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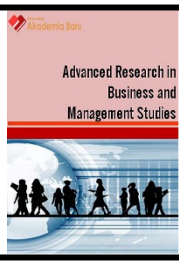

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The impact of climate on economic growth in Malaysia

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ABSTRACT

This study investigates the relationship between factors representing climate change and economic growth in Malaysia, between years 1983 and 2013. The selected varibles include precipitation (mm), temperature(˚C) and arable land (% of land used). The objective of this paper is to understand the siginificance of precipitation, temperature and arable land, towards gross domestic product (current LCU). The methodologies employed are Augmented Dickey-Fuller (ADF) unit root test, Dickey-Fuller GLS (DF-GLS) unit root test, the Johansen-Juselius Cointegration test, Vector Error Correction Model (VECM) test, the Variance Decomposition (VDC) test and the Impulse Response Function (IRF) test. The empirical results imply one cointegrating vector between variables, indicating a unidirectional causality long term relationship between precipitation, temperature and arable land towards GDP. Precipitation appears to be the most exogenous variable whereas Temperature the most endogenous at a 50 year horizon period. The IRF test concludes that the variables in this model are able to recover from shocks caused by another variable within 5 years. The relatively short revival period helps government to monitor the progress made by ongoing strategies. Several policies are recommended for the benefit of the relevant government authorities in dealing with the current climate crisis which will inevitably affect the Malaysian economic growth.

Keywords:
Arable land, Economic, Growth, Precipitation, Temperature

1. Introduction

Climate change is at the top of the agenda of policymakers as they gather in Paris for the United Nations Climate Change Conference, COP21 [1]. It is a threat to the very survival of humanity and has become the single biggest environmental and humanitarian crisis of our time. However, climate change continues to be a complicated phenomenon due to the difficulty to predict the full-scale impact. Changes of weather such as increased temperature and reduced air quality or precipitation affects the members of a society indirectly. Scientists forewarn that the failure to take a timely action will be disastrous [2].

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Carbon dioxide emission and temperature are the main factors causing environmental degradation or climate change[2]. Carbon dioxide is the primary greenhouse gas emitted through human activities like combustion of fossil fuels that include coal, natural gas, and oil for energy and transportation, electricity and industry. Carbon cycle is altered by human activities such as the combustion of fossil fuels which influencs the ability of natural sinks and temperature.

The warmer temperature and the absence of winter frosts subsequently lowers the long-term economic growth in developing nations [26]. [3] found that temperature adversely affects the economic growth in poor countries. Their concluded that a 1 degree centigrade increase in annual average temperature corresponded to a 1.39 percent drop in per-capita gross domestic product in countries studied.

Precipitation is the primary mechanism for waterfrom the atmosphere to reach the surface of earth.[3] The most common form of precipitation is rainfall.Precipitation is naturally present through hydrological cycle, which begins with evaporation from the surface of the ocean or land, followed by the redistribution of water vapor to locations where it forms cloud, before returning to earth as precipitation. Increased precipitation induces a region's susceptibility flooding, rate of soil erosion, mass movement of land and soil moisture availability [2]. On the other hand, work by [27], showed that a decrease in soil moisture leads to reduced downward movement of water and less replenishment of groudwater supplies.

Land reform is define as any purposive change in the way in which agricultural land is held or owned. It is better known as deforestation as a result of the rapidly growing world population and demand for housing. This natural reaction in meeting the basic needs of the people, affects economic growth negatively by rising the greenhouse effect.. The activity of deforestation however, helps in filtering the carbon dioxide in the atmosphere and providingfor oxygen during photosynthesis.

According to [12], climate change can identify with the changes in economic conditions and help estimate the future performance in economic growth and development. Researcher shows that pollution can affect total output and quality of life through reduced productivity of man-made capital and labour [9]. A study by [13] established the negativeve impact of climate change on economic growths of developing countries.

To date, studies on the effects of climate change on economic growth and development has only focused on certain parts of Africa and selected developing countries. Given the Malaysian government's realization of the importance agriculture to national growth, and the cumulative contribution of the land base economic activities to macroeconomic stability through mass employment, a heightened attention towards the care of land sustanilibility is critical. The current research expectS to explore the economic implications of weather changes (which are increasingly drastic of late) on the Malaysian GDP.

Generally, we can claim that Malaysia owns one of the largest rainforest in the world and therefore enjoys many climate related ecosystem benefits. However, the rapid industriliaztion accompanied by the on-going urbanization especially in the suburbs has resulted in problems such as pollution of inland and marine waters, deforestation, soil and coastal erosion, and the problem of water disposal. A thorough study of how different factors such as the three variables applied in this research will enable the government to design and enforce policies to mitigate further adverse affects on the economic growth.

A report by [28] states that precipitation decreases in high latitude regions when there is an increase in temperaturecausing the water crisis in the agricultural sector. It also added that climate

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[2] Definition obtained from http://wwf.panda.org/who_we_are/wwf_offices/malaysia/environmental_problems_malaysia/

[3] Definition retrieved from http://ww2010.atmos.uiuc.edu/%28Gh%29/guides/mtr/hyd/prcp.rxml

change induces a higher incidence of flooding although the changes in weather condition may affect different regions in varied ways. The graph below depicts the drastic fluctuations of precipitations for Malaysia between 1983 and 2013.

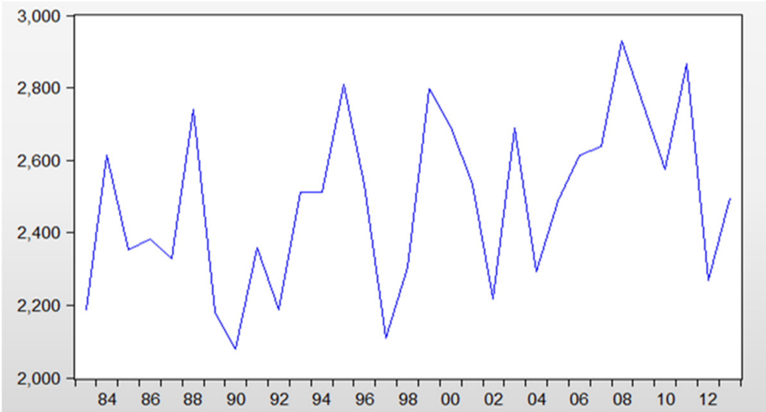

Fig. 1. Average Precipitation from year 1983 to 2013 in Malaysia

Figure 1 reflects the highs and lows of the average precipitation clearly indicates a drastic pattern for Malaysia. By 2013 it was once again on the rise which may explain the recent frequency of flashfloods in many cities, including Kuching, Sarawak.

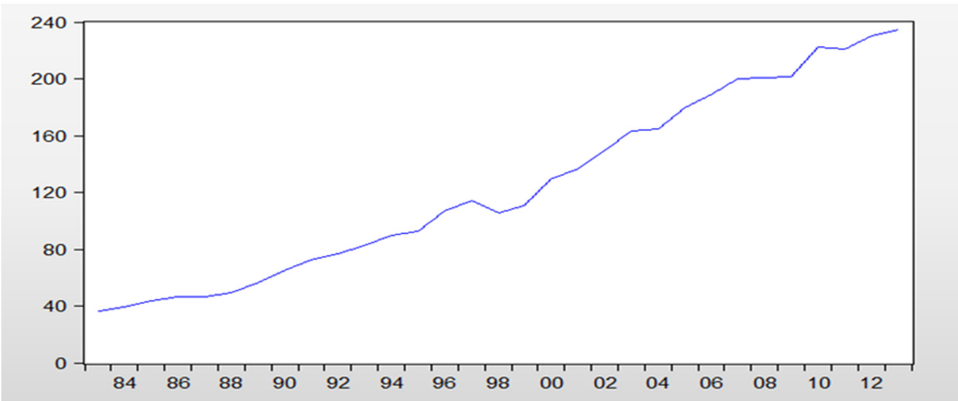

Fig. 2. Annual Temperature (˚C) from year 1983 to 2013 in Malaysia

As evident in Fig. 2, the weather in Malaysia has become increasingly hot and humid, although the change is shown to be more gradual. A point to note is the haze experienced in 1997, which is said to be the worst in the country, due to farmers regular open burning of scurb and forest to clear land for agriculture purpose during dry season [2]. Furthermore, the poor air quality in the Malaysian capital city of Kuala Lumpur is also case of concern since 2005 [29].

Until 2006 Malaysia was the largest leading producer of palm oil, now overtaken by Indonesia, primarily due to constraints of further land expansion for palm plantations. Subsequently, the reduction of tropical forest which acts as lungsto the earth, leads to a rise in temperature and emissions of carbon dioxide. Figure 3 shows the size of arable land in Malaysia has stabilized to a level of 5% of the total land use. There is also evidence of people are moving towards healthier eating habits by moving away from highly starcy food to the consumption of more proteinous food source, such as fruits and vegetables [14]. The sizes of agricultural land use for production of different agricultural crops brings about changes in agricultural land use in favor of higher rewards causing agricultural land use dynamics [14]. Another recent study by the same group of researchers foresaw potential environmental degradation of certain locations from agricultural intensification. This study aided estimating the potential conversion of agricultural land to non–agricultural uses [15].

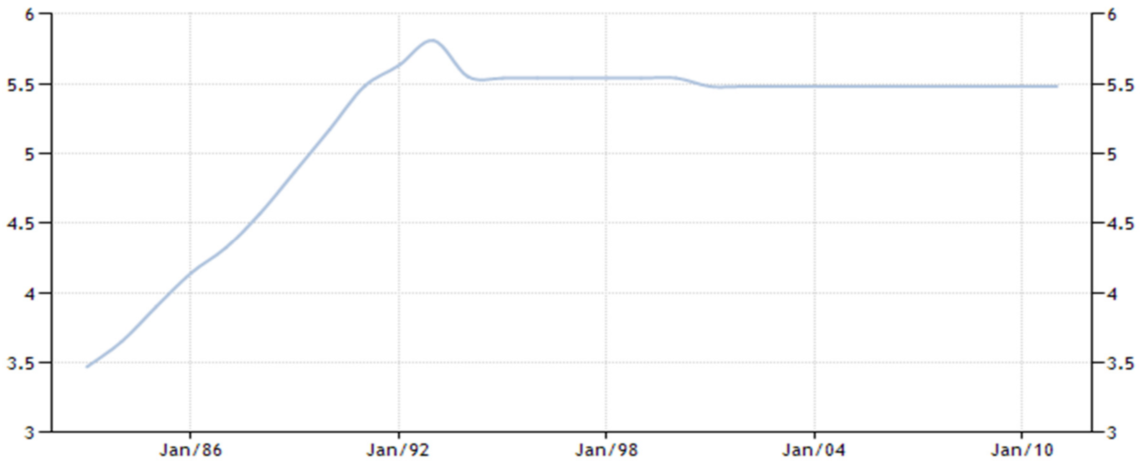

Fig. 3. Arable land (% of land used) from year 1983 to 2013 in Malaysia

2. Literature review

In general economic growth is believed to be affected by variety of climate related factors . There were several studies in many countries such as China [12,18,30], India [7], Africa [6], and Iran [31]. Majority researchers maintain that climate change has a negative impact on economic growth. [4] developed two approaches; emunerative and dynamicto analyse the impact of climate on economic growth. In his study, the fixed effect model (FEM) and seemingly unrelated regression (SUR) was used to investigate the effect of climate change towards economic growth in Asian countries. His findings showed that economic growth was negatively affected by the changes of temperature, precipitation and population growth in these countries. Besides that, [4] also indicated that urbanization and human capital are not significant to economic growth. Similar findings were also reported by as [3,9,10-12,18,19,30-32]. Interestingly, [8] claim that economic growth may not necessaryly result in environmental degradation.

The methods applied by [20], to investigate the cointegration between changes in stock markets and economic growth is adopted in this study.

2.1. Theoretical framework

2.1.1. Temperature

Prior studies by [3,4,9,11,12,16-18,21,22,30-33] investigated the relationship between climate change and economic growth in China using Johansen cointegration, Augmented Dickey Fuller and Granger causality test. The Johansen cointegration result showed that pollution which caused high temperature related to GDP negativelywhile granger causing pollution. [9] found that carbon dioxide emission (temperature) had a significant negative effect on income (national growth), using regression analysis.

2.1.2. Precipitation

By and large, increased in precipitation will induce a region’s susceptibility to a variety of factors such as flooding, rate of soil erosion, mass movement of land and soil moisture availability. These will eventually affect the economic components of gross domestic product such as agricultural productivity, land values, and area's of habitability.

A study by [10] using regression analysis establishes a statistically significant relationship between greater rainfall variability and lower per capita GDP. Other researchers with similar findings include [5,16,17,33,34]. [23] however, pointed out that a rise in precipitation or rainfall affects economic activity positively. Theirfindings are supported by [22].

2.1.3. Arable land

The previous studies maintain a positive relationship between arable land and economic growth. The increase in arable land leads to an increasing in urban expansion and construct the cities for solving problem of rising population. At the same time, it leads to a growth in gross national output due to the increase in building, factory expansion and agriculture production. This was proven by [7] when investigating the relationship between land reform, poverty reduction and economic growth in India. Their results from regression analysis and endogeneity test showed that arable land impacts economic growth positively. A similar study by [24] suggests that in Peninsular Malaysia, agricultural development particularly oil palm, led to deforestation during the 1970s and early 1980s.

[8] also studied the impact of arable land in America (20 countries), Africa (31 countries) and Asia (12 countries) by applyingordinary least square method and the weighted least square method. Deforestation was found to affect economic growth positively and encouraged low income countries to clear their forests area to improve their economic performances.

3. Methodology

3.1. Conceptual framework

$$GDP_{it} = \beta_1 - \beta_2 Temp_{it} - \beta 3 Prep_{it} - \beta 4 Land_{it} + \varepsilon_{it} \quad (3.1)$$

where GDP is GDP (current LCU) and the inputs Temp, Prep, and Land which represents temperature, precipitation and arable land. The *i* and t denotes country and time whereas ε is an error term for country *i* and period t. Lastly, βis the coefficients to be estimated.

$$LGDP_{it} = \beta_1 - \beta_2 LPrep_{it} - \beta_3 LTemp_{it} - \beta_4 Land_{it} + \varepsilon_{it} \quad (3.2)$$

$LGDP_{it}$ = Natural Logarithms of GDP (current LCU) for period t and country *i*
$LPrep_{it}$ = Natural Logarithms of Precipitation for period t and country *i*
$LTemp_{it}$= Natural Logarithms of temperature for period t and country *i*
$Land_{it}$ = Natural Logarithms of Arable Land for period t and country *i*

3.2. Methods

3.3.1. Augmented Dickey-Fuller unit root test

The Augmented Dickey-Fuller (ADF) test is used for investigate the stationary of time series data. The specify simple equation can be express as following:

$$LGDP_t = \alpha + \beta_{temp} LTemp_t + \beta_{prep} LPrep_t + \beta_{land} land_t + \varepsilon_t \quad (3.3)$$

where, $LGDP_t$ is the natural logarithm of growth of gross domestic product for period t, $LPrep_t$ is the natural logarithm of average precipitation for period t, $LTemp_t$ is the natural logarithm of

temperature for period t, $Land_t$ is the arable land for period t and ε_t is the error term for period t. The hypothesis of ADF unit root test are:
H_0: σ=1
H_α: σ<1

3.3.2. Dickey-Fuller GLS (DF-GLS)

The hypothesis of the DF-GLS unit root test are:
H_0: σ=0 (The variable are non-stationary) unit root
H_α: σ<0 (The variable are stationary) does not have unit root

3.3.3. Johansen-Juselius cointegration test

The Johansen-Juselius cointegration approach can be employed within the vector error-correction model (VECM) as:

$$\Delta W_{t=}\emptyset D_t + \pi W_{t-1} + \cdots + \Gamma_{k-1}\Delta W_{t-k+1} + \varepsilon_t \tag{3.4}$$

3.3.4. Vector error correction model (VECM) Granger causality test

In the study of climate impact on economic growth, the regression can be express as follows:

$$\Delta GDP_t = \alpha_1 + \beta_1 EC_{t-1} + \sum_{i=1}^{k} \delta li\Delta Temp_{t-i} + \sum_{i=1}^{k} \delta li\Delta Prep_{t-i} + \sum_{i=1}^{k} \delta li\Delta Land_{t-i} + \varepsilon_t^{GDP} \tag{3.5}$$

$$\Delta Temp_t = \alpha_1 + \beta_1 EC_{t-1} + \sum_{i=1}^{k}.\delta li\Delta GDP_{t-i} + \sum_{i=1}^{k} \delta li\Delta Prep_{t-i} + \sum_{i=1}^{k} \delta li\Delta Land_{t-i} + \varepsilon_t^{GDP} \tag{3.6}$$

$$\Delta Prep_t = \alpha_1 + \beta_1 EC_{t-1} + \sum_{i=1}^{k}.\delta li\Delta GDP_{t-i} + \sum_{i=1}^{k} \delta li\Delta Temp_{t-i} + \sum_{i=1}^{k} \delta li\Delta Land_{t-i} + \varepsilon_t^{GDP} \tag{3.7}$$

$$\Delta Land_t = \alpha_1 + \beta_1 EC_{t-1} + \sum_{i=1}^{k}.\delta li\Delta GDP_{t-i} + \sum_{i=1}^{k} \delta li\Delta Temp_{t-i} + \sum_{i=1}^{k} \delta li\Delta Prep_{t-i} + \varepsilon_t^{GDP} \tag{3.8}$$

where, EC_{t-1} is the error correction term and δ and β are parameters, k denotes the lag length, ε_t^{GDP} is the stationary random process with mean zero and constant variance. The null hypothesis is H_0 : $\tau_{11} = \tau_{12} = \cdots = \tau_{1k} = 0$. It indicated that the Gross Domestic Product do not Granger cause selected variables.

3.3.5. Normalized equation estimation test

Once the cointegration test have been conducted through the Johansen-Juselius Cointegrtion test, the coefficient of the regressions normalized on the dependent variable will be estimated.

3.3.6. Granger causality test

The hypothesis under Granger causality test is:
H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$, there are not causality linkage between independent variable and dependent variables.
H_α: $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$, there are causality linkage between independent variable and dependent variables.

3.3.7. Variance decomposition (VDC) test

VECM cannot define which variables is relatively more exogenous or endogenous. Therefore, to determine the relative strength of the variables and the transmission mechanism responses, we need to shock the system and decompose the forecast error variance decomposition (FEVD) for each of the variables in the system. The FEVD analysis is based on Choleski's decomposition and it is generally sensitive to the sequence of the variables and the lag length [35]. The VDC's results will be in percentage form and the strength of each variable to their own shocks and others is measure by up to 100 percent.

3.3.8. Impulse response function (IRF)

The IRF's illustrate the response over time of a variable caused by the shock of another variable. Thus, both VDC's and IRF's are designed to map out the dynamic response path of a variable due to one-period standard deviation shock to another variable. The graphical way of exposing the relative exogeneity or endogeneity of a variable can be done by IRF's [25].

4. Empirical analysis & findings

Table 1 shows the the results of the ADFF and DFGLS stationary tests. The integration order of each variable is identified at 5 percent level of significance, with both tests concluding that LPrep is stationary at level while LGDP, LTemp and Land at first difference.

Table 1
Result of Integration Order Test

	Level			
	ADF		**DF-GLS**	
	C	C&T	C	C&T
*L*GDP	-0.3413(0)	-2.0427(0)	-1.0690(3)	-2.0717(0)
*L*prep	-4.7549(0)*	-5.1974(0)*	-4.1523(0)*	-5.3110(0)*
*L*Temp	-2.0562(0)	-1.0622(0)	-0.2178(3)	-1.2736(0)
Land	-1.7492(0)	-1.5919(0)	-1.2034 (0)	-1.8354(0)
	First Difference			
	C	C&T	C	C&T
*L*GDP	-4.9196(0)*	-4.8280(0)*	-4.8784(0)*	--4.9226(0)*
*L*Prep	-8.3371(0)*	-8.1475(0)*	-6.0998(0)*	-7.8587(0)*
*L*Temp	-4.7976(0)*	-5.3889(1)*	-4.8675(0)*	-5.6022(1)*
Land	-8.0066(0)*	-7.9479(0)*	-2.1352(1)*	-6.9499(0)*

Note: LGDP, LPrep, LTemp and Land represents natural log of gross domestic product (GDP current LCU), log of precipitation, log oftemperature and log of arable land respectively. C represents Intercept only while C&T represents Intercept and Trend. The optimal lag reported is based on the Newey-West bandwidth criterion. (*) indicates that the variable is significant at 5% level, means the null hypothesis of non-stationary series is rejected if the test statistics is greater than the critical value for ADF and DFGLS.

The next is the results obtained from the Johansen-Juselius Cointegration test, as shown by Table 2. Clearly, when there is a conflict between the trace statistic and Max-Eigen statistic and the resultsof Max-Eigen, the latter is accepted given its predictive power.

There is one cointegrating vector detected for the tested model based on the suggested result of Max-Eigen statistic with 1 lag length indicating a long run relationship between the tested variables. Since there is a cointegrating vector found in themodel, the Vector-Error Correction Model (VECM) Granger causality framework is adopted to investigate the short run relationship between the variables.

Table 2
Result of Cointegration test

Null	Alternative	K=1 r=1			
		Max-Eigen		Trace	
		Unadjusted	95% C.V	Unadjusted	95% C.V
r=0*	r=1	35.7963*	27.5843	58.1412*	47.8561
r<=1	r=2	16.7827	21.1316	22.3449	29.7971
r<=2	r=3	4.3491	14.2646	5.5622	15.4947
r<=3	r=4	1.2131	3.8415	1.2131	3.8415

Note: K is the lag number while r represents the number of cointegrating vectors. (*) denote the variable statistically significant at 5% level.

Table 3 represents the estimated equation for the GDP (current LCU) dependent on precipitation, temperature and arable land in Malaysia. The independent variables are significant at 5 percent level, except for *L*Prep which is significant at 10 percent level. All independendent variables are found to be negatively related to the national GDP . Generally, a 1 percent increase in the precipitation, temperature and arable land will cause GDP (current LCU) to decrease by 0.34 percent, 1.7 percent and 1.1 percent respectively.

Table 3
Estimated Coefficient

Variable	Malaysia
*L*GDP	-
*L*Prep	-0.3428 (-1.6649)**
*L*Temp	-1.7021 (-28.8249)*
Land	-1.0980 (-4.5194)*
Intercept	-12.4224

Note: Dependent variable:*L*GDP. Independent variable:*L*Prep, *L*temp and Land. Jarque-Bera test is for residual normality. Serial Correlation LM test is for residual serial correlation. White heteroscedasticity test for autoregressive. RESET test is the Ramsey RESET test for mispecification. Figures in the brackets represents the t-statistics * indicates significance at 5 percent level while * indicates significance at 10 percent level.

$$LGDP = -12.42 - 0.34LPrep - 1.70Ltemp - 1.10Land \quad (-1.6649) \quad (-28.8249) \quad (-4.5194) \tag{3.9}$$

Based on the results available in Table 4, there is no short run relationship between the selected variables. The long run relationship is represented by ECT which referes to the speed of adjustment of the variables back to the equilibrium level. LGDP solely bears the brunt of short run adjustment to bring about the long run equilibrium. The ECT coefficient of LGDP of -0.3937 means that 39.37 percent of adjustment takes place per year wor an approximately 2.54 years is needed for the model to achieve its long run equilibrium.

Table 4
VECM Granger Causality

Dependent Variable	**Δ*L*GDP**	**Δ*L*Prep**	**Δ*L*Temp**	**ΔLand**	**ECT**	
	x^2-statistics				Coefficient	t-ratio
Δ*L*GDP	-	0.1252 (0.7235)	0.5688 (0.4507)	2.0627 (0.1509)	-0.3937**	-3.4043
Δ*L*Prep	0.4712 (0.4925)	-	2.5824 (0.1081)	0.2250 (0.6353)	-0.0287	-0.1238
Δ*L*Temp	0.0017 (0.9675)	0.9968 (0.3181)	-	0.0053 (0.9418)	-0.1656	1.5618
ΔLand	0.0311 (0.8600)	0.5320 (0.4658)	0.7054 (0.4010)	-	0.1587	1.6976

Note: (*) denote the variable is statistically significant at 5% level while (**) at the ECT of Lgdp3 is not mean significant at 5% level but is denote that it is the correct ECT. ECT represents Error Correction Term.

Table 5
Variance Decomposition of *L*GDP, *L*Prep, *L*Temp and Land in Malaysia

Percentage of variations in:	**Horizon (Quarters)**	**Due to innovation in:**				
		Δ*L*GDP	Δ*L*Prep	Δ*L*Temp	ΔLand	ΔCU
Quarters Relative Variance in: Δ*L*GDP						
	1	**100.00**	0.00	0.00	0.00	0.00
	4	**85.24**	0.69	10.49	3.58	14.76
	8	**81.95**	0.35	13.06	4.63	18.05
	24	**80.13**	0.17	14.49	5.21	19.87
	48	**79.71**	0.12	14.82	5.34	20.29
Quarters Relative Variance in: Δ*L*Prep						
	1	2.41	**97.59**	0.00	0.00	2.41
	4	1.05	**94.12**	3.34	1.50	5.88
	8	0.68	**94.21**	2.90	2.21	5.79
	24	0.40	**94.22**	2.58	2.80	5.78
	48	0.32	**94.22**	2.50	2.96	5.78
Quarters Relative Variance in: Δ*L*Temp						
	1	42.95	8.19	**48.86**	0.00	51.14
	4	51.34	3.80	**41.56**	3.30	58.44
	8	53.06	3.01	**39.58**	4.35	60.42
	24	54.26	2.45	**38.20**	5.09	61.80
	48	54.56	2.31	**37.85**	5.28	62.15
Quarters Relative Variance in: ΔLand						
	1	5.91	7.11	1.55	**85.43**	14.57
	4	2.18	9.61	17.96	**70.25**	29.75
	8	1.24	9.63	21.86	**67.28**	32.72
	24	0.52	9.68	24.79	**65.01**	34.99
	48	0.33	9.69	25.57	**64.41**	35.59

Note: The last column provides the percentage of forecast error variance of each variable explainedcollectively by the other variable. The column in bold represent the impact of their own shock.

In order to gauge the relative strength of the results based on the causality test, we now shock the model and partition the forecast error variance for each variable. Table 5 provides the details. Land seems to be the most interractive variable in this model. The variance decomposition shows that almost 62 percent of the forecast error variance can be explained by GDP (55%), Prep (2%) and Land (5%) at the end of the 48-quarter horizon. Futhermore, Temp is the most endogenous variable whereas Prep is the most exogenous with only about 6% percent of its forecast variance being explained by the remainning variables for the entire forecast horizon.

The overall achievement of the objectives of this research can be summarized as below:

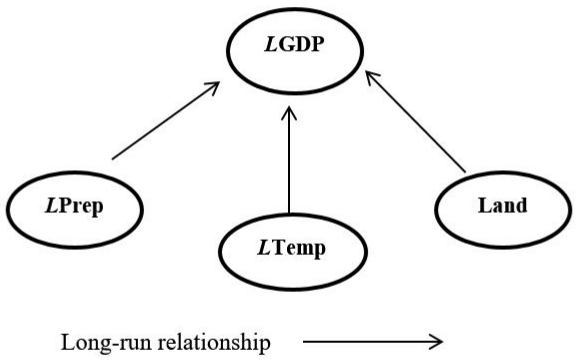

Fig. 4. Causality Relationship between *L*GDP, *L*Prep, *L*Temp, and Land in Malaysia

5. Conclusion and recommendation

5.1. Conclusion

Based on the tests conducted on the annual data of GDP (current LCU), precipitation (mm), temperature (˚C) and arable land (% land used), the conclusions are:

a) The normalized equation is aligned with the theoretical framework.
b) there is one cointegrating vector with a long run relationship between variables in the model.
c) there is no short run relationship between variables, but a unidirectional causality from Prep (mm), Temp (˚C), and Land (% of land used) towards GDP (current LCU) in the long-run.

5.2. Policy Recommendations

Malaysia as one of the developing ASEAN economy experiencesvarious climates related crisesfrom time to time. The government of Malaysia has implemented several policies according to the national ability and needs of its people, although the challenges to do so is esclating by the day. Some examples include the adoption of renewable energy policy in 2001. Since the frequent falsh floods in certain parts of the countries during monsoon seasons, the Federal government has introduced the basin wide-planning and inter-agency collaboration to facilitate flood management. Of late the State governments are also becoming more aware of the expansion of arable land for other than agricultural purposes and have been actively promoting alternative ways to reduce its implications on the economic growth.

Given these on-going efforts, both the private sector and the public play an equally important role in curbing the effects of climate factors on the economic wellbeing. Firstly, there is a pressing need for stronger enforcement of the existing laws in terms of irresponsible land use, environmental pollutions and illegal logging. Secondly, incentives offered to those abiding these laws should be attractive enough for them to sustain good business practices. Lastly, campaigns to enhance awareness of sustainable agriculture among the farmers must be effective in order for the buy ins to take place, especially among the rural folks.

Future researches can be directed towards assessing the effectiveness of the ongoing initiatives by the government to promote responsible land usage and corrective actions taken against parties that refuse to comply with the existing environmental laws.

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