**

Serdeczny,O.,Adams,S.,Baarsch,F.,Coumou,D.,Robinson,A.,Hare,W.,Schaeffer,M., Perrette,M. and Reinhardt,J. (2017). Climate change impacts in sub-Saharan African: from physical changes to their social repercussions. Regional Environmental Change, 17: 1585-1600. **Formatted: Font: Not Italic, Font color: Red**

Bekunda, M.,Nkonya,E.,Mugendi, D.andMsaky,J.(2002). Soil fertility status, management, and research in East Africa. East African Journal of Rural Development, 20:94-112. **Formatted: Font color: Red**

Druilhe,Z. and Barreiro-Hurle,J.(2012).Fertilizer subsidies in sub-Saharan Africa.ESA Working Paper No.12-04.Rome, FAO. **Formatted: Font color: Red**

FAO and ECA (2018). Regional Overview of Food Security and Nutrition. Addressing the threat from climate variability and extremes for food security and nutrition. Accra.:116. **Formatted: Font: Not Italic, Font color: Red**

Frederic, B.,Moti,J,OriamaO,Asheber(2014). Conservation agriculture in African mixed crop-livestock system; Expanding the niche. Agriculture Ecosystems and Environment.

Business Dictionary, (2018). What is Causal Research Design? Definition and Meaning. Web. **Formatted: Font: Not Italic, Font color: Red**

John Dudovisky (2018). The Ultimate Guide to Writing a Dissertation in Business Studies. **Formatted: Font color: Red**

Moraes, Aetal (2013).Integrated crop-livestock systems in the Brazilian subtropics.

Mugenda and Mugenda (2003) Research Methods.

Maoba, S. (2016). Farmers' perception of agricultural extension service delivery in Germiston Region, Gauteng Province, South Africa. *South African Journal of Agricultural Extension*, 44(2), 167-173.

Vanlauwe, b. and Giller, K.E; Popular myths around soil fertility management in sub-Saharan Africa, agric. Ecosyst. Environ., 116, 34-46, 2006. **Formatted: Font: Not Italic, Font color: Red**

Vilela et al. (2011) The impact of acetate metabolism on yeast fermentative and wine quality; reduction of volatile acidity of grapes musts and wine. *Appl Microbial Biotechnol* 89(2);271-80. **Formatted: Font color: Red**

ELD initiative. (2015). The value of the land, prosperous lands, and positive rewards through sustainable land management. Available;www.eld-initiative.org. **Formatted: Font: Not Italic, Font color: Red**

**Formatted: Font color: Red**

Yang et al. (2015), Microconchids from microbialities near Permian-Triassic boundary in the Zuodeng section, Baise area, Guangxi province, South China and their palaeoenvironmental implications. *Journal of earth science*, (in press).

Formatted: Font: Not Italic, Font color: Red

Saunders et al. (2011). Maneuvering towards research decline; the RAE and the fall of Britain's international research standing', *European journal of marketing*, 45, pp. 484-522.

Formatted: Font color: Red

Formatted: Font: Not Italic, Font color: Red

Formatted: Font color: Red

Hejase, A.J., & Hejase, H.J. (2013). *Research Methods: A Practical Approach for Business Students* (2nd edition). Philadelphia, PA, USA: Masadir Incorporated.

Formatted: Font: Not Italic, Font color: Text 1

Formatted: Font color: Text 1

Formatted: Indent: First line: 0"

Recha, C. W. (2018). Local and regional variations in conditions for agriculture and food security in Kenya.

World Bank. (2007). *World development report 2008: Agriculture for development*. The World Bank.

Wetende, E., Olago, D., & Ogara, W. (2018). Perceptions of climate change variability and adaptation strategies on smallholder dairy farming systems: Insights from Siaya Sub-County of Western Kenya. *Environmental Development*, 27, 14-25.

Rayfuse, R. G., & Weisfelt, N. (Eds.). (2012). *The challenge of food security: international policy and regulatory frameworks*. Edward Elgar Publishing.

Lokuruka, M. N. (2020). Food and Nutrition Security in East Africa (Kenya, Uganda, and Tanzania): Status, Challenges, and Prospects. In *Food Security in Africa*. IntechOpen.

Radeny, M., Mungai, C., Amwata, D., Osumba, J., & Solomon, D. (2020). Climate change, agriculture, food and nutrition security policies and frameworks in Kenya.

Amwata, D. A. (2020). Situational analysis study for the agriculture sector in Kenya.

Recha, C. W. (2019). Regional Variations and Conditions for Agriculture in Kenya. *Current Politics and Economics of Africa*, 12(1), 87-130.

Warinda, E., Nyariki, D. M., Wambua, S., Muasya, R. M., & Hanjra, M. A. (2020, February). Sustainable development in East Africa: impact evaluation of regional agricultural development projects in Burundi, Kenya, Rwanda, Tanzania, and Uganda. In *Natural Resources Forum* (Vol. 44, No. 1, pp. 3-39). Oxford, U.K.: Blackwell Publishing Ltd.

- Hutton, G. B., Brugulat-Panés, A., Bhagtani, D., Maadjhou, C. M., Birch, J. M., Shih, H., ... & Unwin, N. (2021). A systematic scoping review of the impacts of community food production initiatives in Kenya, Cameroon, and South Africa. *Journal of global health reports*, 5.
- Obuoyo, J. A. (2017). *The Influence of Household Characteristics and Agricultural Practices on Food Security in Semi-Arid Agro-Ecological Zones of Nyakach Sub-County, Kisumu County, Kenya* (Doctoral dissertation, Maseno University).
- Kabuye, F. M., Waata, F., & Kigulu, D. (2003). Voices of Poor Livestock Keepers in Lake Victoria Basin. *Proceedings of Voices of Poor Livestock Keepers*.
- Vervoort, J. M., Palazzo, A., Mason-D'Croz, D., Ericksen, P. J., Thornton, P. K., Kristjanson, P. M., ... & Rowlands, H. (2013). The future of food security, environments, and livelihoods in Eastern Africa: four socio-economic scenarios.
- Lukuyu, B. A., Kitalyi, A., Franzel, S., Duncan, A. J., & Baltenweck, I. (2009). Constraints and options to enhance high-quality feeds in dairy production in Kenya, Uganda, and Rwanda.
- Kirui, O. K., & Mirzabaev, A. (2014). *Economics of land degradation in Eastern Africa* (No. 128). ZEF working paper series.
- Mutegi, J. K., Jama, B. A., Silim, S., & Ameru, J. N. (2014). Potential of grain legume fallows to address food insecurity and boost household incomes in western Kenya. *International Journal of Development Research*, 4(5), 1154-1161.
- Adolwa, I. S., Schwarze, S., Bellwood-Howard, I., Schareika, N., & Buerkert, A. (2017). A comparative analysis of agricultural knowledge and innovation systems in Kenya and Ghana: sustainable agricultural intensification in the rural-urban interface. *Agriculture and human values*, 34(2), 453-472.
- Darko, R. O., Liu, J., Yuan, S., Sam-Amoah, L. K., & Yan, H. (2020). Irrigated agriculture for food self-sufficiency in the sub-Saharan African region. *International Journal of Agricultural and Biological Engineering*, 13(3), 1-12.
- Nyberg, Y. (2020). Smallholder farm management and priorities: balancing productivity, livelihood, climate adaptation, and ecosystem services.
- Amwata, D. A. (2020). SITUATIONAL ANALYSIS OF THE AGRICULTURE SECTOR IN KENYA.
- Bradesco, F. Climate change, agriculture, and food security.

Rao, E. J. O., Midega, C., Atieno, F., Auma, J., Cadilhon, J. J., Mango, N., ... & Wesonga, M. (2015). A situational analysis of agricultural production and marketing and natural resources management systems in West Kenya.

Formatted: Font: Not Italic, Font color: Red, French (France)

Formatted: Font: Not Italic, Font color: Red

Formatted: Font color: Red

Ayuk, E. T., & Oku, E. E. (Eds.). (2017). *Promoting green economy: implications for natural resources development, food security and poverty reduction in Africa*. United Nations University Institute for Natural Resource

Formatted: Font: Not Italic, Font color: Red

Formatted: Font color: Red

Formatted: Font: Not Italic, Font color: Red

Formatted: Font color: Red

Lamanna, C., Namoi, N., Kimaro, A. A., Mpanda, M., Egeru, A., Okia, C., ... & Rosenstock, T. S. (2016). Evidence-based opportunities for out-scaling climate-smart agriculture in East Africa. *CCAFS Working Paper*.

Formatted: Font: Not Italic, Font color: Red

Formatted: Font color: Red

Benin, S., Pender, J., & Ehui, S. (2003). *Policies for sustainable land management in the East African highlands: summary of papers and proceedings of a conference held at the United Nations Economic Commission for Africa (UNECA), Addis Ababa, Ethiopia, 24-26 April 2002*, (Vol. 50). ILRI (aka ILCA and ILRAD).

Formatted: Font: Not Italic, Font color: Red

Formatted: Font color: Red

Formatted: Font: Not Italic, Font color: Red

Formatted: Font color: Red

Formatted: Font: Not Italic, Font color: Red

Formatted: Font color: Red

Meng, X. (2013, May). Scalable simple random sampling and stratified sampling. In *International Conference on Machine Learning* (pp. 531-539). PMLR.

Formatted: Font: Not Italic, Font color: Red

Formatted: Font color: Red

Formatted: Font: Not Italic, Font color: Red

Formatted: Font color: Red

Nassiuma, D. K. (2001). Survey sampling: Theory and methods.

UNDER PEER REVIEW

UNDER PEER REVIEW

