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Price analysis of paddy rice in Monday-market, Borno state, Nigeria (2009 to 2021)

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ABSTRACT

This study analysed the price of paddy rice in Monday-market in Borno State. Rice is an important staple crop in Borno State and indeed, the whole of Nigeria. However, significant rice price volatility is witnessed across the region which led to the creation of risks and uncertainties among producers, processors and marketers of rice. Consequently, the objectives of this study were to estimate the trends in market prices of rice; examine the seasonal variations/ fluctuations; and forecast the future prices of rice in the study area. Secondary data of average monthly price per 100 kg bag of paddy rice for 156 months (from January, 2009 to December, 2021) was collected from the National Agricultural Extension and Research Liaison Services (NAERLS). The study employed the use of the Multiplicative model, Centred Moving Average (CMA), Seasonality Index (SI), Grand Seasonality Index (GSI), Gross Storage Return (GSR) and Autoregressive Integrated Moving Average (ARIMA). The result showed that the price series has a positive linear trend with R^2 value of 0.91. Furthermore, the GSI peaks in August (105.3) and October prior to largest harvest period. Price declines in November through December and January. The GSI become lowest in March (94.7) when all harvests enter market. The gross storage margin, which is the percentage increase in price from March to August, was 11.19% per season. The study forecasted that price of rice will keep on increasing throughout the period under review. It is concluded that rice prices exhibit a fluctuation pattern (seasonality) within a year period; it peaks in August and declines in January. Therefore, whoever is interested in storing rice should buy it from December to February and sell it off from July to September for maximum profit, all things being equal.

Keywords: Price; seasonality; gross storage index (GSI); forecasting; ARIMA

INTRODUCTION

Rice is one of the most important staple food crops grown in Borno State, Nigeria. Paddy rice is a significant source of income to farmers, traders, processors and retailers. The availability of jobs and income opportunities from rice marketing helps to reduce poverty and unemployment in the state. Monday-market in Borno State is a major trading hub which serves as a critical point for the distribution and pricing of this staple crop. Rice price serves as a factor that binds between production process and consumption of the commodity. It

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determines, to a large extent, farmers' production decisions as well as consumers' buying decision. High price of a commodity encourages more of its production and, at the same time, causes less of its consumption and vice versa (Mani *et al*., 2018).

Prices of agricultural commodity mostly vary across seasons, typically, peaking just before the harvesting period and dropping substantially immediately after the harvest (Gilbert *et al.*, 2017). This price variation creates incentives for market players to engage in trade (Cariappa, *et al*., 2020). However, excessive price variability leads to poverty (Mustapha & Culas, 2013) by reducing farmers income when prices are too low to cover their production costs. And for consumers, rise in rice price can plunge them into high cost of living, especially, low-income households among them who spend large portion of their income on food. The major determinants of price variation include seasonal factors (Dauna, *et al*., 2019); spatial variation in supply, high cost of transportation and inadequate market information (Andarawus *et al*., 2012); exchange rate, money supply, and hoarding attitudes of middlemen (Ojogho & Izekor, 2023); and rising cost of premium motor spirit, conflicts and poor market organization (Nwibo *et al*., 2013) All these factors affect the quantity demanded for and supply of paddy rice.

Due to the importance of understanding price behaviours of paddy rice, several studies were carried out from different parts of Nigeria using different types of methodologies. For instance, Dauna *et al*. (2019) investigated spatial price transmission for rice in Adamawa state using weekly time series data for 52 weeks (September 2015 - August 2016). They reported that seasonal variation in price existed, and that October and November were the periods when rice prices are generally low while the highest price occurred in December. Also, a spatial analysis of paddy rice price variability in Dass and Tafawa Balewa LGAs of Bauchi State was conducted by Andarawus, *et al*. (2012) using time series data of monthly prices and the result of their analysis revealed the existence of price variability in their study area. Similarly, Nwibo *et al*. (2013) analysed spatial price of paddy in Ebonyi North Zone of Ebonyi State using primary data and found that there was a spatiality in the prices of paddy rice among different markets in the zone.

It follows from the above that most literature on paddy rice price studied seasonal and spatial price variations alone and did not go further to estimate the trend and to forecast the future prices of paddy rice. In addition, most of the studies were carried out in states other than Borno State despite the fact that Monday market in Borno State is one of the leading markets in the whole Northeast region of Nigeria. In view of the above, the objectives of this study are to: estimate the trends in market prices of paddy rice; examine the seasonal variations / fluctuations in the prices of paddy rice; and forecast the future price of paddy rice in Maiduguri, Borno State. The findings of this study are expected to contribute to a more stable and efficient paddy rice market, benefitting all stakeholders.

METHODOLOGY

Study Area

Maiduguri is the largest city in Northeast Nigeria and the capital of Borno State. It is a major centre for grains marketing, particularly for sorghum, millet, maize and rice. It lies between latitudes $11^0 45^{'}$N to $11^0 51^{'}$N and longitude $13^0 2^{'}$E to $13^0 9^{'}$E. It is located in the Ngadda Basin, a seasonal river that flows through Maiduguri (google earth, 2018). The hot season goes on for 2.4 months, from March to May, with typical everyday high temperature

above 38.9 ^{0}C. The projected population of Maiduguri in 2019 is around 1,112,44 (World Population Review, 2 019). The grains market in Maiduguri is characterized by bustling activity, especially during harvest seasons, as traders and buyers converge to conduct transactions.

Sampling Technique and Data Collection

Monday-market in Maiduguri, Borno State was selected purposively for two reasons: It is the largest paddy rice market in the state and, secondly, its secondary price data was available with the National Agricultural Extension and Research Liaison Services (NAERLS) Ahmadu Bello University (ABU) Zaria. Therefore, its weekly price data were collected from the NAERLS and used for this study. An average monthly price of a bag of paddy rice was computed for the period of 52 months (from January, 2009 to December, 2021).

Analytical Technique

This study adopts the multiplicative model since the rice price data exhibit irregular variation. The model is presented thus:

$$Y = T \times S \times C \times I \quad \ldots\ldots (1)$$

Where: Y = monthly price of rice (₦/bag); T = trend component (months); S = seasonal variations (per year); C = cyclical component (in a year); and I = irregular variations (in a year).

The model was decomposed by extracting its components as follows:

ii) **Trend**: trend of the price series was determined using multiple regression:

$$Y_t = \alpha + \beta T_t + \varepsilon_t \quad \ldots\ldots (2)$$

Where: Y = rice price (₦/bag); α = the intercept; β = trend coefficient; T_t = period (months); and ε = the error term.

Detrending the series was achieved by dividing the price series (Y) by the Trend (T) as shown in equation (3).

$$\frac{Y}{T} = S \times C \times I \quad \ldots\ldots (3)$$

iii. **Seasonality:** Following Mani *et al*. (2018), seasonality was determined by calculating the moving average (MA) and centred moving average (CMA) using the following formulae:

$$CMA^{12} = \frac{\sum_{i=t-6}^{i=t+5} P_i + \sum_{j=t+6}^{j=t-5} P_i}{24} \quad \ldots\ldots (4)$$

$$SI = \frac{P_i}{CMA^{12}} \times 100 \quad \ldots\ldots (5)$$

$$GSI = \overline{SI} \times \frac{1200}{\sum \overline{SI}} \quad \ldots\ldots (6)$$

Where: CMA = Centred moving average, P_i = rice price (₦), t = time (months)

The CMA completely smoothens out the random components, and the GSI further eliminates the random component in the SI, while summarizing the typical seasonal behaviour of the series.

iv) Gross Storage Returns (GSR):

Following Mani *et al*. (2018), GSR is calculated using the following formula:

$$GSR = \frac{Highest\ GSI - Lowest\ GSI}{Lowest\ GSI} \times 100 \quad \ldots\ldots (7)$$

v) Autoregressive Integrated Moving Average (ARIMA):

In this study ARIMA model was used to predict future prices of rice in the Northeast, Nigeria in which Box Jenkin's method was followed. The methodology has the following procedures, namely: identification, estimation, testing and application of ARIMA model.

Step-I: Model identification (Selecting an initial model)

The first step involves determination of the stationarity or otherwise of the series. This was done by considering the graph of the autocorrelation function (ACF). If the spikes of the graph die down slowly it indicates non-stationarity of the data and hence the need to differentiate the series to make it stationary. If the series became stationary after first difference, it shows that the series is integrated of order (I).

Step-II: Model Estimation and testing

Eviews 7.1 software was used to generate the parameter estimates. The best fit was judged based on the value of the AIC and the number of significant variables.

Step-III: Forecasting with the Model

Forecasting future prices was done using eviews 7.1 software.

RESULTS AND DISCUSSION

The result of rice price trend presented in Table 1 shows that the trend coefficient of 101.09 is positive and highly significant ($p < 0.01$). This positive relationship is an indication of an upward trend of rice prices through-out the period of the study. Further, the value of the coefficient indicates that rice prices increase, on average, by N101/kg monthly in Maiduguri from 2009 to 2021. The value of R-square is 0.91 suggesting that the contribution of time to change in price in the study area was to the extent of 91%, meaning that rice prices change rapidly over a small period of time.

Table 1: Trend of paddy rice price in Maiduguri, ₦/kg (2009 – 2021)

Location	Variable	Coef.	Std. error	t-stat	Prob.	R^2
Monday-market	constant	2043.131	229.4922	8.902831	0.0000	0.911648
	Time	101.0851	2.535839	39.86259	0.0000	

Source: NBS data (2009-2021)

This consistent increase in rice prices could be attributed to factors such as increase in demand for rice due to population growth (Nwofoke *et al*., 2024) and/or change in dietary preference (Abubakar & lawali, 2024); inadequate supply of rice due to low productivity (Tijjani & Suleiman, 2021); rise in production cost such as rise in price of fertilizer and labour (Aina, *et al*., 2015; Ogechi, 2020;); supply chain disruption (Kehinde & Patience, 2016; Edwards, *et al*., 2023); and inflationary pressures (Nwofoke *et al*., 2024). These factors play crucial roles in increasing rice prices and consequently exacerbating food insecurity in the region and Nigeria at large.

Figure 1 depicts the behaviour of rice price in each month of the year. There was a continuous increase in price from January to July. Specifically, from February to March the price increased by about 0.6%, from March to April it increased by 0.17 %, from April to May it further increased by 0.44%, from May to June it increased by 0.36% and from June to July it again increased by 1.22%. However, a relatively tremendous increase in price up to 4.26 % was recorded from July to August and there after slightly decreased by 0.6% from

August to September. The price further decreased from September to October by 3.44% and from October to November the price decreased by 3.37%.

It can be seen from the graph in figure 1 that rice prices were above average in the months of July, August and September and subsequently dropped below average from October through December. Suggesting that rice prices usually peak in August and then drop down in December as a result of seasonality in rice production. The price raises to its peak in August, the period when rice is highly scarce and drops in December when new cultivated rice usually enters markets. Normally, rice is grown mainly during the (April-August) rainy season and harvested during the (September-January) dry season, thus, its scarcity is witnessed during rainy season and oversupply of it during dry season (FAO & ICRISAT, 2019) which consequently results in its soaring prices in August and plummeting in December. This finding is similar to what was reported by Yusuf, *et al*., (2016) in their study on grain storage cost as a factor in explaining seasonal price variation in two states (Kaduna and Katsina) of North-West Nigeria. They stated that rice is, similarly, harvested in the months of August and September and its price rises thereafter, in which expected prices normally exceed cost of storage, indicating that traders make more than normal gain and hence generate more profit.

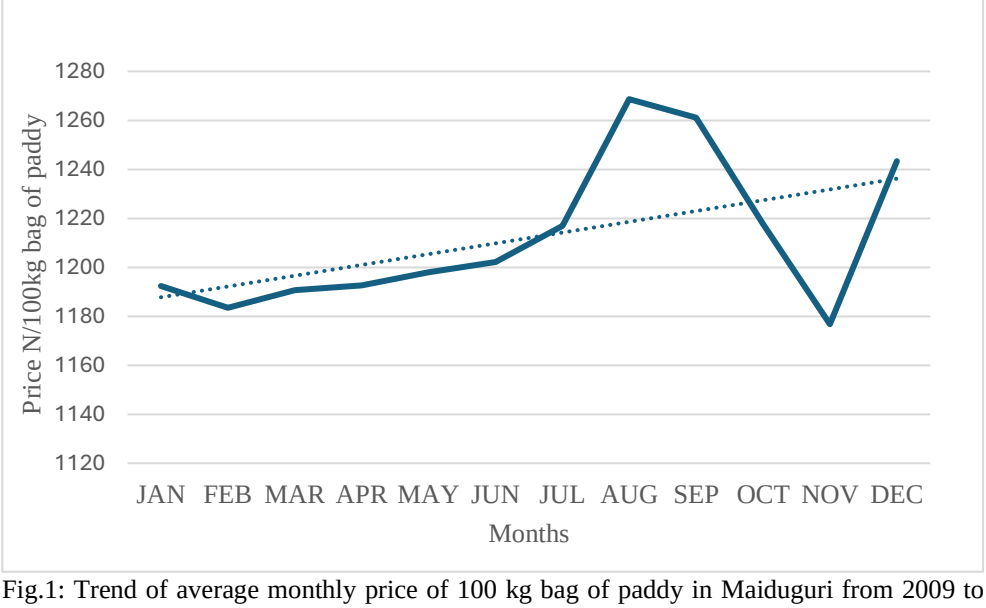

Fig.1: Trend of average monthly price of 100 kg bag of paddy in Maiduguri from 2009 to 2021

Price Variability over Seasons

Seasonality is the statistical variation reflecting the average amount by which prices during any given month deviates from the average value of 100 (Mani *et al*., 2018). Table 2 shows that there is presence of seasonality in the rice price series because the values of the t-test for some months (March, April, August, September and October) are higher than 2.23 (test statistics), implying the rejection of the null hypothesis of no seasonality. The result

further shows a clear cyclical pattern in rice prices. It can be seen that prices are lower than yearly average (100) in the months of January (95.9) to April (94.2) and start to rise tremendously from July (102.0) to October, crossing the annual average.

The Grand Seasonal Index (GSI)

The GSI peaks in August (105.3) and October prior to largest harvest period. Price declines in November through December and January (Table 2). The GSI become lowest in March (94.7) when all harvests enter market. Therefore, the gross storage margin, which is the percentage increase in price from March to August, is 11.19% per season. Thus, the real price increase of 11.19% occurs within five months. This shows that the percentage increase per month stored was 2.24% (11.19/5). Impliedly, agents can compare this figure with the cost of borrowing funds to decide if they can borrow to purchase rice at the lean period and sell it at the peak period.

The low-price months align with post-harvest seasons which is normally characterised by increased supply from fresh harvest. In that period farmers and traders rush to sell their produce. However, for consumers the period represents a favourable time to purchase rice, as price are at their lowest. But for farmers and traders, it will be very difficult for them to secure higher profit margins unless marketing strategies such as storage or delay sales were adopted.

Variably, during high-price months (July to November), consumers face higher costs, which may strain low-income households. Therefore, they may need to plan and strategize well to make bulk purchase during lean period to reduce expenditure. Although, farmers and traders could have high profit from the sales of their commodity in this period, especially if they had stored the produce during lean periods and dispose it during peak periods. This finding corroborates with the results presented by El-Hori and Idris (2011) and Mani, *et al*. (2018) where they stated that prices reliably reach seasonal low one or two months after harvest, then rise over the course of the year prior to the next harvest.

Gross Storage Returns

Gross storage returns are determined by analysing the GSI value. It considers the price changes which sellers can utilize to get better prices for their commodity (Mani *et al*., 2018). The feasibility for storage was 11.19%. This result indicates storing rice from the low-price months to the high-price months yields about 11% increase in value relative to the initial price. This shows that there is a potential profit that will be obtained as a result of storage. Therefore, producers, marketers and consumers can optimize their decisions when they understand and plan around the price variation.

Table 2: Seasonal and grand seasonal indices

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean SI	95.9	96.0	93.7	94.2	97.0	97.3	101.0	104.2	103.2	103.8	101.4	99.2
GSI	96.9	97.1	94.7	95.2	98.1	98.4	102.1	105.3	104.3	105.0	102.6	100.3
t(null=100)	-1.46	-1.44	-3.17	-2.91	-1.27	-0.99	1.62	2.52	2.28	2.60	1.46	0.16
GSI+1SE	1.68	1.73	2.78	1.11	0.24	0.35	-1.33	-1.65	-1.37	-1.94	-1.18	-0.22
GSI-1SE	94.2	94.5	92.7	93.1	96.1	96.2	100.4	102.6	101.9	102.6	100.3	97.8
Trend coefficient	0.95	0.93	1.05	0.52	0.11	0.17	-0.48	-0.93	-0.73	-0.96	-0.59	-0.13

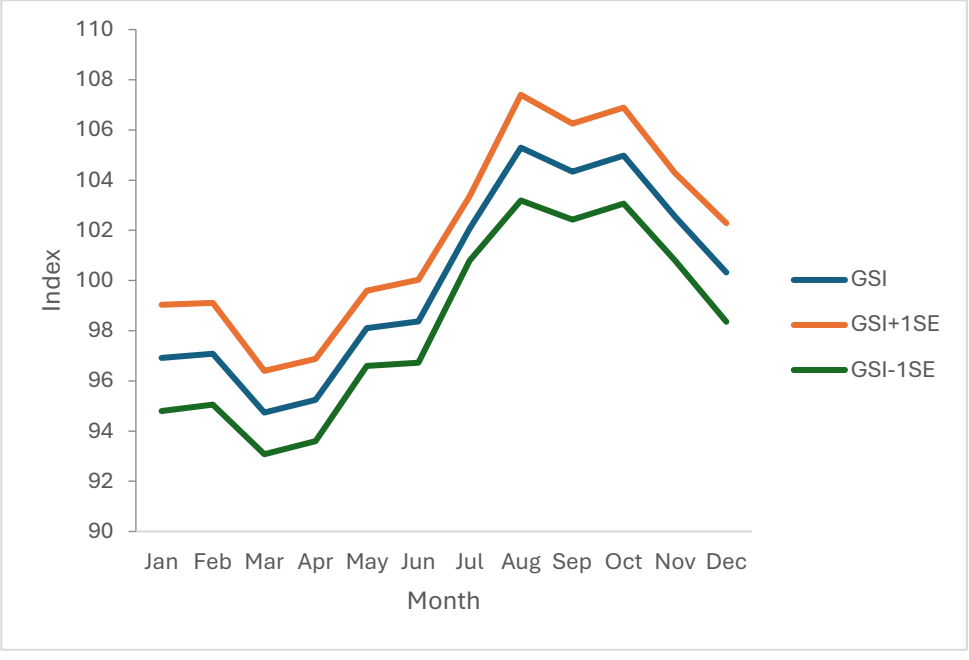

Fig 2: Grand Seasonal Index

Rice Price Forecast

Results from both the correlogram and the unit root test showed that monthly price series data from 2009 to 2021 are not stationary at level but became stationary after first difference as most economic variables behave. This means that to have good forecast values, the data should be differenced once. After differencing, three ARIMA models were estimated (Table 3). ARIMA 0,1,1 appeared to be the best model because it has relatively the lowest SC, AC and HQ as shown in Table 3 and therefore chosen and used for forecasting.

Table 3: Estimated ARIMAs for price series data (January 2009 to December, 2021)

ARIMA Model		Coefficient	St. Error	P-value	SIC	AIC	HIC
ARIMA0,1,1	MA(1)	0.4349***	0.0755	8.30e-09	316.28	2307.15	2310.86
ARIMA1,1,1	AR(1)	-0.0656	0.1709	0.7008	2321.18	2309.00	2313.94
	MA(1)	0.4859***	0.1471	0.0010			
ARIMA1,1,0	AR(1)	0.3235***	0.0762	2.19e-05	2323.19	2314.06	2317.77

Source: NARELS, 2022. SC = Schwarz criterion, AC = Akaike criterion, HQ = Hannan-Quinn

The result of the forecast showed that rice price will continue to have an upward trend throughout the forecasted period (Fig.3). It means that the price of rice will keep on increasing over time. The reasons for the increase in rice prices could be attributed to several factors which may include: (1) Supply chain disruption due to incessant activities of

insurgents in the area which affect production and transportation of rice to markets. (2) High production costs such as fertilizers and labour. (3) Inflation, which affect prices of everything in Nigeria. (4) Increase in demand of rice. (5) Seasonal variation. Higher prices of rice reduce the purchasing power of consumers especially for low-income households which will further exacerbate issues of food insecurity in the country. For retailers, though they may get higher margins, but the margin could be neutralized by the increase in price through reduction of sales as only few consumers can afford rice. Similarly, producers might benefit from higher prices if they can increase the volume of their production, but rising cost of farming inputs may also neutralise the benefit.

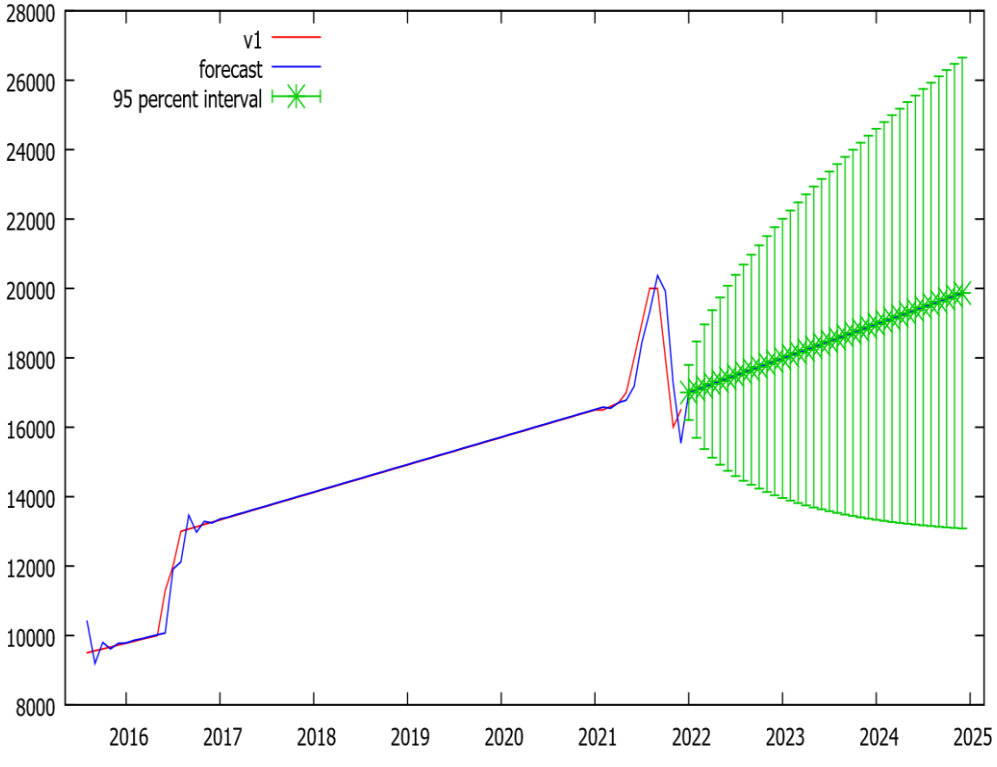

Figure 3: Predicted rice price from 2022 to 2025.

CONCLUSION

The study showed that from 2009 to 2021 the price of rice in the study area has been consistently increasing due to several factors which include an increase in demand for the commodity as a result of increase in population and decrease in supply due to various issues of insecurity. The study also found that the rice price shows a significant seasonal variation in which the price starts increasing from April to September, peaking in August, then declines from October through February. The study forecasted that there will be a continuous increase in rice price throughout the period forecasted.

Therefore, the study concluded that the price of rice, being one of the staple food grains cultivated in the Northeast-Nigeria has been continuously increasing and will continue to increase if appropriate measures are not taken and so there will be a serious challenge of food insecurity and hunger in the study area as well as in the whole country.

It is therefore recommended that rice production should be boosted through subsidization of inputs, provision of mechanization and enhancement of extension services. Whoever is interested in storing rice should buy it from December to February and sell it off from July to September for maximum profit, all things being equal. General security must be enhanced to ensure smooth transportation and access to farms. Mechanism to monitor and regulate pricing should be established to prevent exploitation by middlemen. If these recommendations are implemented, excessive rise in rice price will be drastically reduced.

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