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IMPACTS OF CLIMATE CHANGE ON TOURISM IN THE PROVINCES ALONG THE MEKONG RIVER IN THAILAND

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Abstract: The objective of this study was to consider the impacts of climate change on tourism along the Mekong River in Thailand. The factors to be considered included temperature and rainfall on the number of Thai and international tourists. Panel data were used, i.e., cross-sectional data from eight provinces of Thailand located along the Mekong River, from January 2013 to December 2023. The results revealed that, over the long-term, only higher temperatures affected the number of Thai tourists. In the short run, average temperatures and rainfall showed the opposite relationship with regard to the number of Thai tourists. The results identified climate change as a cause of the smaller number of Thai tourists in those provinces, mainly as a result of higher average temperatures. Therefore, higher temperatures could be considered a major obstacle for tourism activities.

Keywords: climate change, Mekong, tourism development, tourism, GMS

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INTRODUCTION

Climate change is a key cause of environmental changes (Siddiqui and Imran, 2019), which subsequently have impacts on the daily lives of humans. The study of Shivanna (2022), stated that the impacts of climate change will lead to worsened natural degradation, higher sea levels, lower farming productivity, and loss of biodiversity. In regard to the impacts of climate change on tourism, visitors face various types of obstacles which decrease the attractiveness of tourist attractions resulting from the environmental changes at such sites, i.e., floods, fires, storms, landslides, etc., or lower biodiversity, which is more obvious where natural resources are a key attraction. For this reason, climate change may be a cause of decreasing tourism demand in certain countries and may be a huge problem for tourism-dependent countries.

In 1992, the United Nations Framework Convention on Climate Change (FCCC) described the phenomenon as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". According to the definition, this phenomenon can be divided into three points: the phenomenon is caused by human activity; it affects the weather overall, and may not be a temporary change. Temperature is one of the indicators that reflect the climate change phenomenon Lindsey and Dahlman (2023). The impact of global warming, which is caused by human greenhouse gas emissions, on the increasing global temperature was confirmed by a study by Chen et al. (2022), who identified trends in regard to global temperatures and the atmospheric concentration of greenhouse gases. The increasing global temperature affects the severity of rainfall because it intensifies the heating and evaporation of water, especially the water in the ocean, which is a cause of many storms Lindsey and Dahlman (2023), and heavy rainfall in each region. Thus, the severity of rainfall is also a popular climate change indicator.

When focusing on the effects of this phenomenon on tourism demand, a number of recent studies confirmed the negative effect of the indicator on tourism demand, such as the study of Susanto (2020) in Indonesia, and the region of Baltic Sea countries in the study of Atstāja and Cakrani (2024). The results in regard to inland countries showed the negative effect of these indicators on tourism demand such as the study of Nonthapot et el. (2024) in Thailand and in the study of Chang et al. (2024) in China, and a study of European regions by Matei et al. (2023). In the case of Indonesia, Susanto (2020) found that in five provinces which received the largest number of tourists, every time temperatures and relative humidity increased by 1%, the number of international tourists in Indonesia would decrease by 1.37% and 0.59%, respectively. However, climate-related extreme events were found not to have the same effects on tourism in all regions. The study by Atstāja and Cakrani (2024) found that an annual average mean surface air temperature had a negative impact on the total travel inbound expenditure and the total number of overnight visitors in the Baltic Sea countries.

In regard to the study in China, Chang et al. (2024) found a decrease in tourist arrivals and revenue when the temperature rose in the summer, but they increased in autumn when the temperature increased. This is in line with the study by Matei et al. (2023) in Europe, which found increasing tourism demand in winter but reduced demand in summer. The

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cases of China and Europe suggest a negative effect of temperature on tourism demand, which may be a sign that hot weather negatively affects tourism. At the same time, the weather being too cold may also negatively affect tourism. This suggests that tourism demand in these countries may be affected by the suitability of temperature Nonthapot et al. (2024) considered the effects of climate change on representative provinces in each region of Thailand and found the maximum temperature, rainfall and the amount of the PM 10 pollution were the key factors that negatively affected the number of tourists in the popular provinces in each region of Thailand. The study differed from previous research because it did not account for seasonal effects. However, Thailand being a tropical country may explain this approach. Moreover, the direct impact of climate change indicators on tourism demand for islands and inland countries was similar while the differences in the cases of autumn in China and winter in Europe were considered to be seasonal. However, the studies cited above investigated the issue at the national or global regional level, which includes the overall attractiveness of these countries. A domestic regional level study may be a topic for future research. Rivers are one of the most popular attractions as there are a lot of associated tourist activities such as water-skiing, cruising, fishing etc. Moreover, tourists also enjoy cultural attractions along the river. However, river attractions have a high risk of the effects of climate change, especially the effects of temperature and the severity of rainfall. The river may become dry because of high temperatures, storms may cause the river to overflow and flood cities adjacent to the river, causing damage to riverbanks and infrastructure. Unfortunately, few studies have investigated the impact of climate change on tourism demand in regard to river attractions.

In Southeast Asia, the Mekong is the main river flowing through Myanmar, Laos, Thailand, Cambodia, and Vietnam. The river is not only a water source for agriculture, commerce, and electric power, but is also a key resource for tourism in the region, particularly Thailand, and is a popular destination for tourists all along the riverside areas. This utilization includes natural tourist attractions such as rapids that originate from erosion caused by the river, the two-color river phenomenon at the confluence between the Mun River and the Mekong River, the scenic atmosphere at sunrise and sunset, and the beaches on the bank of the Mekong River, which appear for a few months when there are low water levels. Cultural tourist attractions based on the riverside way of life are also popular, such as boat racing festivals and events related to the legend of the Naga, e.g., Naga fireballs seen in the Mekong River in Nong Khai and Bueng Kan.

Thailand is the most popular country in Southeast Asia. In 2019, there were almost 40 million tourists coming to Thailand before the number was hugely reduced due to the COVID-19 pandemic. Eventually, everything recovered again after the world was able to control the outbreak. The data from the Ministry of Tourism Sports of Thailand indicated that there were over 28 million international tourists who came to Thailand in 2023 (Ministry of Tourism & Sports of Thailand, 2024). One of the strengths of Thailand's tourism industry is the diversity of tourist attractions, which are distributed throughout all of Thailand and throughout the domestic region. The Mekong River is a natural resource which is a source of many important attractions in northeastern Thailand. There are eight provinces of Thailand which are located along the Mekong River: Chiang Rai in the northern region and other provinces in the northeastern region of Thailand, such as Amnat Charoen, Bueng Kan, Loei, Mukdahan, Nong Khai, Nakhon Phanom, and Ubon Ratchathani provinces with the total number of international tourists at 756,821; 5,257; 27,564; 29,363; 115,435; 849,968; 118,090; and 19,609, respectively. The numbers of international tourists staying at accommodation establishments from 2013 to 2022 are shown in Table 1.

Table 1. The number of international tourists staying at accommodation establishments in the different provinces (Source: Ministry of Tourism & Sports of Thailand, 2024)

Year	Chiang Rai	Amnat Charoen	Bueng Kan	Loei	Mukdahan	Nong Khai	Nakhon Phanom	Ubon Ratchathani
2013	430,074	5,383	1,872	15,266	11,602	35,404	5,834	61,714
2014	426,630	5,432	1,976	15,799	11,634	34,631	5,944	60,690
2015	461,276	5,712	2,168	17,481	14,232	36,280	6,203	63,238
2016	461,830	5,858	2,220	18,276	14,440	37,313	6,293	65,647
2017	492,345	6,589	2,205	19,325	15,272	36,393	6,458	79,760
2018	513,519	6,611	2,259	20,095	15,832	37,439	6,792	81,697
2019	525,845	6,413	2,268	20,100	16,144	37,516	6,960	82,491
2020	89,244	1,092	443	3,556	2,165	8,841	877	18,220
2021	4,661	23	167	1,233	77	1,021	294	252
2022	153,076	459	4,411	7,369	4,697	17,288	7,331	2,335

Thailand has also been hugely affected by climate change. According to Limjirakan and Limsakul (2012), it was found that the maximum, minimum, and average temperatures in Thailand increased by 0.96, 0.92, and 1.04 °C within 40 years between 1970 and 2009. The World Bank (n.d.) revealed that Thailand's mean annual temperature has increased by 0.8 Celsius per century since the 1950s, with particularly significant impacts of climate change in the northeastern region, a region which partly adjoins the Mekong River, with a high risk of major disasters, i.e., heat, floods, and drought. There were also negative impacts on biodiversity and loss of cultural aspects as well as natural tourism areas caused by destruction from disasters (Office of Natural Resources and Environmental Policy and Planning, 2022). This may be an obstacle to tourism in the area.

The study by Nonthapot et al. (2024) revealed the effects of those factors on tourism, and it was found that there were different effects of climate on tourists in each region (Susanto, 2020). The study by Nonthapot et al. (2024) considered the overall impact by employing the data on tourism, climate change and economic factors in the main tourism provinces in each region. However, it was found that each province had various tourist attraction characteristics, which did not always reflect the natural and cultural tourism attractions in the provinces. The study focused on tourism demand in eight provinces located along the Mekong River. The key objective of this study was to consider the impacts of climate change, which is indicated by temperature and rainfall, on tourism demand, such as the number of Thai and international tourists visiting the provinces along the Mekong River in Thailand. The researcher expects that the results will be useful for the development of local tourism under environmental changes in the riverside areas of the Mekong River in the future.

LITERATURE REVIEW

Climate change is a cause of environmental change as a result of sea level change, loss of forest resources caused by wildfire, melting glaciers, and other phenomena (Siddiqui and Imran, 2019). These all affect tourism resources. However, these obvious incidents of environmental changes have occurred after the climate has slightly changed over a long period of time. Temperatures and rainfall are one of the key factors which can be used to observe the climate change phenomena. There is much research about the impact of climate change on the tourism demand which pick the temperature or the rainfall as the climate change factors in their papers such as Nonthapot et al. (2024), Susanto (2020), Chang et al. (2024), Atstāja and Cakrani (2024), Fauzel (2019), and Matei et al. (2023). The negative impact of temperatures and rainfall on tourism demand was usually found when the relationship wasn’t considered with the season, as in the case of Nonthapot et al. (2024), Susanto (2020) and Matei et al. (2023). However, the seasonal separation from the relationship may indicate that tourism demand may be attracted by the suitable temperature. However, the ambiguity of the impact directional to tourism demand is not only the temperature, but also the rainfall situation. Nonthapot et al. (2024) and Fauzel (2019) studies found the negative effect of rainfall on tourism demand in Thailand and the Small Island Developing States respectively. In contrast, the domestic tourism of Korea on Jeju Island was positively affected by the rainfall (Bae and Nam, 2019).

In the case of Thailand, Nonthapot et al. (2024) found negative effects in both indicators of overall tourism demand by employing data on tourism, climate change and economic factors in the main tourism provinces in each region. Although the study conforms with previous studies, this result also differs from findings in China and Europe, which assessed seasonal impacts on the relationship. However, Thailand is a tropical country located approximately between 5° to 21° North (latitude) and 97° to 106° East (longitude) which experiences hot weather throughout the year. Although there is a cooler period from December to February, it is still relatively warm compared to temperate regions. During this time, the lowest recorded temperature, such as in December 2023, was not below 4.5°C, occurring in specific locations like Doi Inthanon (Thai Meteorological Department, 2023). The average annual minimum temperature was around 23.39°C during 2011-2020 (Thai Meteorological Department, 2022). This situation implies that Thailand's temperature is suitable for tourism activities all year round. Thus, seasonal effects in Thailand may not occur.

In addition to the factors of climate, tourism can be affected by other factors as well, particularly economic factors, e.g., the factors of price and tourism-related economic conditions. The factors of price can be considered from the data that reflect inflation such as CPI. The factors that reflect tourism-related economic conditions can be considered from the data that reflect national income such as GDP and GDP per capita. These factors affect tourism demands differently. Nonthapot et al. (2024) applied the factors of price, i.e., CPI, to support this consideration. They found the opposite relationship regarding the number of tourists in the famous provinces among the international tourists in each region of Thailand. Soofi (2018) also found the congruent relationship resulting from GDP per capita to be the same as other considered factors, i.e., the exchange rates, population, and free trade, but the relationship between CPI and tourism demands was not found. When considering tourism demands based on income for research in the Organization of Islamic Cooperation (OIC), with regard to the results of a study conducted in Tunisia by Dekkiche (2023), the researcher found the opposite relationship among CPI, GDP per capita, and real exchange rates. Seetanah et al. (2015) applied CPI by categorizing it into relative price with comparison between the CPI of tourist attractions and the country of origin, and relative cost with comparison between the CPI of tourist attractions and competitive countries. The results revealed the opposite relationship between relative price and tourism demands, and also the long-term congruent relationship between relative cost and tourism demands.

METHODOLOGY

This study on the effects of climate change on the number of tourists in the provinces along the Mekong River in Thailand used the relevant data, average temperatures, and monthly rainfall as the indicators of climate change. The number of Thai and international tourists was considered based on the total number of tourists staying at accommodation establishments in the target provinces using panel data. This data included cross-sectional data from eight provinces in Thailand along the Mekong River, i.e., Chiang Rai, Amnat Charoen, Bueng Kan, Loei, Mukdahan, Nong Khai, Nakhon Phanom, and Ubon Ratchathani, and time-series data as monthly data from January 2013 to December 2023, a total of 132 months. The variables and sources of data are shown in Table 2.

Table 2. Data used in the study (Source: The researcher)

Variable	Symbol	Definition	Unit	Source
The number of international tourists	TR_F	The number of international tourists staying at accommodation establishments in the target provinces	Person	Ministry of Tourism and Sports (2024)
The number of Thai tourists	TR_T	The number of Thai tourists staying at accommodation establishments in the target provinces	Person	Ministry of Tourism and Sports (2024)
Rainfall	Rain	Monthly average rainfall from weather stations in the target provinces	millimeter	Hydro and Agro Informatics Institute (2024)
Average temperatures	Tmean	Monthly average temperatures (°C) from weather stations in the target provinces	Celsius	Hydro and Agro Informatics Institute (2024)
GPP per capita	GPP	Gross Provincial Product per capita	Baht	Office of the National Economic and Social Development Council (2024)
CPI	CPI	Basic consumer price index in each province	-	Office of Trade Economic Indices (2024)

The data on rainfall and average temperatures in this study were obtained by purposive sampling, with one site/province as the representative from several weather stations in each province. Completeness of the data collected by those stations was considered throughout the study duration. These data were modified from hourly into recorded monthly data. More specifically, means were used for all data on temperature. The sum of all data in one month was used for rainfall.

Furthermore, the data on GPP were also improved. As the data of each province were not officially announced in 2023, It was inferred from the results of Thailand's estimated economic expansion from the Office of the National Economic and Social Development Council, assuming that Thailand had the growth rate of 1.9% in 2023. After that, the data were transformed throughout the study duration into monthly data. The value of GPP each month was set to be equal to the GPP for that year. Because the panel data in this study were the data that collected the qualifications and limitations of the cross-sectional data and time-series data, when using this data to consider relationships under regression-related statistical tools, the suitability of the qualifications of the data and relationships must be considered in order to reduce conclusion errors. Qualifications of the data to be considered included cross-sectional dependence and panel unit root testing, and the qualifications of the relationships to be tested included slope homogeneity and cointegration. The results of each test led to the selection of a suitable related test, including the characteristics of the models that would be used to consider the relationships between the independent variables and dependent variables. Cross-sectional dependence testing was used to test the independence of the cross-sectional data. Dependences of this type of data can cause errors of data analysis results (Baltagi and Pirotte, 2010), e.g., the size of the Chow type F-test that is larger than usual (Basak and Das, 2017). In this study, the cross-sectional dependence was tested by Pesaran's method, as per Equation (1).

$$CD = \sqrt{\frac{2}{N \times (N-1)}} \times \sum_{i}^{N}\sum_{t}^{T}\sqrt{T_{ij} \times r_{ij}} \qquad \text{Eq (1)}$$

Where CD refers to the CD test statistic that was used to test cross-sectional dependence under the key hypothesis; in other words, whether the data used for analysis showed strict cross-sectional independence (Pesaran, 2004) or weak cross-sectional dependence (Pesaran, 2015). x refers to a variable for testing, N refers to the number of the total cross section or total provinces in the study, T refers to the total duration of the study while i refers to cross-section or the data about that variable in a certain target province, t refers to the data for the variable in a certain target year, and r_{ij} refers to the correlation coefficient obtained by the following calculation.

$$r_{ij} = \frac{1}{T_i - 1} \sum_{t}^{T}\left(\frac{x_{it} - \bar{x}_{it}}{s_i} \times \frac{x_{jt} - \bar{x}_{jt}}{s_j}\right) \qquad \text{Eq (2)}$$

Furthermore, s_i refers to the standard deviation obtained by the following calculation.

$$s_i = \sqrt{\left(\frac{1}{T_i - 1} \times \sum_{t}(x_{it} - \bar{x}_{it})^2\right)} \qquad \text{Eq (3)}$$

Therefore, in the case of significant rejection of the key hypothesis, it could be said that the cross section of the considered data might not be independent or might have cross-sectional dependence. As for consideration of the interfering factor in terms of the time-series data from the panel data that usually cause conclusion errors by regression equations for data analysis, it mainly relied on panel unit root testing. The interfered data might be non-stationary or have a unit root. In case of cross-sectional dependence, the panel unit root was required for testing by methods in the 2nd generation, e.g., the cross-sectionally augmented IPS test (CIPS test) of Pesaran (2007), which relieved the qualifications of the cross-sectional independence of the tested data. The statistics for the CIPS test were considered as follows.

$$CIPS(N,T) = N^{-1}\sum_{i=1}^{N} t_i(N,T) \qquad \text{Eq (4)}$$

Where $t_i(N,T)$ refers to the t-ratio of b_i in Eq(5) as follows.

$$\Delta y_{it} = a_i + \delta_i t + b_i y_{i,t-1} + c_i \bar{y}_{t-1} + d_i \Delta \bar{y}_t + e_{it} \qquad \text{Eq (5)}$$

Where a_i and $\delta_i t$ are the terms of the intercepts and trend, respectively. Their values were not set. In the case that the data were not considered for co-effects in the model, of which the key hypothesis for testing was homogeneous non-stationary data, $b_i = 0$ for all cross-sectional data.

In the case of stationary data, the results of the model for long-term relationships might be reliable, without cointegration, a qualification which indicates reliable relationships between the independent variables and the dependent variables obtained by estimation, despite interference from the unit root. That was because those relationships adjusted to long-term equilibrium when they were affected. Still, if all data used were non-stationary, those data would be tested again after they had been modified into the 1st difference to consider cointegration testing, and to set a suitable model for estimating relationships, particularly panel autoregressive distribution lag (panel ARDL) that could be used for testing qualifications, along with consideration of long-term and short-term relationships.

Apart from the qualifications of the studied data according to the previous testing, the results of the estimated panel data might contain errors due to the effects of the different independent variables in the cross-sectional data on the dependent variables (slope heterogeneity). Therefore, those qualifications must be considered according to the results of the estimated relationships for panel data. In this study, slope homogeneity was applied for the standard delta test (Pesaran and Yamagta, 2008) under the key hypothesis: "The independent variables in the cross-sectional data have effects on the dependent variables in the same way." In order to determine if the results revealed slope heterogeneity, the use of the Pedroni test (Pedroni, 1999) and Westerlund test (Westerlund, 2005) for testing panel cointegration was a suitable method. The Pedroni test and Westerlund test for testing panel cointegration were modified to consider relationships in the case of slope heterogeneity. Basically, this method was applied from the test of Engle-Granger. Cointegration was considered based on the stationary data and errors due to estimation by regression. For the Pedroni test, the statistics obtained by error estimation were tested by comparison with critical values in different forms, i.e., Modified PP t (MPP), PP t (PP), and ADF t (ADF). Likewise, the Westerlund test was employed to apply the statistical values obtained by error estimation, and then they were compared with the critical values of VR. If the errors from estimation for testing were stationary, they indicated that the relationships under consideration contained cointegration. When cointegration was confirmed, the analysis of the effects of climate change on tourism were considered by panel autoregressive distribution lag (panel ARDL). In this study, the relationships of the independent variables, i.e., GPP, CPI, Tmean, and Rain, on the dependent variables, i.e., TR_T and TR_F, were considered. The general models for this study are as follows.

$$TR\_F_{it} = \Sigma_{j=1}^{p} b_{1,i,j} TR\_F_{i,t-j} + \Sigma_{j=0}^{q_2} b_{2,i,j} \text{GPP}_{i,t-j} + \Sigma_{j=0}^{q_3} b_{3,i,j} CPI_{i,t-j} + \Sigma_{j=0}^{q_4} b_{4,i,j} \text{Tmean}_{i,t-j} + \Sigma_{j=0}^{q_5} b_{5,i,j} Rain_{i,t-j} + u_{i,t} \quad \text{Eq (6)}$$

$$TR\_T_{it} = \Sigma_{j=1}^{p} d_{1,i,j} TR\_T_{i,t-j} + \Sigma_{j=0}^{q_2} d_{2,i,j} \text{GPP}_{i,t-j} + \Sigma_{j=0}^{q_3} d_{3,i,j} CPI_{i,t-j} + \Sigma_{j=0}^{q_4} d_{4,i,j} \text{Tmean}_{i,t-j} + \Sigma_{j=0}^{q_5} d_{5,i,j} Rain_{i,t-j} + v_{i,t} \quad \text{Eq (7)}$$

Where $b_{1,i,j}$ and $d_{1,i,j}$ revealed their long-term effects based on the number of former tourists affecting the number of current tourists, while $b_{2,i,j} \ldots b_{5,i,j}$ and $d_{2,i,j} \ldots d_{5,i,j}$ revealed the long-term effects of the independent variables on the number of tourists. They were transformed into a vector error correction mechanism as follows.

$$\Delta TR\_F_{it} = \alpha_i + \beta_i ECM_{i,t-1} + \Sigma_{j=1}^{p} \gamma_{1,i,j} \Delta TR\_F_{i,t-j} + \Sigma_{j=0}^{q_2} \gamma_{2,i,j} \Delta \text{GPP}_{i,t-j} + \Sigma_{j=0}^{q_3} \gamma_{3,i,j} \Delta CPI_{i,t-j} + \Sigma_{j=0}^{q_4} \gamma_{4,i,j} \Delta \text{Tmean}_{i,t-j} + \Sigma_{j=0}^{q_5} \gamma_{5,i,j} \Delta Rain_{i,t-j} + D_1 Co + u_{i,t} \quad \text{Eq (8)}$$

$$\Delta TR\_T_{it} = \eta_i + \theta_i ECM_{i,t-1} + \Sigma_{j=1}^{r} \lambda_{1,i,j} \Delta TR\_T_{i,t-j} + \Sigma_{j=0}^{s_2} \lambda_{2,i,j} \Delta \text{GPP}_{i,t-j} + \Sigma_{j=0}^{s_3} \lambda_{3,i,j} \Delta CPI_{i,t-j} + \Sigma_{j=0}^{s_4} \lambda_{4,i,j} \Delta \text{Tmean}_{i,t-j} + \Sigma_{j=0}^{s_5} \lambda_{5,i,j} \Delta Rain_{i,t-j} + D_2 Co + v_{i,t} \quad \text{Eq (9)}$$

While Eq (8) revealed the short-term relationship of the independent variables on the number of international tourists, Eq (9) revealed the short-term relationship of the independent variables on the number of Thai tourists, α_i and η_i represented the intercepts, D_1 and D_2 revealed the short-term effects of COVID-19 on tourism, $\gamma_{1,i,j}$ and $\lambda_{1,i,j}$ revealed the short-term effects of the number of former tourists on the number of current tourists, and $\gamma_{2,i,j} \ldots \gamma_{5,i,j}$, and $\lambda_{2,i,j} \ldots \lambda_{5,i,j}$ revealed the short-term effects of the independent variables on the number of tourists.

The models were applied to suit three estimation methods, i.e., pooled mean group (PMG), mean group (MG), and dynamic fixed effect (DFE). The data obtained by these methods were selected, with the consideration to use the Hausman test. According to the methodology, the progress of this study can be illustrated as shown in Figure 1 below.

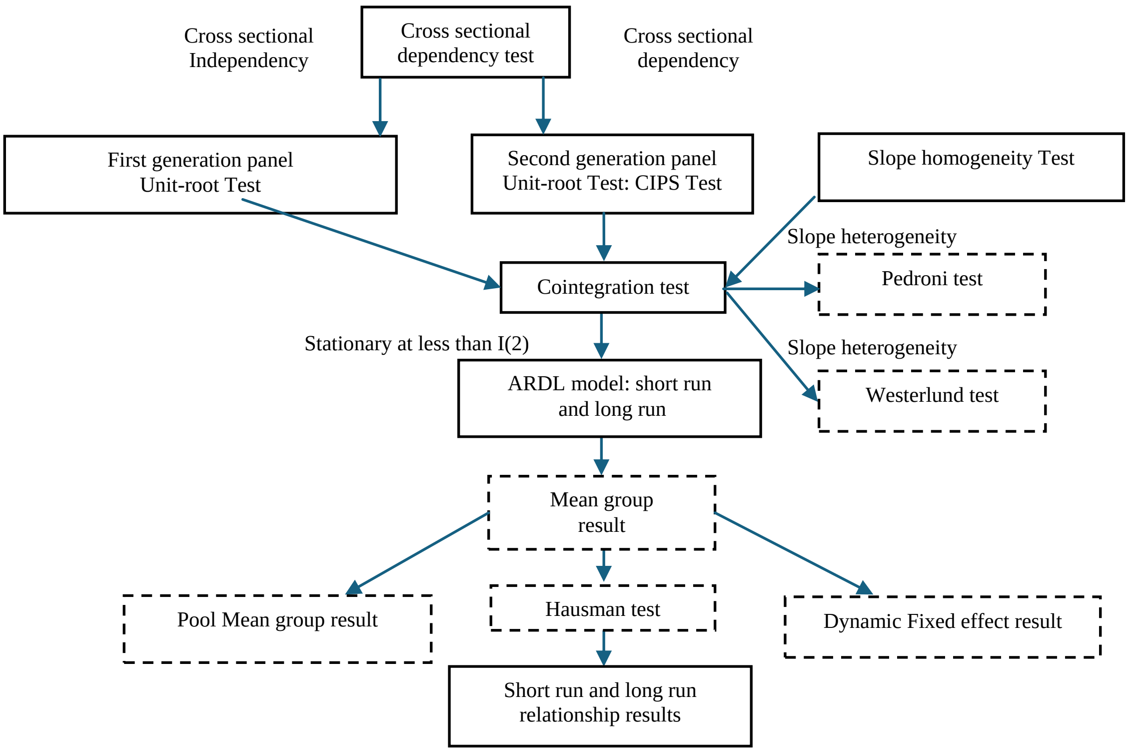

Figure 1. Methodology

RESULTS AND DISCUSSION

As seen in Table 3, which displays the results of the tested cross-sectional independence by Pesaran's CD-test for cross-sectional dependence in the panel variables, it was found that all panel variables contained dependent cross-sectional data. Therefore, the unit root test in these panel data should rely on the method in the 2nd generation unit root test in the panel variables that relieved the qualifications of independence of cross-sectional independence in the panel variables. In this study, cross-sectionally augmented Im, the Pesaran test, and the Shin test (CIPS test) were used for further consideration.

Table 3. The results of tested cross-sectional independence in the panel variables (Note: ***, **, * significant at 99%, 95% and 90%, respectively)

Variable	CD-test
TR_F	31.68***
TR_T	53.614***
Rain	34.762***
GPP	56.659***
CPI	59.117***
Tmean	45.081***

When considering the results of the panel unit root test by CIPS test at the data level, it was found that all variables, except TR_F and GPP, were without unit root process, i.e., the model without trend and intercepts, the model with the effects of the intercepts, and the model with the effects of trend and the intercepts. However, for TR_F, the unit root process was found in the model without trend and intercepts as well as the model with the effects of the intercepts. This process was also found in GPP in all three models. When removing the results of the unit root process by changing the current data using the 1st difference, it was found that TR_F and GPP were without the effects of the unit root process at the 1st difference of the data (Table 4).

Table 4. The results of tested panel unit root by CIPS test (Note: ***, **, * significant at 99%, 95% and 90%, respectively)

Variable	Level			1st difference		
	None	Intercept	Intercept and Trend	None	Intercept	Intercept and Trend
TR_F	-1.570	-2.076	-3.365***	-6.120***	-6.190***	-6.420***
TR_T	-4.321***	-5.032***	-5.424***	-	-	-
Rain	-5.915***	-5.978***	-6.249***	-	-	-
GPP	-1.342	-2.011	-2.125	-6.120***	-6.190***	-6.420***
CPI	-2.250***	-3.050***	-3.417***	-	-	-
Tmean	-4.530***	-4.686***	-5.036***	-	-	-

According to the tested slope homogeneity as seen in Table 5, it was found that the effects of the independent variables affecting the dependent variables contained a range of slope heterogeneity, which might cause errors in the models or hypothesis testing that rely on the relationship analysis under the hypothesis of similarity of slope heterogeneity.

Table 5. The results of tested slope homogeneity (Note: ***, **, * significant at 99%, 95% and 90%, respectively)

Dependent Variable	Delta	Adj. Delta
TR_F	34.556***	35.510***
TR_T	31.409***	32.276***

According to the panel cointegration testing by these two methods, it was found that the relationships of the independent variables; i.e., GPP, CPI, Rain, and Tmean; including the effects of COVID-19 on TR_F, contained cointegration when evaluated by the Pedroni test, but it was not found when they were considered using the Westerlund method. Moreover, when considering Thai tourists, the relationships of the independent variables; i.e., GPP, CPI, Rain, and Tmean, including the effects of COVID-19 on TR_F; contained cointegration according to both methods (Table 6).

Table 6. The results of panel cointegration tested by the Pedroni test and Westerlund test (Note: ***, **, * significant at 99%, 95% and 90%, respectively)

Dependent Variable	Pedroni						Westerlund	
	None			Trend			None	Trend
	MPP	PP	ADF	MPP	PP	ADF		
TR_F	-4.945***	-4.734***	-5.268***	-4.454	-4.642***	-4.750***	-1.180	-0.172
TR_T	-5.789***	-5.806***	-6.023***	-5.477***	-5.756***	-5.451***	2.069**	-1.920**

According to the cointegration from the independent variables on the number of Thai and international tourists, the long-term relationships of the independent variables on the number of those tourists could be noticed. However, when considering the qualifications of the stationary data at different levels, the relationships in the ARDL models must be estimated. This relieved the limitations of the different levels for stationary data. Analysis by ARDL models in the panel data can be considered by applying three models, i.e., pooled mean group (PMG), mean group (MG), and dynamic fixed effect (DFE), as shown in Table 7.

Table 7. The suitable models obtained by the Hausman test and cointegration test from ECM
(Note: ***, **, * significant at 99%, 95% and 90%, respectively)

Independent Variable	Hausman test (β)				ECM
	β	PMG	MG	DFE	
TR_F	PMG	-	-	-	-0.073 (0.046)
	MG	-	-	-2.99	-0.268*** (0.057)
	DFE	-	0	-	-0.055*** (0.0123)
TR_T	PMG	-	-1.88	-217.47	-0.158*** (0.0405)
	MG	1.54	-	-146.96	-0.272*** (0.0263)
	DFE	0	0	-	-0.156*** (0.0175)

The results of the long-term and short-term relationships of GPP, CPI, Tmean, and Rain on TR_F and TR_T are displayed in Table 8 and 9, respectively. Long-term relationships from the independent variables on the dependent variables were confirmed through the coefficient of ECM, which was significantly negative. This reflects the rapidity of adjustment to long-term equilibrium when they were affected by other factors. The relationships of the independent variables on the number of international tourists estimated by MG and DFE and the relationships of the independent variables on the number of Thai tourists according to the estimation results of all three models are seen in Table 7.

Moreover, the results from the Hausman test revealed DFE as the most effective method to estimate relationships from the models of relationships of the independent variables on international and Thai tourists. According to the relationships of the independent variables on international tourists, it was found that the considered values did not contain statistical significance when considering the selection results between DFE and MG. To clarify, the DFE model was more suitable than the MG model. For the relationships of the independent variables on Thai tourists, it was found that the considered values did not contain statistical significance when considering the selection results between MG and PMG. To clarify, the MG model was more suitable than the PMG model.

When considering the selection results between DFE and MG, and DFE and PMG, it was found that the considered values did not contain statistical significance. To clarify, the DFE model was more suitable. According to the results of the long-term equilibrium estimation by DFE, it was found that Tmean affected the number of Thai tourists only in the opposite way at 99% reliability, and CPI affected the number of Thai and international tourists in the same way at 99% and 95% reliability, respectively. In contrast, the results from the DFE estimation for the effects of GPP and Rain on the number of Thai and international tourists did not have statistical significance.

Table 8. Long-term relationships from the panel ARDL (Note: ***, **, * significant at 99%, 95% and 90%, respectively)

Independent Variables	Dependent Variables					
	TR_F			TR_T		
	PMG	MG	DFE	PMG	MG	DFE
GPP	0.370 (0.269)	0.090 (0.072)	0.230 (0.340)	1.123 (0.653)	0.0873 (0.5451)	-0.6091 (0.8756)
CPI	1787.680*** (469.918)	1347.092 (834.012)	2208.893** (1043.959)	8876.750*** (1425.936)	9268.419*** (2734.284)	12667.48*** (2094.703)
Tmean	-1820.039 (447.930)***	-755.233 (391.877)	-1357.863 (756.324)	-9187.306 (1624.45)***	-8073.872 (2508.034)***	-7634.194*** (1669.526)
Rain	-28.161** (13.021)	-8.917 (4.730)	-5.786 (20.302)	31.132 (33.481)	-13.339 (17.036)	2.306 (44.510)

When considering the short-term relationships, it was found that the number of international tourists was not affected by any independent variables besides the impacts of COVID-19, no matter by which estimation methods. This was different from the results for Thai tourists, which indicated opposite short-term relationships due to climate change, i.e., average temperatures and rainfall, according to estimation by DFE. In contrast, these effects were not found from the estimation by PMG and MG. However, the results from all estimation methods revealed the negative impacts of COVID-19.

Table 9. Short-term relationships from the panel ARDL (Note: ***, **, * significant at 99%, 95% and 90%, respectively)

Independent Variables	Dependent Variables					
	TR_F			TR_T		
	PMG	MG	DFE	PMG	MG	DFE
ECM	-0.073 (0.046)	-0.268*** (0.057)	-0.055*** (0.0123)	-0.158*** (0.041)	-0.2718***(0.0263)	-0.156*** (0.0175)
ΔGPP	-0.083 (0.2135)	-0.1013 (0.2064)	0.076 (0.0898)	-0.027 (0.8843)	-0.246 (0.6235)	-0.397 (0.559)
ΔCPI	-193.081 (175.879)	-265.792 (221.898)	-218.426 (200.1472)	91.901 (820.995)	107.2509 (792.3757)	-537.3753 (1249.062)
ΔTmean	-50.108 (94.132)	0.925 (113.697)	-54.178 (50.921)	-852.392 (1217.029)	-158.8302 (678.9181)	-572.746 (321.357)
ΔRain	-0.380 (0.514)	0.320 (0.369)	-0.799 (1.073)	-23.9471 (15.9143)	-13.351 (8.700)	-11.345 (6.698)*
CO	-2892.480 (2274.680)	-3579.124 (2272.188)	-1295.122*** (306.634)	-15331.590*** (4335.768)	-21580.180*** (5648.117)	-12882.39*** (1999.891)
Constant	-9139.423 (5396.690)	-18353.060 (11818.510)	-10194.870** (4009.676)	-94950.23*** (23622.49)	-156465.600*** (45678.090)	-141108.100*** (26825.05)

CONCLUSIONS

In this study, the relationships between climate change and the number of tourists were analyzed. They were considered based on the climate change data on average temperatures and rainfall. The number of Thai and international tourists was also considered based on the number of tourists staying at accommodation establishments in the target provinces. The data that reflected economic conditions in each province were based on GPP per capita as well as CPI, and the results of COVID-19 were also considered.

According to estimation by the most suitable models, the relationships of the independent variables on the number of Thai and international tourists were revealed. To clarify, there were opposite relationships of Tmean on the number of Thai and international tourists. Moreover, the results of this part also conformed to the results obtained by other estimation methods. In contrast, they were different from the study of Falk (2013) in Australia and Chen and Lin (2014) in Taiwan. However, they conformed to the study of Nonthapot et al. (2024) in Thailand and Susanto (2020) in Indonesia. These differences might be caused by the variations of the areas. Because Thailand and Indonesia are located close to the equator, temperatures are relatively high all year round. As a consequence, increasing average temperatures have become an obstacle for tourism activities and can be harmful for health. In contrast, Taiwan and Australia are located farther from the equator. Therefore, increasing temperatures can attract local tourism because they are suitable for tourism activities in those areas.

For estimation by DFE and other methods for the effects of rain on the number of Thai and international tourists, relationships were not found. This did not conform to Nonthapot et al. (2024) in Thailand, Falk (2013), or Chen and Lin (2014), who found opposite relationships to tourism demands. To clarify, Nonthapot et al. (2024) considered tourism using the panel data used in the samples as cross-sectional data, i.e., the provinces which represented tourism in each region, reflecting general rainfall, but this study used the provinces in Thailand as cross-sectional data. Those target provinces adjoin the Mekong River, with slight spatial distribution. Therefore, the relationships of rainfall on tourism in the target areas contained the effects of spatial characteristics. Also, this lack of conformity to the studies of Falk (2013) and Chen and Lin (2014) could be clarified as follows. The areas along the Mekong River were not negatively affected by rainfall to a significant degree, while Australia and Taiwan were more obviously affected by this phenomenon. Nevertheless, the results of estimation by PMG and MG for international tourists might also confirm the obstacles to tourism caused by rainfall.

For the results of the relationships of climate change on the number of tourists, it was found that average temperatures were a factor with long-term impacts on the number of tourists in each province along the Mekong River in Thailand. An increase of average temperatures by 1 °C resulted in the decrease of international tourists in the areas by 1,358 on average. Similarly, such change also resulted in the decrease of Thai tourists by 7,634 on average. In contrast, there were no long-term effects of rainfall either on the number of international tourists or Thai tourists in those areas. Therefore, it could be said that climate change negatively affected the number of Thai tourists in the provinces along the Mekong River mainly through average temperatures, possibly because temperatures in those areas were relatively high. Therefore, increasing temperatures might be an obstacle for tourism activities. Ruamree and Khonwai (2018) stated that higher temperatures and drought negatively affected biodiversity and ecosystems, which basically attract ecotourists. These impacts could be considered to obviously result from drought, which caused damage to famous tourist attractions in Nakhon Phanom, i.e., Tad Pho Waterfall and Tad Kham Waterfall, which completely ran out of water in 2015. This phenomenon affected local tourism, particularly tourist attractions' entrepreneurs, who were impacted by the lower number of tourists (MGR Online, 2015).

The results of this study reflect that the entrepreneurs of tourism areas along the Mekong River must find measures to motivate tourists to join local activities, or to change some types of investment in accommodation activities, e.g., using thin and ventilating tent sheets instead of thick materials. Furthermore, they can provide activities that are suitable in areas with high temperatures, e.g., tourism activities or sightseeing boats on the Mekong River.

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