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Impact of Climate Change and Economic Activity on Philippine Agriculture: A Cointegration and Causality Analysis

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Abstract Climate change impact is particularly severe in developing countries like the Philippines mainly because of low incomes, geographic state or condition, dependence on climate-sensitive sectors and inadequate capability to adapt to global warming. This paper aimed at analyzing the risk posed by climate change using climatic variables on Philippine agriculture. Likewise, it focused on the empirical measurement of the hypothesized relationship between agricultural output and the condition or predicted economic variables. This paper employed not only the Cobb-Douglas production function using time series data from 1980 to 2014 but also the modeling techniques - Cointegration and Granger causality to simulate the impact of changes of the aforementioned variables on output of Philippine agriculture. Results show that only three variables indicated considerable significance on agricultural production in the Philippines based on their respective t-ratios: Agricultural Employment (EA), temperature (TEMP), and La Nina (D1). Other things equally, a 1% rise in agricultural employment paves a 0.2% increase in agricultural production. On the other hand, a 1% increase in temperature, cet. par., decreases agricultural production by 0.08%. Correspondingly, the incidence of El Nino, other things equally, deceases agricultural output by 0.02%. The other variables are not statistically significant but are interpreted in the same way. With this, government expenditure should be redirected toward R&D in agriculture to improve resilience, competence and sustainability of the agriculture sector.

Keywords Climate Change, Agriculture, Time-Series, Regression

1. Introduction

Climate Change is one of the most alarming incidences fronting the world as it also serves as a threat not only to the environment but also to both social and economic sectors. In the past decades, the increase in global mean surface temperature has been observed, along with the increase of average sea level worldwide and melting of ice in the Northern Hemisphere. Changes in global temperature have contributed much to the volatility of climatic conditions in different areas around the globe [19, 21].

The variability in climate is attributed to various ocean oscillations that influence the amount of warming or cooling – generally known as El Niño (warming) and La Niña (cooling) (Impact Forecasting 2013). Aside from that, greenhouse gases (GHGs) from carbon dioxide contribute to global warming [28].

Deviations from the current conditions in the mean climate possibly will entail modifications to present-day agricultural practices to be able to sustain productivity, and in some cases the optimum type of farming may change [14].

Theoretical and empirical investigation on predicting climate change effects on agriculture indicates that different regions vary considerably in whether they win or lose in agricultural suitability, even if average change across the entire study region is small. A positive relationship between the wealth of nations and change in agriculture conditions was found, but variability around this trend was high. Parts of Africa, Europe and southern and eastern Asia were predicted to be particularly negatively affected, while northeastern Europe, can expect more favorable conditions for agriculture [4].

The variability in climate affects man’s primary source of food resource - the environment. Climate change endangers agricultural productivity and destabilizes production efficiency. Due to low resilience to climate change and variability, a lot of developing countries across the globe who are agriculture-dependent and insufficiently productive are estimated to have lower agricultural production and capacity [5, 12, 20].

Increased floods and droughts, soil degradation, water shortages, and possible increases in damaging pests and diseases are all possible consequences of climate change. The fishing sector is negatively impacted by hotter water as a result of rising temperatures. It has an impact on coral reefs, causing coral bleaching and poor reef health. Hotter water is linked to increased sedimentation and wave action, both of which harm sea grasses and result in population decline. The loss of arable land is caused by rising sea levels. It promotes seawater intrusion into groundwater resources and intensifies soil salinity in low-lying agricultural lands, causing coastal habitats to drown. Reduced oxygen levels could be a result of climatic change in water quality, which would lead to fish extinction. This is in addition to ocean acidification, which has an impact on mariculture and lowers production [11, 27, 31].

Severe changes in climate conditions have brought about environmental damage as a result of floods, droughts, denuded forests, soil erosions and loss of endangered species; which eventually leads to slow economic growth because of scarce resources [1].

Though most of the countries have developed mitigation plans on climate change, IPCC revealed that climate change has become particularly graver in developing countries mainly because of low incomes, geographic state or condition, dependence on climate-sensitive sectors and inadequate capability to adapt to global warming and the Philippines is one of the countries considered highly vulnerable to climate change [20, 21]. Small-farmers are also the most prone to the damaging effects of the El Niño Southern Oscillation in the country (ENSO) because of limited mitigation policies in the country [16, 33].

Agriculture still plays a vital role in the Philippines’ overall economic development as it provides food and vital raw materials for the rest of the economy. Agriculture employment shares 31% in the total employment ratio, its total share in the GDP and exports of the country is 10% and 12% respectively [30]. The agricultural sector’s contribution to the country’s GDP is vital in achieving inclusive growth and poverty reduction.

To supplement changes in the agricultural sector, the Department of Agriculture has also delivered more infrastructures, farm mechanization, post-harvest facilities, research and extension, and market development [7]. In 2014, it launched the Philippine Rural Development Project to lay agri-fishery infrastructure or modernization to support value-adding activities to enable farmers and fishers to participate in growing the economy and share in the gains of development. Aside from that , the Department of Agriculture, under the General Appropriations Act of 2013, also appropriated a P1 billion loan funds to the Agricultural Credit Policy Council (ACPC) to establish a flexible credit facility for the benefit of small farmers registered in the Registry System of Basic Sectors in Agriculture (RSBSA) as an alternative to the rigid and stringent credit facilities usually provided by banks [8].

The Philippine government’s program on increasing agricultural productivity has increased demands on the sector’s capacity and has put pressure on its natural resource base. The employment of unsustainable agricultural practices to increase production led to devastation of land resources and water shortage. Unfortunately, climate change has aggravated the essential weaknesses of the sector.

Ample literature and studies are found on the harmful effects of climate change on agriculture, however, there are limited studies on empirical climate science using decadal variability on climate in the Philippines. Thus, this paper is imperative to understand and analyze the linkage between climate and selected economic variables to agricultural production in the Philippines to allow policy-makers in mitigating climate change and develop measures to increase agricultural production in the country.

The purpose of this paper therefore, is to quantitatively evaluate how climate variability and various economic activities in agriculture affect output of Philippine agriculture. At the same time, it aims to understand the movement of climatic indicators such as temperature, precipitation, number of typhoons that hit landfall, carbon emissions, el niño and la niña in the last thirty-four (34) years in so far as the Philippines is concerned; and understand the movement of economic factors such as agricultural credit, agricultural expenditure, employment in agriculture and land area devoted in agriculture in the last thirty-four (34) years as well. Furthermore, it aims to find a causal link between agricultural production in the Philippines and the aforecited climatic indicators in particular.

2. Materials and Methods

On understanding the impact of climate change on agricultural productivity, a lot of studies used computable general or partial equilibrium models, production functions, and even Ricardian models, to modify, apply and analyze the impact of climate variability of precipitation, temperature and carbon on agricultural production [1]. On measuring climate change, studies made use of the Seleaninov index [18]. Others made use of the biophysical statistical model to link the primary climate change impact on temperature and precipitation to changes in yield per unit of land [36]. This method however, is founded on the correlation analysis and not necessarily on causal methods.

To address this concern, this research used time series models to simulate the long- run and causality relationships between climate change variables, economic activities in agriculture and value added of agriculture. This paper will make use not only of the Cobb-Douglas function but also of the modeling techniques - Cointegration and Granger causality to simulate the impact of changes in the total levels of carbon emissions, precipitation, temperature, number of typhoons that hit landfall and the incidence of the El Niño and La Niña phenomenon on the added value of Philippine agriculture. In the same way, to understand the relationship of the agricultural credit, agricultural expenditure, employment in agriculture and land area is devoted to agriculture on the output of Philippine agriculture.

The Cobb-Douglas production function or aggregate production function allows determining the output of an economy given inputs of capital, labor, human capital, and technology. It assumes that the household's agricultural productivity (Y) in any time period is a function of agricultural Labor input (L), materials (M), physical capital investment (K), human capital (H) and physical resource endowment (R). More generally, this may be expressed in the abstract form as follows:

$$Y = F(K, L, M, .): F_1, F_2, F_3 > 0; \text{ and } F_{11}, F_{22}, F_{33} < 0 \quad (1)$$

Where - Y is output, K is usage of capital, L is employment of labor, M is the use of raw materials. Other input factors are admittedly possible as described by the ellipsis [26]. A similar representation of a generalized production function was expressed in a book on managerial economics [10]. The notations F_1, F_2, F_3 are first order derivatives that represent marginal productivities of factor inputs. While the 2nd order partial derivatives F_{11}, F_{22}, F_{33} recognize diminishing marginal productivities for each factor.

This paper adopted the standard material-augmented Cobb-douglas production function model using the different variables under investigation: Value added of Agriculture (VAA) in any time period is a function of temperature (Temp), precipitation (Prec), carbon emission (CE), Number of Typhoons that hit landfall (NT), El Niño (EN) and La Niña (LN), employment in agriculture (EA), agricultural expenditure (AE), and land area devoted to agriculture (LA). In functional terms, the model will be described as follows:

$$VAA = f(\overset{(+)}{EA}, \overset{(+)}{AE}, \overset{(+)}{LA}, \overset{(+)}{EA}, \overset{(-)}{LN}, \overset{(-)}{EN}, \overset{(-)}{NT}, \overset{(-)}{Prec}, \overset{(-)}{Temp}, \overset{(-)}{CE}) \quad (2)$$

The algebraic signs on top of each predictor variable represent the expected impact of a unit change on one of these conditioning variables, holding other variables constant on agricultural output. Other things constantly, an increase in capital investments or number of agricultural workers is likely to cause agricultural output to increase but the increase would be at a diminishing rate. Increases in number of farmers, agricultural loans, public investment in agriculture and price index of agriculture will lead to increased production. On the other hand, increased quantities of carbon emissions, precipitation and increases in temperature based on mounting scientific evidence can have adverse effects on agricultural production.

This paper focused on agricultural credit, agricultural expenditure, employment in agriculture, land area in agriculture, carbon emissions, number of typhoons that hit landfall, precipitation, temperature, La Niña and El Niño affect total output of Philippine agriculture using regression analysis, thereby creating mitigation measures in combatting climate change.

Data Sources and Description

In an attempt to determine the relationship between variables of climate change, economic activity on agriculture and the output of Philippine agriculture, this study employed annual time series data for the Philippines from 1980 to 2014. Value added of agriculture was gathered from the Bureau of Agricultural Statistics. On the other hand, data on temperature, precipitation, number of typhoon that had hit landfall, the El Niño & La Niña phenomena and carbon emissions were gathered from the Climatic Research Unit at the University of East Anglia, the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAG-ASA) and the World Bank. While data on agricultural credit, agricultural expenditure, employment in agriculture and land area devoted to agriculture were from the Department of Agriculture and the Bureau of Agricultural Statistics.

Empirical Model

The economic model describing how agricultural output is affected by the identified predictor variables followed a Cobb-Douglas form. The estimating equation is in logarithmic form as follows:

$$\ln VA = \beta_1 + \beta_2 \ln AC + \beta_3 \ln AE + \beta_4 \ln NF + \beta_5 \ln LA + \beta_6 \ln T + \beta_7 \ln P + \beta_8 \ln CE + \varepsilon \quad (3)$$

The Cobb-Douglas production function was used in this paper to represent the technological relationship of two inputs, labor and capital, and the expanse of produce using those inputs. This function was developed and tested from 1927 to 1947 by Charles Cobb and Paul Douglas [15].

Cointegration Test

Cointegration analysis was used in this paper to determine the long run, dynamic relationship between the predictor variables used in this study. Albeit two variables are non-stationary individually, it is nevertheless possible a stationary linear combination of the two variables [27]. If so, X and Y are cointegrated and have a tendency to move together [10]. This implies that a cointegration test must be conducted before doing a causality test. To conjure the dynamic relationship between the aggregate value of agriculture, variables of climate change, and agricultural economic activity, Johansen's Variance Autoregressive (VAR) technique was utilized. [22].

Let the added value of Philippine agriculture be Qt; and Wt be the seasonal level of the climate variable, t denoting time. If there is an equilibrium, long-term relationship between Qt and Wi, the two time series variables with stochastic trends are said to be cointegrated [32]. The following form can be used to assess whether there is a cointegration relationship between Qt and Wi using Johansen's method:

$$y = \mu + A1 - Yt\text{-}1 + A1 - Yt\text{-}1 + \ldots + An - Yt\text{-}n + \varepsilon i \quad (4)$$

Assuming a VAR process, Yt = (Qt and t Wi) is a n x 1 vector of variables, where μ is a vector of intercept terms, Yt-i are the lagged values of Yt, Ai are vector coefficient matrices, and εi is a n x 1 vector of error terms.

The standard Granger causality test will be used if the results of the stationary tests indicate that the two variables, X (variables of climate change and economic activities in agriculture) and Y (aggregate value of Philippine agriculture) are stationary.

Granger causality is implied by the existence of cointegration between X and Y. Granger causality analysis must be used to demonstrate causality between the variables because cointegration between variables does not necessarily suggest that there is a causal relationship between them. If X Ganger-causes Y, then X's previous values can be used to estimate Y's present value [9], hence:

$$Yt = \sum \alpha iYt\text{-}1 + \sum ßjXj\text{-}1 \quad (5)$$

The lagged values of X should not be included in the equation if X does not Granger-cause Y.

Ho: X does not Granger-cause Y

or **Ho:** $ß1 = ß2 = \ldots ßn = 0$

Granger Causality testing will be done because, despite the fact that two variables are known to be related, it is unclear which variable changes the other. As a result, the equation: will also undergo a Granger Causality Test in this study.

$$Xt = \sum Yi\ Xt\text{-}1 + \sum \delta j\ Yt\text{-}j$$

3. Results and Discussions

The outcome of the regression results in the succeeding pages of this paper shows that the model is consistent with expectations made by several researches and studies; and therefore, was used in the analysis of the threats posed by climate change on Philippine agriculture.

Unit Root and Cointegration Test Results

Results show that all the variables were nonstationary at levels as shown in Table 1. All of the economic and climatic variables showed stochastic patterns, thus the ADF's constant/intercept option was used to assess all of the univariate series at first difference. At the 1 percent level of significance of the MacKinnon critical values, it was determined that both the dependent and independent variables were stationary. Hence, the variables of the model can be regressed at level series.

Table 1. Augmented Dickey Fuller (First Difference, Intercept)

UNIT ROOT TEST AT FIRST DIFFERENCE, INTERCEPT		
VARIABLES	**ADF TEST STATISTICS**	**CONCLUSION**
Agricultural Expenditure	-7.948037	Stationary
Agricultural Credit	-5.373256	Stationary
Employment in Agriculture	-9.218647	Stationary
Land Area Devoted in Agriculture	-4.282420	Stationary
Carbon Emissions	-.3774851	Stationary
Temperature	-7.082855	Stationary
Precipitation	-5.770639	Stationary
Number of Typhoons that hit Landfall	-6.249265	Stationary
Value Added to Agricultural Production	-5.899651	Stationary

Table 2. Cointegration Results

Unrestricted Cointegration Rank Test (Trace)

Hypothesized Number of CE(s)	**Eigenvalue**	**Trace Statistics**	**0.05 Critical Value**	**Prob.****
None*	0.858577	178.0447	125.6154	0.0000
At most 1*	0.743769	121.3207	95.75366	0.0003
At most 2*	0.726134	81.83213	69.81889	0.0041
At most 3	0.606424	44.27376	47.85613	0.1044
At most 4	0.353306	17.23181	29.79707	0.6229
At most 5	0.138639	4.591243	15.49471	0.8506
At most 6	0.009036	0.263243	3.841466	0.6079

Trace test indicates 3 cointegrating eqn(s) at the 0.05
*denotes rejection of the hypothesis at the 0.05 level
**Mackinnon-Haug-Michelis (1999) p-values
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized Number of CE(s)	**Eigenvalue**	**Trace Statistics**	**0.05 Critical Value**	**Prob.****
None*	0.858577	56.72398	46.23142	0.0027
At most 1	0.743769	39.48859	40.07757	0.0581
At most 2*	0.726134	37.55838	33.87687	0.0173
At most 3	0.606424	27.04194	27.58434	0.0585
At most 4	0.353306	12.64057	21.13162	0.4858
At most 5	0.138639	4.327999	14.26460	0.8232
At most 6	0.009036	0.263243	3.841466	0.6079

Max-eigenvalue test indicates 1 cointegrating eqn (s) at the 0.05 level
*denotes rejection of the hypothesis at the 0.05 level
**Mackinnon-Haug-Michelis (1999) p-values

Table 3. Granger Causality

VARIABLES	RELATIONSHIP	
	UNILATERAL	BILATERAL
Value Added of Agriculture		Employment in Agriculture
Temperature	Value Added of Agriculture	
La Niña	Value Added of Agriculture	
Land Area	Employment in Agriculture	
Temperature	Employment in Agriculture	
Land Area	Number of Typhoons that hit Landfall	
Number of Typhoons that hit Landfall	El Niño	
El Niño		La Niña

While the variables of the model are stationary at first difference, there is no guarantee that the regression results are not spurious. A more powerful test is needed for the multivariate model employed in this paper. Using Johansen’s Cointegeration Test, the number of cointegrating relationships is presented in Table 2.

The maximum Eigenvalue and trace test reveal, respectively, 1 and 3 cointegrating equations. This indicates that the regression result is valid and that the aforementioned predictor variables and that Philippine agricultural production have a long-term equilibrium relationship; consistent with the empirical evidence on the long-run relationship between inter-annual changes in temperature and rainfall and different crop yields in Northern Ghana [2].

Since there exists cointegration among the variables of the model, testing for the direction of causal links can now be carried using the Granger Causality test procedure. The results are summarized in Table 3.

A similar study conducted in India made use of the granger causality method that showed that water depletion has a big impact on Agriculture production of crops. The results of the Granger causality tests of the model show that there is unidirectional causality between Agriculture production and Rainfall and that Rainfall Granger causes Agriculture production. The results provide a convincing indication of a unidirectional causality consecutively from Agricultural productivity to rainfall at 10% level of significance [23]. Conversely, data from 1976 to 2010 in Ghana, exhibited the cointegration and Granger causality models of inter-annual yields of the crops have been influenced by the total amounts of rainfall but changes in temperature were stationary, and were suspected to have minimal effect on crop yields [2].

Granger causality results of this paper show that value added in agriculture exhibits a bilateral relationship with employment in agriculture, which means that employment in agriculture impacts Philippine agriculture and vice versa. Factors of climate change – the La Niña and El Niño phenomenon, have an influence on each other. Conversely, temperature and La Niña exert a unilateral relationship with value added of agriculture; land area as well as temperature affect employment in agriculture; and number of typhoons that hit landfall has a unilateral relationship with El Niño.

Analysis of Regression Results and Diagnostic Tests

An econometric model was created using time series data on the variables covered to validate the hypothesized relationships specified in the preceding chapter of this paper and the formulated hypotheses by employing applicable diagnostic tests. The following is a presentation of the model's final results:

$$\mathbf{lnVAA = 134.66 + .02\,(lnEA) + .03(lnLA) - 7.71\,(lnTYPH) - .08\,(lnTEMP) - .02(D1) - .001(D2)}$$

$$(0.01) \quad (2.24) \quad (0.05) \quad (-0.06) \quad (-3.75) \quad (-2.73) \quad (-0.91)$$

$$\mathbf{R^2 = .99 \;\; F\text{-}stat = 406.83 \;\; D.W. = 1.98 \;\; s.e.e = 0.02}$$

$$\mathbf{n = 31}$$

Accordingly, the growing changes in temperature and precipitation as a result of climate change would lead to the shift of production seasons, changes in pest and disease forms, and would adjust the set of possible produce affecting agricultural production, prices, incomes, profitability, opportunity cost of planting, and ultimately, livelihoods and lives [17, 36].

It was also found out the consequences of climate change on economic activity using temperature and market prices of farms in the United States, which led to established damage aggregation using the "bottom-up" approach that would control diverse aspects of fundamental institutions. Accordingly, projections on climate change and the damaging effect on economic activities remain high [27].

Outcomes of the econometric model of this paper show that Agricultural Expenditure and Agricultural Credit are no longer included although they were part of the original model. This will be explained shortly. Only three (3) factors reflected statistically significant effects on agricultural production in the Philippines based on their respective t-ratios: Agricultural Employment (EA), temperature (TEMP), and La Nina (D1). The rest of the predictor variables exert no statistically significant effects on agricultural production in the Philippines although their respective signs are consistent with theoretical expectations similar to the significant factors. Although taken collectively, all the predictor variables exert a significant effect on agricultural production.

The results are consistent with studies in Economic Community of West African States exhibiting the influence of climate variables such as rainfall and temperature, and economic variables like capital and labor affects agricultural output [29]. In the same manner, it was found out that climate change in Nigeria deters the growth of the technology and manufacturing sector decreasing labor and capital productivity consequently hampering growth and sustainable development [12, 34].

The predictive power of the model is in fact very good with an R2 of 99%. Literally, only 1% of variation in the dependent variable could be accounted for by factors, which are excluded from the model.

Other things equally, a 1% rise in agricultural employment gives rise to a 0.2% increase in agricultural production. On the other hand, a 1% rise in temperature, other things equally, leads to a decline in agricultural production by 0.08%. Similarly, the incidence of El Nino, other things equally, leads to a decline in agricultural output by 0.02%; which is in conformity with a study in Australia that a moderate increase in both temperature and rainfall and a moderate increase in temperature and a decline in rainfall would affect agricultural productivity. It exhibited that a moderate increase in both temperature and rainfall would yield increase by 2 to 9 per cent, and under the second scenario – a moderate increase in temperature and a decline in rainfall are projected to increase yield by 7 to 16 per cent [35]. The other predictors are to be interpreted in similar fashion albeit they are not statistically significant.

Comparably, research done in the Philippines between 2001 and 2009 that looked at the relationship between rainfall and agricultural production revealed that above-average amounts of rainfall during the wet season are unfavorable for agricultural production, while increased precipitation is beneficial during the dry season [6]. In the same way, a study in Batac, Ilocos Norte on rainfall and temperature variability using annual data from 1976 to 2010 showed that the consequences brought about by climate change hamper agricultural productivity in the province [13].

In the same way, the impact of climate change in Norway, as a result of changes in temperature and precipitation, on agricultural productivity over the period 1958–2001 found out that in 18 per cent of cases, temperature positively impacts yield and in 20 per cent of cases, precipitation has a negative impact on crop yields [38]. In the same way, higher temperature would substantially affect crop yields and livestock, consequently farm incomes and food security [3].

In China, it was likewise ascertained that the major rice-producing regions experienced great yield losses because of the occurrence of more frequent drought and it has threatened food security as well [24]. In Java, it was also predicted that droughts have significantly affected rice production – small buildups in the global heat resulted to lower production on highly dependent rain areas [39].

The deviation of the actual values vs fitted values estimated by the model is clustered around zero as seen in Figure 1. This means that there is very little difference between the actual data series on agricultural production and the estimates taken from the regression model.

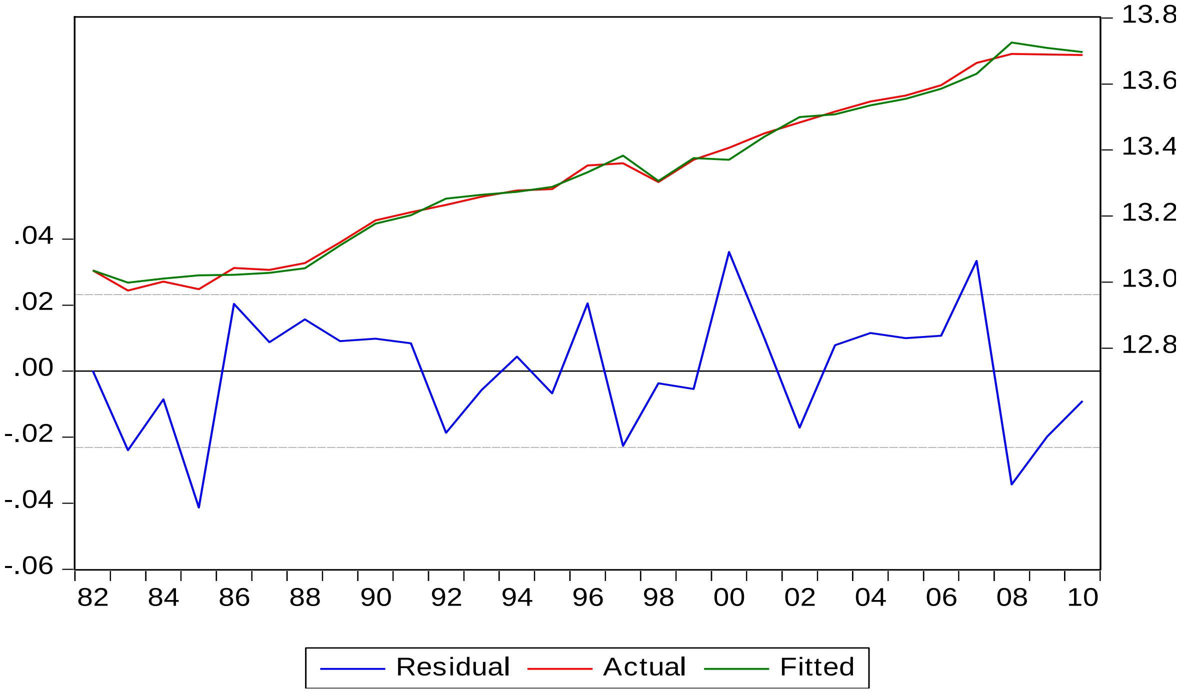
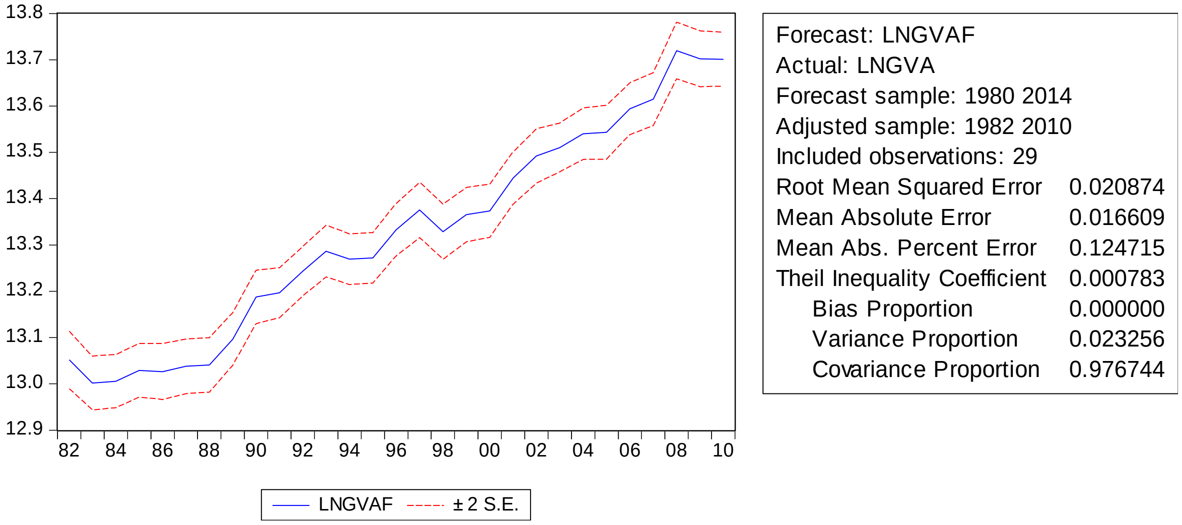


Figure 1. Actual, Fitted and Residual Graph



```
Forecast: LNGVAF
Actual: LNGVA
Forecast sample: 1980 2014
Adjusted sample: 1982 2010
Included observations: 29
Root Mean Squared Error      0.020874
Mean Absolute Error          0.016609
Mean Abs. Percent Error      0.124715
Theil Inequality Coefficient 0.000783
     Bias Proportion         0.000000
     Variance Proportion     0.023256
     Covariance Proportion   0.976744
```

Figure 2. Post-forecast Graph

Table 4. Variance Inflation Factor (VIF)

Independent Variables	Code	VIF	Without AGRIEXP	Without AGRICREDIT
Agricultural Expenditure	AE	20.85178	-	-
Agricultural Credit	AC	8.786774	8.769968	-
Employment in Agriculture	EA	1.406201	1.394538	1.379177
Land Area in Agriculture	LA	9.253080	2.687609	2.676111
Carbon Emissions	CE	11.29887	6.661678	2.111242
Precipitation	PREC	3.433603	3.377799	3.082328
Number of Typhoons	TYPH	2.137635	1.544439	1.514490
Temperature	TEMP	2.148692	2.134577	1.569857

Table 5. Final Diagnostic Test Results

DIAGNOSTIC TESTS		T-STATISTICS	CONCLUSION
Durbin-Watson Test	Autocorrelation	1.98	Autocorrelation does not exist
LM Test	Autocorrelation	0.95	Autocorrelation does not exist
Jarque Bera	Normality of Errors	0.87	Error Terms are normally distributed
ARCH	Heterokedsticity	0.24	Variables are homoskedastic
WHITE	Heterokedsticity	0.61	Variables are homoskedastic
Chow Breakpoint Test	Structural Stability Test	0.61	Model is structurally stable
Ramsey Reset Test	Specification Error Test	0.09	Specification error does not exist

Forecast Performance of Model

To find out further the predictive power of the model – ex-post forecast was applied using actual data series of the variables from 2010-2014. Using the same equation of the econometric model, at +/- 2 standard error of forecasts, which gives a 95% confidence interval that forecast will fall within the interval, as shown in the resulting forecast. The predictive power of the model of this paper may be gleaned from Figure 2.

Post-Estimation Diagnostic Tests

To ensure that data used in the study is not spurious, a post-estimation diagnostic test was carried out as shown in Table 4.

Results suggest that the model adequately satisfied the economic and statistical criteria and has ruled out breaches of pertinent diagnostic tests.

Table 4 demonstrates that as a measure of severe multicollinearity when testing for variance inflation factor (VIF). Agricultural Expenditure, Agricultural Credit, Land Area allocated to agriculture, and Carbon Emissions have all exceeded 10. Agricultural Expenditure was also excluded using sequential variable removal, having the highest VIF of 20.85. The regression model was rerun and tested again for VIF. With Agricultural Credit registering the highest VIF result of 8.77, this variable was also excluded from the model. Severe multicollinearity is no longer present in the remaining explanatory variables. Therefore, the problem on multicollinearity has been resolved by deleting two independent variables.

After eliminating multicollinearity, the model was re-estimated and subjected to a new round of diagnostic tests. It indicated that the results are evidenced with structurally unstable parameters, which will render the model unsuitable for policy formulation and forecasting. Moreover, there is also evidence of specification error in the model, which is quite serious.

As a remedial measure, Carbon Emission and Precipitation, both indicators of climate change, had to be removed from the previous model based on their VIF results, thus reducing the number of predictor variables from nine (9) down to six (6). The final diagnostic tests results are shown on Table 5.

The aforementioned summary results have ruled out the relevance of any diagnostic test breaches and show that the model adequately satisfied the statistical and economic requirements. The final regression result is exhibited in Table 6, which now shows greater detail.

The Durbin-Watson statistics at 1.98 is approximately equal to 2.0 indicating that evidence of serial correlation can be ruled out. The Breusch-Godfrey LM test was also employed to corroborate the elimination of autocorrelation. The p-value of the F-statistic at 0.95 percent exceeds the .05 percent level of significance suggesting that autocorrelation is no longer present.

With a sample size of 29 observations, which may not be large enough for a model using time series data, a test of the normality of the regression residuals is vital to ensure that tests of significance of parameters are valid. Test shows that the error terms are normally distributed given a p-value of 0.645 for the Jarque-Bera statistic.

Test of heteroskedasticity for a regression model using time series data was implemented using the autoregressive conditional heteroskedasticity (ARCH). Given a p-value of 0.25 for the F-statistic, which exceeds 5 percent level of significance, the regression residuals are deemed homoskedastic. Another heteroskedasticity test using White procedure was used in the model, which yielded a p-value of 0.61. This exceeds 5 percent level of significance suggesting that the residuals are indeed homoskedastic. A test of structural stability of the regression parameters was also carried out using the Chow Breakpoint Test. Since the p-values of the relevant F-ratio**,** chi-square, and Wald statistics all exceed 0.05 percent level of significance, evidence of structural instability in the model is ruled out. The model therefore is suitable for use in policy formulation and forecasting. A serious problem would still be possible if specification error exists in the model. With a p-value of 0.09 on the F-statistic which exceeds 0.05 percent level of significance, the presence of specification error in the model is also ruled out. The model therefore is considered correctly specified.

Table 6. Final Regression Result

Dependent Variable: LNVAA
Method: Least Squares
Sample (adjusted): 1882 2010
Included Observations: 29 after adjustments
Convergence achieved after 180 iterartions

Variable	Coefficient	St. Error	t-Statistics	Prob.
C	134.6596	11462.11	0.011748	0.9907
LNEA	0.018877	0.008440	2.236685	0.0369
LNLA	0.029260	0.571585	0.051191	0.9597
TYPH	-7.71E-05	0.001230	-0.062680	0.9506
TEMP	-0.076168	0.020330	-3.746556	0.0013
LN	-0.023224	0.008507	-2.732409	0.0128
EN	0.006348	0.006970	-0.910757	0.3733
AR (1)	1.157740	0.2345696	4.935034	0.0001
AR (2)	-0.157926	0.236418	-0.667995	0.5118

R-squared	0.993892	Mean dependent var	13.32356
Adjusted R-squared	0.991449	S.D. dependent var	0.234350
S.E. of regression	0.021670	Alkaike info criterion	-4.576628
Sum squared resid	0.009392	Schwarz criterion	-4.152295
Log likelihood	75.36111	Hannan-Quinn criiter.	-4.443733
F-statistics	406.8268	Durbin-Watson stat	1.982843
Prob (F-statistics)	0.000000		

Evidence from both theory and practice illuminates how climate change has a negative impact on agricultural productivity, climate change significantly affects agricultural productivity and impacts Philippine agriculture directly and indirectly. As demonstrated by the findings of this paper, recognizing the risk posed by climate change and the relationship between each variable will help implement policy measures, increase the resilience of Philippine agriculture to weather shocks, and forecast long-term economic implications of climate change.

4. Conclusions

This study was carried out to gather data on the threats that climate change poses to Philippine agriculture. Regression analysis shows that the model is consistent with predictions made by many studies and journals cited in the survey of related literature.

The study shows that there is a long-term relationship between value added in Agriculture in the Philippines and the different economic and climatic variables. The Philippines as basically an agricultural country, should assure the availability of vital inputs in agriculture, major government expenditure should be redirected toward R&D in agriculture to improve resilience, competence and sustainability of the agriculture sector.

In order to attain agricultural productivity, food security, adaptation, and climate change mitigation, the Philippine government should address elements that affect agricultural production; which are: Employment in agriculture, and the incidence of the La Niña phenomenon and Temperature, as variables of climate change.

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