WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Forecasting Corn: A Mathematical Approach to Analyzing Production Value Trends (2008-2022)

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DOI : https://doi.org/10.55248/gengpi.5.0724.1933

ABSTRACT

Corn, a pivotal crop in global agriculture, holds significant importance in the Philippines for its diverse applications. This study aims to predict the value of corn production and identify key influencing factors to guide strategic agricultural development. Using data from the Philippine Statistics Authority (2008-2022), various statistical methods were employed including trend analysis, simple and multiple linear regression, and time series modeling. The findings indicate an overall increasing trend in corn production value, peaking in 2022. Volume of production and yield per hectare showed positive linear relationships with production value, whereas area planted/harvested showed a negative relationship. Among the time series models, the polynomial (Sextic) model demonstrated superior predictive accuracy, with a coefficient of determination (R^2) of 0.9198 and the lowest standard error. The projected value of corn production for 2023 is expected to rise by 77,090.209 million pesos. The study concludes that enhancing both the cultivation area and yield per hectare is crucial for maximizing production value. Future research should further explore additional factors affecting corn production to refine predictive models and support agricultural policy-making.

INTRODUCTION

Corn is one of the most widely distributed of the world's food crops. It is used as a livestock feed, as human food, as biofuel and as raw material in industry. This is one of the most important crops in the Philippines also in other countries therefore it is important to develop Philippine agriculture. There are many factors affecting the value of corn production. That is why it is important to predict the probable increase or decrease of in the corn production. This is to prepare corn corporations to develop business strategy to increase the value of corn production and to develop a right decision for the improvement of the value of corn production. The research objective is to determine the trend of the value of corn production, determine the greatest factor that affect the value of corn production, and determine the best fit model that will predict the value of corn production in the year 2023.

Statement of the Problem

This study aimed to identify the factors that affect the value of corn production. Specifically, this study aimed to;

1. Determine the trend of the value of corn manufactured in the year 2008-2022.

2. Find if the value of corn production has a significant linear relationship with the following variables;

    a. volume of production;

    b. area planted/ harvested;

    c. yield per hectare; and

    d. value of production; area planted/ harvested, and yield per hectare altogether.

3. Construct time series model of the value of corn production using the following models to predict the percentage for the year 2023.

    a. Linear

    b. Quadratic

    c. Exponential

    d. Polynomial (cubic, quartic, quintic, sextic)

    e. Power

f. Moving Average

g. Exponential Smoothing

h. Auto Regression

4. Determine the best fit models and predict the value of corn production in the year 2023.

METHODS

Research Design

This research used the descriptive- predictive design. To predict if the value of corn production increases or decreases forecasting was used as a technique.

Data Sources

In this research Selected Statistics of Agriculture (2013, 2018, and 2023 edition) of the Philippine Statistics Authority was used for the data.

Research Procedure

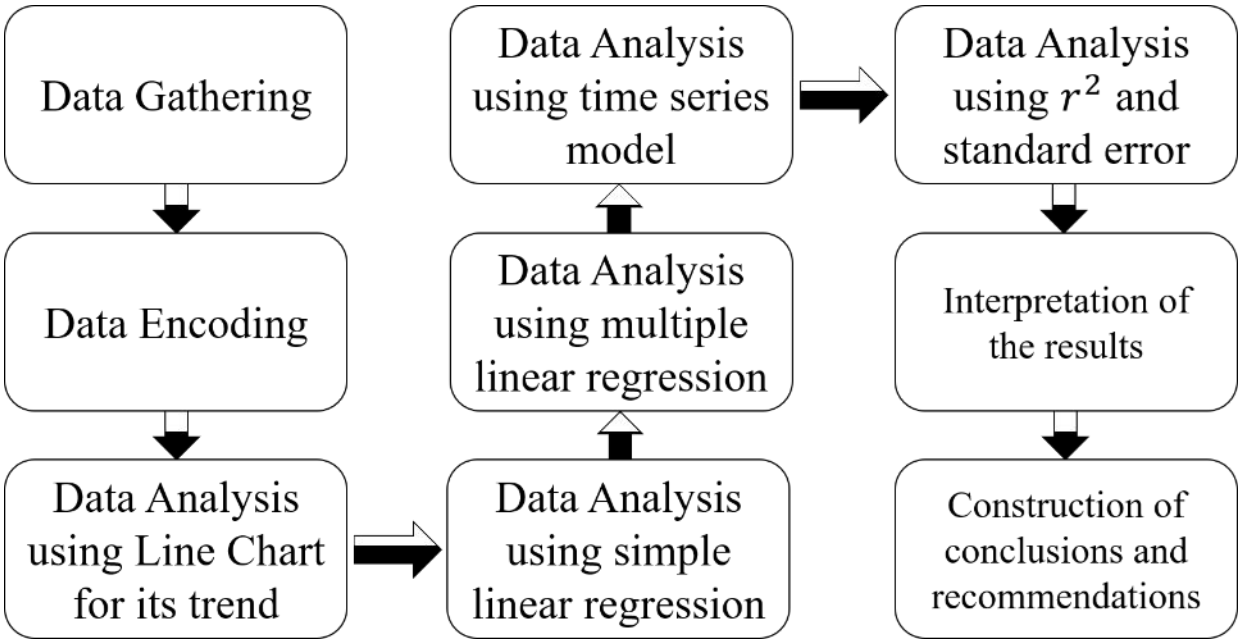

Figure 1: Flow Chart of the Research

The research started with gathering of data by browsing the internet, data should be appropriate for different statistics models. After which the data should be encoded in order to analyze the data. The data were analyzed by line chart, simple linear regression, multiple linear regression, time series models, $r2$ and standard error. Results were interpreted and discussed, and conclusion and recommendations were constructed afterwards.

Data Analysis

In determining the trend of the value of corn production line charts was use. Simple linear regression was used to determine if value of corn production has a significant relationship to the volume of production, area planted/ harvested and yield per hectare. Multiple linear regression was used to determine if the value of corn production has a significant relationship to the three variables altogether. $r2$ and standard error was used to determine the best fit model/s that will predict the value of corn production for the year 2023.

RESULTS AND DISCUSSIONS

Section 1. Trend of the value of corn production

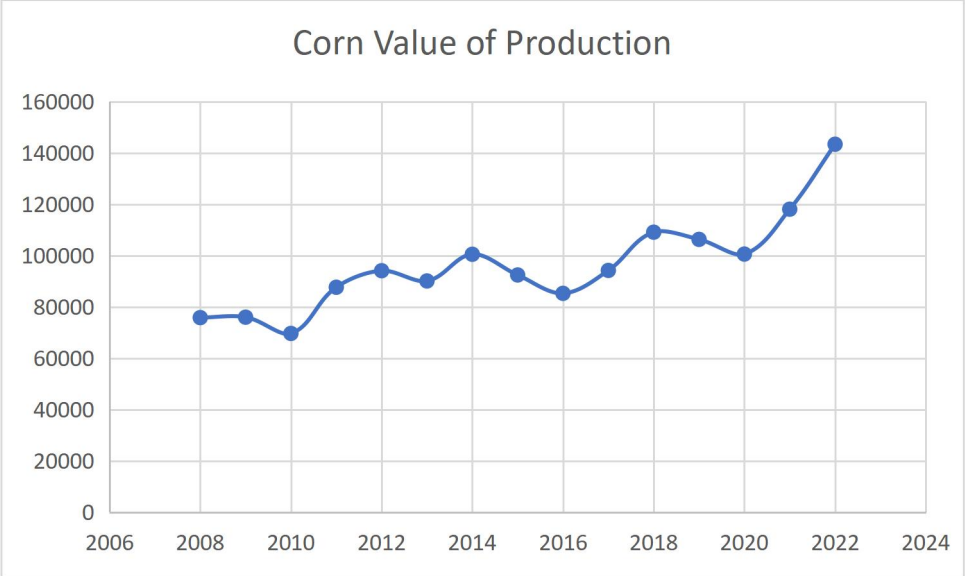

Figure 2: Trend line of the Value of Corn Production from 2008-2022

The figure demonstrates the trend in the value of corn production from 2008 to 2022, measured in millions of pesos. Over this 15-year period, the data reveals fluctuations and overall growth.From 2008 to 2010, the value of corn production remained relatively consistent. A notable increase occurred from 2011 to 2013, peaking in 2012. This was followed by a slight decrease and subsequent rise from 2014 to 2016. From 2017 to 2019, the value stabilized with minor variations. A significant upward trend is evident from 2020 to 2022, with the value reaching its highest point in 2022 with a value of 143440.8 (in million of pesos)

Section 2. Find if the value of corn production has a significant linear relationship with the following variables;

2.1 Volume of Production

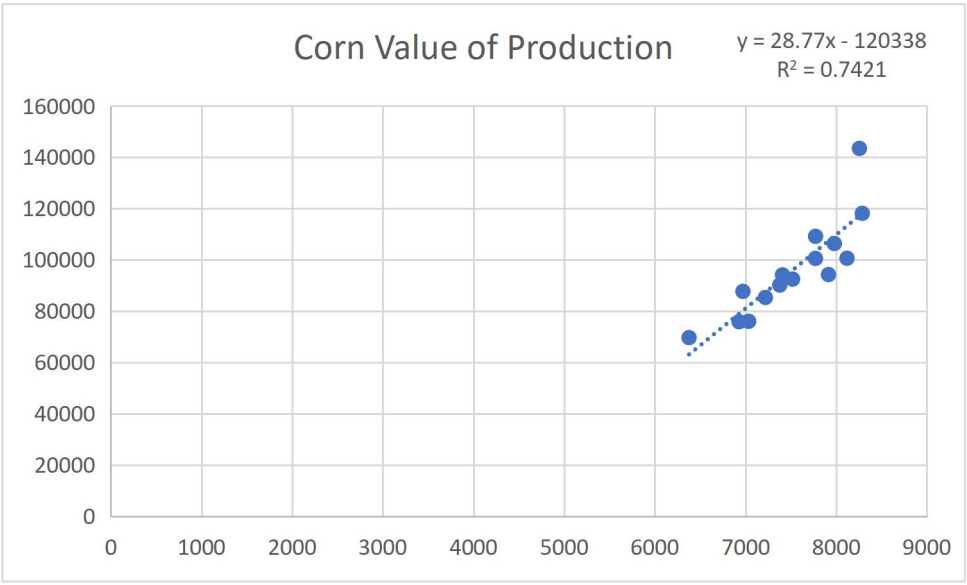

Figure 3: Relationship of the Volume of Production and the Value of Production Figure 3 forms a positive line in the data. This means that the value of corn production has

a positive linear relationship with the volume of corn production. Therefore, the volume of corn production affects the increase or decrease of the value of corn production. The slope is 28.77 this means that if there is one unit increase in the volume of corn production there is 28.77(in million pesos) increase in the value of corn production. The y- intercept is -120338 this means that if there is no volume of corn production there is a decrease of 120338(in million pesos) in the value of corn production.

2.2 Area planted and harvested

Figure 4: Relationship of Area planted/ harvested and Value of Production

Figure 4 shows a negative linear relationship between the value of production and the area planted/ harvested. The slope is -8.2661 this means that if there is one unit decrease in the area planted/ harvested there is 5778.0661 (in million pesos) decrease in the value of corn production. The y- intercept is 2634.9 this means that if there is no area planted/ harvested there is an increase of 2634.9 (in million pesos) in the value of corn production.

2.2 Yield per hectare

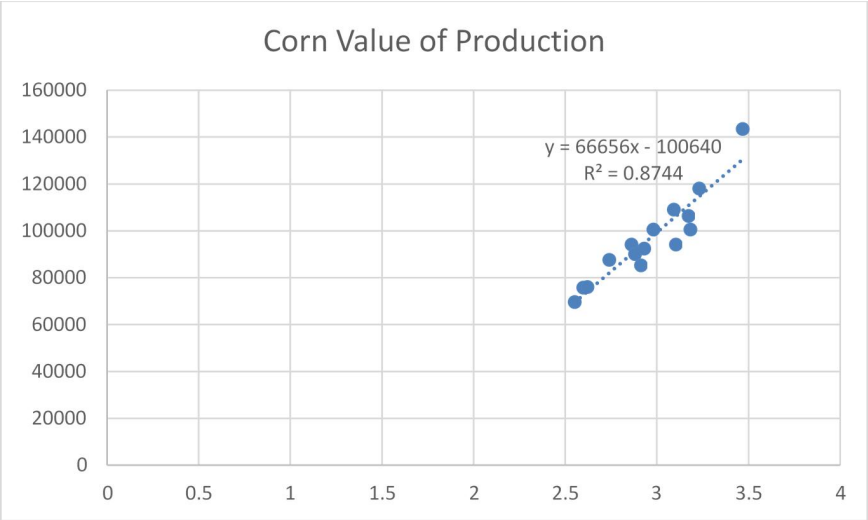

Figure 5: Relationship of Yield per Hectare and Value Production

Figure 5 illustrates a positive linear relationship between the yield per hectare and the value of corn production. The linear regression equation y=66656x−100640y = 66656x - 100640y=66656x−100640 with an R2=0.8744R^2 = 0.8744 R2=0.8744 indicates a strong correlation between the two variables. This means that for each unit increase in yield per hectare, the value of corn production increases by 66,656 million pesos. The y-intercept at -100,640 million pesos suggests that if the yield per hectare were zero, the value of corn production would decrease by this amount. This relationship highlights the significant impact that yield per hectare has on the overall value of corn production..

2.3 Volume of Production, Area Planted/ Harvested and Yield per Hectare altogether

Table 1 presents that value of corn production has a significant linear relationship with the volume of production, area planted/ harvested and yield per hectare.

Table 1. Multiple Regression Results of volume of production; area planted/ harvested, and yield per hectare.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.887578
R Square	0.787795
Adjusted R Square	0.729921
Standard Error	9616.031
Observations	15

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	3776081831	1258693944	13.6122	0.000506627
Residual	11	1017148532	92468048.38		
Total	14	4793230363			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-73695	134406.1293	-0.548300966	0.594438	-369520.9065	222130.9	-369521	222130.9
Corn Volume of production (x_1)	24.78592	5.311719836	4.666269724	0.000687	13.09490092	36.47693	13.0949	36.47693
Corn Area Planted/ Harvested (x_2)	-27.8713	44.64511653	-0.624285086	0.54517	-126.1345194	70.39196	-126.135	70.39196
Corn Yield Per Hectare (x_3)	14304.57	10814.02015	1.322780195	0.212749	-9496.926188	38106.07	-9496.93	38106.07

The regression analysis shows a strong positive relationship between corn production variables and an unspecified outcome, likely total production or revenue. The model accounts for 78.78% of the variation in the outcome. Corn volume of production is the most significant factor, with each unit increase in volume leading to a 24.7859 increase in the outcome, assuming other variables remain constant. Although corn area planted/harvested and yield per hectare also affect the outcome, their impact is not statistically significant. The r square of this relationship is 0.787795. The equation to be used will be $y = 24.78592x_1 - 27.8713x_2 + 14304.57x_3 - 73695$ in determining the predicted value of production (in million pesos).

SECTION 3 TIME SERIES MODEL

Linear

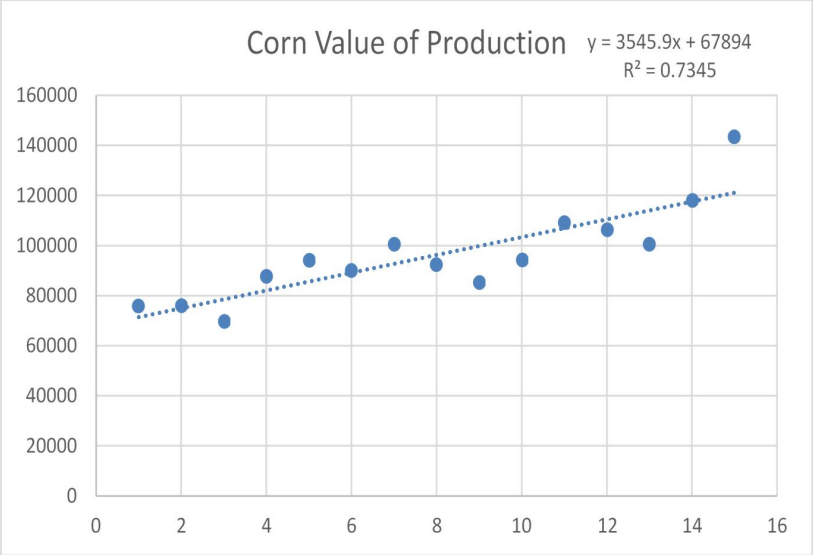

Figure 6: Linear Model of the Value of Corn Production from 2008-2022

The equation of this linear model is y = 3545.9x + 78089 and the coefficient of determination is 0.7345

Quadratic

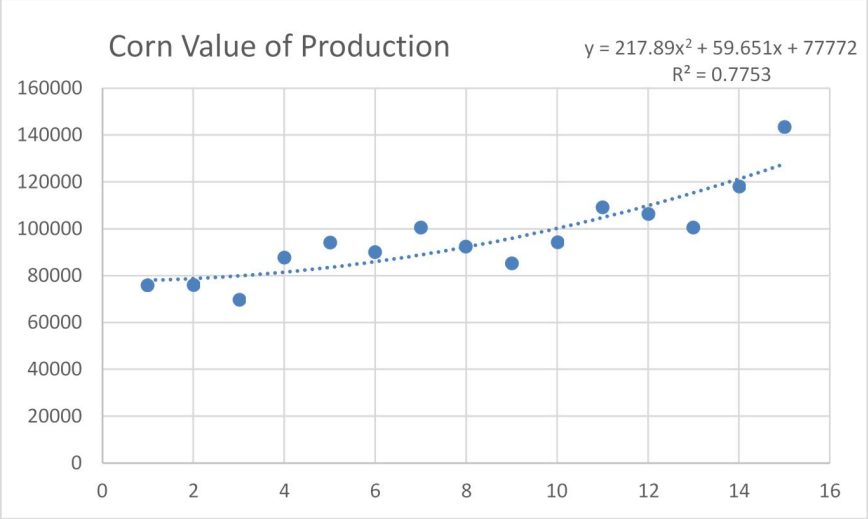

Figure 7: Quadratic Model of the Value of Corn Production from 2008-2022

The quadratic model of the value of corn production has an equation of $y = 217.89x^2 + 59.651x + 77772$ and a coefficient of determination of 0.7753.

Exponential

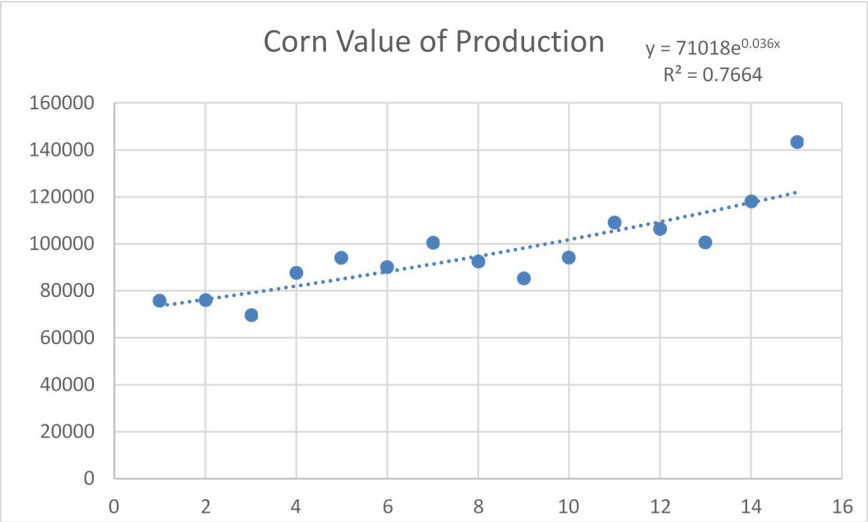

Figure 8: Exponential Model of the Value of Corn Production from 2008-2022

Exponential Model of the value of corn production produced an equation $y = 71018e^{0.036x}$ and a coefficient of determination of 0.7565.

Polynomial (Cubic)

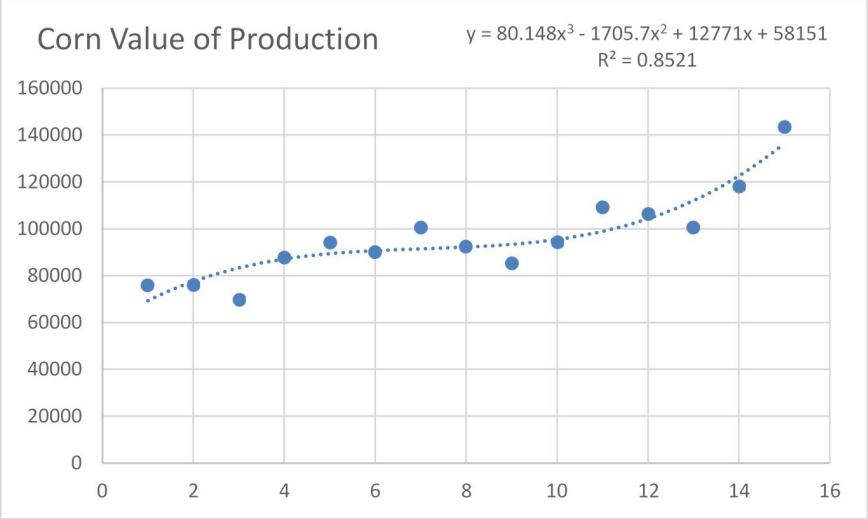

Figure 9: Polynomial (Cubic) Model of the Value of Corn Production from 2008-2022

The equation of this polynomial cubic model of the value of corm production is $y = 80.148x^3 - 4678.7x^2 + 12771x + 58151$ and its r^2 is equivalent to 0. 8521.

Polynomial (Quartic)

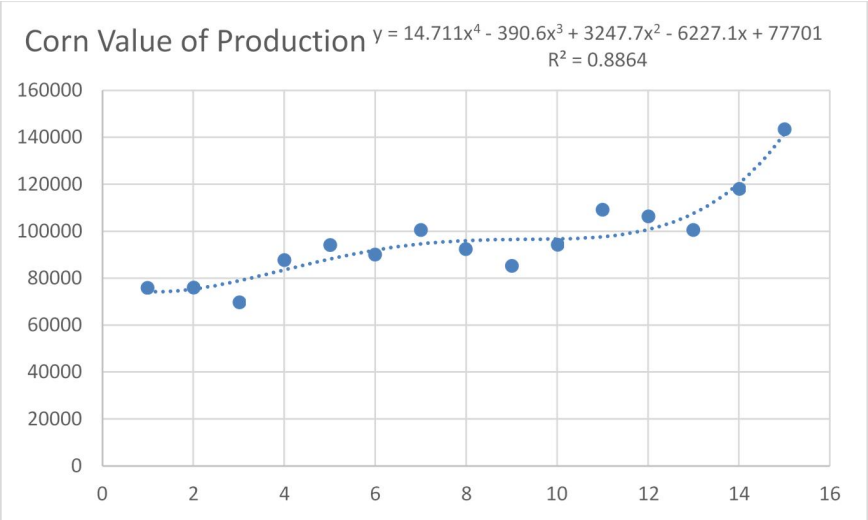

Figure 10: Polynomial (Quartic) Model of the Value of Corn Production from 2008-2022

The figure shows an equation of y = 14.711x4 - 390.6x3 + 3247.7x2 - 6227.1x + 77701 and a coefficient of determination of 0.8864.

Polynomial (Quintic)

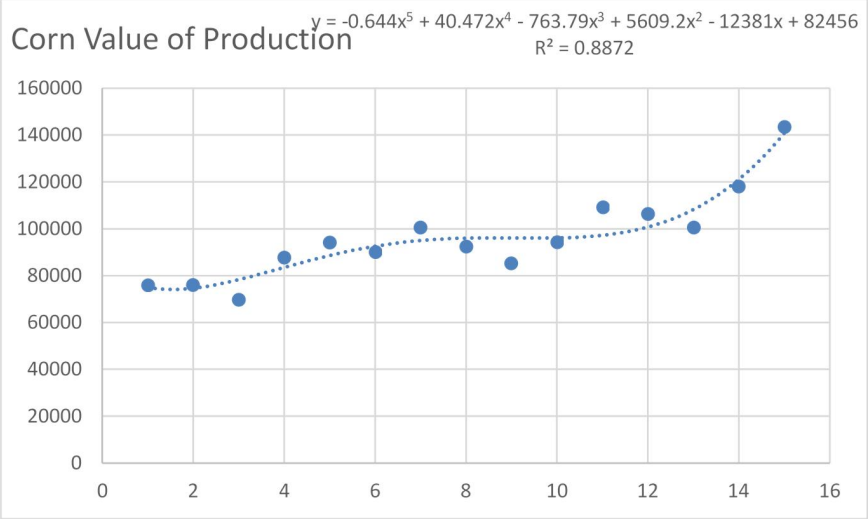

Figure 11: Polynomial (Quintic) Model of the Value of Corn Production from 2008-2022

Figure 11 of polynomial quintic of the value of corn production from 2008-2022 presents an equation of $y = -0.644x^5 + 40.472x^4 - 763.79x^3 + 5609.2x^2 - 12381x + 82456$ and a coefficient of determination of 0.8872

Polynomial (Sextic)

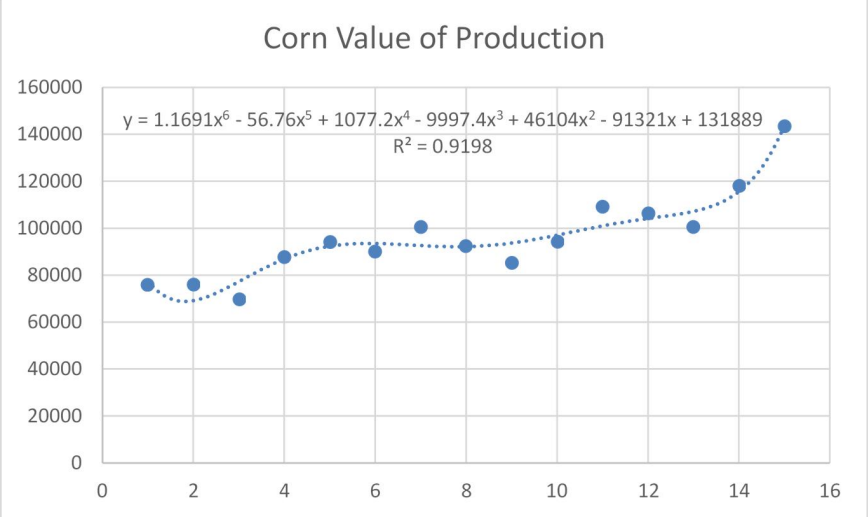

Figure 12: Polynomial (Sextic) Model of the Value of Corn Production from 2008-2022

This polynomial(sextic) model of the value of corn production from 2008-2022 produced an equation of y = 1.1691x6 - 56.76x5 + 1077.2x4 - 9997.4x3 + 46104x2 - 91321x + 131889 and $r^2 = 0.9198$.

Power

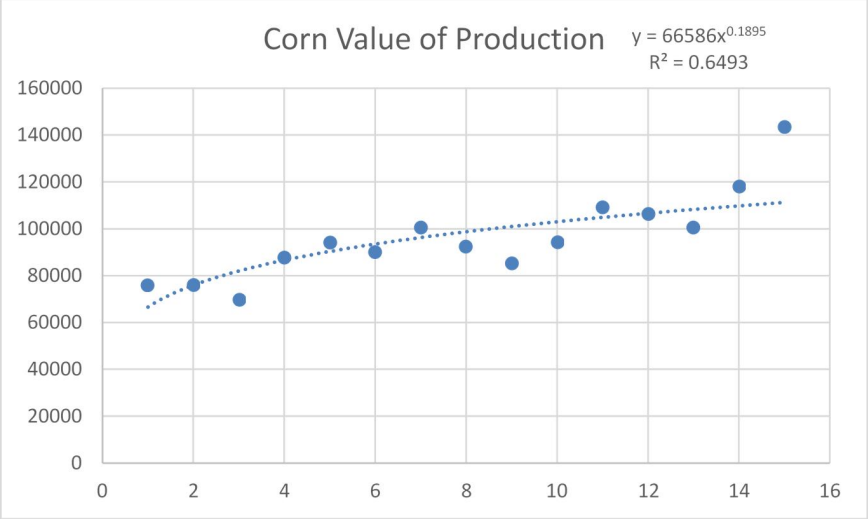

Figure 13: Power Model of the Value of Corn Production from 2008-2022

The equation of this power model of value of corn production is $y = 66586x^{0.1895}$ and the coefficient of determination is 0.626

Moving Average

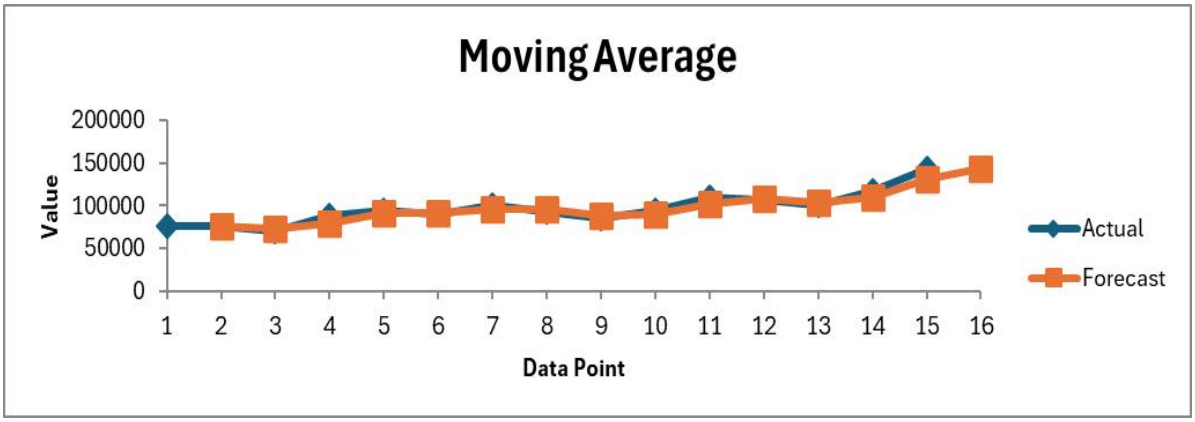

Figure 14: Moving Average Model of the Value of Corn Production from 2008-2022

Exponential Smoothing

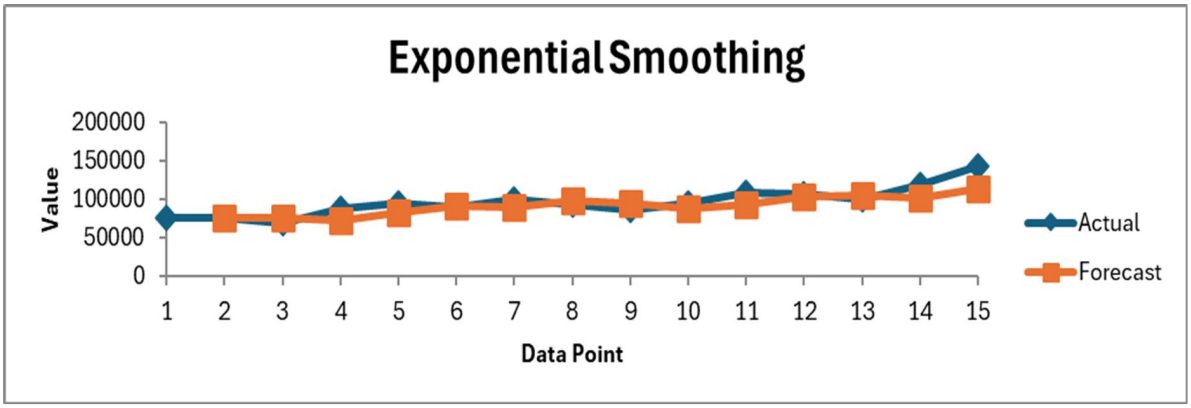

Figure 15: Exponential Smoothing Model of the Value of Corn Production from 2008-2022

Auto Regression

Table 2 presents the results of the auto regression model of the value of corn production from 2008-2022

Table 2. Auto regression model of the value of corn production from 2008-2022.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.766658
R Square	0.587764
Adjusted R Square	0.550289
Standard Error	11998.21
Observations	13

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2.26E+09	2.26E+09	15.68377	0.002233
Residual	11	1.58E+09	1.44E+08		
Total	12	3.84E+09			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1618.378	24910.2	0.064968	0.949365	-53208.6	56445.36	-53208.6	56445.36
x variable 1	1.03786	0.262068	3.960275	0.002233	0.461053	1.614668	0.461053	1.614668

Table 2 has an r^2 of 0.587764 and using the coefficients of intercept and x variable 1 we can produce and equation of $y(t) = 1618.378 + 1.03786y_{t-1}$

Summary Table

Table 3 presents the summary of all models used in the value of corn production from year 2008-2022 and the equation of different models.

Table 3. Summary Table of different models and the equation of each model.

Model	Equation
Linear	$y = 3545.9x + 78089$
Quadratic	$y = 217.89x^2 + 59.651x + 77772$
Exponential	$y = 71018e^{0.36x}$
Polynomial (Cubic)	$y = 80.148x^3 - 1705.7x^2 + 12771x + 58151$
Polynomial (Quartic)	$y = 14.711x^4 - 390.6x^3 + 3247.7x^2 - 6227.1x + 77701$
Polynomial (Quintic)	y = -0.644x5 + 40.472x4 - 763.79x3 + 5609.2x2 - 12381x + 82456
Polynomial (Sextic)	y = 1.1691x6 - 56.76x5 + 1077.2x4 - 9997.4x3 + 46104x2 - 91321x + 131889
Power	$y = 66586x^{0.1895}$
Moving Average	N/A
Exponential Smoothing	N/A

Autoregression	$y(t) = 1618.378 + 1.03786y_{t-1}$

SECTION 4: BEST FIT MODEL AND PREDICTION

Table 4 presents the different models used in the value of corn production from 2008-2022, the equation, coefficient of determination and the standard error of each model.

Table 4. Summary of different models used in in the value of corn production from 2008-2022, the equation, coefficient of determination and the standard error of each model.

Model	Equation	*R*2	SE
Linear	$y = 3545.9x + 78089$	$R^2 = 0.7345$	9534.138422
Quadratic	$y = 217.89x^2 + 59.651x + 77772$	$R^2 = 0.7753$	8771.032625
Exponential	$y = 71018e^{0.36x}$	$R^2 = 0.7565$	9130.586454
Polynomial (Cubic)	$y = 80.148x^3 - 1705.7x^2 + 12771x + 58151$	$R^2 = 0.8521$	7115.95638
Polynomial (Quartic)	$y = 14.711x^4 - 390.6x^3 + 3247.7x^2 - 6227.1x + 77701$	$R^2 = 0.8864$	6236.463084
Polynomial (Quintic)	y = -0.644x5 + 40.472x4 - 763.79x3 + 5609.2x2 - 12381x + 82456	$R^2 = 0.8872$	6214.464909
Polynomial (Sextic)	$y = 1.1691x^6 - 56.76x^5 + 1077.2x^4 - 9997.4x^3 + 46104x^2 - 91321x + 131889$	$R^2 = 0.9198$	5240.061383
Power	$y = 66586x^{0.1895}$	$R^2 = 0.6263$	11311.25359
Autoregression	$y(t) = 1618.378 + 1.03786y_{t-1}$	*R*2 = 0.587764	11880.15612

Table 4 shows that polynomial (sextic) has a coefficient of determination of 0.9198 which is very close to 1 and has a standard error of 5240.061383 which is lowest among the standard error of the other models. Thus, the best fit model to predict the value of corn production in the following year is the polynomial particularly the sextic model. Using this model, the value of corn production will increase 77090.209 (in million pesos).

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary

One of the important techniques in any kind of businesses is predicting their profit or the forecasting technique. In this study the researcher tries to predict the value of corn production in the next years using different models, there is a need to predict the value of corn production because it helps the corporation of corn to develop a business strategy and make a right decision for the business.

Summary of Findings

1. Trend: The value of corn production from 2008 to 2022 exhibited fluctuations but demonstrated an overall increasing trend. While there was initial stability from 2008 to 2010, a significant rise was observed from 2011 to 2013, peaking in 2012. Subsequent years saw fluctuations, with a period of stabilization from 2017 to 2019. The most notable growth occurred from 2020 to 2022, culminating in the highest recorded value in 2022, reaching 143,440.8 million pesos. This consistent growth underscores the increasing importance of corn in the Philippine agricultural landscape.
2. Linear Relationships: The analysis revealed clear linear relationships between the value of corn production and several key factors. Volume of production exhibited a positive linear relationship, indicating that as production volume increases, so does the value. Conversely, area planted/harvested showed a negative linear relationship, suggesting potential challenges in optimizing land use efficiency. Yield per hectare demonstrated a positive linear relationship, highlighting the importance of improving productivity per unit area. When analyzed collectively through multiple regression, these three factors together exhibited a significant positive relationship with the value of corn production, explaining 78.78% of the variation, underscoring their combined influence on the overall value.

3. Time Series Models: A comprehensive assessment of various time series models identified the polynomial (sextic) model as the most accurate predictor. This model exhibited the highest coefficient of determination (0.9198), indicating its strong ability to explain the variation in the data. Furthermore, it displayed the lowest standard error, suggesting minimal deviation from the actual values. The polynomial (sextic) model's superior performance in capturing the complex trends and patterns in corn production value establishes it as the most reliable tool for forecasting future values.
4. Best Fit Model and Prediction: Based on the analysis, the polynomial (sextic) model emerged as the best fit model for predicting the value of corn production. Utilizing this model, the projected value of corn production in 2023 is estimated to increase by 77,090.209 million pesos. This prediction indicates a substantial growth potential in the corn industry, offering valuable insights for stakeholders and policymakers to make informed decisions for future development.

Conclusions

The results show the possibilities in the value of production in the year 2024. Where, there is a great increase in value of corn production.

Recommendations

Based on the research findings and projected increase in corn production value, it is highly recommended to prioritize expanding corn cultivation in the Philippines by increasing the area planted/harvested while also focusing on improving yield per hectare through the adoption of modern agricultural practices and technologies.
For future researchers, there is a need to study more about the factors that affect the value of corn production.

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