Modeling and forecasting of agricultural crop production and economic stability based on Gross Regional Domestic Product

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ABSTRACT

The Philippine economy is largely dependent on agriculture with a total land area of 11.6 million hectares dedicated to crops. Rice and corn are the leading produce so far, occupying around 5.5 million of the total number of hectares. This figure is followed by 4.8 million hectares taken up by major crops consisting of fruits such as coconut, pineapple, banana, and mango, and other crops in demand like sugar and coffee. The other 1.3 million hectares are distributed to other minor crops. The Philippine economy is largely sustained by crop production because in spite of the occurrence of natural disasters and economic pitfalls (such as unemployment or displacement) that regularly hit the nation, people are able to continually feed themselves and support each other. In 2002, Eastern Visayas registered 330.8 thousand farms for agricultural use, covering 723 thousand hectares. Among the provinces in Eastern Visayas, Leyte shared the highest number of farms with 136.2 thousand, covering 258.6 thousand hectares of agricultural land. Samar ranked second with 57 thousand farms, covering 102 thousand hectares, while Northern Samar came in third with 49.9 thousand farms, covering 179.5 thousand hectares. Hence, the Philippines' quests for global competitiveness and food security requires an effective and efficient crop forecasting system that can be used for monitoring as well as strategic and tactical decision-making on crop production. This study aimed to forecast the agricultural crop production and economic stability based on GRDP in Eastern Visayas from 2nd quarter of 2015 to 4th quarter of 2017. The findings of the study give significant effects and impacts on Philippine economy which threatens our agricultural production in the country. The study also showed no significant relationship between the agricultural production like production volume, area harvested and yields per hectare of corn and palay and the economic stability in terms of GRDP per capita, imports and exports of agricultural products. We therefore established that the economic stability based on gross domestic product is not a predictive factor on the agricultural crop production in Region VIII.

Keywords: *agricultural crops, economic stability, forecasting, time series, GRDP*

I. INTRODUCTION

The demand for cereal crops in Asia, especially rice, has resulted to higher commercialization and diversification in its agriculture. However, it has been an observed trend that in the process of a country's development the role played by agriculture eventually plunges towards a decline. Data gathered on agricultural transformation plainly shows that the decline in the labor share of agriculture is much slower than that of the share of agriculture in national GDP. In the Philippine scenario, efforts to move towards more sustainable development on both regional and national levels have become focused towards the natural resources sector including agriculture and food security.

There is some level of commitment from the Pacific regional governments and their international partners have committed to address which has impact on agriculture and crop production. It gives priorities in terms of resource allocation and development planning by regional countries in the past and supports the majority of the people's livelihood (Ivanova, Aladjajiyan & Goushlekov, 2006).

The agricultural sector has been a major play in the Philippine economy. With changing national and global trends, the sector has identified a number of strategies to be competitive, especially strategies that can help alleviate poverty and increase crop productivity. The passage by the Philippine Congress of the Agriculture and Fisheries Modernization Act of 1997 is a giant leap towards reaping the previous efforts of both government and private sectors on crop production (Espino & Atienza 2008).

The role of agriculture in the Philippine economy has undergone dramatic changes. Its contribution of agriculture to Gross Domestic Product (GDP) and exports of the Philippines is declining, consistent with the country's transition to middle income status. Structural change and population growth has caused a shift in its position from net food exporter to net food importer in the late 1980s.

Eastern Visayas is primarily an agricultural region where its population of presently more than four million largely depends on rice as a staple food. It directly faces the Pacific Ocean which relatively, has consequential effect to its unique climatic condition. It receives heavy rainfall throughout the year and is frequently visited by typhoons. It has no pronounced dry season which was found to have substantial bearing on rice production. The first half of the year (January to June) yields a reasonably higher rate of rice production within the region: around 54%, in contrast to the 46% yield produced within the next half of the year from July to December (Briones, 2013).

Indeed, rice provides for sustenance and as a source of staple food; many families depend on rice cultivation for income. By means of applying proper rice production technologies, farmers can earn an average net income of as much as 21 to 41 thousand pesos. Raising rice productivity per unit area is one way of ensuring increase in farmers' income.

Rice also plays an important cultural role in the region. In many areas, the role of rice as a staple food has become so ingrained in the culture to the point that it has inspired various festivals in the region. Some of these festivals include the Pintados- Kasadyaan festival in Leyte, Sangyaw in Tacloban City, and Padul-ong in Borongan, Eastern Samar.

Corn is second to rice as the most important crop in the country. In fact the Department of Agriculture through its corn program continues to intensify the promotion of white corn grits as a staple food. Likewise, it aims to increase production of quality of corn for human consumption, feeds and industrial uses, and to boost the income of corn farmers in the region.

Hence, the Philippines' quests for global competitiveness and food security requires an effective and efficient crop forecasting system that can be used for monitoring as well as strategic and tactical decision-making on crop production (Lansigan, Salvacion, Paningbatan, Solivas & Matienzo, 2007). Advances in systems research tools provide opportunities to predict or forecast crop production and the economic stability in the region to certain lead time with reasonable accuracy.

Moreover, appropriate mathematical modeling should be used for this particular design for an effective way in predicting or forecasting data. This method allows for a clearer understanding and a deeper exploration of the connection shared by agricultural crop production and economic stability based on gross domestic product like the exports, imports and GRDP per capita. It also bodes well as a method of translating problems from real life systems to conformable and manageable mathematical expressions (Hepelwa, 2010).

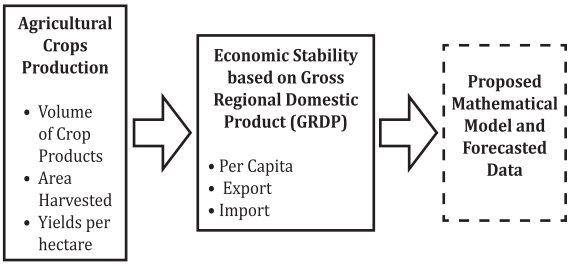

Figure 1. A schema depicting the relationships of agricultural crop production and economic stability based on Gross Regional Domestic Product (GRDP).

II. OBJECTIVES

The study aimed to forecast and develop a mathematical model in terms of agricultural crop production and economic stability based on Gross Regional Domestic Product (GRDP) in Eastern Visayas from 2nd quarter of 2015 to 4th quarter of 2017.

Thus, specific requirements are considered to examine trends and cycles in historical data with the use of mathematical models to extrapolate to the future. These requirements include: the agricultural crop production i.e volume of crop products, area harvested, yields per hectare and economic stability based on gross regional domestic product (GRDP) i.e per capita, export and import.

III. RESEARCH METHODOLOGY

This study used the correlational-observation research design in which the variables are correlated and predicted to come up with a mathematical model. A time series design which used the data from the past to predict agricultural crop production and economic stability based on GRDP is illustrated in the figure below.

$$O_1O_2O_3O_4 \ X \ O_5O_6O_7O_8$$

Legend: $O_1O_2O_3O_4$ = observed data from the past
$O_5O_6O_7O_8$ = observed data as predicted
x = proposed mathematical model

Figure 2. Time Series Design

The researchers made a letter of permission to the office of the Department of Agriculture to ask information about agricultural crop productions including exports and imports in Eastern Visayas region. Likewise, a letter of approval was also sent to the Philippine Statistics Authority Region VIII for additional data and information in terms of volume of productions, area harvested and yields per hectare in Region VIII. The online data banking was used from the office of the Bureau of Agricultural Statistics (Briones, 2013).

After data gathering, the data were stored in a spreadsheet database file in the researcher's personal computer and were utilized in the computations and statistical analysis. The data collected was consolidated and interpreted using SPSS V18 in terms of agricultural crops production and economic stability based on the gross regional domestic product (GRDP). The actual gathered data were from the 1st quarter of 2004 to the 2nd quarter of 2017. The relationship between the agricultural crops production profile and economic stability was used as the basis in the development of mathematical model. Finally, the researchers formulated conclusions and recommendations.

The collected data from this study were presented in spreadsheet tables designed by the researcher using Microsoft Excel and SPSS V18. This database file storing the responses was exported to statistical software for query information.

All data were treated statistically using the appropriate formulas approaches in forecasting.

a. Graphical Method - Line Graph
b. Time Series Analysis - Exponential Smoothing and ARIMA (Autoregressive Integrated Moving Average)
c. Correlation Analysis - Pearson-r
d. Predictive Modeling

IV. RESULTS AND DISCUSSIONS

Volume of Production of *Palay* in Eastern Visayas

Table 1 shows the ARIMA and simple seasonal mathematical models in time series analysis for production volume of *palay* in Eastern Visayas.

Table 1
Time series analysis model type in production volume of palay

		Mathematical Model
Volume of Production of Palay in Biliran	Model 1	Simple Seasonal
Volume of Production of Palay in Eastern Samar	Model 2	ARIMA(0.0.0)(0.1.0)
Volume of Production of Palay in Leyte	Model 3	ARIMA)1.0.0)(0.1.0)
Volume of Production of Palay in Northern Samar	Model 4	Simple Seasonal
Volume of Production of Palay in Southern Leyte	Model 5	ARIMA(0.0.1)(0.1.0)
Volume of Production of Palay in Western Samar	Model 6	ARIMA(0.0.0)(0.1.0)

Table 2 shows no significant difference across all models between the observed and forecasted data in production volume of *palay* in Eastern Visayas. It implies that all models fit to the observed data.

Table 2
Significant difference between observed and forecasted data in production volume of palay.

Model	Ljung Box Q(18)			Interpretation
	Statistics	df	*p*- value	Not Significant
Biliran- Model 1	15.645	16	.478	Not Significant
Eastern Samar-Model 2	12.090	18	.843	Not Significant
Leyte- Model 3	16.399	17	.496	Not Significant
Northern Samar-Model 4	17.734	16	.340	Not Significant
Southern Leyte-Model 5	6.689	17	.987	Not Significant
Western Samar-Model 6	12.049	18	.845	Not Significant

Figure 3 shows the observed and forecasted data in terms of production volume of *palay* in Region VIII. Eastern Samar and Western Samar show the increased of trend and seasonality in production volume of *palay*. It implies potential improvement in production of *palay* in a particular area. Other provinces show the stationary trend and seasonality in production. It means that the production of *palay* in other provinces are stable.

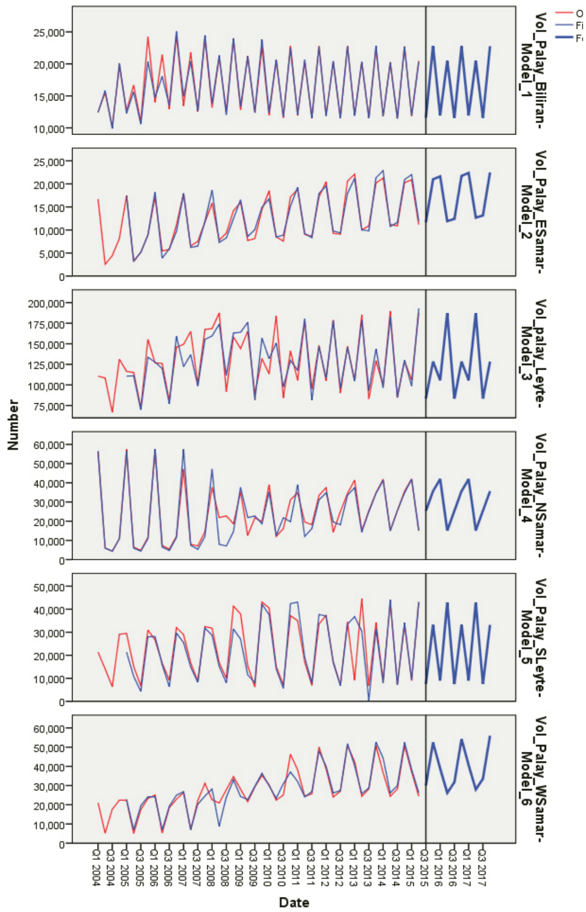

Figure 3. Graphical presentation of the observed and forecasted data in production volume of *palay* in Region 8.

Volume of Production of Corn in Eastern Visayas

Table 3 shows the simple seasonal, winters' additive/multiplicative and ARIMA mathematical models in time series analysis for production volume of corn in Eastern Visayas.

Table 3
Time Series analysis model type in production volume of palay

	Model Description		Mathematical Model
Model ID	Volume of Production of Corn in Biliran	Model 1	Simple Seasonal
	Volume of Production of Corn in Eastern Samar	Model 2	Winters' Addictive
	Volume of Production of Corn in Leyte	Model 3	Winters' Multiplicative
	Volume of Production of Corn in Northern Samar	Model 4	ARIMA(0,0,0)(0,1,0)
	Volume of Production of Corn in Southern Leyte	Model 5	ARIMA(1,0,0)(0,1,0)
	Volume of Production of Corn in Western Samar	Model 6	ARIMA(1,0,0)(0,1,0)

Table 4 shows no significant difference across all models between the observed and forecasted data in production volume of corn in Eastern Visayas. It implies that all models fit to the observed data.

Table 4
Significant different between observed and forecasted data in production volume of corn.

Model	Ljung Box Q(18) Statistics	df	*p*-value	Interpretation
Biliran- Model 1	24.537	16	.078	Not Significant
Eastern Samar- Model 2	13.184	15	.588	Not Significant
Leyte- Model 3	30.440	15	.050	Not Significant
Northern Samar- Model 4	6.699	18	.992	Not Significant
Southern Leyte- Model 5	17.077	17	.449	Not Significant
Western Samar- Model 6	17.553	17	.478	Not Significant

Figure 4 shows the graph of the observed and forecasted data in terms of production volume of corn in Region VIII. Eastern Samar and Northern Samar show the increase of trend and seasonality in production volume of corn. It implies a potential improvement in production volume of corn in a particular area. Other provinces show a stationary trend and seasonality in production. It means that the production volume of corn in other provinces are stable.

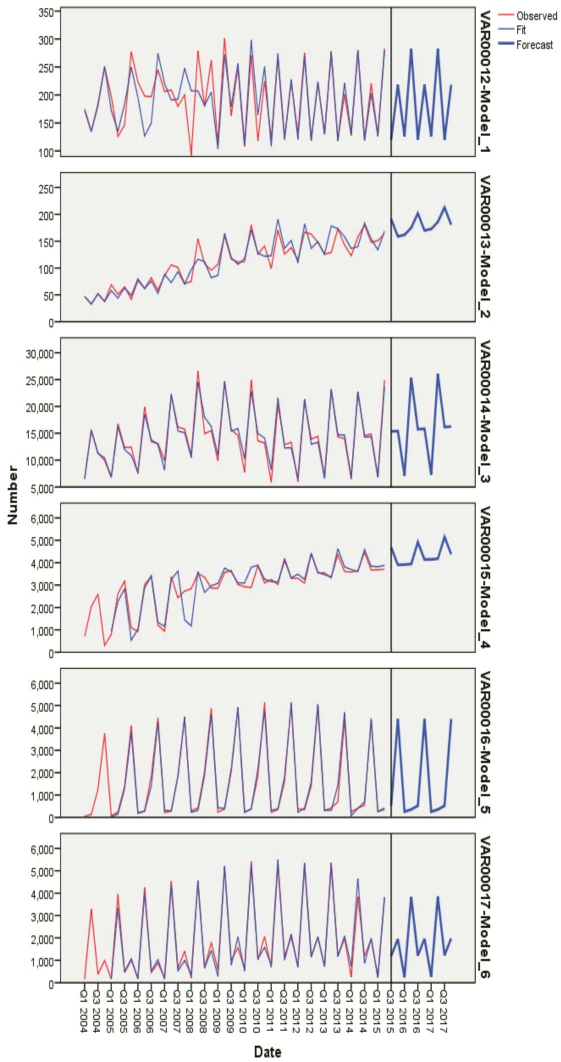

Figure 4. Graphical presentation of the observed and forecasted data in production volume of corn in Region 8.

Area harvested of *Palay* in Eastern Visayas

Table 5 shows the simple seasonal and ARIMA mathematical models in time series analysis for area harvested *palay* in Eastern Visayas.

Table 5

Time series analysis model type in area harvested of palay

	Model Description		Mathematical Model
Model ID	Area Harvested of Palay in Biliran	Model 1	ARIMA(0,0,0)(0,1,0)
	Area Harvested of Palay in Eastern Samar	Model 2	ARIMA(0,0,0)(0,1,0)
	Area Harvested of Palay in Leyte	Model 3	ARIMA(1,0,0)(0,1,0)
	Area Harvested of Palay Northern Samar	Model 4	Simple Seasonal
	Area Harvested of Palay in Southern Leyte	Model 5	ARIMA(0,0,1)(0,1,0)
	Area Harvested of Palay in Western Samar	Model 6	ARIMA(0,0,0)(0,1,0)

Table 6 shows no significant difference across all models between the observed and forecasted data in area harvested *palay* in Eastern Visayas. It implies that all models fit to the observed data.

Table 6

Significant difference between observed and forcasted data in area harvested palay.

Model	Ljung-Box Q(18)			Interpretation
	Statistics	df	*p*-value	
Biliran- Model 1	9.75	18	.940	Not Significant
Eastern Samar- Model 2	12.986	18	.792	Not Significant
Leyte - Model 3	11.928	17	.804	Not Significant
Northern Samar- Model 4	26.065	16	.053	Not Significant
Southern Leyte- Model 5	7.527	17	.976	Not Significant
Western Samar- Model 6	9.248	18	.954	Not Significant

Figure 5 shows the graph of the observed and forecasted data in terms of area harvested *palay* in Eastern Visayas. Eastern Samar and Western Samar show the increased of trend and seasonality in area harvested *palay*. It implies a vast harvest in production of *palay* in particular area. The remaining provinces show a stationary trend and seasonality except in Northern Samar, where there tends to be a decrease the conditions in harvested area in production of *palay* due to frequent typhoons and poor climatic conditions.

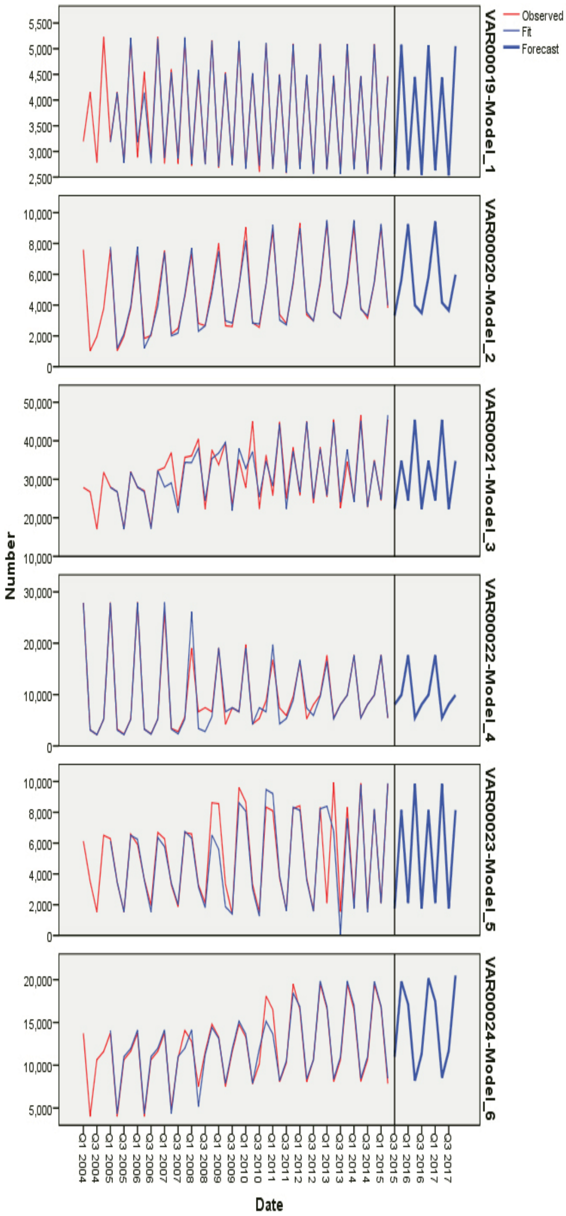

Figure 5. Graphical presentation of the observed and forecasted data in area harvested *palay* in Region 8.

Area harvested of Corn in Eastern Visayas

Table 7 shows the winters' additive/ multiplicative and ARIMA mathematical models in time series analysis for area harvested corn in Eastern Visayas.

Table 7
Time series analysis model type in area harvested corn

	Model Description		Mathematical Model
Model ID	Area Harvested of Corn in Biliran	Model 1	ARIMA(0,0,0)(0,1,0)
	Area Harvested of Corn in Eastern Samar	Model 2	Winters' Addictive
	Area Harvested of Corn in Leyte	Model 3	Winters' Multiplicative
	Area Harvested of Corn in Northern Samar	Model 4	ARIMA(0,0,0)(0,1,0)
	Area Harvested of Corn in Southern Leyte	Model 5	ARIMA(0,0,0)(1,2,0)
	Area Harvested of Corn in Western Samar	Model 6	ARIMA(1,0,0)(0,1,0)

Table 8 shows no significant difference across all models between the observed and forecasted data in area harvested corn in Eastern Visayas. It implies that all models fit to the observed data.

Table 8
Significant difference between observed and forecasted data in area harvested corn.

Model	Ljung-Box Q(18)			Interpretation
	Statis-tics	df	*p*-value	
Biliran-Model 1	17.094	18	.517	Not Significant
Eastern Samar- Model 2	18.033	15	.261	Not Significant
Leyte-Model 3	10.151	15	.810	Not Significant
Northern Samar - Model 4	12.067	18	.844	Not Significant
Southern Leyte- Model 5	22.934	17	.151	Not Significant
Western Samar- Model 6	6.142	17	.992	Not Significant

Figure 6 shows the graph of the observed and forecasted data in terms of area harvested corn in Eastern Visayas. Eastern Samar and Northern Samar show the increased of trend and seasonality in area harvested corn. It implies a vast harvest in production of corn. The remaining provinces show the stationary trend and seasonality except in Southern Leyte tends to decline the conditions in area harvested in corn might due to past soil erosion occurrence in some particular area.

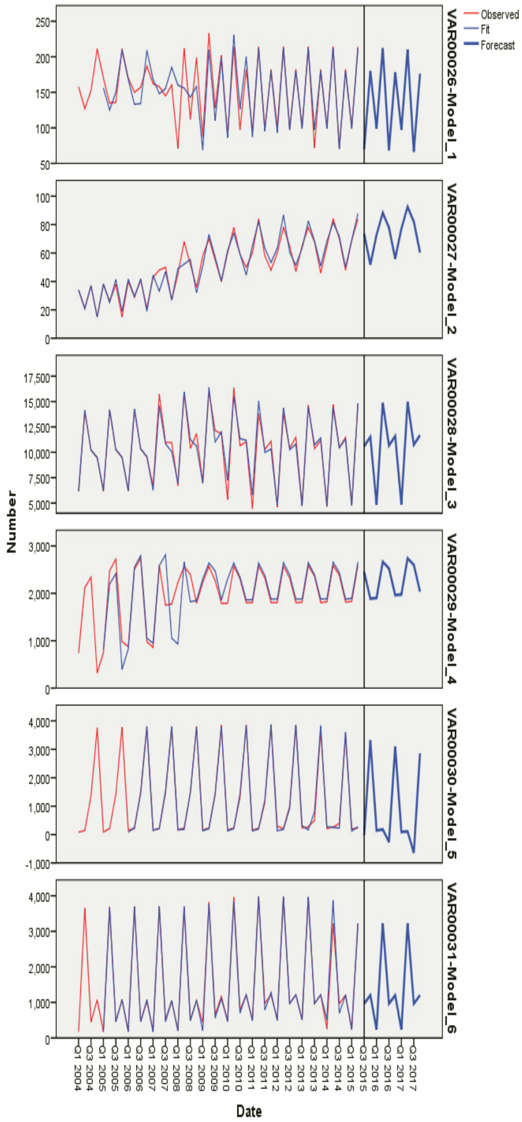

Figure 6. Graphical presentation of the observed and forecasted data in area harvested corn in Region 8.

Yield of *Palay* in Eastern Visayas

Table 9 shows the simple seasonal and ARIMA mathematical models in time series analysis in terms of *palay* yield per hectare in Eastern Visayas.

Table 9

Time Series Analysis Model Type in terms of palay yield per hectare

	Model Description		Mathematical Model
Model ID	Yield of Palay in Biliran	Model 1	ARIMA(0,1,0)(1,0,0)
	Yield of Palay in Eastern Samar	Model 2	ARIMA(0,0,0)(0,1,0)
	Yield of Palay in Leyte	Model 3	Simple Seasonal
	Yield of Palay in Northern Samar	Model 4	ARIMA(0,0,1)(0,1,0)
	Yield of Palay in Southern Leyte	Model 5	Simple Seasonal
	Yield of Palay in Western Samar	Model 6	Simple Seasonal

Table 10 shows no significant difference across all models between the observed and forecasted data in terms of yield of *palay* harvested per hectare. It implies that all models fit to the observed data.

Table 10

Significant difference between observed and forecasted data in terms of yield of palay harvested per hectare

Model	Ljung-Box Q(18)			Interpretation
	Statistics	df	*p*-value	
Biliran-Model 1	12.794	17	.750	Not significant
Eastern Samar-Model 2	14.633	18	.687	Not significant
Leyte-Model 3	10.726	16	.826	Not significant
Northern Samar-Model 4	18.101	17	.383	Not significant
Southern Leyte-Model 5	9.439	16	.894	Not significant
Western Samar-Model 6	8.279	16	.940	Not significant

Figure 7 shows the graph of the observed and forecasted data in terms of *palay* yield per hectare in Region VIII. Eastern Samar, Northern Samar and Western Samar show the increased of trend and seasonality in terms of *palay* yield per hectare. It implies a possible increased of *palay* yield in a particular area. The remaining provinces show a stationary trend and seasonality, which means that they have static and stable conditions in terms of *palay* yield per hectare.

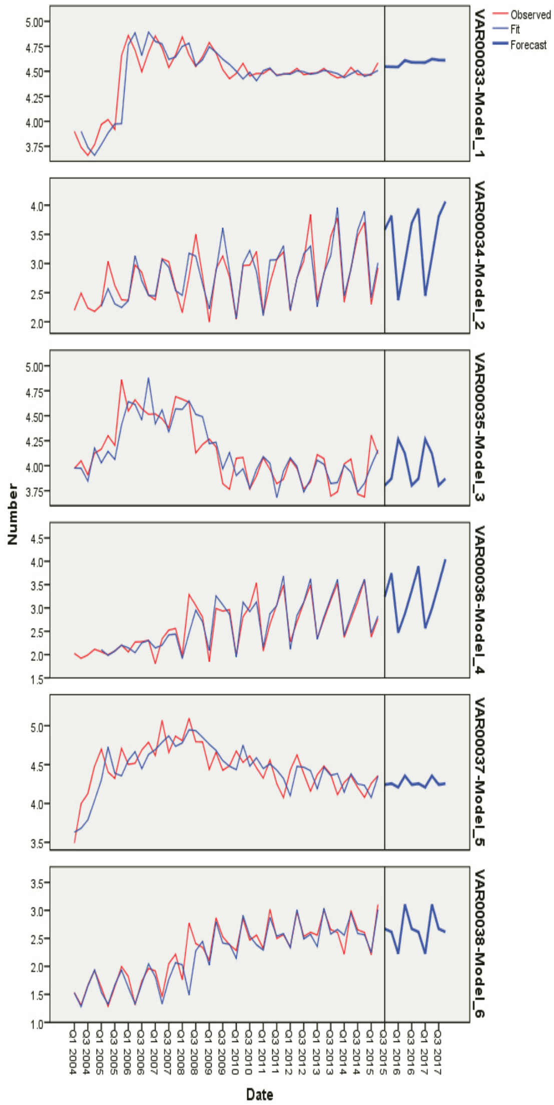

Figure 7. Graphical presentation of the observed and forecasted data in terms of *palay* yield per hectare in Region 8.

Yield of Corn in Eastern Visayas

Table 11 shows the simple seasonal, ARIMA and winters' additive mathematical models in time series analysis for corn yield per hectare in Eastern Visayas.

Table 11

Time series analysis model type in terms of corn yield per hectare

Model Description			Mathematical Model
Model ID	Yield of Corn in Biliran	Model 1	Simple Seasonal
	Yield of Corn in Eastern Samar	Model 2	Simple Seasonal
	Yield of Corn in Leyte	Model 3	Simple Seasonal
	Yield of Corn in Northern Samar	Model 4	ARIMA(0,0,3)(0,1,0)
	Yield of Corn in Southern Leyte	Model 5	Winters' Additive
	Yield of Corn in Western Samar	Model 6	Winters' Additive

Table 12 shows no significant difference across all models between the observed and forecasted data in terms of corn yield per hectare. It implies that all models fit to the observed data.

Table 12

Significant difference between observed and forecasted data in terms of corn yield per hectare.

Model	Ljung-Box Q(18)			Interpretation
	Statistics	df	*p*-value	
Yield of Corn in Biliran-Model 1	20.363	16	.204	Not significant
Yield of Corn in Eastern Samar-Model 2	11.932	16	.794	Not significant
Yield of Corn in Leyte-Model 3	21.535	16	.159	Not significant
Yield of Corn in Northern Samar-Model 4	13.748	17	.685	Not significant
Yield of Corn in Southern Leyte-Model 5	25.030	15	.050	Not significant
Yield of Corn in Western Samar-Model 6	8.671	15	.894	Not significant

Figure 8 shows the graph of the observed and forecasted data in terms of corn yield per hectare in Region VIII. Eastern Samar, Leyte and Northern Samar show an increase of trend and seasonality in terms of corn yield per hectare. It implies a possible increased of corn yield per hectare in particular area. Other provinces show a stationary trend and seasonality in terms of corn yield per hectare except in Western Samar which has projected a very low corn yield, which might be due to poor climatic and soil conditions in a particular area.

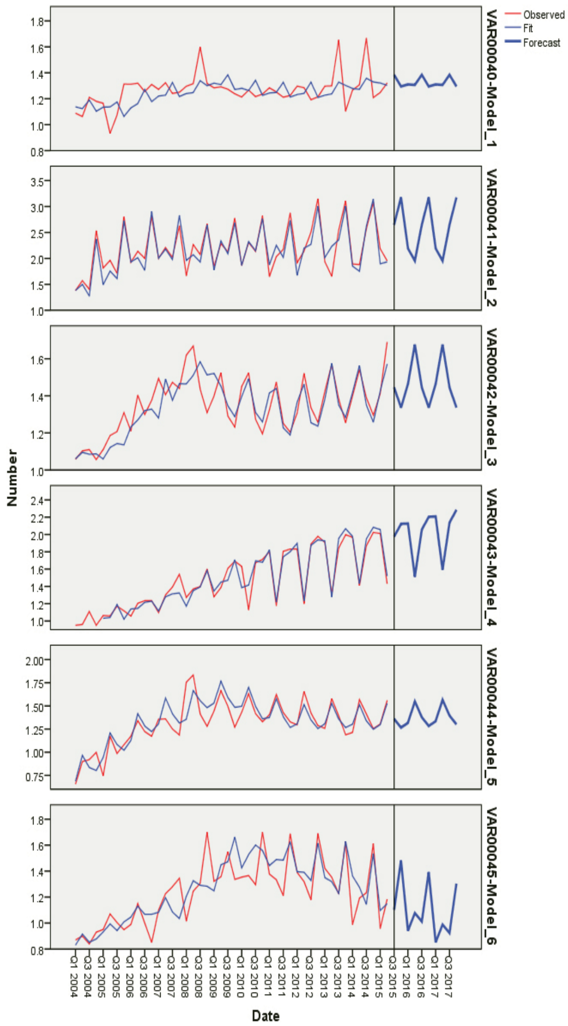

Figure 8. Graphical presentation of the observed and forecasted data in terms of corn yield per hectare in Region 8.

Economic Stability in Eastern Visayas

Table 13 shows the simple seasonal mathematical models in time series analysis in terms of per capita, export and import in Eastern Visayas.

Table 13.
Time series analysis model type in terms of per capita, export and import of agricultural products.

	Model Description		Mathematical Model
Model ID	Per Capita GRDP (in pesos at 2000 constant prices)	Model 1	Simple
	Export in Eastern Visayas (FOB Value in Thousand US Dollars)	Model 2	Simple Seasonal
	Import in Eastern Visayas (FOB Value in Thousand US Dollars)	Model 3	Simple

Table 14 shows no significant difference across all models between the observed and forecasted data in terms of per capita, export and import of agricultural products. It implies that all models fit to the observed data.

Table 14
Significant difference between observed and forecasted data in terms for per capita, export and import of agricultural products.

MODEL	Ljung-BoxQ(18)			Interpretation
	Statistics	*df*	*p*-value	
Per Capita GRDP (in pesos at 2000 constant prices)-Model 1	1.306	17	1.000	Not significant
Export in Eastern Visayas (FOB Value in Thousand US Dollars)-Model 2	15.602	16	.481	Not significant
Export in Eastern Visayas (FOB Value in Thousand US Dollars)-Model 3	24.507	17	.106	Not significant

Figure 9 shows the graph of the observed and forecasted data in terms of per capita, export and import of agricultural products in Eastern Visayas. It shows a stationary trend across models in GRDP per capita and import but a seasonality trend occurs in export forecast. Hence, it has static and stable conditions in the region in terms of per capita, export and import of agricultural products.

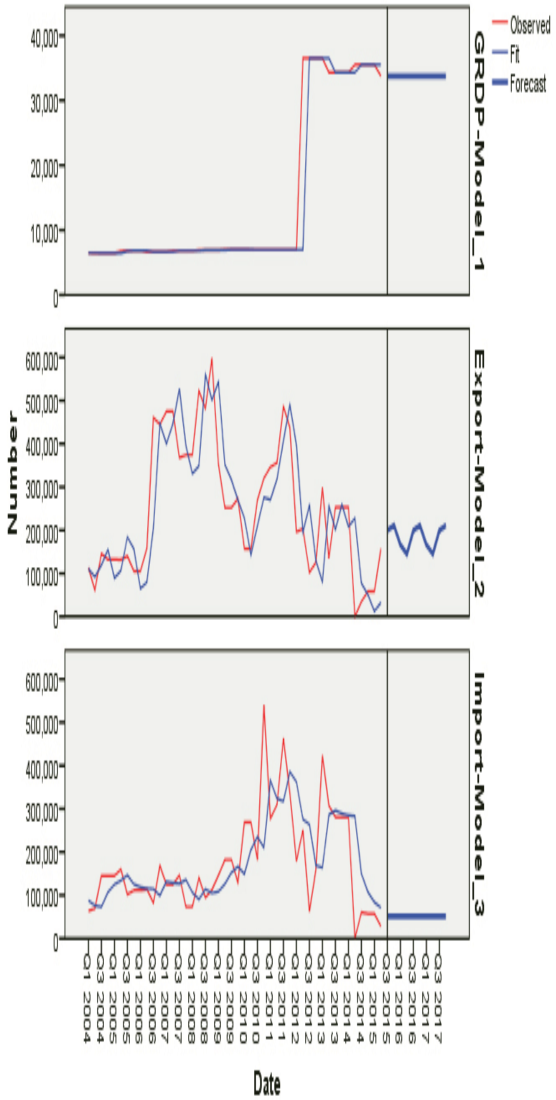

Figure 9. Graphical presentation of the observed and forecasted data in terms of per capita, export, and import of agricultural products in Region 8.

Relationship between Crop Production and Economic Stability in Eastern Visayas

Table 15 shows the relationships between the agricultural crop production and economic stability based on gross regional domestic product (GRDP) in terms of per capita, imports and exports in Eastern Visayas.

Table 15
Correlations between the agricultural crop production and economic stability in terms of per capita, export and import of agricultural products in Eastern Visayas.

N=46		Per Capita GRDP (in pesos at 2000 constant prices)	Export in Eastern Visayas (FOB Value in Thousand US Dollars)	Import in Eastern Visayas (FOB Value in Thousand US Dollars)
Volume of Production of Palay in Eastern Visayas	Pearson Correlation	.184	.084	.114
	p-value	.222	.581	.450
Volume of Production of Corn in Eastern Visayas	Pearson Correlation	.159	.101	.011
	p-value	.292	.506	.942
Area Harvested of Palay in Eastern Visayas	Pearson Correlation	.163	.007	.133
	p-value	.281	.965	.379
Area Harvested of Corn in Eastern Visayas	Pearson Correlation	.041	.046	-.017
	p-value	.788	.759	.912
Yield of Palay in Eastern Visayas	Pearson Correlation	-.010	.200	-.069
	p-value	.945	.182	.646
Yield of Corn in Eastern Visayas	Pearson Correlation	.231	.229	.157
	p-value	.124	.126	.298

Correlation is significant at the 0.01 level (2-tailed).

As shown in Table 15, that there is no significant relationship between the agricultural production like production volume, area harvested and yields per hectare of corn and *palay* and the economic stability in terms of GRDP per capita, imports and exports of agricultural products. It implies that economic stability based on gross domestic product has no influence on the agricultural crop production in Region VIII as forecasted from 2nd quarter of 2015 to 4th quarter of 2017.

V. CONCLUSIONS

The researchers made the following conclusions based on the findings of the study:

1. The agricultural crop production particularly the *palay* and corn with the economic stability in terms of per capita, exports and imports based on GRDP in Eastern Visayas showed no significant relationships.

This is in contrast with the national scenario where in the GRDP is dependent on agricultural crop production. In fact, our study focus the crop production in Region VIII which are limited only to *palay* and corn in terms of production volume, yields per hectare and area harvested. However, it has been observed that there are no records on exports and imports of *palay* and corn in the region except on *abaca* and other products from the metal industry.

2. The observed and forecasted data in terms of production volume, yield per hectare and area harvested for both corn and *palay* show no significant difference across all models, therefore all models fit to the observed data.

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