INTERNATIONAL JOUNAL OF: BUILT ENVIRONMENT AND EARTH SCIENCE

TIMBOU-AFRICA ACADEMIC PUBLICATIONS
INTERNATIONAL JOURNAL, MAY, 2022 EDITIONS
VOL. 9 NO. 4 ISSN: 1881-2167

ASSESSING FADAMA AGRICULTURE LAND PRODUCTIVITY IN AUCHI

[1]SEGHOSIME, ABDUL MUTANEBI; [2]RILWANI, MOMOH LAWAL; & [3]OJEIFO, MAGNUS O.

[1]Department of Humanities & Social Sciences, Auchi Polytechnic, Auchi. [2&3]Department of Geography and Environmental Management, Ambrose Alli University, Ekpoma, Nigeria.

ABSTRACT

This paper shows the application of Pearson product moment correlation coefficient (PPMC) in assessing Fadama land agricultural crop production. Data were generated from the field survey carried out in Auchi Fadama Agriculture land, where twenty (20) farm plots were sampled. Measurement of the farm sizes were carried out with the help of measuring tape rule and the unit

Introduction

Statistics according to Spiegel (1972) in Rilwani (2005) is concerned with the scientific methods for collecting, organising, summarising, presenting and analysing data as well as drawing valid conclusions and making reasonable decisions on the basis of such analysis. The term statistics in the words of Gupta and Gupta (2006) is used to mean either statistical data or statistical method. When used in the sense of statistical data it refers to quantitative aspects of things and it is numerical descriptive statistics where a single figure can be used to summarise a whole lot of data through the application of various data reduction techniques such as mean, mode, median, variance, standard deviation, etc.

The other aspect of statistics is as a body of theories and techniques employed in analysing the numerical information and using same to make

of measurement was in hectares while three crops (maize, yam & cassava) were sampled. Their output per farm plot measured with a weight scale in Kilogram (kg) and converted to tonnes, maize had 88.8 tonnes, yam had 112.4 tonnes while cassava had over 60% of the total output of 555.3 tonnes of crop yield annually. The results showed a correlation of: maize had 0.85; yam had 0.83 and cassava had 0.96 while the aggregate crop output had 0.98 which means that there is a strong positive relationship between farm size and farm yield. The origin, procedure for calculating the PPMC, its strength and weakness were highlighted too in this paper. It was therefore, concluded that the Pearson product moment correlation coefficient is a good statistical model to assess the strength and direction of association or correlation of two variables (farm size and farm yield).

Keywords: *Pearsonia Product Moment Correlation, Fadama, Agriculture, Farm size and Farm Yield*

wise decisions after scientific counting or measurement have been carried out. This is inferential statistics which is necessary for further decision making based on the available information which may not be complete with regards to our daily activities. Such inferential statistical techniques are probability, normal binomial and Poisson distribution theories, as well as Chi-square, Pearson product moment coefficient of correlation and regression analysis amongst several others (Lucey, 2002; Rilwani, 2005).

Pearsonian product moment coefficient of correlation is one of the statistical technique used in correlation analysis which deals with exploring relationship that may be linear or non-linear (Laerd, 2018). It is very useful in making accurate decisions after rigorous statistical manipulation in conjunction with the student t-test in testing the stated hypothesis which is a tentative statement about geographic phenomena in terms of relationship between variables subject to verification. A hypothesis assist researcher regarding geographic characteristics in making precised statements that would guide him in taking accurate decisions relating to geographic studies (Uluocha, 2015). The role of hypothesis in any research is to give credence to the final result when it is eventually tested empirically thereby helping to bridge the difference of reality and one's assumed belief.

In testing hypothesis, especially when it involves bivariate analysis, the parametric statistical technique such as the Pearson Product Moment Correlation Coefficient (PPMC) becomes paramount (Gbakeji, 2013) so as to determine the correlation between the independent and the dependent variables. Other statistical techniques like regression could also suffice in demonstrating correlation among variables as regards linearity or otherwise. Pearson's correlation coefficient according to Wikipedia is the covariance of the two variables divided by the product of their standard deviations. The form of the definition involves a product moment, that is, the mean - the first moment about the origin- of the product of the mean-adjusted random variables; hence the modifier *product-moment* in the name (Laerd, 2018).

The aim of this paper is to demonstrate the application of Pearson product moment correlation coefficient in assessing Fadama land agriculture productivity. And with specific objectives to: determine its origin; procedure for its calculation; strengths and weaknesses; and demonstrate the application of Pearson product moment correlation coefficient in assessing Fadama land agriculture crop productivity in Auchi.

Origin of Pearson Product Moment Correlation Coefficient (PPMC)

Rilwani (2005) stated that the origin of r is tied to Sir Galton and Pearson. It was developed by **Karl Pearson** from a related idea introduced by **Francis Galton** in the 1880 (Stingler, 1989). Galton wanted a single value that would express the amount of the regression phenomena in any particular relationship problem. Karl Pearson solved the problem with the formula r to which his name is attached (Rilwani, 2005). In statistics, the **Pearson correlation coefficient** (**PCC**), also referred to as **Pearson's r**, the **Pearson product-moment correlation coefficient** (**PPMCC**) or the **bivariate correlation**, is a measure of the linear correlation between two variables X and Y (Lucey, 2002; Rilwani, 2005; Uluocha, 2015; Laerd, 2018). It has a value between +1 and −1, where 1 is total positive linear correlation, 0 is no linear correlation, and −1 is total negative linear correlation (Uluocha, 2015). The Pearson r is the slope of the regression line when both x and y are measured in standard deviation units (Rilwani 2005).

Pearson's correlation coefficient when applied to a sample is commonly represented by the letter *r* and may be referred to as the sample correlation coefficient or the sample Pearson correlation coefficient (Moriya, 2008). We can obtain a formula for *r* by substituting estimates of the covariances and variances based on a sample. So if we have one dataset ($x_1,\ldots,x_n$) containing *n* values and another dataset ($y_1,\ldots,y_n$) containing *n* values then that formula for *r* is:

$$r = \frac{\sum (X-\bar{X})(Y-\bar{Y})}{\sqrt{(\sum(X-\bar{X})^2)(\sum(Y-\bar{Y})^2)}}$$

The absolute values of both the sample and population Pearson correlation coefficients are less than or equal to 1. Correlations equal to 1 or −1 correspond to data points lying exactly on a line (in the case of the sample correlation), or to a bivariate distribution entirely supported on a line (in the case of the population correlation).

According to Andrzej & Andrzej (2010), a key mathematical property of the Pearson correlation coefficient is that it is *invariant* under separate changes in location and scale in the two variables. That is, we may transform *X* to *a* + *bX* and transform *Y* to *c* + *dY*, where *a*, *b*, *c*, and *d* are constants with *b*, *d* > 0, without changing the correlation coefficient. Note that more general linear transformations do change the correlation.

Strengths and Weaknesses of PPMC

PPMC is widely used in the sciences. The interpretation of a correlation coefficient depends on the context and purposes. A correlation of 0.8 may be very low if one is verifying a physical law using high-quality instruments, but may be regarded as very high in the social sciences where there may be a greater contribution from complicating factors.

According to Laerd (2018), the Pearson product-moment correlation does not take into consideration whether a variable has been classified as a dependent or independent variable but treats all variables equally.
Lucey (2002) observed that the PPMC provides a measure of the strength of association between two variables; one the dependent variable, the other the independent variable. Furthermore, he stated that **r** can range from **+1**, that is, perfect positive correlation where the variables change value in the same direction as each other, to **-1** perfect negative correlation where **y** decreases linearly as **x** increases.
Under heavy noise conditions, extracting the correlation coefficient between two sets of stochastic variables is nontrivial, in particular where Canonical Correlation Analysis reports degraded correlation values due to the heavy noise contributions (Moriya, 2008).
Another weakness is that it cannot be calculated for non-numeric data. It is important to realize that the Pearson correlation coefficient, *r*, does not represent the slope of the line of best fit. Therefore, if you get a Pearson correlation coefficient of +1 this does not mean that for every unit increase in one variable there is a unit increase in another. It simply means that there is no variation between the data points and the line of best fit.
The Pearson correlation cannot determine a cause-and-effect relationship. It can only establish the strength of linear association between two variables (Laerd, 2018).

Procedures for Calculating PPMC

There are two methods of computing r. The first method of 'r' computation which involves the sum of squares and product of the variables (X & Y) is demonstrated in appendix I to IV, while the second (alternative) method is demonstrated in appendix I. The Following steps are involved in calculating PPMC (r) according to Uluocha (2015):
Step one: Find the mean of the values of the independent variable as well as that of the dependent variable. (We can denote the independent variable as X and the dependent variable as Y. The mean of the independent variable can therefore be expressed as X and the dependent variable as Y).

Step Two: Subtract the mean of each variable from each of the values of that variable (i.e X-X and also Y-Y).
Step Three: Square each of the values obtained in step two above {i.e. (X-X)^2 as well as (Y-Y)^2 }, and sum the product {i.e. ∑(X-X)^2 and ∑(Y-Y)^2}.
Step Four: Multiply each X-X value with the corresponding Y-Y value {i.e. (X-X)(Y-Y)} and sum the product {i.e. ∑(X̅-X)(Y-Y)}.
Step Five: Apply the formula to find 'r'.

Interpretation of Correlation Coefficient

The correlation coefficient ranges from −1 to 1. A value of 1 implies that a linear equation describes the relationship between *X* and *Y* perfectly, with all data points lying on a line for which *Y* increases as *X* increases. A value of −1 implies that all data points lie on a line for which *Y* decreases as *X* increases. A value of 0 implies that there is no linear correlation between the variables (Wikipedia, 2018).

More generally, note that $(X - \bar{X})(Y - \bar{Y})$ is positive if and only if *X* and *Y* lie on the same side of their respective means. Thus the correlation coefficient is positive if *X* and *Y* tend to be simultaneously greater than, or simultaneously less than, their respective means. The correlation coefficient is negative (anti-correlation) if *X* and *Y* tend to lie on opposite sides of their respective means. Moreover, the stronger is either tendency, the larger is the absolute value of the correlation coefficient (Gupta & Gupta, 2006).

Rogers and Nicewander (1988) catalogued thirteen ways of interpreting correlation:

- Function of raw scores and means
- Standardized covariance
- Standardized slope of the regression line
- Geometric mean of the two regression slopes
- Square root of the ratio of two variances
- Mean cross-product of standardized variables
- Function of the angle between two standardized regression lines
- Function of the angle between two variable vectors
- Rescaled variance of the difference between standardized scores
- Estimated from the balloon rule

TIJBEES
ISSN: 1881-2167

- Related to the bivariate ellipses of isoconcentration
- Function of test statistics from designed experiments
- Ratio of two means

Review of Literature

Agriculture does not only play a central role of providing food and employment for the large population but also provides the basic source of industrial raw materials for industrial growth and national development (Yesufu & Gbakeji, 2006). A large number of Nigerians depends on agriculture for livelihood (Rilwani & Gbakeji 2008). The contribution of agriculture to national development declined due to oil exploitation and exportation; thus, there was need to boost agriculture and this has been achieved through various national programs such as Operation Feed the Nation (OFN), Directorate of Food, Road and Rural Infrastructure (DIFFRI), the National Fadama Development Project (NFDP), etc. Some of the factors that militated against the full realization of the potential benefits of agricultural production activities, which include poor rural infrastructure, low investment in irrigation technology, poor organization of farmers and the futility of individual/subsistence farming systems are gradually being addressed by the present administration through infrastructural development and a host of other measures.

In Nigeria, the term "Fadama" is of Hausa origin which means irrigable land—usually low-lying by shallow aquifers found along major river systems (Fadama Development Project -FDP-, 2003). In addition to providing a source of water for livestock during dry seasons, Fadama also support large and diverse resident of transient wildlife including herbivores, carnivores and migratory birds. Fadama lands are suitable for dry season cultivation; hence the concept is often referred to as dry season farming (Seghosime, 2015). According to Agbo (2012), the Fadama project is a World Bank Assisted Project, involving agricultural diversification with development objective to increase and sustain the incomes of users; that is, those who depend directly or indirectly on Fadama resources, like crop farmers, livestock farmers, fish farmers, among other types of farming.

Fadama agricultural land use is influenced by economic, cultural, political, and historical and land – tenure factors at multiple scales. Land use according to Meyer (as cited in Izuagbe, 2012) refers to the manner in which humans employ the land and its resources. He further stated that examples of land use include agriculture and urban development. Generally, land use is referred to as man's activities and the various uses which are carried on land. Land cover is referred to as natural vegetation, water bodies, rock/soil, artificial cover and others resulting due to land transformation. Since both land use and land cover are closely related and are not mutually exclusive they are interchangeable as the former is inferred based on the land cover and on their contextual evidence.

Uluocha (2015) argued that the PPMC is the most powerful and commonly used method of computing a correlation coefficient between variables that are linearly related. He further stated that it is a parametric test and the standard measure of correlation for numeric data. Edobor (2016) used the Pearson product moment correlation coefficient to examine the spatial correlation between population density and incidence of typhoid fever in Benin City and concluded that the coefficient of correlation 'r' is 0.978 which is a very strong positive correlation.

Akangbe, Komolafe & Oduwaiye (2015) applied the Pearson product moment correlation (PPMC) analysis to shows that all the selected socio-economic characteristics of the respondents (gender, age, marital status, educational status, and farm size) were not statistically significant, with perceived effects of occupational hazards of respondents. In other words, the perceived effects of occupational hazards experienced by farmers in the study were not influenced by the socio-economic characteristics of respondents. In a similar study, Onasanya (2009) applying the PPMC found that there is no significant relationship between farm-related health problems and farmer productivity.

Similarly, Seghosime (2015) had applied same in determining the relationship between Fadama farm sizes and the farms output in Auchi and its environs, and concluded that they are positively correlated with 'r' of 0.98 which is a very strong positive correlation. Robert (1991) examines the use of the Pearson product moment correlation coefficient and the Spearman rank correlation coefficient on map data that are spatially correlated and infer that in this case standard estimators underestimate the true sampling variance of the Pearson coefficient. Furthermore, he stated that Correlation coefficients are calculated to measure the linear association between two variables (X and Y). When data are collected on X and Y for n points or areas on a map, such coefficients measures the association between the two sets of map observations but the measures are a spatial in that they disregard the spatial distribution of the pairs of values.

Demonstration of PPMC Application in Fadama land Agriculture Productivity in Auchi

Mixed cropping is a system of agricultural practice in Nigeria. It is a common farm practice within Edo state and Auchi in particular see figure 1. It enables the farmer to cultivate more than one particular crop within a plot of farm land. Crops such as maize, yam cassava, spinach, groundnut, okra, etc, could be found in a plot of land. The harvest period of these crops varies from four months to twelve months depending on the time of the year they were cultivated (sown). Fadama agricultural land productivity were assessed through examining the cultivation of plots of farm land with particular interest in maize, yam and cassava production as staple food crops within Auchi.

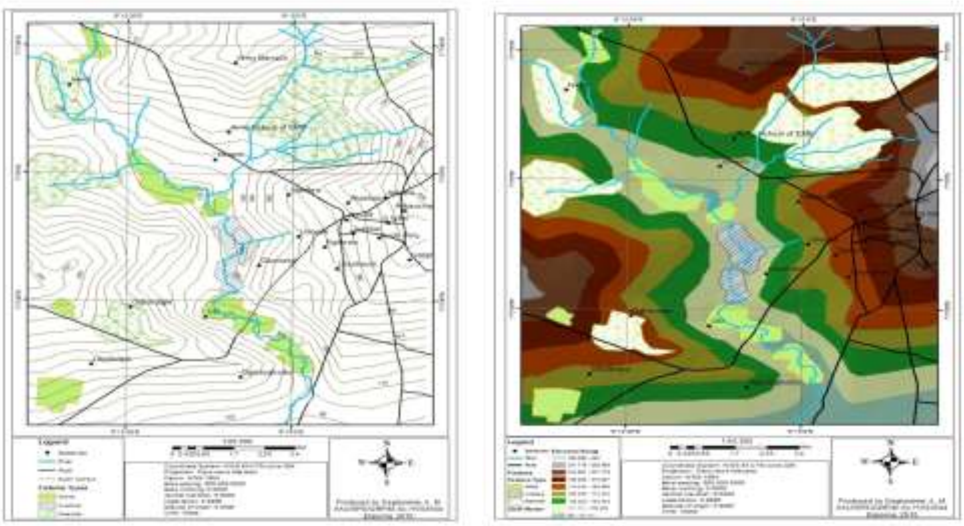

Figure 1: Contour Map of Fadama Agriculture Land use of Auchi

TIJBEES
ISSN: 1881-2167

Hypotheses

The following hypotheses were tested based on the sampled farm sizes of farmers and their sampled farm output (crop yield).

- There is no relationship between the size of farm in Fadama land and maize output in the study area.
- There is no relationship between the size of farm in Fadama land and yam output in the study area.
- There is no relationship between the size of farm in Fadama land and cassava output in the study area.
- There is no correlation between the size of farm and agricultural productivity.

Research Method

Data on farm sizes and crop yield were sourced from field measurement. Measuring tape was used in determining the size of farms in hectares and crop yield were measured with a weight scale in kilograms which were converted to tonnes. The harvest (Maize, Yam and Cassava) measurement were carried out within plots of the sampled farms and through interpolation the yield for the entire farm calculated. These activities were carried out at various points on different occasion. Maize was measured putting the harvested curbs of maize into a bag and weighing them (bags) on a weight scale. Same procedure was also applied to determining the weight of both yam and cassava within the sampled farm plots.

It is important to note here that, the average yam size for the purpose of this study is 13cm in diameter and 41cm in length, with an average weight of 6.2kg. An average curb of maize is 7cm in diameter and 26cm in length with a weight of 1.8kg. And cassava bunch harvested from a single point aggregate weight ranges from 17.6kg to 24.7kg on the average for a 12months old cassava. Personal interview with the farmers with respect to their farm sizes was very helpful and these constitute the primary sources of data. And the secondary sources were already published literature as referenced in this write-up.

Data Presentation and Discussion of Results

Data on farm sizes and crop yields are presented in a tabular format and analysed applying the Pearson product moment correlation coefficient (PPMC) in conjunction with the student t-test to test the various hypotheses.

Below are data obtained from a field survey in Auchi to assess Fadama agriculture land crop productivity as shown in tables 1, 2, 3 and 4.

Table 1: Farm sizes and Maize Output in Auchi

Number of Sampled Farms	Size of Farm (Hectares)	Annual Maize Output (Tons.)
1	2.6	2.3
2	4.3	3.7
3	2.3	5.2
4	6.7	2.8
5	6.3	4.1
6	6.4	2.8
7	5.9	4.2
8	3.9	1.9
9	2.3	2.5
10	10.4	10.1
11	6.5	6.3
12	11.0	9.7
13	2.4	3.1
14	4.0	3.0
15	4.1	2.0
16	5.7	2.8
17	3.6	1.8
18	25.2	12.6
19	4.0	2.8
20	5.9	5.1
Total	123.5	88.8

Source: Field Survey (2015)

Table 1 and appendix I indicate that the correlation coefficient (r) of the above distribution is 0.85 which shows a strong association between the variables of farm size and maize production within the study area. An alternative method indicates that the correlation coefficient (r) is 0.85 which shows a strong positive correlation between the variables.

Table 2: Farm sizes and Yam Output in Auchi

Number of Sampled Farms	Size of Farm (Hectares)	Annual Yam Output (Tons.)
1	2.6	5.8
2	4.3	4.9
3	2.3	2.6
4	6.7	4.2
5	6.3	4.7
6	6.4	3.9
7	5.9	5.1
8	3.9	1.9
9	2.3	3.7
10	10.4	2.8
11	6.5	12.1
12	11.0	4.7
13	2.4	6.2
14	4.0	2.5
15	4.1	1.5
16	5.7	4.4
17	3.6	0.6
18	25.2	28.3
19	4.0	4.9
20	5.9	7.6
Total	123.5	112.4

Source: Field Survey (2015)

From the Correlation analysis in appendix II, it is clear that there is a strong positive correlation between farm size and yam productivity within the study area as r is 0.83

Table 3: Farm sizes and Cassava Output

Number of Sampled Farms	Size of Farm (Hectares)	Annual Cassava Output (Tons.)
1	2.6	6.3
2	4.3	7.3
3	2.3	6.8
4	6.7	19.2
5	6.3	18.6

6	6.4	18.9
7	5.9	17.8
8	3.9	13.8
9	2.3	7.7
10	10.4	35.8
11	6.5	23.7
12	11.0	34.9
13	2.4	5.0
14	4.0	9.6
15	4.1	15.7
16	5.7	13.8
17	3.6	14.3
18	25.2	74.1
19	4.0	7.6
20	5.9	3.3
Total	123.5	354.2

Source: Field Survey (2015)

From the Correlation analysis in appendix III, it is clear that there is a perfect strong positive correlation between farm size and cassava output within the study area as r is 0.96

Table 4: Farm sizes and Aggregate Farm Output (Maize, Yam & Cassava) in Auchi

Number of Sampled Farms	Size of Farm (Hectares)	Annual Farm Output (Tons.)
1	2.6	14.4
2	4.3	15.9
3	2.3	14.6
4	6.7	26.2
5	6.3	27.3
6	6.4	25.6
7	5.9	27.1
8	3.9	17.6
9	2.3	13.9

ISSN: 1881-2167

10	10.4	48.7
11	6.5	42.1
12	11.0	49.3
13	2.4	14.3
14	4.0	15.1
15	4.1	19.2
16	5.7	21.0
17	3.6	16.7
18	25.2	115.0
19	4.0	15.3
20	5.9	16.0
Total	123.5	555.3

Source: Field Survey (2015)

Applying the Pearson Product Moment Correlation Coefficient (r) with the formula given below

$$r = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{(N\sum X^2 - (\sum X)^2)\ (N\sum Y^2 - (\sum Y)^2)}}$$

Where:
N = Total number of Sampled Farms
∑ = Summation
X = Farm Sizes in Hectares
Y = Annual Farm Output in Tonnage (Tons.)

r= 0.98 (See Appendix I)

ISSN: 1881-2167

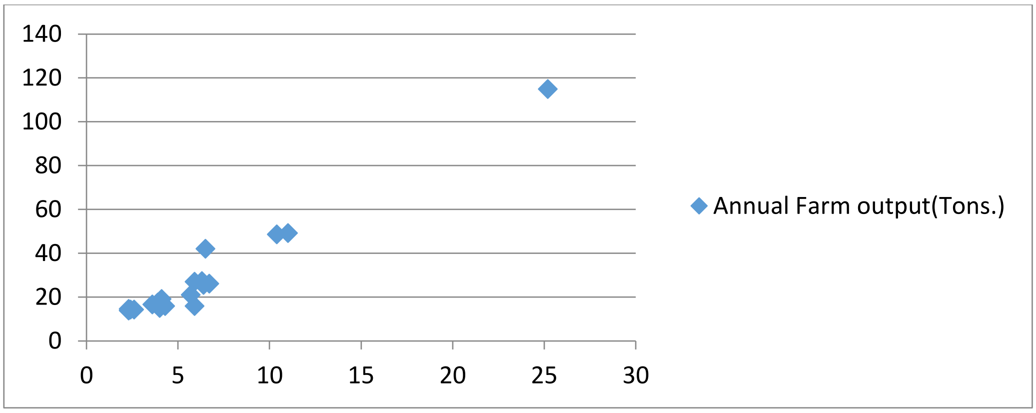

Figure 1: Farm sizes and farm yield/output

From figure 1 above, the visual inspection of the scatter plot implies that the correlation between farm sizes (hectares) and farm output (tonnes) is direct (positive).

Interpretation

The coefficient of determination shows that $r^2 = 0.9604$ (96.04%) is very close to +1 which falls within the range > or = (≥) 0.90 but < 1.0. The interpretation is that there is a very strong or very high (Good) positive correlation between Fadama Land and Crop Production in Auchi.

Substituting 'r' in 't'- test formula, calculated 't' value is 20.89 (see appendix IV) while the tabulated 't' values at 18 degree of freedom at 5% and 1% level of significance are 2.101 and 2.878 respectively.

Decision

The numerical evidence is strong enough to reject the null hypothesis which states that "there is no correlation between the size of farm and agricultural productivity in Auchi". And conclude that there is a very strong positive correlation between the size of farm and agricultural productivity in Auchi.

Discussion of Results/Findings

Table 1 and appendix I indicate that the correlation coefficient (r) of the distribution is 0.85 which shows a strong association between the variables of farm size and maize production within the study area. An alternative method indicates that the correlation coefficient (r) is 0.85 which shows a strong positive correlation between the variables. It is clear that maize production within the study area from the data in table 1 varied from farm to farm with an average yield of 0.8 tonne per hectare which is less than the 2 tonnes per hectare as the national standard. Looking at the total yield per sampled crop, it is very glaring that maize had the least yield per annum of 88.8 tonnes (16%) followed by yam with 112.4 tonnes (20.2%) while cassava accounted for the highest yield of 354.2 tonnes (63.8%) out of the total farm yield of 555.3 tonnes of crop output annually.

From table 2, the correlation analysis in appendix II, clearly indicates that there is a strong positive correlation between farm size and yam productivity within the study area as r is 0.83. Yield with regards to yam production varies from farm to farm irrespective of the farm sizes. This could be attributed the varied soil fertility, quality of seedlings, methodology of yam production adopted by farmers, etc. The total yield from the sampled farms culminated to 112.4 tonnes per annum with an average yield of 0.91tonne of yam per hectares which is far below the national standard of five (5) tonnes per hectare. The largest sampled farm has an average yam yield of 1.12 tonnes per hectare. On the other hand, the smallest sampled farm yield had 1.13 tonnes per hectare. The implication of this is that certain farmers may prefer to cultivate cassava and maize more than yam and the yields varied as such as shown in tables 1, 2 and 3.

Similarly, from table 3, it is clear that the cassava yield varied from farm to farm as the sizes varies too. Cassava production is a well organised and developed crop within the region as its yield account for over 60% of the total crop output within the area annually. This can be attributed to its ease of cultivation as lesser inputs are required and coupled with its high demand and uses for a variety of purposes. The average annual output or yield per hectare is 2.87 tonnes which is far below the national output per hectare of 10.6 tonnes. It is also clear that the correlation analysis in appendix III, shows that there is a very strong positive correlation between farm size and cassava output within the study area as r is 0.96.

The aggregate farm yield for the three sampled crops as stated in table 4, the coefficient of correlation shows that 0.98 is very close to +1 which falls within the range > or = 0.90 but < 1.0. The interpretation is that there is a very strong or very high (Good) positive correlation between Fadama Land and Crop Production in Auchi.

Conclusion

In conclusion, for correlation analysis the coefficient gives an indication of the direction and strength or magnitude of the linear relationship between two variables. The study shows that there is a very high positive correlation between farm size within Fadama land and crop production. This has also shown that the PPMC is a very important tool for measuring the linear correlation between two variables when considering bivariate normal distribution. It is therefore, recommended for statistical analysis involving bivariate analysis.

References

Akangbe, J.A.; Komolafe, S.E. & Oduwaiye, M.O. (2015) Perceived effects of occupational hazards on farmers' productivity in Kwara State, Nigeria J UOEH 37（3）: 69 — 175 https://www.jstage.jst.go.jp/article/juoeh/37/3/37_169/_pdf/-char/en

Andrzej, B & Andrzej, J. (2010). *Life time of correlations and its applications.* Wydawnictwo Niezależne. 5–21. ISBN 9788391527290.

Edobor, W.W. (2015) Population density and the incidence of typhoid fever in Benin City. *Annals of Environmental Studies* 1, no. 1. 149-156

Galton, F. (1886) Regression towards mediocrity in hereditary stature, *Journal of the Anthropological Institute of Great Britain and Ireland*, **15** : 246–263.

Gbakeji, J.O. (2013). *Lecture note on Quantitative Techniques*. GEM., AAU. Ekpoma.

Gupta, C.B. & Gupta, V. (2006) *An introduction to statistical methods* (23rd Rev. edition) New Delhi. Vikas Publishing

Izuagie, H. (2012) *Production of landuse and land cover map of Ekpoma from satellite imagery.* A.A.U., Geography and Regional Planning , Unpublished Thesis

Laerd, S. (2018) ***Statistics - Pearson product-moment correlation***
https://statistics.laerd.com/statistical-guides/pearson-correlation-coefficient-statistical-guide.php

Lucey, T. (2002) *Quantitative techniques* (sixth edition) London. Bookpower.

Moriya, N. (2008). Fengshan-Yang, (ed). *Noise-related multivariate optimal joint-analysis in longitudinal stochastic processes.* Nova Science Publishers, Inc.: 223–260. ISBN 978-1-60021-976-4

Onasanya, A.S. (2009).Perceived effects of faming related health problems of farmers' productivity in Yewa north area of Ogun State, Nigeria. *The Social Sciences* 4: 42-48

Pearson, K. (20 June 1895) "Notes on regression and inheritance in the case of two parents," *Proceedings of the Royal Society of London*, 58: 240–242.

Rilwani, M. L. & Gbakeji, J. O. (2008). An assessment of the impact of asphalt production on soil quality for crop production. *Confluence Journal of Environmental Studies,* 3(1) 1-15

Rilwani, M. L. (2005) *Statistics for environmental and social sciences.* Easy-way computers/printing. Benin City.

Robert, H. (1991). Bivariate correlation with spatial data, *Geographical Analysis*, Vol.23, No.3 Ohio State University Press Revised version

Rogers, J. and Nicewander, N. (1988). Thirteen ways to look at the correlation coefficient (pdf). *The American Statistician*. 42 (1): 59–66. doi:10.2307/2685263.

Seghosime, A.M. (2015). *Mapping and assessment of Fadama land use agriculture production from satellite imagery in Auchi and its environs.* MSc. Thesis in Department of Geography and Environmental Management, AAU Ekpoma.

Segynola, A. A. (2003). *Concept of sustainable development*. Easy Printers, Benin City.

Stigler, S. M. (1989). Francis Galton's account of the invention of correlation. *Statistical Science. 4 (2): 73–79.* doi:10.1214/ss/1177012580. JSTOR 2245329.

Uluocha, N.O. (2015) *Research methods in Geography and Environmental tudies.* Akoka Yaba, Lagos. Sam Iroanusi publications.

Yesufu, A.O. & Gbakeji J.O. (2006) Agricultural finance: a case study of rice production in Esan West local government area, Edo state. *Confluence Journal of Environmental Studies,* 1(2), 40-47.

APPENDIX I: HYPOTHESIS TESTING

Data to Illustrate the Calculation of Correlation between Farm size and Maize Production within the study area

Sampled Farm	Size of Farm (Hectares) – X	Annual Maize Output(Tons.) – Y	(X-X)	(Y-Y)	(X-X)²	(Y-Y)²	(X-X)(Y-Y)
1	2.6	2.3	-3.6	-2.1	13.0	4.4	7.6
2	4.3	3.7	-1.9	-0.7	3.6	0.5	1.3
3	2.3	5.2	-3.9	0.8	15.2	0.6	-3.1
4	6.7	2.8	0.5	-1.6	0.3	2.6	-0.8
5	6.3	4.1	0.1	-0.3	0.0	0.1	-0.0
6	6.4	2.8	0.2	-1.6	0.0	2.6	-0.3
7	5.9	4.2	-0.3	-0.2	0.1	0.0	0.1
8	3.9	1.9	-2.3	-2.5	5.3	6.3	5.8
9	2.3	2.5	-3.9	-1.9	15.2	3.6	7.4
10	10.4	10.1	4.2	5.7	17.6	32.5	23.9
11	6.5	6.3	0.3	1.9	0.1	3.6	0.6
12	11.0	9.7	4.8	5.3	23.0	28.0	25.4
13	2.4	3.1	-3.8	-1.3	14.4	1.7	4.9
14	4.0	3.0	-2.2	-1.4	4.8	2.0	3.0
15	4.1	2.0	-2.1	-2.4	4.4	5.8	5.0
16	5.7	2.8	-0.5	-1.6	0.3	2.6	0.8
17	3.6	1.8	-2.6	-2.6	6.8	6.8	6.8
18	25.2	12.6	19.0	8.2	361.0	67.2	155.8
19	4.0	2.8	-2.2	-1.6	4.8	2.6	3.5

20	5.9	5.1	-0.3	0.7	0.1	0.5	-0.2
Total	**∑ X=123.5** **$\bar{X}$ = 6.175**	**∑Y=88.8** **$\bar{Y}$ = 4.44**			**∑ = 490.0**	**∑ = 174.0**	**∑= 247.5**

Substituting the above in the formula below,

$$r = \frac{\sum (X-\bar{X})(Y-\bar{Y})}{\sqrt{(\sum(X-\bar{X})^2)(\sum(Y-\bar{Y})^2)}}$$

$$r = \frac{247.5}{\sqrt{(490.0 \times 174.0)}}$$

$$r = \frac{247.5}{\sqrt{85,260}}$$

$$r = \frac{247.5}{292} = 0.848$$

$$\mathbf{r = 0.85}$$

Therefore, the coefficient of determination is $r^2 = (0.85)^2 = 0.72$ (72%) which means that there is a strong association between the size of farm land and crop output

Applying the t-test formula

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

$$t = 0.85\sqrt{\frac{20-2}{1-(0.85^2)}}$$

$$t = 6.8425$$

Therefore, calculated 't' value is: 6.8425

Tabulated value for 'n – 2' for 18 degree of freedom applying 5% level of significance is 2.101 and applying 1% level of significance is 2.878.

Decision/ Conclusion

Since 6.8425 is greater than 2.101 or 2.878 the numerical evidence is strong enough to reject the null hypothesis and conclude that "there is relationship between the size of farm in Fadama land and maize output in the study area".

Alternative Method for Determining (Calculating) PPMC

Farm sizes and Maize Output at the river Orle Fadama area in Auchi

Sampled Farms	Size of Farm (Hectares) X	Annual Maize Output(Tons.) Y	X^2	Y^2	XY
1	2.6	2.3	6.76	5.29	5.98
2	4.3	3.7	18.49	13.69	15.91

TIJBEES
ISSN: 1881-2167

3	2.3	5.2	5.29	27.04	11.96
4	6.7	2.8	44.89	7.84	18.76
5	6.3	4.1	39.69	16.81	25.83
6	6.4	2.8	40.96	7.84	17.92
7	5.9	4.2	34.81	17.64	24.78
8	3.9	1.9	15.21	3.61	7.41
9	2.3	2.5	5.29	6.25	5.75
10	10.4	10.1	108.16	102.01	105.04
11	6.5	6.3	42.25	39.69	40.95
12	11.0	9.7	121.00	94.09	106.70
13	2.4	3.1	5.76	9.61	7.44
14	4.0	3.0	16.00	9.00	12.00
15	4.1	2.0	16.81	4.00	8.20
16	5.7	2.8	32.49	7.84	15.96
17	3.6	1.8	12.96	3.24	6.48
18	25.2	12.6	635.04	158.76	317.52
19	4.0	2.8	16.00	7.84	11.20
20	5.9	5.1	34.81	26.01	30.09
Total	$\sum X$=123.5	$\sum Y$= 88.8	$\sum X^2$=1252.67	$\sum Y^2$= 568.10	$\sum XY$=795.88

Applying the formula below and by substituting the above in the formula,

$$r = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{(N\sum X^2 - (\sum X)^2)\ (N\sum Y^2 - (\sum Y)^2)}}$$

Where:

$N\sum XY = 20 \times 795.88 = 15,917.60$

$\sum X = 123.5$

$\sum Y = 88.8$

$N\sum X^2 = 20 \times 1252.67 = 25053.4$

$(\sum X)^2 = 15252.25$

$N\sum Y^2 = 20 \times 568.10 = 11,362.00$

$(\sum Y)^2 = 88.8^2 = 7,885.44$

Substituting the above in the Product Moment Coefficient of Correlation formula, we have:

$$r = \frac{15,917.60 - (123.5 \times 88.8)}{\sqrt{(25,053.4 - 15,252.25) \times (11,362.00 - 7,885.44)}}$$

$$r = \frac{4,950.8}{\sqrt{9,801.15 \times 3,476.56}}$$

$$r = \frac{4,950.8}{\sqrt{34,074286.044}}$$

$$r = \frac{4,950.8}{5,837.32} = 0.848$$

r= 0.85

Therefore, the coefficient of determination is $r^2 = (0.85)^2 = 0.72$ (72%) which means that there is a strong positive association between the size of farm land and crop output.

TIJBEES
ISSN: 1881-2167

Applying the t-test formula

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

$$t = 0.85\sqrt{\frac{20-2}{1-(0.85^2)}}$$

t = 6.82

Therefore, calculated 't' value is: 6.82

Tabulated value for 'n – 2' for 18 degree of freedom applying 5% level of significance is 2.101 and applying 1% level of significance is 2.878.

Decision/ Conclusion

Since 6.82 is greater than 2.101 or 2.878 the numerical evidence is strong enough to reject the null hypothesis and conclude that "there is relationship between the size of farm in Fadama land and maize output in the study area".

APPENDIX II: HYPOTHESIS TESTING

Farm sizes and Yam Output at the river Orle Fadama area in Auchi

Sampled Farms	Size of Farm (Hectares) X	Annual Yam Output(Tons.) Y	X^2	Y^2	XY
1	2.6	5.8	6.76	33.64	15.08
2	4.3	4.9	18.49	24.01	21.07
3	2.3	2.6	5.29	6.76	5.98
4	6.7	4.2	44.89	17.64	28.14
5	6.3	4.7	39.69	22.09	29.61
6	6.4	3.9	40.96	15.21	24.96
7	5.9	5.1	34.81	26.01	30.09
8	3.9	1.9	15.21	3.61	7.41
9	2.3	3.7	5.29	13.69	8.51
10	10.4	2.8	108.16	7.84	29.12
11	6.5	12.1	42.25	146.41	78.65
12	11.0	4.7	121.00	22.09	51.70
13	2.4	6.2	5.76	38.44	14.88
14	4.0	2.5	16.00	6.25	10.00
15	4.1	1.5	16.81	2.25	6.15
16	5.7	4.4	32.49	19.36	25.08
17	3.6	0.6	12.96	0.36	2.16
18	25.2	28.3	635.04	800.89	713.16
19	4.0	4.9	16.00	24.01	19.60
20	5.9	7.6	34.81	57.76	44.84

Total	$\sum X$=123.5	$\sum Y$=112.4	$\sum X^2$=1,252.67	$\sum Y^2$=1,288.32	$\sum XY$=1,166.19

Applying the formula below and by substituting the above in the formula,

$$r = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{(N\sum X^2 - (\sum X)^2)(N\sum Y^2 - (\sum Y)^2)}}$$

Where:

$N\sum XY = 20 \times 1{,}166.19 = 23{,}323.8$

$\sum X = 123.5$

$\sum Y = 112.4$

$N\sum X^2 = 20 \times 1{,}252.67 = 25{,}053.4$

$(\sum X)^2 = 15{,}252.25$

$N\sum Y^2 = 20 \times 1{,}288.32 = 25{,}766.4$

$(\sum Y)^2 = (112.4)^2 = 12{,}633.76$

Substituting the above in the Product Moment Coefficient of Correlation formula, we have:

$$r = \frac{23{,}323.8 - (123.5 \times 112.4)}{\sqrt{(25{,}053.4 - 15{,}252.25) \times (25{,}766.4 - 12{,}633.76)}}$$

$$r = \frac{9{,}442.4}{\sqrt{9{,}801.15 \times 13{,}132.64}}$$

$$r = \frac{9{,}442.4}{\sqrt{128{,}714{,}974.54}}$$

$$r = \frac{9{,}442.4}{11{,}345.26}$$

r= 0.83

Applying the t-test formula

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

$$t = 0.83\sqrt{\frac{20-2}{1-(0.83^2)}}$$

t = 48.02

Therefore, calculated 't' value is:48.02

Tabulated value for 'n – 2' for 18 degree of freedom applying 5% level of significance is 2.101 and applying 1% level of significance is 2.878.

Decision/ Conclusion

Since 48.02 is greater than 2.101 or 2.878, the numerical evidence is strong enough to reject the null hypothesis and conclude that "there is relationship between the size of farm in Fadama land and yam production in the study area".

APPENDIX III: HYPOTHESIS TESTING

Farm sizes and Cassava Output at the river Orle Fadama area in Auchi

Sampled Farms	Size of Farm (Hectares) X	Annual Cassava Output(Tons.) Y	X^2	Y^2	XY
1	2.6	6.3	6.76	39.69	16.38
2	4.3	7.3	18.49	53.29	31.39
3	2.3	6.8	5.29	46.24	15.64
4	6.7	19.2	44.89	368.64	128.64
5	6.3	18.6	39.69	345.96	117.18
6	6.4	18.9	40.96	357.21	120.96
7	5.9	17.8	34.81	316.84	105.02
8	3.9	13.8	15.21	190.44	53.82
9	2.3	7.7	5.29	59.29	17.71
10	10.4	35.8	108.16	1,281.64	372.32
11	6.5	23.7	42.25	561.69	154.05
12	11.0	34.9	121.00	1,218.01	383.90
13	2.4	5.0	5.76	25.00	12.00
14	4.0	9.6	16.00	92.16	38.40
15	4.1	15.7	16.81	246.49	64.37
16	5.7	13.8	32.49	190.44	78.66
17	3.6	14.3	12.96	204.49	51.48
18	25.2	74.1	635.04	5,490.81	1,867.32
19	4.0	7.6	16.00	57.76	30.40
20	5.9	3.3	34.81	10.89	19.47
Total	$\sum X = 123.5$	$\sum Y = 354.2$	$\sum X^2 = 1,252.67$	$\sum Y^2 = 11,156.98$	$\sum XY = 3,679.11$

Applying the formula below and by substituting the above in the formula,

$$r = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{(N\sum X^2 - (\sum X)^2)\ (N\sum Y^2 - (\sum Y)^2)}}$$

Where:

$N\sum XY = 20 \times 3,679.11 = 73,582.2$

$\sum X = 123.5$

$\sum Y = 354.2$

$N\sum X^2 = 20 \times 1,252.67 = 25,053.4$

$(\sum X)^2 = 15,252.25$

$N\sum Y^2 = 20 \times 11,156.98 = 223,139.6$

$(\sum Y)^2 = 354.2^2 = 125,457.64$

Substituting the above in the Product Moment Coefficient of Correlation formula, we have:

$$r = \frac{73{,}582.2 - (123.5 \times 354.2)}{\sqrt{(25{,}053.4 - 15{,}252.25) \times (223{,}139.6 - 125{,}457.64)}}$$

$$r = \frac{73{,}582.2 - 43{,}743.7}{\sqrt{9{,}801.15 \times 97{,}681.96}}$$

$$r = \frac{29{,}838.5}{\sqrt{957{,}395{,}542.25}}$$

$$r = \frac{29{,}838.5}{30{,}941.81}$$

r= 0.96

Applying the t-test formula

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

$$t = 0.96\sqrt{\frac{20-2}{1-(0.96^2)}}$$

t = 14.5461

Therefore, calculated 't' value is: 14.5461
Tabulated value for 'n – 2' for 18 degree of freedom applying 5% level of significance is 2.101 and applying 1% level of significance is 2.878.

Decision/ Conclusion

Since 14.5461 is greater than 2.101 or 2.878 the numerical evidence is strong enough to reject the null hypothesis and conclude that "there is relationship between the size of farm in Fadama land and cassava output in the study area".

APPENDIX IV: HYPOTHESIS TESTING

Farm sizes and Sampled Aggregate Crop Output at the River Orle Fadama area in Auchi

Sampled Farms	Size of Farm(s) (Hectares) X	Annual Maize, Yam & Cassava Output(Tons.) Y	X^2	Y^2	XY
1	2.6	14.4	6.76	207.36	37.44
2	4.3	15.9	18.49	252.81	68.37
3	2.3	14.6	5.29	213.16	33.58
4	6.7	26.2	44.89	686.44	175.54
5	6.3	27.3	39.69	745.29	171.99

6	6.4	25.6	40.96	655.36	163.84
7	5.9	27.1	34.81	734.41	159.89
8	3.9	17.6	15.21	309.76	68.64
9	2.3	13.9	5.29	193.21	31.97
10	10.4	48.7	108.16	2,371.69	506.48
11	6.5	42.1	42.25	1,772.41	273.65
12	11.0	49.3	121.00	2,430.49	542.30
13	2.4	14.3	5.76	204.49	34.32
14	4.0	15.1	16.00	228.01	60.40
15	4.1	19.2	16.81	368.64	78.72
16	5.7	21.0	32.49	441.00	119.70
17	3.6	16.7	12.96	278.89	60.12
18	25.2	115.0	635.04	13,225.00	2,898.00
19	4.0	15.3	16.00	234.09	61.20
20	5.9	16.0	34.81	256.00	94.40
Total	$\sum X = 123.5$	$\sum Y = 555.3$	$\sum X^2 =$ 1,252.67	$\sum Y^2 =$ 25,808.51	$\sum XY =$ 5,640.55

Source: Seghosime, 2015

To test for significance, we therefore apply the students' t-test and the formula is given as:

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

Where: t = t-test
r = Correlation coefficient
N = Number of Sampled Farms

Therefore, applying the Product Moment Coefficient of Correlation (r) with the formula given below as:

$$\mathbf{r = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{(N\sum X^2 - (\sum X)^2)\ (N\sum Y^2 - (\sum Y)^2)}}}$$

Where:
$N\sum XY = 20 \times 5{,}640.55 = 112{,}811.00$
$\sum X = 123.5$
$\sum Y = 555.3$
$N\sum X^2 = 20 \times 1{,}252.67 = 25{,}053.4$
$(\sum X)^2 = 15{,}252.\ 25$
$N\sum Y^2 = 20 \times 25{,}808.51 = 516{,}170.20$
$(\sum Y)^2 = 308{,}358.09$
Substituting the above in the Product Moment Coefficient of Correlation formula, we have:

TIJBEES
ISSN: 1881-2167

$$r = \frac{112{,}811 - (123.5 \times 555.3)}{\sqrt{(25{,}053.4 - 15{,}252.25) \times (516{,}170.2 - 308{,}358.09)}}$$

$$r = \frac{44{,}231.45}{\sqrt{2{,}036{,}797{,}662}}$$

$$r = \frac{44{,}231.45}{45{,}130.9}$$

r= 0.98

Applying the t-test formula

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

$$t = .98\sqrt{\frac{20-2}{1-0.9604}}$$

t = 20.89

Therefore, calculated 't' value is: 20.89

Tabulated value for 'n – 2' for 18 degree of freedom applying 5% level of significance is 2.101 and applying 1% level of significance is 2.878.

Decision/ Conclusion

Since 20.89, is greater than 2.101 or 2.878 the numerical evidence is strong enough to reject the null hypothesis and accept that "there is relationship between the size of farm in Fadama land and crop output in the study area".

TIJBEES
ISSN: 1881-2167