Suratman, Maman; Hitam, Mizan

Article

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Examining the Influence of Forestry Value Added Dimensions on Climate Change in Thailand

Maman Suratman[1], Mizan Hitam[2]*

[1]Institut Koperasi Indonesia (IKOPIN), Indonesia, [2]Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA Selangor, Malaysia. *Email: drmizan@uitm.edu.my

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ABSTRACT

To get the meaningful results against the increasing challenges of the nature and climate, more focus is required towards sustainability in multiple dimensions. This study examines the six dimensions of forestry on four measures of climate change. The time duration of this study has considered the five decades; 1970-2018 on annual basis. Overall results are presented under descriptive results, whereas findings for the individual coefficients are presented. It is observed that There is a negative impact of agriculture, forestry, and fishing or FA on electric power consumption abbreviated as CH1, whereas positive and significant impact from FD, FE and FF is observed. On the other hand, for CH2 or energy usage, key determinants are FA, FD-FF under full sample period. For CH3 or Nitrous Oxide emission, there is highly significant and negative impact from FA, while FD and FF are also positively influencing the Nitrous Oxide emission during 1970-2018 on annual basis. For Methane emissions, positive determination is experienced from FD and FF. The findings under present study would provide good understand for the relationship between forestry factors and climate change dimensions in Thailand. In addition, literature contribution is also observed with the help of present study and in the regional context of Thailand too. As per the implication present study can be utilized for examining the relationship between forestry factors and climate change dynamics. However, some limitations are associated with this research like, examining the two directional association between forest and climate change, cross sectional regional comparisons, and implication of both short and long term relationship between the variables of the study. Future studies may reasonably address these limitations as it can provide some more literature contribution in the targeted fields.

Keywords: Forestry Factors, Climate Change, Energy
JEL Classifications: Q23, Q54, P18

1. INTRODUCTION

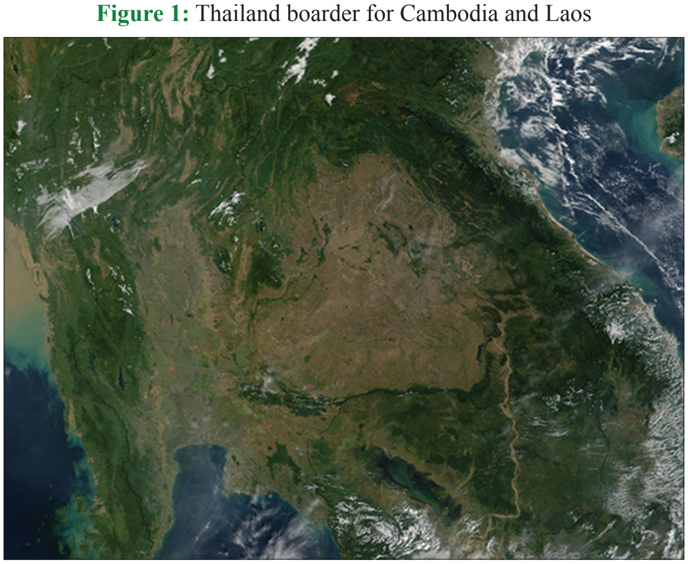
The relationship of forest and the changing climate is under good attention of the researchers not in recent years, but over the last many decades (Castanho et al., 2020; Hanna et al., 2017; Hayter, 2003; Hou et al., 2017; MacKinnon et al., 2020; Mishra, 2015). The research studies for the relationship between climate change and forests have explained their dual association to each other. It is a common notion that changing forest and related policies have their direct natural impact, therefore, more attention is required towards them (Omran and Kamran, 2018; Omran and Schwarz-Herion, 2019). At the same time, changing climate is predicted to affect the present and future situation of the forest (Gilliam, 2016; Machar et al., 2017; Omran and Schwarz-Herion, 2019; Martín-Urbano et al., 2020; Missaglia and Sanchez, 2020). The ecological outcome of economic growth and relative development is not a new topic in the field of environmental economics; therefore the increasing climate issues need some compensation too. This is due to the fact that changing climate is not only affecting the economies but also their financial and non-financial sector as well (Kamran et al., 2020; Carranza et al., 2020; Chena et al., 2020; Cómbita, 2020).

On the other hand, the management of forest and associated sources is still a major challenge in different economies (Loucks and Van Beek, 2017; Machar et al., 2017; Seymour and Busch, 2016; Xia et al., 2017; Handoyo et al., 2020; Ilyassov et al., 2020). Although biodiversity has been recognized with significant benefits to the human beings and society, however, it is declining over the years because of the ecosystem resistance and ecosystem resilience. The management of forest is observed in different economies due to its vital significance in the changing climate and similar problems (Bowditch et al., 2020; MacDicken et al., 2015; Siyum, 2020). For this purpose, range of studies are exploring the forest management and its relationship with the ecosystem and several biodiversity indicators too.

The issue of climate change is accepted as a core challenge for all the economies, hence altering the biophysical and production condition. The increasing frequency of extreme events and climatic variability are leading towards some alarming threats like loss of crop yield and reduction of food provision services. Numerous dimensions are explored in the literature to support the measuring factors of climate change like more emission of carbon in the environment (Liu et al., 2015), energy consumption (Minchala-Avila et al., 2016), nitrous oxide emission (Storer et al., 2018), and emission from the methane (Robertson et al., 2017; Yun, 2020; Brichieri-Colombi, 2020).

In the economy of Thailand, deforestation refers to the conversation of the forest land to some other uses and as per the report of Royal Forest in recent year of 2019, the covered forest area in the Thailand is 31.60% (Yotapakdee et al., 2019; Mehmood and Farooqi, 2020; Naeem et al., 2020; Goo, 2020; Khvatskaya et al., 2020; Kim et al., 2020). However, between the time duration of 1945 to 1975, the total covered area in the Thailand under forest title was declined from 61% to approximately 34%. This fact has indicated that the country is losing its forest area by 3.1% on annual basis. Due to more expansion of agriculture related activities, there is more deforestation in Thailand. the ministry of Interior was established during the year of 1896 with the core purpose to conserve the forest area. However, various other factors are also observed for the more deforestation like growth of population, agriculture policy, ownership policy about the land, and various types of illegal logging etc. Figure 1 below shows the Thailand boarder with the Cambodia and Laos as observed through brown color, showing the deforestation in the country.

Figure 1: Thailand boarder for Cambodia and Laos



This research study is conducted to explore the relationship among forestry factors in the region of Thailand with the climate change measures like energy consumption, and emission of carbon and other gases in the natural environment during the last 5 decades. The key motivation behind this study was to explore how the Forestry, agriculture, and fishing value addition is associated with the climate change dynamics which is observed as missing part in the literature. Therefore, this research is a core contribution in the field of climate change and environmental economies.

2. LITERATURE: FOREST AND CLIMATE CHANGE

The field of studies for forest and climate change are widely observed in the literature in both direction and two directional dynamics. In this matter, research work as contributed by Tovar et al. (2019) have focused on the concept of low disturbance for persistence foresting. It is observed that the factors like fossil pollen and macro-charcoal are playing a significant role in the climate change. Falco et al. (2019) has tested the relationship between climate change and the migration under the shadow of agriculture sector. It is believed that both mitigation and climate change are widely connected to each other. Whereas climate change is affecting the migration while its influence on the productivity of the agriculture. Augustynczik et al. (2020) have suggested an optimal framework for the supply of forest biodiversity. It is expressed that there is a significant implication for the biodiversity of the climate change. The core reason behind this relationship is that biodiversity of the forests can reasonably provide the social benefit addition to ecosystem as well. Foster et al. (2019) has shown their empirical contribution for exploring the interaction between the wildfire, change in the climate and warming climate with forest change in the region of Alaska. Some other studies contribute their work to explore the climate change dynamics and forestry factors (Bolte et al., 2009; Bowman et al., 2013; Dyderski et al., 2018; Jönsson et al., 2015; Linder, 2000; Noss, 2001; Schelhaas et al., 2015; Spittlehouse and Stewart, 2003; Subramanian et al., 2016; Goo, 2020).

Seidl et al. (2017) have claimed that forest disturbances are sensitive to the climate change and at the same time, the responses of the world community towards the climate change is not good enough. On the other hand, Venäläinen et al. (2020) indicate that due to climate change, various abiotic and biotic risks are found for the forestry and forests as well. However, for the sustainable multifunctional management of the forests for various ecosystem services, significant need is required for these risk factors which are associated to forests and forestry. Meanwhile, the magnitude of the future emission of the greenhouse gases and the development of their atmosphere constraints have affected the global climate. Moomaw et al. (2019) have their view that due to climate change and with the loss of biodiversity various environmental challenges are occur in current time. It is believed that forests annually sequester large quantity of carbon dioxide and store the carbon above and below the ground for the long period.

Schulze et al. (2020) have tried to examine the mitigation effect of climate change from the sustainably managed forests in the Central Europe. Authors claim that for the purpose of sustainably managed forests, the carbon storage which is based on the ecosystem biomass and products is seemed to be insufficient regarding their contribution towards the mitigation effect of climate change. Furnas (2020) states that there is a significant change as observed in the global climate comparatively to earlier expectation. For conducting his empirical work, 42% of all the conifer forests in the California states was under observation during the time of 2002 to 2016. Author claims that expansion in terms of biodiversity monitoring across large taxonomic spatial and temporal extend is assumed to something vital for the effective planning regarding the sustainable environment. Based on the above discussion, present study aims to examine the relationship between forestry value added dimensions and climate change in the region of Thailand.

3. VARIABLE EXPLANATION

Table 1 shows the variable details as observed in this study.

4. METHODOLOGY AND RESULTS

For examining the relationship between the study variables, over the annual series, present study has used multiple regression technique, where annual observations for all the variables have been considered. Equation below are explaining the relationship between the variables, covering both dependent and independent variables, Equation 1-4 are developed and empirically tested. However, while going for the checking the casual relationship between the study variables, following points are also under consideration while conducting the robust regression analysis.

- The relation is linear so that the errors all have expected value zero; E(ei) = 0 for all i
- The errors all have the same variance: $Var(e_i) = s^2_e$ for all *i*
- The errors are independent of each other.
- The errors are all normally distributed: e_i is normally distributed for all *i*.

In addition, the issue of outlier is also resolved by applying the robust regression analysis. A common notion about the outliers is that it can cause the estimate of the regression slope line to change drastically from the trend line, hence there will be a changed in the regression parameters from their actual point which is not good enough. In addition, under least squares approach we measure the response values in relation to the mean. However, the mean is very sensitive to outliers – one outlier can change the mean value of the data set so it has a breakdown point of 0%. On the other hand, the median is not as sensitive due to the fact that it is resistant to gross errors and has a 50% breakdown point. So if the data is not normal, the mean may not be the best measure of central tendency. Another option with a higher breakdown point is the trimmed mean. All these issues are reasonably addressed through applying the robust regression.

$$Electric\ power\ consumption\left(CH1\right)=ð+b1\left(FA\right)+b2\left(FB\right)+b3\left(FC\right)+b4\left(FD\right)+b5\left(FE\right)+b6\left(FF\right)+E \quad (1)$$

$$Energy\ use\left(CH2\right)=ð+b1\left(FA\right)+b2\left(FB\right)+b3\left(FC\right)+b4\left(FD\right)+b5\left(FE\right)+b6\left(FF\right)+E \quad (2)$$

$$\text{Nitrous oxide emissions}\left(CH3\right)=ð+b1\left(FA\right)+b2\left(FB\right)+b3\left(FC\right)+b4\left(FD\right)+b5\left(FE\right)+b6\left(FF\right)+E \quad (3)$$

$$\text{Methance Emission}\left(CH4\right)=ð+b1\left(FA\right)+b2\left(FB\right)+b3\left(FC\right)+b4\left(FD\right)+b5\left(FE\right)+b6\left(FF\right)+E \quad (4)$$

The above equation is predicting the relationship between core measures of climate change and forestry factors, where C presents the constant value, and b1-b6 are showing the regression coefficients and E reflects the error terms. All the variables are measured on annual basis during the period of 1970-2018.

Data tendencies are significantly analyzed with the help of descriptive measures like mean value its standard deviation, highest and lowest scores, percentile score and both skewness and kurtosis for the normal distribution as well. The observed title for forest factors are entitled under Table 2 through FA-FF, whereas climate change factors are observed with the

Table 1: Variables of the study

Name of the variable	Title of the variable	Nature of the variable	Measurement of the variable	Data source
Agriculture, forestry, and fishing, value added	FA	Independent Variable I	(% of GDP)	World Bank data indicators
Agriculture, forestry, and fishing, value added	FB	Independent Variable II	(Annual % growth)	World Bank data indicators
Agriculture, forestry, and fishing, value added	FC	Independent Variable III	(Constant 2010 US$)	World Bank data indicators
Agriculture, forestry, and fishing, value added	FD	Independent Variable IV	(Current LCU)	World Bank data indicators
Agriculture, forestry, and fishing, value added	FE	Independent Variable V	(Current US$)	World Bank data indicators
Agriculture, forestry, and fishing, value added per worker	FF	Independent Variable VI	(Constant 2010 US$)	World Bank data indicators
Electric power consumption	CH1	Dependent Variable I	(kWh per capita)	World Bank data indicators
Energy use	CH2	Dependent Variable II	(kg of oil equivalent per capita)	World Bank data indicators
Nitrous oxide emissions	CH3	Dependent Variable III	(Thousand metric tons of CO_2 equivalent)	World Bank data indicators
Methane emissions	CH4	Dependent Variable IV	(kt of CO_2 equivalent)	World Bank data indicators

abbreviations like CH1 to CH5. It is explained that total number of observations for each of the titles being explained are 49, showing that there is no missing value in any of the stated year during 1970 to 2018 which is found as period of study. This fact helps to analyze the best statistical relationship between independent and dependent variable because it states that all set of variables have their 100% trends, so that causal relationship is fit and best. For FA to FF, mean score is in different range as measured through % of GDP, annual growth, constant 2010 US$, current LCU, current US$, constant 2010 US$. Whereas the factors for the measurement of climate change are measured through KWH per capita, KG of oil per capita, thousand metric ton of CO_2, kt of CO_2 equivalent respectively. However, highest deviation from the mean trend is reflected through CH3 and CH4. In the same case, both of these variables have their highest mean score among all the measures of the study. Figure 2 is presenting the mean, SD, Min, Max and percentile measures of all the variables during 1970 to 2018.

Table 3 indicates the percentile values for all the variables along with normality distribution in terms of Skewness and Kurtosis. As per the numeric facts all variables showing a good heterogeneity trend during the study period, reflecting the fact that different measures of forest and climate change are not on a same measure but difference over the time.

Under Table 4, forestry factors and their impact on electric power consumption is tested. As observed, FA is causing a negative influence on electric power consumption. The coefficient of −37.142 and standard error of 7.863 have provided enough evidence to accept the adverse and significant relationship with FA and electric power consumption. It explains that higher FA means lower electric power consumption. Through FB, and FC impact on electric power consumption is insignificant. However, FD to FF are observed as direct determinant of electric power consumption in Thailand. The relative betas' coefficients are 0.857, 0.197, and 0.735 respectively. It is believed that all these coefficients are statistically proving their presence for the change in the value of electric power consumption during the last 49 years of the study.

Considering the stated factors of forestry and their impact on the climate change, Table 5 has provided individual coefficients, P score, and their significance level. FA is found to be positive determinant of energy usage as measured through equivalent per capita. It means that there is a direct, positive and significance relationship between the growth of agriculture, forestry, and finishing value added as percentage of GDP and energy use in Thailand. This coefficient of 19.86 indicates that one unit change in FA causing a change of almost 20 unites in energy use. In the same way, FB shows a positive impact of 0.2575 on energy usage, but this impact is not significant at 1, 5 or even

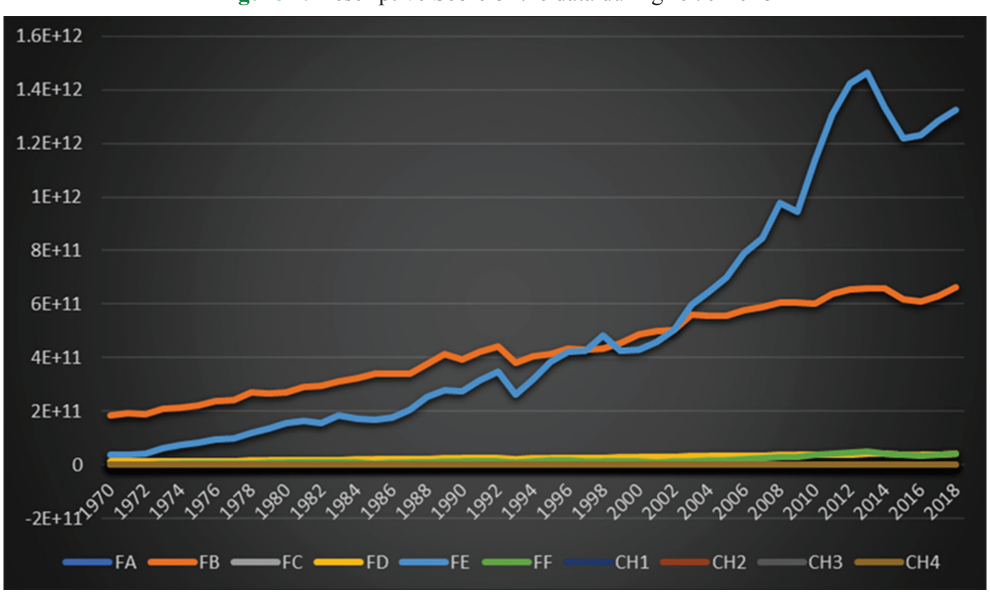
Table 2: Descriptive statistics as mean, SD, min and max

Variables	Obs	Mean	SD.	Min	Max
FA	49	14.645	6.72	8.028	27.69
FB	49	4.29E+11	1.53E+11	1.85E+11	6.63E+11
FC	49	2.828	4.643	−13.896	12.545
FD	49	2.56E+10	9.13E+09	1.10E+10	3.96E+10
FE	49	5.10E+11	4.47E+11	3.67E+10	1.46E+12
FF	49	1.61E+10	1.31E+10	1.76E+09	4.76E+10
CH1	49	1236.674	890.057	120.327	2658.983
CH2	49	1028.381	576.598	360.594	1991.594
CH3	49	19412.07	6506.248	10032.31	30832.95
CH4	49	88770.04	11246.04	69003.8	113000

Table 3: Descriptive statistics as P1, P99, Skew, and Kurt

Variables	p1	p99	Skew.	Kurt.
FA	8.028	27.69	0.761	2.006
FB	1.85E+11	6.63E+11	0.016	1.723
FC	−13.896	12.545	−0.699	5.307
FD	1.10E+10	3.96E+10	0.016	1.723
FE	3.67E+10	1.46E+12	0.883	2.382
FF	1.76E+09	4.76E+10	1.082	2.878
CH1	120.327	2658.983	0.242	1.573
CH2	360.594	1991.594	0.369	1.674
CH3	10032.31	30832.95	0.53	2.346
CH4	69003.8	113000	0.656	2.76

Figure 2: Descriptive Score of the data during 1970-2018



10%, so there is no significant relationship exists between the both. FC is showing a negative but insignificant impact with the standard coefficient of −0.843. It means that an upward shift in FC, causing a decline in energy usage, but statistically not significant et. all.

With the increasing value added portion of agriculture, forestry, and fishing is showing a direct influence of 0.018 and standard error of 0.005. Both of these are finally providing the t-score of 3.601, hence above the cut point of 1.96 as observed in the existing literature of statistics. It would explain that with the higher FD higher energy usage and vice versa. FE and FF are also showing their direct impact on energy usage with the coefficients of 0.017 and 0.160 and $P < 1\%$. It means that increasing trend in FE and FF is putting a direct impact on more energy usage in Thailand, leading to more climate change. Overall inference under Table 3 is that higher the activities like FA, and FD-FF are the true source of causing more climate and environmental change in Thailand.

Table 6 is predicting the relationship of climate change as measured through nitrous oxide emission and forestry indicators during 1970 to 2018. FA is highly significant and negative determinant of nitrous oxide emission in the climate. Where FB and FC are both insignificant determinant for nitrous oxide emission. However, FD and FF are positive indicators showing the coefficients of 0.634 and 0.1254 and standard error of 0.2170 and 0.147, providing the t-values of 2.921 and 5.601 respectively. For model fitness, F-test is found to be the good evidence, showing that regressor's coefficients are different from zero and causing a changing influence on DV during the stud period with no missing observations too.

Table 7 provides the coefficients for methane emission as measured with kt of CO_2 equivalent in Thailand as predicted by set of forestry

Table 4: How forestry factors impacting on climate change; electric power consumption

Electric power consumption (kWh per capita)	Coef.	St. err	t-value	P-value	Sig.
FA: Agriculture, forestry, and fishing, value added (% of GDP)	−37.142	7.863	−4.72	0.000	***
FB: Agriculture, forestry, and fishing, value added (annual % growth)	0.128	0.001	0.35	0.724	
FC: Agriculture, forestry, and fishing, value added (constant 2010 US$)	0.153	4.147	0.04	0.971	
O.FD: Agriculture, forestry, and fishing, value added (current LCU)	0.857	0.105	8.160	0.000	***
FE: Agriculture, forestry, and fishing, value added (current US$)	0.197	0.000	7.75	0.000	***
FF: Agriculture, forestry, and fishing, value added per worker (constant 2010 US$)	0.735	0.000	−5.50	0.000	***
_CONS	993.440	342.240	2.90	0.006	***
Mean dependent var	1236.674		SD dependent var		890.057
R-squared	0.986		Number of obs		49.000
F-test	589.925		Prob >F		0.000
Akaike crit. (AIC)	603.699		Bayesian crit. (BIC)		611.266

***P<0.01, **P<0.05, *P<0.1

Table 5: How forestry factors impacting on climate change; energy use Kg of oil E. P. capita

Energy use (kg of oil equivalent per capita)	Coef.	St. err	t-value	P-value	Sig.
FA: Agriculture, forestry, and fishing, value added (% of GDP)	19.862	5.829	−3.41	0.001	***
FB: Agriculture, forestry, and fishing, value added (annual % growth)	0.2575	.3671	0.701	0.701	
FC: Agriculture, forestry, and fishing, value added (constant 2010 US$)	−0.843	3.074	−0.272	0.785	
FD: Agriculture, forestry, and fishing, value added (current LCU)	0.018	0.005	3.601	0.000	***
FE: Agriculture, forestry, and fishing, value added (current US$)	0.017	0010	17.00	0.000	***
FF: Agriculture, forestry, and fishing, value added per worker (constant 2010 US$)	0.160	0.010	16.01	0.000	***
_cons	873.320	253.704	3.44	0.001	***
Mean dependent var	1028.381	SD dependent var		576.598	
R-squared	0.981	Number of obs		49.000	
F-test	448.487	Prob >F		0.000	
Akaike crit. (AIC)	574.363	Bayesian crit. (BIC)		581.931	

***P<0.01, **P<0.05, *P<0.1

Table 6: How forestry factors impacting on climate change; energy use kg of oil E. P. capita

Nitrous oxide emissions (thousand metric tons of CO_2 equivalent)	Coef.	St. err	t-value	P-value	Sig.
FA: Agriculture, forestry, and fishing, value added (% of GDP)	−482.927	95.524	−5.06	0.000	***
FB: Agriculture, forestry, and fishing, value added (annual % growth)	0.004	0.215	0.018	0.175	
FC: Agriculture, forestry, and fishing, value added (constant 2010 US$)	−6.764	50.381	−0.13	0.894	
O.FD: Agriculture, forestry, and fishing, value added (current LCU)	0.634	0.2170	2.921	0.012	**
FE: Agriculture, forestry, and fishing, value added (current US$)	0.1254	0.000	1.57	0.124	
FF: Agriculture, forestry, and fishing, value added per worker (constant 2010 US$)	0.824	0.147	5.601	0.000	***
_cons	26812.446	4157.567	6.45	0.000	***
Mean dependent var	19412.072	SD dependent var		6506.248	
R-squared	0.960	Number of obs		49.000	
F-test	208.117	Prob >F		0.000	
Akaike crit. (AIC)	850.422	Bayesian crit. (BIC)		859.881	

***P<0.01, **P<0.05, *P<0.1

Table 7: How forestry factors impacting on climate change; energy use kg of oil E. P. capita

Methane emissions (kt of CO_2 equivalent)	Coef.	St. err	t-value	P-value	Sig.
FA: Agriculture, forestry, and fishing, value added (% of GDP)	−43.285	256.773	−0.17	0.867	
FB: Agriculture, forestry, and fishing, value added (annual % growth)	0.157	0.104	1.50	0.124	
FC: Agriculture, forestry, and fishing, value added (constant 2010 US$)	−9.338	135.427	−0.07	0.945	
O.FD: Agriculture, forestry, and fishing, value added (current LCU)	0.827	0.170	4.864	0.000	***
FE: Agriculture, forestry, and fishing, value added (current US$)	0.000	0.000	−0.84	0.406	
FF: Agriculture, forestry, and fishing, value added per worker (constant 2010 US$)	0.258	0.018	14.33	0.000	***
_cons	71265.249	11175.742	6.38	0.000	***
Mean dependent var	88770.036	SD dependent var		11246.035	
R-squared	0.904	Number of obs		49.000	
F-test	81.010	Prob >F		0.000	
Akaike crit. (AIC)	949.326	Bayesian crit. (BIC)		960.677	

***P<0.01, **P<0.05, *P<0.1

measures. Under the stated result, FA to FC have proved to be insignificant determinant for the methane emissions in Thailand. It means that there is no relationship between FA and Mathane emission, between FB and Mathane emission, between FC and Mathane emission during the research period. on the other hand, FD is found to be a positive and highly significant indicator of Methane emission, showing an increasing threat for the nature and climate. However, FE is found to be insignificant determinant for Methane emissions in Thailand. In the end, the influence of FF on Methane emission is 0.258 and standard error of 0.018 and t-value of 14.33. This would show a higher value of Methane emission.

5. CONCLUSION AND FUTURE DIRECTION

This study has been conducted an empirical investigation to explore that how the forestry measures are putting their influence on the natural environment of Thailand through climate change indicators. To the best of our findings, this study is one of those work which are initially contributed to explore the relationship between forestry factors and climate change in Thailand economy. The data period of the study was during 1970 to 2018, making this research one of the most influential research work in the targeted fields and empirical relationship between forestry and climate change. Overall empirical findings were presented under Tables 4-7 where the impact of forestry measures on all four measured of climate change in the form of electric power consumption, energy usage, nitrous oxide emission, and Methane emission in the same region.

Findings have explained that Electric power consumption is negatively influenced by FA, where positively impact from FD, FE and FF accordingly. In case of energy usage, key determinants are the FA, FD, FE and FF with their highly significant and positive influenced. It is believed that such factors are causing an increase in the energy usage, hence more issues for the nature and changing climate. For the emission of Nitrous oxide in the natural environment of Thailand, key factors are the FA which is causing a decline in such emission. Whereas the determinants like FD and FF are causing more Nitrous oxide emission in the climate of Thailand. In a conclusion, Table 7 shows that FD and FF are causing an increase in the Methane emission. It is widely believed that forest factors are playing their major role in the changing natural environment, hence more attention is required towards this factor. However, the positive relationship between value added factors of forestry and other measures are showing some serious concerns for the policy-makers due to their uneven positive relationship.

Meanwhile, this study is suggested to the decision makers in the field of environmental economy, climate change, and sustainability as much attention with some strategic decisions are the need of time. At the same time, study is highly recommended to the researchers in the relevant fields and students community also who are conducted their present or proposed research work. Last but not the least, this research has some limitations which can reasonably cover the future directions like expanding the two directional relationship between forestry and climate change, implication of the study in other nearby regions like Malaysia, Indonesia and ASEAN members, and implication of some other statistical analyses like examining the short run and long run impact of climate change on forest and related dimensions.

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