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Effectiveness of Extension Information Services in Improving Agricultural Productivity among Smallholder Farmers in Western, Kenya

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Abstract: ***Food security reports highlight that remote areas face limited access to information and technology critical for agricultural productivity. This study explores the relationship between extension information services and agricultural productivity among smallholder farmers in Western Kenya. Using correlational analysis, including Pearson Correlation, Simple Linear Regression, and Paired Samples T-Test, the research found a strong positive relationship (r = 0.8) between extension services and productivity. These findings underscore the importance of extension information services in enhancing smallholder agricultural outcomes and contribute to policy discourse on agricultural extension globally.***

Keywords: Food Security, Agricultural Extension, Smallholder Farmers, Sustainable Agriculture.

1. Introduction and Background to the Study

Extension is essentially how new knowledge and ideas are introduced into rural areas to bring about change and improve the lives of farmers and their families. Agricultural Extension is defined by FAO Agricultural Extension Manual for Extension Workers (FAO, 2019) as systems that should facilitate the access of farmers, their organizations and other market actors to knowledge, information and technologies; facilitate their interaction with partners in research, education, agribusiness, and other relevant institutions; and assist them to develop their own technical, organizational and management skills and practices. Without agricultural extension, farmers would lack access to the support and services required to improve their agriculture and other productive activities.

Agricultural Extension involves disseminating farming information to enhance productivity. A premise exists that if the dissemination of information to farmers is well planned and farmers are enabled to use the information then farming output will improve. Agricultural extension services can however be improved by leveraging tools like information and communication technologies, trainer incentives, or social learning to support small-scale farmers' decisions to invest in new, profitable practices. Extension programs that target both male and female members of the household or bundle advisory services with other offerings focused on alleviating gender-based barriers can also improve women's agricultural outcomes (FAO, 2020). However, Extension and advisory services (EAS) providers often fall short of this goal: services are usually geared towards male heads of household, and only seldom do EAS actors have the skills to effectively support women.

To achieve an effective agricultural extension information system, there is need to meaningfully improve the quality of public extension information services that support agriculture through increasing farmer access to relevant and timely farming information, that will contribute to improving the effectiveness of decision making among smallholder farmers (Rao N.H., 2007).

Transformation of public agricultural extension information services has become an essential part of strategic development agendas, with the role of agricultural extension information service providers being regarded as essential in food security endeavors. It is for this reason that the United Nations Sustainable Development Goals (SDGs) Agenda 2030 agreed by UN Member Countries in 2015 aims to achieve food security by promoting sustainable agriculture for smallholder farmers by the year 2030, Nevertheless, this endeavor can only be achieved through ensuring that farmers have access to agricultural extension information services. The connections between the challenges of agricultural and rural development and the SDG targets are very clear.

2. Materials and Methodology

The research applied a correlation study design and measured the relationship between use of extension information services and agricultural productivity among smallholder Maize farmers in western Kenya Counties of Siaya, Bungoma and Kakamega.

The correlation strategy helped determine the strength of the relationship between use of extension information services and agricultural productivity. The results from the correlational research were used to determine occurrence of associations, forecast occurrence of relationship among the variables and make predictions using the data and knowledge gathered.

The correlation technique was applied to measure the strength of relationship between use of extension information services and agricultural productivity among smallholder farmers in western, Kenya. The Pearson correlation coefficient (PCC) formula shown below was applied on the data collected on the major agricultural enterprise i.e. Maize, to measure the linear correlation between variable X (number of extension visits) and variable Y (household agricultural productivity or yield marketed).

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{n(\Sigma x^2)-(\Sigma x)^2} * \sqrt{n(\Sigma y^2)-(\Sigma y)^2}}$$

Where;-
n = the sample size,
Σx = sum of x scores,
Σy = sum of y scores,
Σxy = sum of the products of paired scores,
Σx^2 = sum of squared x scores,
Σy^2 = sum of squared y scores

The computation of a correlation coefficient (r) produces a digit that ranges from -1 to +1. The value of 'r' is ± 1. A positive value of r shows a positive relationship between the two variables i.e. agricultural productivity or marketed produce and use of extension services, whereas a negative value of 'r' signifies negative association. A zero value of 'r' showed that there was no relationship between the two variables. Where 'r' = (+) 1, it showed perfect positive relationship and when it was 'r' = (–) 1, it showed perfect negative association, meaning that variations in independent variable 'use of extension services' (X) described 100% of the differences in the dependent variable 'agricultural productivity' or agricultural marketing (Y). In cases where the value of 'r' was closer to +1 or –1, it was an indicator of great degree of relationship between the two variables.

A Significance test was undertaken to test whether the association was merely apparent and might have arisen by chance. The study used the t-test to understand the significance of the correlation coefficient calculated. The t-test formula below was used to calculate a test statistic to test the hypothesis of correlation coefficient and Scatter graphs were drawn to indicate the direction of the relationship.

$$t = r\sqrt{\frac{n-2}{1-r^2}}$$

A paired t-test was used to relate the on-farm income means from the registered household income from the sale of agricultural produce. The t test carried out was essentially to test the study hypothesis by comparing the household on farm income mean for the year 2023 and 2024.

The sum of incomes for the two years under study was calculated and the differences determined between year 2023 and year 2024. The sum of the differences was calculated and squared, and the t-test formula below was applied to compare the mean on farm income for the agricultural enterprise evaluated over the years under review.

$$t = \frac{(\Sigma D)/N}{\sqrt{\frac{\Sigma D^2 - \left(\frac{(\Sigma D)^2}{N}\right)}{(N-1)(N)}}}$$

Where;-
ΣD: Sum of the differences (Sum of x-y)
ΣD^2: Sum of the squared differences (Sum of $(x-y)^2$)
$(\Sigma D)^2$: Sum of the differences squared. (Sum of x-y squared)

The study then used Simple Linear Regression to assesses the relationship between independent variable x (use of extension information services) and dependent variable y (Agricultural productivity). The simple linear model was expressed using the equation:

$$y = mx + b$$

Where;
y– Dependent variable
x– Independent variable
m– Intercept
b– Slope

From the analyzed data, extension information visits and agricultural production values were summed up and squared and the mean production calculated to solve for ***m*** and ***b*** using the function.

$$m = \frac{n(\Sigma xy)-(\Sigma x)(\Sigma y)}{n(\Sigma x^2)-(\Sigma x)^2} \qquad b = \frac{\Sigma y - m(\Sigma x)}{n}$$

Based on the calculations, predictions of ***y*** (production) were made from the given values of ***x*** (Extension information use) using the simple regression equation ***y = mx + b.***

3. Findings, Interpretation, and Discussion

To evaluate the relationship between use of extension information services and agricultural productivity, the study analyzed all the major agricultural value chains based on their importance to the livelihoods and economic activities of the inhabitants of western Kenya Counties of Siaya, Bungoma and Kakamega. The enquiry considered these major economically viable agricultural value chains because they were found to be practiced by most smallholder farmers in Western Kenya and an examination of each was undertaken by requesting the practicing smallholder farmers to provide data on the number of extension visits made by extension service providers during the year 2024 and the corresponding yield.

The extension visits were considered as agricultural information dissemination sessions. This was followed by capturing the corresponding production for each agricultural enterprise to assess any form of relationship that existed between the information provided by the extension agents and farm yield. The data collected was analyzed and a correlation coefficient calculated to determine the degree of the relationship between the information and productivity variables. This data was considered necessary in analyzing the relationship between the use of extension information services and agricultural productivity. The data collected on the agricultural enterprises in western Kenya was analyzed per every agricultural enterprise selected as below.

(i) Effectiveness of Extension Information Services in enhancing Maize Productivity

In analyzing the relationship between the use of extension information services and Maize (Zea mays L.) productivity among smallholder farmers in Western Kenya counties of Siaya, Bungoma and Kakamega Counties, a sample of 33 maize farming households with an average of three acres of land under the crop was chosen for the research.

The sampled farmers were requested to offer information on the number of extension visits made to their farms by extension service providers and the corresponding yield during the year 2024, the unit of study being household head. The extension service information was measured in terms extension training and visits made to farming households and the visits were considered as information dissemination sessions.

To ensure that the extension visits were equated to the use of information disseminated, farmers were requested to only provide the number of times when they received and applied the useful information on maize production, the number of visits where information not relevant to maize farming was disseminated were disregarded. From the data collected the value of extension visits was the independent variable denoted as x while the yield was the dependent variable denoted as y.

Out of the 33 maize farming households sampled, extension information visits per household ranged between 10 and 97 times per year with a corresponding mean maize yield of 15 bags per acre. However, Farmers receiving over 70 extension visits produced more than 30 bags per acre, showing a correlation between extension services and productivity.

This information was corroborated by Figures sourced from Ministry of Agriculture, Livestock and Fisheries (MoALF, 2017), by Tegemeo Institute of Agricultural Policy and Development and the International Maize and Wheat Improvement Centre (IMWIC) report which acknowledged that Kenya's smallholder maize production potential ranged between 16 -20 bags per acre, but could yield up to 40 bags an acre, if farmers practiced good crop husbandry, used the right inputs and had access to relevant agricultural information.

To lay the basis for calculating the relationship between the two variables; use of extension information and Maize (Zea mays L.) productivity, the sum of the scores of x (extension visits) and y (maize yield) were computed. The sum of products and squares of the two variables were then calculated and based on the acreage captured per household the average maize production per acres was then calculated. More details on the relationship between the use of extension information services and maize productivity are shown in table 1.1 below.

Table 1.1: Relationship between use of Extension Information Services and Maize Productivity

Maize (Zea mays L.) Enterprise				n=33		
Extension Visits in days per Year (*x*)	Maize Yield in 90kg bags per year (*y*)	(*xy*)	(x^2)	(y^2)	Acreage (a)	Mean Maize Production per acre in 90kg bags (y/a)
97	61	5917	9409	3721	1.7	35.88
75	47	3525	5625	2209	1.5	31.33
75	66	4950	5625	4356	2.1	31.43
65	41	2665	4225	1681	1.5	27.33
59	52	3068	3481	2704	1.8	28.89
47	39	1833	2209	1521	1.7	22.94
47	40	1880	2209	1600	2.1	19.05
37	55	2035	1369	3025	2.4	22.92
33	32	1056	1089	1024	1.5	21.33
27	30	810	729	900	2.1	14.29
25	21	525	625	441	1.4	15.00
25	23	575	625	529	1.7	13.53
24	21	504	576	441	1.8	11.67
22	19	418	484	361	1.2	15.83
22	23	506	484	529	2.1	10.95
21	28	588	441	784	2.3	12.17
21	15	315	441	225	1.7	8.82
21	16	336	441	256	2.6	6.15
19	19	361	361	361	2.1	9.05
19	15	285	361	225	1.3	11.54
17	13	221	289	169	1.5	8.67
17	41	697	289	1681	2.4	17.08
16	43	688	256	1849	2.1	20.48
13	17	221	169	289	1.5	11.33
13	41	533	169	1681	2.3	17.83
11	13	143	121	169	2.1	6.19
11	13	143	121	169	2.2	5.91
10	15	150	100	225	1.7	8.82
9	9	81	81	81	1.3	6.92
9	11	99	81	121	1.7	6.47
7	9	63	49	81	1.4	6.43
5	7	35	25	49	1.3	5.38
4	5	20	16	25	1.3	3.85
Σx=923	Σy=900	Σxy=35246	Σx^2=42575	Σy^2=33482	x̄=1.8	x̄=15.01

Source: Research Data, 2024

To measure how strong a relationship is between the two variables; use of extension information (x) and maize productivity (y), a Pearson Correlation Coefficient (r) formula was applied on the data analyzed in table 1.1 above to calculate the correlation coefficient. A covariance of the two variables was calculated and then divided by the product of their standard deviations as shown below: -

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{n(\Sigma x^2) - (\Sigma x)^2} * \sqrt{n(\Sigma y^2) - (\Sigma y)^2}}$$

r =33(35246) – (923× 900) / [√ {[33(42575) – (923)2] × √ [33(33482) – (900)2]}
r = 1,163,118 – 830,700/√ {[1,404,975 – 851,929] × [1,104,906– 810,000]}
r = 332,418/√ (553,046× 294,906)
r = 332,418/√ 163,096,583,676
r = 332,418/ 403,852.18
r = 0.8231
r = 0.823

From the calculation, the numerical value of the correlation coefficient was 0. 0.823 and on a scale of −1 to +1 this figure was closer to 1.0, therefore suggesting the presence of a strong positive relationship between the use of extension information services and maize productivity. The sign of the correlation coefficient being positive also suggested that increased use of agricultural information strongly increased maize production and vice versa.

The effect of the size of the correlation called the coefficient of determination defined as r^2 showed that the percentage maize production that could be attributed to access to extension information services could be predicted from the relationship between the two variables. For **r = 0.823** the **r^2** is **0.677**, which predestined that **67.73%** of the variation in maize productivity could be credited to the utilization of public extension information services. Conversely, **32.27%** of the variation in maize production could not be explained as resulting from utilization of public extension services.

(ii) Maize production Predictions based on effective Extension information use

Using the x (extension Visits) and y (Maize yield) values in table. 1.1 above a scatter graph was plotted to represent the direction of the relationship as shown in figure 1.1 below; -

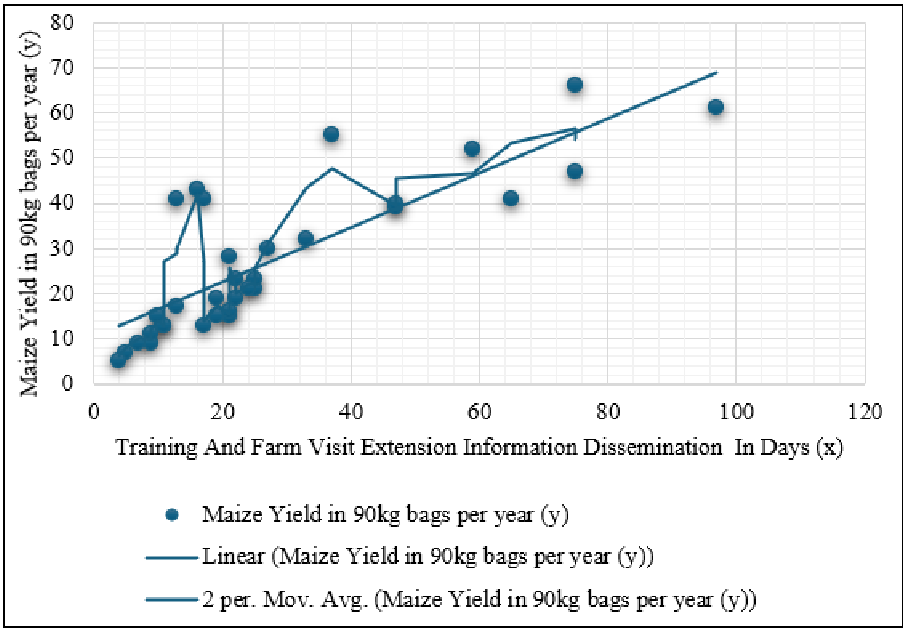

Figure 1.1: Training and farm visit Extension Information Dissemination vs Maize Yield
Source: Research Data, 2024

As shown in the scatter graph in figure 1.1 above, a line was drawn through the data to get the best fit or the least square line. To draw comparison between use of extension services information and Maize yield, this line of best fit was used to calculate the slope intercept form ***y* = *mx* + *b*** that was used to make true predictions. The study then used linear regression to forecast the value of ***y*** (maize production) for a given value of ***x*** (extension information use), by determining, the line ***y* = *mx* + *b***

According to Lial, Greenwell and Ritchey, (2016), the "least squares" method is a form of linear regression that gives the relationship between the data points. From the data analyzed data, extension information visits and maize production values were summed up and squared and the mean production calculated by dividing the maize yield by the acreage.

The sum of extension visits (∑x), sum of maize yield (∑y), sum of extension visits multiplied by the corresponding maize yield (∑xy), the sum of the squares of extension visits ($\sum x^2$), and the sum of the squares of maize yield ($\sum y^2$) were calculated as shown above in Table 1.1 above. Based on the analyzed data in table 1.1, the equations below were used to solve for **m** first, and then solve for **b.**

$$m = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{n(\Sigma x^2) - (\Sigma x)^2} \qquad b = \frac{\Sigma y - m(\Sigma x)}{n}$$

m=33(35,246) – (923) (900) /33(42,575) -(923)^2,
m =1,163,118-830,700/1,404,975-851,929

m =332,418/553,046
m= 0.601
b =900-0.601 (923)/33,
b = 900-554.723/33,
=345.277/33
b = 10.463
y = mx + b
y = 0.601x + 10.463

From the calculations, predictions of ***y*** (Maize Production) were made from the given values of ***x*** (Agricultural Extension Information use***)*** using the equation **y = 0.601x + 10.463** as shown in the graph in figure 1.2 below; -

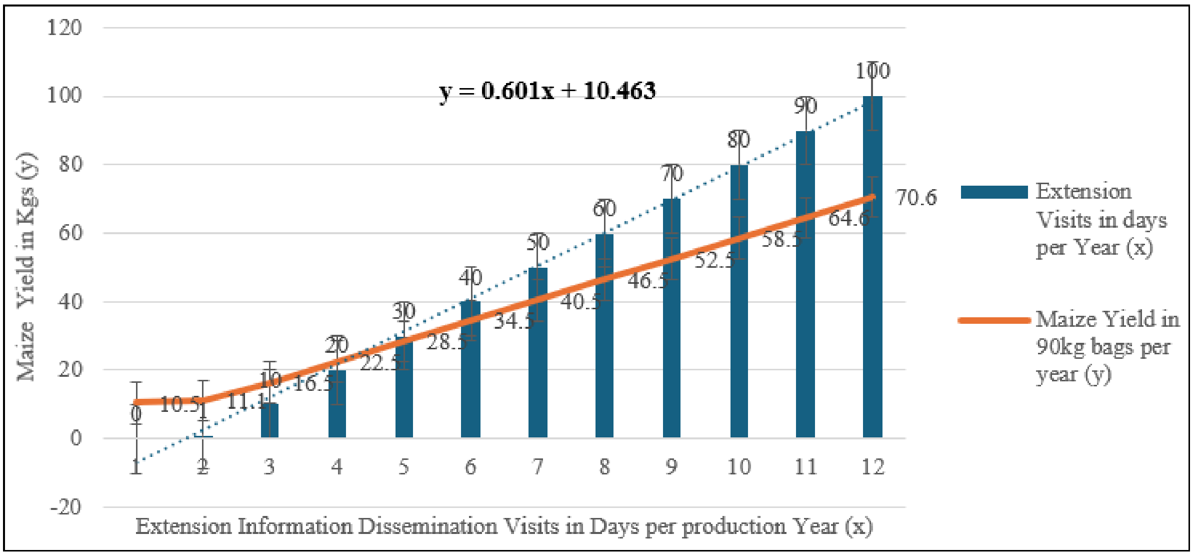

Figure 1.2: Maize yield production based on Extension Information use

Source: Research Data, 2024

From the graph in figure 1.2 above, the line starts out at **10.5 bags** (10.463 rounded off) and the y-values increase by **0.601** bags for every 1 visit that a public extension information service provider makes to a maize farming household in Western Kenya. Using the function **y = 0.601x + 10.463** predictions were made for the increase in maize yield (Production) because of increase or decrease in extension information use (extension information dissemination visits).

The regression analysis also informed that households in western Kenya could still produce up to 10 bags of maize per acre using the previously acquired agricultural knowledge or information from other sources other than from public extension information service providers.

Additionally, qualitative data gathered from Public extension service providers informed that certified maize seeds sourced from Kenya Seed Company could yield up to a maximum of 60 bags per acre when farmers utilized agricultural information, and therefore a regression analysis was used to predict the maximum number of extension information dissemination visits required (**x visits**) to attain maximum maize yields of 60 bags (**i.e. y=60**) per acres using the linear regression analysis function ***y = mx + b***

y = 0.601x + 10.463
60 = 0.601x + 10.463
60-10.463 = 0.601x
49.537=0.601x
x=49.537/0.601
x=82.424.

This linear regression analysis implies that for a farmer to produce the optimal 60 bags of maize in a single production season from 1 acre of land, approximately 82 extension information dissemination visits would be required, however for any extra visits above the 82 the economic law of Diminishing Marginal Productivity would apply.

This is an economic rule governing production which holds that if more variable input units are used along with a certain number of fixed inputs, the overall output might grow at a faster rate initially, then at a steady rate, but ultimately, it will grow at a declining rate. Based on this law it means that any extra visits beyond the optimal 82 will not yield any extra bags of maize. However, from the analysis it was noted that while the regression analysis helped in making predictions, to qualify the predictions a Correlation Coefficient analysis was required, to help describe how well the data would fit the calculated line.

(iii) Effectiveness of Extension Information Services in Marketing of Agricultural Produce

Through both descriptive and inferential statistics, the study also determined if a relationship existed between extension information service provision and agricultural marketing in Western Kenya Counties of Kakamega, Bungoma and Siaya. This was considered necessary since, literature review of the study had discovered that farmers needed extension information not only about production but also throughout all the other stages of the entire value chain including agribusiness, to enable them to apply scientific research and knowledge to agricultural practices.

The study identified agricultural enterprises that farmers preferred based on sales volumes and on farm income. Through the recall method, 365 smallholder farmers were asked to provide data on sales volume for every enterprise from baseline (2023 sales) and follow-up actual (2024 sales). The data gathered was analyzed and grouped into three main clusters based on household on farm income as shown in table 1.2 below.

Table 1.2: Agricultural Value Chain Preference in Western Kenya

Agricultural Enterprise	Sample Size (n=365)	2023				2024				Level of Marketing Preference
		Extension Visits in days per Year	Baseline Sales	Unit Price (Kes)	On-Farm Income (Kes)	sum of Extension Visits in days per Year	Actual Sales	Unit Price (Kes)	On-Farm Income (Kes)	
Kales	21	559	73111kgs	20	1,462,220	923	81050kgs	25	2,026,250	High Preference
Cow Milk	28	499	34298kgs	50	1,714,900	911	47450kgs	60	2,847,000	
Maize	28	501	77771kgs	50	3,888,550	871	85590kgs	60	5,135,400	
Dry Beans	23	599	25777kgs	120	3,093,240	444	29700kgs	110	3,267,000	
Tomatoes	21	679	27897kgs	80	2,231,760	584	28410kgs	100	2,841,000	
Chicken Eggs	23	101	17682pcs	10	176,820	348	18798pcs	15	281,970	
Onions	I8	149	55991kgs	100	5,599,100	218	68900kgs	100	6,890,000	
Totals	**144**	**3,087**	**312,527**		**18,166,590**	**4,299**	**359,898**		**23,288,620**	
Watermelon	16	299	31177kgs	65	2,026,505	564	43485kgs	55	2,391,675	Moderate Preference
Cabbage	13	111	45385kgs	55	2,496,175	215	57250kgs	50	2,862,500	
Chilies	19	612	22417kgs	60	1,345,020	494	23040kgs	80	1,843,200	
Sorghum	17	100	19999kgs	100	1,999,900	385	20505kgs	100	2,050,500	
Goats Milk	18	573	26891kgs	50	1,344,550	452	27780kgs	60	1,666,800	
ALVs	23	111	16110kgs	20	322,200	410	17010kgs	20	340,200	
Sweet Potatoes	17	107	10118kgs	105	1,062,390	225	11240kgs	110	1,236,400	
Millet	15	311	3,150kgs	95	299,250	150	3987kgs	95	378,765	
Honey	13	329	2171kgs	450	976,950	216	2565kgs	500	1,282,500	
Pond Fish	17	499	3111kgs	250	777,750	398	3965kgs	350	1,387,750	
Totals	**168**	**3,052**	**180,529**		**12,650,690**	**3,509**	**210,827**		**15,440,290**	
soya beans	8	499	6673kgs	200	1,334,600	367	6500kgs	200	1,300,000	low preference
Sunflower	9	299	8101kgs	150	1,215,150	169	7567kgs	160	1,210,720	
Bananas	9	367	5620kgs	160	899,200	216	5520kgs	150	828,000	
Sesame Seed	8	231	8579kgs	155	1,329,745	127	7360kgs	150	1,104,000	
Cassava	9	239	1117kgs	130	145,210	148	2160kgs	140	302,400	
Butternuts	10	156	1097kgs	85	93,245	77	1520kgs	100	152,000	
Totals	**53**	**1,791**	**31,187**		**5,017,150**	**1,104**	**30,627**		**4,897,120**	

Source: Research Data, 2024

Applying descriptive statistics, the total on farm income was calculated for all the twenty-three agricultural value chains. This information offered an understanding of market preferences and as shown in table 1.5 above. From the analysis it was deducted that based on, on farm revenue, the highly preferred agricultural enterprises were Kales, Cow Milk, Maize, Dry Beans, Tomatoes, Chicken for Eggs and Onions, while the least preferred enterprises were Cotton, Sunflower, Bananas, Sesame (simsim) Seed, Cassava and Butternuts.

Qualitative data gathered further revealed that extension information dissemination visits also influenced agricultural enterprise preference, sales and household income e.g. in the year 2023 a total of 3,087 visits were made for the highly preferred enterprises with a corresponding income of Kes. 18,166,590 for the year, while in the corresponding year 2024 extension visits increased to 4,299 generating an income of Kes. 23,288,620. This change in on farm household income was attributed to the increased use of agricultural information considering that data was gathered from the same farmers and same enterprises.

The same positive effect on, on farm income because of increased extension interactions was depicted for the moderately preferred Agricultural enterprises where 3,052 visits were made in the year 2023 with a corresponding income of Kes. 12,650,690 while in the following year 2024, the visits increased to 3,509 with a corresponding income of Kes. 15,440,290.

However, for the least preferred Agricultural enterprises the data analyzed confirmed that there was a reduction in extension information dissemination interactions, and this was perceived to have contributed to the reduced revenues. In the year 2023 only 1,791 visits were made by the extension information service providers for the least preferred enterprises, which resulted in a household income of Kes. 5,017,150, this trend continued during the following year 2024 where the visits were further reduced to 1,104, the effect being a corresponding reduction in the on-farm incomes to Kes. 4,897,120.

The data analyzed therefore enabled the study to draw an inference that there was a relationship between the two variables; use of agricultural extension information and marketing, however, to qualify the study hypothesis the study carried out a paired t test (also called a correlated pairs t-test, a paired sample t-test or dependent samples t-test).

A paired t-test was used to compare two income means for the for the year 2023 and 2024. The registered income from the sale of agricultural produce from the 23 enterprises was collected from the farming households through questionnaires and the registered income for the year 2017 paired with the registered incomes for the year 2018. The t-test carried out was essentially to test the study hypothesis by comparing the on-farm income mean for the year 2023 and 2024. The On-farm income data on 23 agricultural enterprises for the year 2023 and the corresponding year 2024 was collected from 365 farming households and analyzed as shown in table 1.3 below.

Table 1.3: On Farm Income Mean comparison

Agricultural Enterprise	Respondents (n=365)	2023 On-Farm Income (Kes) Score 1 (x)	2024 On-Farm Income (Kes) Score 2 (y)	(x-y)	(x-y)2
Kales	21	1,462,220.00	2,026,250.00	- 564,030.00	318,129,840,900.00
Cow Milk	28	1,714,900.00	2,847,000.00	-1,132,100.00	1,281,650,410,000.00
Maize	28	3,888,550.00	5,135,400.00	-1,246,850.00	1,554,634,922,500.00
Dry Beans	23	3,093,240.00	3,267,000.00	-173,760.00	30,192,537,600.00
Tomatoes	21	2,231,760.00	2,841,000.00	-609,240.00	371,173,377,600.00
Chicken Eggs	23	176,820.00	281,970.00	-105,150.00	11,056,522,500.00
Onions	I8	5,599,100.00	6,890,000.00	-1,290,900.00	1,666,422,810,000.00
Watermelon	16	2,026,505.00	2,391,675.00	-365,170.00	133,349,128,900.00
Cabbage	13	2,496,175.00	2,862,500.00	-366,325.00	134,194,005,625.00
Chilies	19	1,345,020.00	1,843,200.00	-498,180.00	248,183,312,400.00
Sorghum	17	1,999,900.00	2,050,500.00	-50,600.00	2,560,360,000.00
Goats Milk	18	1,344,550.00	1,666,800.00	-322,250.00	103,845,062,500.00
ALVs	23	322,200.00	340,200.00	-18,000.00	324,000,000.00
Sweet Potatoes	17	1,062,390.00	1,236,400.00	-174,010.00	30,279,480,100.00
Millet	15	299,250.00	378,765.00	-79,515.00	6,322,635,225.00
Honey	13	976,950.00	1,282,500.00	-305,550.00	93,360,802,500.00
Pond Fish	17	777,750.00	1,387,750.00	-610,000.00	372,100,000,000.00
soya beans	8	1,334,600.00	1,300,000.00	34,600.00	1,197,160,000.00
Sunflower	9	1,215,150.00	1,210,720.00	4,430.00	19,624,900.00
Bananas	9	899,200.00	828,000.00	71,200.00	5,069,440,000.00
Sesame Seed	8	1,329,745.00	1,104,000.00	225,745.00	50,960,805,025.00
Cassava	9	145,210.00	302,400.00	-157,190.00	24,708,696,100.00
Butternuts	10	93,245.00	152,000.00	-58,755.00	3,452,150,025.00
SUM	**365**	**35,834,430.00**	**43,626,030.00**	**-7,791,600.00**	**6,443,187,084,400.00**

Source: Research Data, 2024

From table 1.3 above the sum of incomes from Maize production for the two years referred to as x income for year 2023 and y income for year 2024 (2023 as score 1 and 2024 as score 2) was calculated and the differences determined between year 2023 and year 2024. The sum of the differences was calculated and squared, and the formula below was applied to compare the mean on farm income for the maize enterprise over the years under review.

$$t = \frac{(\sum D)/N}{\sqrt{\frac{\sum D^2 - \left(\frac{(\sum D)^2}{N}\right)}{(N-1)(N)}}}$$

Were
ΣD: Sum of the differences (Sum of x-y)
ΣD^2: Sum of the squared differences (Sum of $(x\text{-}y)^2$)
$(\Sigma D)^2$: Sum of the differences squared. (Sum of x-y squared)

t = -7,791,600/365/√ {[6,443,187,084,400 – (-7,791,600)^2/365]/ (365-1) (365)}
t = -21,346.8493/√ {[6,443,187,084,400 – (60,709,030,560,000/365]/ (364) (365)}
t = -21,346.8493/√ {[6,443,187,084,400 – 166,326,111,123.2877]/132,860}
t -21,346.8493/√ {6,276,860,973,276.712/132,860
t = -21,346.8493/√47,244,174.1177
t = = -21,346.8493/6,873.4398
t = -3.106

In the calculation 1 was Subtracted from the sample size to get the degrees of freedom (df). The study had a sample of 365 items, so 365-1 = 364. After calculating the t-value as above the p-value was found in the t-table, using the degrees of freedom 364 basing on an alpha level (Significance level) of 0.05 (5%). With df = 364, the t-value is 1.962. as shown in Table 1.4 below

Table 1.4: T-Distribution Table of Critical Values

t-test table

cum. prob	$t_{.50}$	$t_{.75}$	$t_{.80}$	$t_{.85}$	$t_{.90}$	$t_{.95}$	$t_{.975}$	$t_{.99}$	$t_{.995}$	$t_{.999}$	$t_{.9995}$
one-tail	0.50	0.25	0.20	0.15	0.10	0.05	0.025	0.01	0.005	0.001	0.0005
two-tails	1.00	0.50	0.40	0.30	0.20	0.10	0.05	0.02	0.01	0.002	0.001
df											
1	0.000	1.000	1.376	1.963	3.078	6.314	12.71	31.82	63.66	318.31	636.62
2	0.000	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	22.327	31.599
3	0.000	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	10.215	12.924
4	0.000	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	7.173	8.610
5	0.000	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	5.893	6.869
6	0.000	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	5.208	5.959
7	0.000	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	4.785	5.408
8	0.000	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	4.501	5.041
9	0.000	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	4.297	4.781
10	0.000	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	4.144	4.587
11	0.000	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	4.025	4.437
12	0.000	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	3.930	4.318
13	0.000	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	3.852	4.221
14	0.000	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	3.787	4.140
15	0.000	0.691	0.866	1.074	1.341	1.753	2.131	2.602	2.947	3.733	4.073
16	0.000	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	3.686	4.015
17	0.000	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.646	3.965
18	0.000	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.610	3.922
19	0.000	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861	3.579	3.883
20	0.000	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845	3.552	3.850
21	0.000	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831	3.527	3.819
22	0.000	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819	3.505	3.792
23	0.000	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807	3.485	3.768
24	0.000	0.685	0.857	1.059	1.318	1.711	2.064	2.492	2.797	3.467	3.745
25	0.000	0.684	0.856	1.058	1.316	1.708	2.060	2.485	2.787	3.450	3.725
26	0.000	0.684	0.856	1.058	1.315	1.706	2.056	2.479	2.779	3.435	3.707
27	0.000	0.684	0.855	1.057	1.314	1.703	2.052	2.473	2.771	3.421	3.690
28	0.000	0.683	0.855	1.056	1.313	1.701	2.048	2.467	2.763	3.408	3.674
29	0.000	0.683	0.854	1.055	1.311	1.699	2.045	2.462	2.756	3.396	3.659
30	0.000	0.683	0.854	1.055	1.310	1.697	2.042	2.457	2.750	3.385	3.646
40	0.000	0.681	0.851	1.050	1.303	1.684	2.021	2.423	2.704	3.307	3.551
60	0.000	0.679	0.848	1.045	1.296	1.671	2.000	2.390	2.660	3.232	3.460
80	0.000	0.678	0.846	1.043	1.292	1.664	1.990	2.374	2.639	3.195	3.416
100	0.000	0.677	0.845	1.042	1.290	1.660	1.984	2.364	2.626	3.174	3.390
1000	0.000	0.675	0.842	1.037	1.282	1.646	1.962	2.330	2.581	3.098	3.300
z	0.000	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576	3.090	3.291
	0%	50%	60%	70%	80%	90%	95%	98%	99%	99.8%	99.9%
	Confidence Level										

The t-table indicates that the critical values for the test are -1.962 and +1.962. We use both the positive and negative values for a two-sided test. Results are statistically significant if the t-value is less than the negative value or greater than the positive value.

Comparing the t-table value (1.962) to the calculated t-value (-3.106), The calculated t-value is greater than the table value at an alpha level of 0.05. The p-value is less than the alpha level: $p < .05$. The minus sign is ignored when comparing the two t-values, as ± indicates the direction; the p-value remains the same for both directions.

Based on the t-test there was a clear and distinct difference between the mean for the year 2023 and 2024. The alternative hypothesis that there is a relationship between use of extension information services and marketing of agricultural produce was therefore qualified, considering that the comparison of the mean of on farm income for the two years revealed that there was an increment from Kes. 35,834,430.00 in 2023 to Kes. 43,626,030.00 in 2024.

4. Summary of the Findings

This study established a strong positive relationship between agricultural extension information services and productivity among smallholder farmers in Western Kenya. It highlights the potential of extension services to improve agricultural outcomes and supports their integration into sustainable agricultural policies. Future research should explore scaling these findings to other regions and crops to enhance global food security.

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