# Application of Non-Parametric Methods To Local Paddy Rice Yield In Funtua Senatorial District of Katsina State, Nigeria

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***Abstract*— As Nigerian government is aiming at diversifying the economy to agriculture, determining the factors affecting the yield of rice is an essential procedure for supporting policies regarding food security. The study investigates the yield differences of the rainy and dry seasons in 2016. This research is a purposive sampling of 200 farmers from Funtua Senatorial zone. The data was analyzed using non-parametric techniques. However, the Mann-Whitney's test result shows that rainy season plays a leading role on the paddy rice yield in the zone and there was no significant difference among the dry and rainy season farming on the selected areas based on the result from Kruskal-Wallis one-way analysis of Variance test. Furthermore, shortage of fertilizer, pest attack and unpredictable weather brought on by climate change affected the farming process in some areas. Therefore, the government should improve on seeds, fertilizer allocation at a right time, agrochemicals, and Modern methods of rice production which can boost the yield of rice in the senatorial district and the country at large.**

**Keywords**: *Mann-Whitney`s U, Kruskal-Wallis One-way ANOVA, Paddy rice, factors affecting yield.*

## I. INTRODUCTION

Rice is the second most widely grown cereal and staple food for more than half the world population [2]. It also, remains diet by typical Nigerians as well as main livelihood of many local farmers in the country. It therefore becomes an important agricultural commodity that needs to draw the attention of government and policy makers to its impacts on both domestic and international market for the wellbeing and development of the nation. People solely depend on rice for food, especially in developing countries [5]. In 2015, Nigeria was the world`s second and Africa`s largest importer of rice [8], the country has depended so much on import to fill the local supply gap which arose due to inability of local producers to meet demand. It is also on the frontline in the fight against world hunger and poverty [7]. Also [2] opined that some challenges facing rice production include the declining/stagnating productivity, degradation of soil and water resources.

Furthermore, rice production is affected by the environmental changes; as such climate change has emerged as key concern for environmentally and economically vulnerable countries [11]. For these reasons, farmers adopt various agricultural practices to confront these differences in weather patterns which still resulted to poor harvest of paddy by many farmers in the country. Thus damaged infrastructures affect food prices and increased reliance on food aid import [3].

Various studies have been conducted in different places on rice production by different authors such as [9] in which data on envelopment analysis were used to evaluate the impact of fertilizer usage on the technical efficiency of rice farms in Kogi state, Nigeria. Their result suggested that rice farms cultivated with fertilizer could expand output potentials by 74% as compared to those farms without fertilizer application and concludes that farmers should be encouraged to adopt optimal fertilizer rate in order to achieve increase in rice production.

The impacts of climate change, shortage of fertilizer and other farming inputs on rice production have been a subject of research by many researchers due to its importance on human life. However, the dry season is usually a challenging period for farmers far more than the rainy season; sometimes the rain comes late and ends early and in some other cases farmers find it tedious to farm during the dry season with eight months of aridity. According to National Cereals Research institute farmers can harvest 12 tonnes of paddy rice in one hectare if technology will get to the farmers easily for 20cm by 2ocm plant spacing not one meter by 20cm, this is almost one third of the field being utilized and the remaining two-thirds was not utilized, such farmers cannot obtain optimum yield [6].

Table 1: Summary Statistics of Rice Production during the Rainy and Dry Seasons in Katsina, Nigeria.

| | 1stQuantile | 2ndQuantile | Median | 3thQunatile | Max. |
|---|---|---|---|---|---|
| *Dandume Local Government (tonne/ha)* | | | | | |
| Rainy Season | 4.62 | 5.92 | 6.28 | 6.50 | 7.01 |
| Dry Season | 4.90 | 5.58 | 6.02 | 6.26 | 6.98 |
| *Difference* | -0.28 | 0.34 | 0.26 | 0.24 | 0.02 |
| *Danja Local Government (tonne/ha)* | | | | | |
| Rainy Season | 4.60 | 5.80 | 6.20 | 6.36 | 7.00 |
| Dry Season | 4.90 | 5.22 | 5.58 | 6.00 | 6.90 |
| *Difference* | -0.3 | 0.58 | 0.62 | 0.36 | 0.1 |
| *Kafur Local Government (tonne/ha)* | | | | | |
| Rainy Season | 4.60 | 5.72 | 6.24 | 6.44 | 7.00 |
| Dry Season | 4.90 | 5.38 | 5.78 | 6.08 | 6.97 |
| *Difference* | -0.3 | 0.34 | 0.46 | 0.36 | 0.03 |
| *Sabuwa Local Government (tonne/ha)* | | | | | |
| Rainy Season | 4.60 | 5.72 | 6.28 | 6.60 | 7.00 |
| Dry Season | 4.90 | 5.38 | 5.70 | 6.08 | 6.90 |
| *Difference* | -0.3 | 0.34 | 0.58 | 0.52 | 0.1 |

Funtua Senatorial district area covers the relatively wet southern parts in Katsina state of Nigeria. It is located between latitude 11° 05` north of the Equator and longitude 7° 08` east of the Greenwich Meridian. The study area is part of the tropical intercontinental north where the annual rainfall ranges between 50cm to 100cm. It enjoys some four months of rainfall and has some eight months of aridity. Also, the relative humidity is always low about 40 percent in January and rise to about 60 percent in July. There are two principal winds that govern the climate of the area namely, the Tropical Maritime air mass (Tm) and the Continental air mass (Tc). While the former airmass brings rain to the entire study area during the wet season, the later air mass brings aridity, since it originates from the desert area; it is always cold, dry and dusty locally known as harmattan wind [1].

The Wilcoxon rank-sum test and Krsukal-Wallis one-way ANOVA are widely used for computing median differences of two or more independent samples (unpaired). The Wilcoxon rank sum test was named after Frank Wilcoxon (1892 – 1965) who, in a single paper, proposed both Wilcoxon signed rank test and the rank-sum test which he discards any tied data and then calculate the signed-rank [4]. The Wilcoxon`s test has played a vital role in developing approaches of bivariate data for non-parametric methods. Modified Wilcoxon signed-rank (MWSR) test was developed for incorporating data with ties for an exact p-value for paired and unpaired data. The Kruskal-Wallis rank sum test is a non-parametric method of multivariate data for testing whether sample originate from the same distribution. It is used for comparing more than two independent samples of equal or different sample sizes [10].

## II. Materials and Methods

The data used for this study were collected in kilogram per hectare in Funtua senatorial district for the year 2016. The purposive sampling of 200 farmers from Dandume, Sabuwa, Kafur and Danja with the use of questionnaires which were administered by the researcher with the contents of Age, paddy in Kilogram (Rainy/Dry), level of Education and Main source of income among others.

Table 2: Socio-Economic characteristics of the respondents in the study areas.

| Variables | Frequency | Percentage |
|---|---|---|
| *Age* | | |
| 31 – 40 | 21 | 10.5 |
| 41 – 50 | 34 | 17 |
| 51 – 60 | 70 | 35 |
| 61 – 70 | 75 | 37.5 |
| *Gender* | | |
| Male | 200 | 100 |
| *Education* | | |
| No formal Education | 41 | 20.5 |
| Primary School | 96 | 48 |
| Secondary School | 40 | 20 |
| Tertiary institution | 23 | 11.5 |
| *Local government* | | |
| Dandume | 50 | 25 |
| Danja | 50 | 25 |
| Kafur | 50 | 25 |
| Sabuwa | 50 | 25 |
| *Main source of Income* | | |

| | | |
|---|---|---|
| Farming | 200 | 100 |

Moreover, for an easy computation and analysis, the data was converted into tonnes per hectare. The R – package was used for statistical analysis and data visualization. The data was screened for normality using Shapiro-Wilk`s test and Bartlett test for homogeneity of variance. The non-parametric approach was considered because the original data failed the parametric assumptions. Therefore, the Modified Wilcoxon signed rank and Kruskal-Wallis Techniques were incorporated with ties values in the ranking procedure for the two or more independent samples.

Likewise, for the two non-parametric methods, if the p-values less than the selected $\propto$ then the null hypothesis is rejected and conclude the sample is determined to be different. Therefore, it is expedient to observe the boxplot of the data before analysis since it is the visual display of five numbers. Finally, to compliment the boxplot we use the quantile command for the minimum, first quantile, median, third quantile and maximum value.

*A. Kruskal-Wallis One-Way ANOVA test*

$$H = \frac{12}{N(N+1)}\left(\frac{R_1^2}{n_1} + \frac{R_2^2}{n_2} + \cdots \frac{R_K^2}{n_k}\right) - 3(n+1) \qquad (1)$$

Where $n_1, n_2, \ldots n_k$ are the number in each of k samples such that $N = n_1 + n_2 + \cdots + n_k$ and $R_1, R_2, \ldots R_K$ are the rank sums on paddy of Rainy and Dry season for the four LGAs. Consequently, the null hypothesis is rejected when $H > \chi^2$ for k – 1 degrees of freedom or when $p < \alpha$ level of significance.

*B. Wilcoxon Rank sum test*

If $n_1$ and $n_2$ are the sizes of the samples are $R_1$ and $R_2$ is simply the sum of first $n_1 + n_2$ positive integers, which is known to be $(n_1+n_2)(n_1+n_2+1)/2$. This formula enables us to find $R_2$ if we know $R_1$ and vice versa. When the use of the rank sums was first proposed as a non-parametric alternative to the two-sample t-test, the decision was based on $R_1$or $R_2$.

$$U_1 = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1 (2)$$

$$U_2 = n_1 n_2 + \frac{n_2(n_2+1)}{2} - R_1 (3)$$

$$U = \min(U_1, U_2)\ (4)$$

Where $n_1$ and $n_2$ are the sizes of the samples and $R_1$ and $R_2$ are the rank sums of the corresponding samples. As of the Wilcoxon version of the test, if the observed value of U is > U critical or when $p < \alpha$, then the test statistics is rejected at α level of significance.

## III. Statistical Analysis

*A. Modified Wilcoxon Signed Rank test for Kafur, Dandume, Sabuwa and Danja LG*

$H_0$: The Median difference for the paddy rice yield in the rainy season equals that of dry season.

| | | |
|---|---|---|
| **Asymptotic Wilcoxon rank sum test (Dandume LG)** | Data | Dry & Rainy season |
| | W | 833 |
| | P – value | 0.004017 |
| **Asymptotic Wilcoxon rank sum test (Danja LG)** | Data | Dry & Rainy season |
| | W | 601 |
| | P – value | 0.000075 |
| **Asymptotic Wilcoxon rank sum test (Sabuwa LG)** | Data | Dry and Rainy season |
| | W | 830 |
| | P –value | 0.003752 |
| **Asymptotic Wilcoxon rank sum test (Kafur LG)** | Data | Dry & Rainy season |
| | W | 799 |
| | P –value | 0.001863 |

*B. Kruskal Wallis test for the Rainy& Dry season of the four local government areas.*

$H_0$: The significant differences in the population median on the paddy rice yield for the rainy&dry season is the same for all the Local Governments.

| **Kruskal-Wallis rank sum test (Rainy season)** | |
|---|---|
| Data | yields by seasons |
| Chi-square | 6.0527 |
| DF | 3 |
| P-value | 0.1091 |
| **Kruskal-Wallis rank sum test (Dry season)** | |
| Data | yields by seasons |
| DF | 3 |
| Chi-square | 1.6399 |
| P-value | 0.6504 |

## IV. RESULTS

Table 3: Modified Wilcoxon signed – rank test for the rainy and dry season.

| s/no | LGA | W Statistics | P –value |
|---|---|---|---|
| 1 | Dandume (DDM) | 833 | 0.004017 |
| 2 | Danja (DJA) | 601 | 0.000075 |
| 3 | Kafur (KFR) | 799 | 0.001863 |
| 4 | Sabuwa (SBW) | 830 | 0.003752 |

Table 4: Kruskal Wallis Test of the four Local Governments over the two seasons.

| | | |
|---|---|---|
| **Rainy Season** | Chi Square Statistics | 6.0527 |
| | D.F. | 3 |
| | P – value | 0.1091 |
| **Dry Season** | Chi Square Statistics | 1.6399 |
| | D.F. | 3 |
| | P –value | 0.6504 |

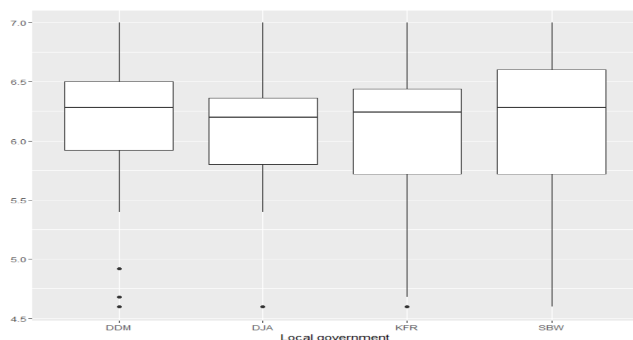


Figure 1: Rainy season Data visualization of Paddy yield

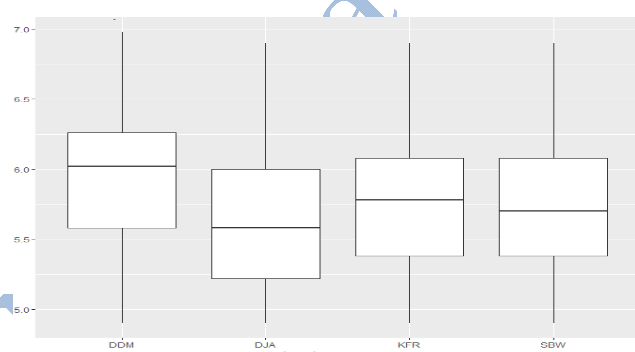


Figure 2: Dry season Data visualization of Paddy yield

## V. DISCUSSION

After a careful analysis of the rainy and dry season in the all the four local government areas in the senatorial zone, the data analysis for the Modified Wilcoxon signed rank test as shown in Table 3 that rainy season produces more yields for all the local governments compared to dry season since all the p-values of 0.003752, 0.001863, 0.000075 and 0.004017 are less than the value of $\propto = 0.025$ lvel of significance.

In Table 4, the Kruskal Wallis test shows no significant differences for the yield of dry and rainy season in Dandume vs Danja, Dandume vs Kafur, Dandume vs Sabuwa, Danja vs Kafur, Danja vs Sabuwa, and Kafur vs Sabuwa as the p values (0.1091 and 0.6504) are greater than $\propto = 0.025$ level of significance for rainy and dry season respectively. However, In Table 2 considering the socio economic characteristics of the respondents on age shows that 37.5% are above 60 years and 35% are within 51-60 years of age while 27.5% are within 31-50 years. It was observed that only 11.5% attain tertiary level of education and 21% have no formal education while 68% are within primary and secondary level of education.

Finally, table 1 from the analysis shows that the maximum yield difference for the rainy and dry season was 0.02, 0.1, 0.03 and 0.1 tonne. The first quantile illustrate that dry season slightly produced the highest yield for all the areas under study, while for the second quantile, the rainy season produced the highest yield by the difference of 0.34 tonne and Danja LG with 0.58 tonne and for the median difference, it ranges between (0.26 – 0.62) tonne for all the local governments.

## V. CONCLUSSIONS

Generally, it was observed from Table 1 and the visual inspection in Fig 1 and 2 that the paddy rice yield is very low in some areas under study. Some farmers in the study areas are not using improved varieties for one reason or the other, either they are not being exposed to them or they are attached to the one they have been using traditionally. Moreover, some farmers don't apply fertilizer while those that do, apply very little to their crops.

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## REFERENCES

[1] Adefila, J.O. (2014): Pattern of Agriculture Development in Southern parts of Katsina state, Nigeria. Journal of Agriculture and Veterinary Science, 7(1):14- 20.

[2] Chamhuri,S. and Nor, M.I., (2014). Issues and challenges facing rice production and food security in the Granary Areas, Malaysia. Journal of Applied sciences, Engineering and Technology, 7(4):711-722

[3] Food and Agricultural Organisation (FAO), (2008). The State of Food insecurity in the World 2008. High food prices and Food Security–threat. Retrieved on from: ftp://ftp.foa.org/docrep/foa/011/i0291e00.pdf.

[4] Francis, S.N. (2016). Non – parametric statistical test for the continuous data. International Journal by Korean Journal of Anesthesiology. 69(1):8 – 14.

[5] International Rice Research Institute (IRRI), (2004). World rice statistics Retrieved from: http://www.irri.org/index.php100346.

[6] NCRI (National Cereals Research Institute), (2016). Local farmers can also harvest 12 tonnes from a hectare. Retrieved from: http://www.dailytrust.com.ng/daily/agriculture/32867loca rice-farmers.

[7] Nguyen, N.V. and Ferrero, (2006). Meeting the Challenges of Global Rice production Paddy Water Environment, 4:1-9.

[8] Nkwazema, A., (2016). Why Nigeria can`t meet local Rice production Demand Retrieved from:http://www.thisdaylive.com/index.php/2016/11/05/

[9] Orefi, A.,(2011). Fertilizer Usage and Technical Efficiency of Rice farms Under Tropical Conditions: A Data Envelopment Analysis. *Journal of Agricultural Science*, 2(2):83-87.

[10] Peter, E., (2011). Three rountines in R that calucltae the wilcoxonsigned-rank test and kruskall-Wallis. Retrieved from: http://stat.ethz.ch/pipemail/r-help/2011.

[11] Sarker, M.A.R., K. Alam and J. Gow, (2012). Exploring the relationship between climate change and rice yield in Bangladesh: An analysis of time series data. Agricultural System. 112: 11 – 16.