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CLIMATE CHANGE, AGRICULTURE GROWTH, AND FISCAL POLICY OF LOCAL GOVERNMENTS: THE CASE OF LAMPUNG

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ABSTRACT
Research originality — The climate change has impacted several sectors, mainly the agriculture sector. The government of Indonesia has issued public policies to achieve a national target regarding climate change by allocating budgets to regional governments at both province and regency/city levels. While most existing studies focus on national or provincial levels, this paper offers a novel contribution by analyzing the effect of climate-related expenditures at the regency level, specifically in Lampung Province.
Research objectives — The paper aims to observe the relationship between the spending on climate change in regency/city governments in Lampung by examining the correlation between the spending and the growth of local GRDP in agriculture in Lampung.
Research methods — We utilize pooled ordinary least square panel data analysis on 13 regencies and two cities in Lampung from 2015 to 2023. This localized panel data approach provides a more granular understanding of public spending outcomes.
Empirical Result — The analysis reveals a significant positive correlation between climate-related expenditures and agricultural growth, particularly through investments in irrigation and infrastructure. These spendings directly enhance agricultural productivity by improving water management, mitigating the effects of extreme weather, and ensuring the resilience of critical agricultural systems.
Implications — However, the findings also highlight that while irrigation and infrastructure spending are essential, their correlation with agricultural performance may reflect their direct purpose in enhancing agricultural productivity. This underscores the importance of optimizing budget allocation towards initiatives that offer broader, less obvious benefits, such as sustainability and long-term resilience. The findings aim to inform policy improvements for more effective use of climate-related budgets at the local level.

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INTRODUCTION

The climate change has severe economic impacts in Indonesia and worldwide. In Indonesia, environment-related issues have become a central agenda in public policy. The central government, in accordance with the Paris Agreement ratification and the government decentralization program, has delegated the programs for mitigation and adaptation of climate change to the regional governments in Indonesia. This delegation aims to ensure that regional efforts collectively contribute to achieving Indonesia's nationally determined contributions (NDCs) under the Paris Agreement, as mandated in *Peraturan Presiden Nomor 98 Tahun 2021* (Peraturan Presiden, 2021).

The agriculture sector has been directly impacted by the climate change, mostly due to the shifting of the rainy season and, consequently, the planting season. The growth of the agriculture sector is predicted to decrease because of climate changes. Thus, Indonesia, as an agricultural country that highly depends on the agriculture sector, pays its full attention to the issue.

In Indonesia, the Province of Lampung is the sixth highest province in producing paddy, the main product in the agriculture sector and the main staple food in Indonesia. Despite the significant role of agriculture in Lampung's economy and the increasing emphasis on climate-related public spending, there is a lack of research examining the correlation between environment-related government expenditures and agricultural growth at the regional level. Specifically, studies exploring how regional governments contribute to mitigating climate change impacts and promoting agricultural resilience through targeted spending are scarce. This research addresses this gap by providing empirical evidence on the relationship between climate-related spending and agricultural sector performance in Lampung.

APPLICATION FOR PRACTICE

- The district/city governments in Lampung should focus and spend more on the irrigation which helps the farmer to adapt to climate change rather than on fertilizer subsidy, especially chemical fertilizer which is harmful to the land and the environment and thus contributes to climate change.
- The public spending is better to be invested in infrastructure rather than in non-infrastructure.

The most recent event in 2023 was the El Nino phenomenon observed in the Province of Lampung, which caused the shifting of paddy plantations and disrupted the income of the farmers who constitute most of the Lampung population. The regional government of Lampung has been dealing with climate change actively by applying the mitigation and adaptation of climate change delegated by the central government. However, the delegation has not been extended to the local governments of districts and cities within the Lampung Province. According to interviews with local government officials, the knowledge and awareness of climate change have not been transferred adequately to the district/city level. Hence, the lack of preparedness among human resources at the district and city levels has hindered the effective implementation of climate change policies. As a result, only the Provincial Government carries out the policies. Consequently, the overall results of the implementation are far from what was expected. Nonetheless, current public spending by local government increases the GRDP, and climate spending, which is public spending on mitigation or adaptation to climate change, would have an additional impact by sustaining the environment and, thus, indirectly increasing the productivity of the agriculture sector.

The objective of the study is to observe the correlation between climate-change-related spendings in the budget of local governments of districts/cities in Lampung and the growth of the agriculture sector. Along with COVID, climate, and harvested land control variables, we examine whether the spending has a positive or negative correlation. Further, we examine several other categories of climate-related spending to identify better budget allocation strategies for these local governments. This dissection is driven by the understanding that different types of climate-related expenditures may impact agricultural growth differently.

The decision to categorize spending in this way was inspired by several studies that suggest different forms of government expenditure (e.g., irrigation vs. fertilizer subsidies) have distinct roles in supporting agricultural resilience and productivity. For example, studies by Panuju et al. (2013) and Suwardi (2011) highlight that investments in irrigation infrastructure can directly improve agricultural productivity by addressing water scarcity, while fertilizer subsidies may have less direct or even negative effects on long-term agricultural sustainability. Similarly, infrastructure projects (e.g., roads, flood defenses) are expected to have broader economic benefits that can indirectly support agriculture, while non-infrastructure spending (e.g., training, policy development) may contribute less tangibly to growth.

In achieving the objective of the paper stated above, we observe 15 (fifteen) local governments of districts and cities in the Province of Lampung to answer three main research questions:

1. What is the correlation between total climate-related spending by local governments and the growth of the agriculture sector in the Province of Lampung?
2. How do public infrastructure investments (e.g., irrigation systems) and non-infrastructure expenditures (e.g., training programs) within climate-related spending categories correlate with the growth of the agriculture sector in the Province of Lampung?
3. How do targeted climate-related expenditures on irrigation systems and fertilizer subsidies specifically impact the growth of the agriculture sector in the Province of Lampung?

We conducted regression analyses and interviews to answer these questions to complete the overall analysis. The regression analysis utilized in the paper is pooled ordinary least square (OLS) regressions by observing the period of 2015 to 2023. The data source is obtained from the governmental institutions, both central and regional governments, and from the interview of officers who are responsible for planning and implementing the climate-related policies in the Province of Lampung.

Hypotheses of the work is that no significant correlation between any of the climate-related spending components (total of the spending, irrigation, fertilizer, infrastructure, or non-infrastructure) and the growth of the GRDP of agriculture sector is observed. This assumption is based on the limited capacity and preparedness of local governments to effectively implement climate-related programs, as well as potential inefficiencies in budget allocation and execution.

The research results evaluate the current implementation of climate change policies at the regional level of government. They are hopefully helpful in improving policy implementation, budget allocation, and coordination between the central and regional governments, both provincial and local levels, to achieve the national goal more effectively.

LITERATURE REVIEW

Several studies have explored the complex relationship between rice production, climate change, and government policies in Indonesia. Massagony et al. (2023) found that climate change significantly and negatively impacts rice production in Indonesia, particularly in West Java. However, mitigation policies, such as the implementation of plantation calendar maps, have proven effective in reducing these negative effects. Yusuf et al. (2024) emphasized the importance of developing new rice varieties to combat the effects of climate change and pests, ensuring accurate fertilizer subsidies, and enhancing the ability to cope with global food crises.

Anggraini et al. (2023) identified that the total funding required for climate change mitigation actions from 2018 to 2030 is substantial, approximately USD281 billion or Rp4,002.4 trillion. The current government budget allocation (APBN) is insufficient to meet the full funding needs for these mitigation and adaptation actions. To address this funding gap, the government needs to explore other sources of funding, such as planned grants, direct grants, domestic and foreign loans, result-based payments, and innovative financing mechanisms like public-private partnerships and the issuance of green bonds or sukuk. This comprehensive approach to funding is critical for ensuring the effective implementation of climate change mitigation strategies.

Budiyanto et al. (2015) highlighted that the amount and composition of government spending significantly impact aggregate demand, national output, and resource allocation in the economy. Appropriately determining the amount and composition of government spending is crucial to maximizing private investment growth and employment opportunities across Indonesia's diverse regions. Increased government spending in the agricultural sector, in particular, leads to higher private investment and employment in that sector. This relationship underscores the importance of targeted and efficient public expenditure in promoting economic growth and stability.

Setiartiti (2021) noted a serious ongoing issue: the annual reduction of between 150,000 to 200,000 hectares of agricultural land due to conversion for infrastructure development. This loss of agricultural land exacerbates the challenges faced by the agricultural sector, especially in the context of climate change and the need for increased agricultural productivity. The continuous conversion of agricultural land to non-agricultural uses poses a significant threat to food security and the overall sustainability of agricultural practices in Indonesia.

Climate Change

Ruminta et al. (2018) provided further insights into the impact of climate change on agriculture in Indonesia, highlighting changes in temperature, rainfall patterns, and other climatic variables. Their study noted that these changes have led to a decline in rice production, particularly in high-risk areas such as South Sumatra and Malang Raya. The average annual decline in rice production due to climate change is estimated at 1.37%, which poses a significant risk to national food production and security.

Panuju et al. (2013) underlined the importance of irrigation, biotechnology, and plant alternatives in adapting to climate change. They observed that investment in agricultural infrastructure and intensification programs has helped increase rice production despite several challenges. Their study emphasized the need for continued investment in these areas to sustain agricultural productivity in the face of climate change.

In a comprehensive observation, Ikhwali et al. (2022) presented that climate change affects rainfall, temperature, and extreme weather events, all of which decrease rice production. They suggested strategies for adaptation, including the utilization of durable rice varieties and improved water management. These strategies require supportive policies and further research to enhance their effectiveness.

Syaukat (2011) evaluated the impact of climate change on food production and food security in Indonesia and the adaptation programs implemented to address these challenges. The study found that climate change increases the frequency and intensity of extreme weather events, threatening food production. Adaptation programs, such as developing durable food varieties and improving irrigation

systems, have been effective in mitigating these impacts. Additionally, the study highlighted the importance of institutional coordination in enhancing future food security.

Gross Domestic Product (GDP)

Gross Domestic Product (GDP) is a fundamental concept in macroeconomics, representing the total monetary value of all final goods and services produced within a country's borders over a specific period. According to Mankiw (2016), GDP is a key indicator of a country's economic performance and is used to gauge the health of an economy. Mankiw emphasizes that GDP not only reflects economic output but also the income generated from that output, making it a comprehensive measure of economic activity.

The formula for GDP (Y) is expressed as:

$$Y = C + I + G + NX \quad \ldots\ldots (1)$$

where:

C : represents consumption, the total spending by households on goods and services.
I : stands for investment, which includes business investments in equipment and structures, residential construction, and changes in business inventories.
G : denotes government spending, encompassing government expenditures on goods and services.
NX : is net exports, calculated as exports minus imports.

Basuki et al. (2019) noted that government expenditure on agriculture is the second largest contributor to economic growth in Indonesia after marine and fisheries. This highlights the critical role of public spending in driving agricultural productivity and overall economic growth.

Government Spending on Agricultural Productivity

Armas et al. (2012) found that well-targeted public spending can significantly increase agricultural productivity and thus boost economic growth. Investments in infrastructure, research and development, and government assistance programs have been effective in increasing agricultural output. However, public spending on fertilizer subsidies had a negative impact on agricultural growth. The spending pattern composition in Indonesia over the past decade, with a large and increasing portion allocated to subsidies, can partially explain why increased public spending on agriculture has not resulted in proportional increases in agricultural production. The study recommends increasing budget allocation and implementing bureaucratic reforms to enhance the efficiency of public spending. The effectiveness of public spending is crucial for realizing the potential benefits of government investments in agriculture.

Wardhani et al. (2017) emphasized that good public governance positively influences the performance of local governments in Indonesia and can reduce the inefficiency of government spending, which negatively affects performance. Effective governance ensures that public funds are used efficiently and achieve the intended outcomes. Meanwhile, Dirgantoro et al. (2018) underlined that an increase in regional government spending did not significantly increase labor absorption and output value or reduce poverty.

Salqaura et al. (2019) investigated the influence of fiscal policy on the agricultural sector in Java. They found that total government expenditure has a significant positive effect on the GDP of agriculture subsectors such as food crops, plantations, livestock, and fisheries. The study suggests that provincial governments should support agricultural subsectors by allocating expenditure that will increase GDP and attract foreign and domestic investments.

Rosmika (2020) examined the relationship between the agricultural sector and economic growth in Indonesia, finding that the agricultural sector has the highest multiplier effect on the economy. Increased government spending and investment in agriculture can significantly boost output, highlighting the sector's critical role in driving economic growth.

Suwardi (2011) demonstrated that local government spending on infrastructure and education significantly affects agricultural productivity and poverty in Indonesia. The largest multiplier effect on poverty reduction is from investments in roads, followed by education and irrigation. These findings underline the importance of strategic public spending in enhancing agricultural productivity and reducing poverty.

Nugroho (2017) noted that additional government spending on agriculture and education has the highest impact on increasing agricultural productivity and reducing poverty in Indonesia. Spending on infrastructure, such as roads, irrigation, and power, has a limited effect on agricultural growth and poverty reduction. The study highlights that different types of government spending are complementary, with limited trade-offs between their impacts on productivity and poverty.

Sayifullah & Emmalian (2018) found that labor in the agriculture sector has a significant positive influence on the GDP of the agriculture sector. Government expenditure in the agriculture sector also

positively impacts the GDP, emphasizing the importance of targeted public spending to enhance sectoral productivity. Several studies have explored the complex relationship between rice production, climate change, and government policies in Indonesia.

METHODS

Regression analyses are conducted using balanced panel data which are from 13 districts and two cities in the Province of Lampung: West Lampung, South Lampung, Central Lampung, East Lampung, North Lampung, Mesuji, Pesawaran, West Pesisir, Pringsewu, Tanggamus, Tulang Bawang, West Tulang Bawang, Way Kanan, Bandar Lampung, and Metro. The province government is excluded from the analysis to focus on these 15 (fifteen) local governments and to observe the implementation of current climate-related public spending. By having nine observations periods, from 2015 until 2023, the research has 135 observations, consisting of 15 individuals and nine years of observation. While the sample size is relatively small for a panel data estimation, it provides a focused analysis specific to the Province of Lampung. The results should be interpreted with caution, considering the limitations in our dataset's scope and size.

Data Set

Data utilized in the analysis are collected from the Ministry of Finance units: the public spending data provided by the Regional Office of the Directorate General of Treasury of the Province of Lampung and the Directorate General of Fiscal Balance, the items of climate-related spending provided by the Regional National Development Planning Board of the Province of Lampung, gross regional domestic product (GRDP) and the details, the inflations, and the harvested area of agriculture data provided by the Regional Bureau of Statistics of Lampung (*https://lampung.bps.go.id*), the rainfall data provided by the Regional Meteorological, Climatological, and Geophysical Agency of Lampung.

In the data preparation stage, local government climate spending data is identified and calculated through a climate-related spending tagging process. The local government climate spending data are utilized in the three regressions of the correlation between spending and the growth of the agriculture sector's GRDP (y-o-y).

The control variables in the examination are a rainfall variable, which is the average of rainfall per year in a district/city; a land variable, which is the land area in a district/city; a dummy variable for COVID year, which is 1 for the year 2020 and 2021, and 0 for the rest of the years, and error term (ε). Rainfall is the control variable for climate change because it is directly affected by it. The variables of the models are described in Table 1, while Table 2 presents each variable's descriptive statistics.

Table 1 Description of Variables

Variables	Description
y	Growth of GRDP of agriculture
$climate.spending$	Climate-related regional spending
$irrigation$	Irrigation regional spending
$fertilizer$	Subsidy on fertilizer
$infra$	Infrastructure component of climate spending
$non.infra$	Non-infrastructure component of climate spending
$land$	Harvested land for agriculture
$rainfall$	The average yearly rainfall
$dummy\ covid$	For Covid-19 in 2020 and 2021

Source: Prossess by the authors

Table 2 Descriptive Statistics

Variables	Unit	Mean	Maximum	Minimum	Std. Dev	Obs
climate.spending	Rp (in billions)	151.80	506.70	58.46	83.80	135
infra	Rp (in billions)	125.70	296.00	53.17	55.64	135
non.infra	Rp (in billions)	26.16	218.00	5.26	40.92	135
irrigation	Rp (in billions)	124.50	285.50	53.44	53.97	135
fertilizer	Rp (in billions)	0.0035	0.02	0.0014	0.0021	135
rainfall	mm	182.36	430.32	11.25	65.56	135
land	ha	37,317.38	157,873.00	423.74	34,580.89	135
dummy covid	dummy	0.22	1.00	0.00	0.42	135
y	%	0.02	0.08	-0.032548	0.03	135

Source: Data analysis by the authors

Methods

The regression model is as follows:

$$y_{it} = b_0 + b_1 \ln climate.spending_{it} + b_2 \Delta \ln rainfall_{it} + b_3\, land_{it} + b_4\, dummy\ covid + \varepsilon_{it}$$

The model is utilized to observe three regressions by using a different variable (s) as the *public spending* variable:

1. The *public.spending* is the total climate-related regional spending variable
$$y_{it} = b_0 + b_1 \Delta \ln climate.spending_{it} + b_2 \Delta \ln rainfall_{it} + b_3\ land_{it} + b_4\ dummy\ covid + \varepsilon_{it}$$
2. The *public.spending* is the infrastructure and non-infrastructure components variables
$$y_{it} = b_0 + b_1 \Delta \ln infra_{it} + b_2 \Delta \ln non.infra_{it} + b_3 \Delta \ln rainfall_{it} + b_4\ land_{it} + b_5\ dummy\ covid + \varepsilon_{it}$$
3. The *public.spending* is the irrigation and fertilizer subsidy variables
$$y_{it} = b_0 + b_1 \Delta \ln irrigation_{it} + b_2 \Delta \ln fertilizer_{it} + b_3 \Delta \ln rainfall_{it} + b_4\ land_{it} + b_5\ dummy\ covid + \varepsilon_{it}$$

y_{it}, the *dependent variable* is the growth of GDRP in the agriculture sector in district/city *i* of year *t*.

The model indicates that ε is residual in the model, which reflects the uncaptured components in the model. b_1, b_2, b_3, b_4, b_5 are the estimated parameters for each variable. b_0 is the intercept of the model, which means the dependent variable is equal to the intercept when all other variables are zero.

The first approach examines the correlation between total climate spending and the growth of the agriculture sector's GRDP, while the second and third models dissect the spending into two main components. The second regression analysis examines the climate spending in two categories: fertilizer subsidy and irrigation, the two main spending in the agriculture sector. The third analysis divides the climate spending into two groups: infrastructure and non-infrastructure groups. By analyzing the groups, the estimations provide a comparison between these two options.

Interview

Two officials were interviewed to deepen the understanding of the results of the regression analyses. They are responsible for the planning and implementation of the climate-change-related programs, both mitigation and adaptation programs, in the Province of Lampung, who work for the regional government finance and asset management office (BPKAD, Badan Pengelola Keuangan dan Aset Daerah) and the regional development planning agency (Bappeda, Badan Perencanaan Pembangunan Daerah) of the Province of Lampung.

The interviews are divided into five sections: planning, budgeting, spending of budget, the causes of ineffectiveness in all stages, and evaluation. From the interview, the regression analysis can be further explained not merely from the regression estimation but also from the practical perception.

RESULTS AND DISCUSSION

Regression Analysis Result

The regression analysis involves three models designed to examine the correlation between specific local government climate-related spending and the growth of the agriculture sector in Lampung Province. The first model explores the influence of various factors on the growth rate of agricultural GRDP, with a particular focus on climate-related spending. This model aims to identify the overall impact of climate-related expenditures on agricultural growth, providing a broad view of how these investments affect the sector.

The second model builds on the first by distinguishing between infrastructure and non-infrastructure climate spending. This differentiation allows us to see how spending on physical infrastructure, such as irrigation systems and buildings, compares to non-infrastructure spending, such as services and programs, in influencing agricultural GRDP growth. By breaking down the types of climate-related expenditures, we can better understand the specific areas where investments are most effective.

Finally, the third model further refines the analysis by focusing on the impact of irrigation and fertilizer spending on agricultural GRDP growth. This model delves into the specifics of agricultural inputs, examining how targeted investments in irrigation systems and fertilizer usage contribute to the sector's performance. By homing in on these key areas, we can determine the direct effects of these crucial agricultural inputs on the growth of the agriculture sector in Lampung Province.

The correlation between climate-related local government spending and the growth of the agriculture sector in the province of Lampung

Model 1, as the estimation shown in Table 3, reveals several key insights into the factors influencing agricultural GRDP growth in Lampung Province. Firstly, for every 1% increase in climate-related spending (climate.spending), agricultural GRDP growth is expected to rise by 0.0102%. This positive effect underscores the importance of investing in climate-related initiatives to enhance agricultural productivity. Additionally, for every 1% increase in average rainfall (rainfall), agricultural GRDP growth is anticipated to increase by 0.0196%, highlighting the critical role of adequate rainfall in boosting agricultural output.

The variable land, representing the harvested area, shows that for every additional hectare, agricultural GRDP growth increases by approximately 0.0000153%. Although this effect is modest, it emphasizes the importance of expanding agricultural land to achieve higher economic growth in the sector.

Conversely, the dummy COVID variable indicates that during the COVID-19 pandemic (2020 and 2021), agricultural GRDP growth was reduced by 3.41%. This significant negative impact highlights the disruptions caused by the pandemic on agricultural activities and productivity.

Model 1:

$$y = 0216522 + 0.0102301\ \Delta \ln climate.spending + 0.0195711\ \Delta \ln rainfall + 1.53\text{E} - 07\ land - 0.034091\ dummy\ covid$$

Model 1 is statistically significant (p<.0001) with approximately 37.55% of the variability (R-Square 0.375539) in y can be explained by the independent variables in the model.

These findings lead to the rejection of the null hypothesis (Ho), as there is a correlation between climate-related local government spending and the growth of the agriculture sector in Lampung Province.

Table 3 Parameter Estimation and Multicollinearity Test Results for the First Model

Term	Estimate	Prob>|t|*	VIF**
Intercept	0.0216522	<.0001	.
D(Ln climate.spending)	0.0102301	0.0389	1.0043
D(Ln rainfall)	0.0195711	<.0001	1.0662
land	1.53E-07	0.0054	1.0061
dummy covid	-0.034091	<.0001	1.0684

*At the 5% significance level
** VIF < 5 indicates no multicollinearity

Source: Data analysis by the authors

The correlations between public infrastructure and non-infrastructure components of climate-related spending and the growth of the agriculture sector in the province of Lampung

Model 2, as the estimation presented in Table 4, provides deeper insights by distinguishing between infrastructure and non-infrastructure climate spending. The results indicate that for every 1% increase in climate infrastructure spending (infra), agricultural GRDP growth rises by 0.0207%. This substantial positive effect suggests that investments in climate infrastructure, such as irrigation systems and flood defenses, significantly enhance agricultural productivity.

Table 4 Parameter Estimation and Multicollinearity Test Results for the Second Model

Term	Estimate	Prob>|t|*	VIF**
Intercept	0.0218643	<.0001	.
D(Ln infra)	0.0206517	0.0029	1.100429
D(Ln non.infra)	-0.001322	0.4516	1.102271
D(Ln rainfall)	0.0189054	<.0001	1.070896
land	1.54E-07	0.0045	1.00635
dummy covid	-3.38E-02	<.0001	1.069137

*At the 5% significance level
** VIF < 5 indicates no multicollinearity

Source: Data analysis by the authors

On the other hand, for every 1% increase in non-infrastructure climate spending (non.infra), there is an insignificant change (a decrease of 0.0013%) in agricultural GRDP growth. This implies that non-infrastructure expenditures, such as policy development or training, may not have a direct impact on growth. Consistent with Model 1, a 1% increase in rainfall (rainfall) boosts agricultural GRDP growth by 0.0189%, and every additional hectare of harvested area (land) increases agricultural GRDP growth by approximately 0.0000154%. The negative impact of the COVID-19 pandemic (dummy COVID) persists, reducing agricultural GRDP growth by 3.38%.

Model 2:

$$y = 0.0218643 + 0.0206517\ \Delta \ln infra\ - 0.001322\ \Delta \ln\ \ + 0.0189054\ \Delta \ln rainfall + 1.54\text{E} - 07\ land - \ 3.38\text{E} - 02\ dummy\ covid$$

Model 2 is statistically significant (p<.0001) with approximately 39.78% of the variability (R-Square 0.397768) in y can be explained by the independent variables in the model.

These findings lead to the rejection of the null hypothesis (Ho), as there is a correlation between public infrastructure components of climate-related spending and the growth of the agriculture sector in Lampung Province. However, the null hypothesis that there is no correlation between public non-infrastructure

components of climate-related spending and the growth of the agriculture sector in Lampung Province cannot be rejected.

The correlations between public spending on irrigation and fertilizer subsidies and the growth of the agriculture sector in the province of Lampung

As the estimation shown in Table 5, Model 3 refines the analysis further by focusing on irrigation and fertilizer spending. The results show that for every 1% increase in irrigation spending (irrigation), agricultural GRDP growth increases by 0.0247%. This solid positive effect highlights the critical importance of investing in irrigation to support agricultural growth.

In contrast, for every 1% increase in spending on fertilizers (fertilizer), there is an insignificant change (a decrease of 0.0069%) in agricultural GRDP growth, suggesting that fertilizer spending alone may not directly drive growth. Consistent with previous models, a 1% increase in rainfall (rainfall) results in a 0.0184% increase in agricultural GRDP growth, and every additional hectare of harvested area (land) increases agricultural GRDP growth by approximately 0.0000153%, reaffirming the role of land expansion in growth. The negative impact of the COVID-19 pandemic (dummy COVID) continues, reducing agricultural GRDP growth by 3.33%.

Model 3:

$$y = 0.0217496 + 0.0247105\ \Delta \ln irrigation - 0.006896\ \Delta \ln fertilizer + 0.0183895\ \Delta \ln rainfall + 1.53\text{E} - 07\ land - 3.33\text{E} - 02\ dummy\ covid$$

Model 3 is statistically significant (p<.0001), with approximately 39.99% of the variability (R-Square 0.399999) in y can be explained by the independent variables in the model.

These findings lead to the rejection of the null hypothesis (Ho), as there is a correlation between public spending on irrigation and the growth of the agriculture sector in Lampung Province. However, the null hypothesis that there is no correlation between public spending on fertilizer subsidies and the growth of the agriculture sector in Lampung Province cannot be rejected.

Table 5 Parameter Estimation and Multicollinearity Test Results for the Third Model

Term	Estimate	Prob>|t|*	VIF**
Intercept	0.0217496	<.0001	.
D(Ln irrigation)	0.0247105	0.0039	1.690819
D(Ln fertilizer)	-0.006896	0.2919	1.69803
D(Ln rainfall)	0.0183895	<.0001	1.084883
land	1.53E-07	0.0046	1.004637
dummy covid	-3.33E-02	<.0001	1.081995

*At the 5% significance level

** VIF < 5 indicates no multicollinearity

Source: Data analysis by the authors

Discussion

The regression analysis across the three models provides practical insights into the factors influencing agricultural GRDP growth in Lampung Province. Increasing climate-related spending, especially on infrastructure and irrigation, ensuring adequate water, and expanding harvested areas are crucial for boosting agricultural productivity. Conversely, the COVID-19 pandemic has had a significant adverse effect on the sector, highlighting the need for resilience strategies. Understanding these dynamics can help policymakers and stakeholders make informed decisions to support sustainable agricultural growth.

COVID-19

The agricultural GRDP growth in each region of Lampung Province (Appendix 2), which declined in 2020 and 2021, supports research findings that COVID-19 had a negative impact on agricultural growth. This significant negative impact underscores the disruptions caused by the pandemic on agricultural activities and productivity. The subsequent recovery observed in some regions starting in 2022 highlights the resilience of the agricultural sector and the effectiveness of recovery measures implemented post-pandemic.

Harvested Land

The positive correlation between harvested land and the growth of agriculture sector is expected. However, the harvested land in each district or city shows decreasing trend especially in the most productive districts in Lampung: The Central Lampung (Appendix 3). The result reflects the condition of agriculture area in Indonesia. Another study of the topic on Indonesia found that harvested area is decreasing as well due to several infrastructure projects.

Climate Spending

The first regression analysis examines the correlation between the climate spending of the local governments in Lampung and the growth of local agriculture growth. The analysis produces a positive relation. This spending includes various components such as irrigation projects, reforestation programs, flood prevention infrastructure, and renewable energy initiatives. These expenditures are part of government spending (G), which is a GRDP component and contributes positively to the GDP or GRDP, and throughout the years of observation, it shows climate spending is positive in relation to the growth of the agriculture GRDP as well. This finding aligns with Basuki et al. (2019), who underlined the critical role of public spending in supporting economic growth in Indonesia. In addition, climate spending is expected to sustain the environment, which indirectly improve agricultural productivity by mitigating the adverse effects of climate change.

Infrastructure

Infrastructure is capital expenditure and the maintenance of the capital while non-infrastructure spending is other than those categories. The second analysis in the regression estimation gives positive correlation between the infrastructure with the growth of agriculture sector. Infrastructure spending includes spending on irrigation programs, which contributes positively to the growth of the agriculture area as well. The finding is similar to almost all other studies on infrastructure in agriculture (Armas et al., 2012; Nugroho, 2017; Panuju et al., 2013; Suwardi, 2011).

Irrigation

Irrigation acts as an adaptation to climate change to sustain agriculture production (Panuju et al., 2013; Suwardi, 2011; Syaukat, 2011). The irrigation program is effective in reducing poverty (Nugroho, 2017; Suwardi, 2011). It has a positive correlation with the growth of agriculture production, while the subsidy of fertilizer shows no significant correlation in the third regression analysis. This indicates that public investment in irrigation is better than investment in fertilizer subsidies. The fact is supported by the interview in which the official states that the fertilizer subsidy is mostly spent to buy chemical fertilizer. The usage of chemical fertilizers is harmful to land fertility and to the environment Das et al. (2023). This issue can be overcome by investing more in organic fertilizer, which is now encouraged by the local governments in Lampung.

Rainfall

The rainfall indicator is a control variable of the estimation regression due to the impact of climate change. Three regression estimations present constant positive correlations between rainfall and the growth of the agriculture sector. According to a previous study in Indonesia, Ikhwali et al. (2022), rainfall is one of the variables that indicates the climate change effect, and the rainfall variable affects agriculture production. Further, Ruminta et al. (2018) pointed out that the pattern of the rainfall is also as significant as the amount of the rainfall itself. However, the study does not cover the pattern due to the data limitation. The estimated correlation between rainfall and the growth in agriculture in Lampung is supported by the fact in which due to the lengthy dry season in Lampung by the end of 2023, the rain pattern has affected the paddy production by shifting the paddy harvest period from 2023 to 2024 (Badan Perencanaan dan Pembangunan Provinsi Lampung, 2024).

2023 El Nino

From the extreme climate data collected, it is found that Lampung experienced El Nino, the extreme draught at the end of 2023 (Suci Puspita W et al., 2023). However, the regression analyses do not capture it, since there is time-lag in the agriculture production. The impacted period is the end of 2023 until 2024.

CONCLUSION

Even though the governments of districts and cities in Lampung have not fully participated in mitigation and adaptation to climate change programs, the analyses indicate that the current climate- or environment-related spendings positively correlate with the growth of GRDP in agriculture. Specifically, the analysis reveals that spending on irrigation and infrastructure positively influences agricultural productivity, while fertilizer subsidies show no significant impact. These results highlight the critical role of targeted water management and infrastructure investments in enhancing agricultural resilience to climate change. Additionally, the study suggests that non-infrastructure spending, such as training and policy development, has a limited direct effect on agricultural growth.

The findings of this study provide important insights for regional governments in Lampung. First, the evidence supports a policy shift toward prioritizing investments in irrigation systems and infrastructure that directly benefit agriculture. Given the positive correlation between climate-related spending and agricultural growth, local governments must allocate budgets more efficiently, focusing on initiatives that

enhance agricultural productivity while ensuring environmental sustainability. Furthermore, regional governments should reconsider the emphasis on fertilizer subsidies, particularly chemical fertilizers, which may not yield the desired long-term benefits for agriculture. Instead, investing in sustainable agricultural practices and technologies could prove more effective in mitigating the impacts of climate change.

However, this study is still limited in scope due to data constrains. Government spending data is generally available only at the provincial or national level, while this study requires district- and city-level data. Moreover, climate-related data remains scarce, requiring the researchers to manually tag climate-related spending to estimate annual values. Despite these limitations, the analyses may contribute to immediate policy improvement and to the scarcity of the literature on the topic. The results of the Pooled OLS analysis underscore the need for targeted climate-related expenditures that address the specific challenges faced by the agricultural sector in Lampung. By optimizing budget allocation and focusing on irrigation and infrastructure, local governments can enhance agricultural resilience and contribute to sustainable economic growth in the region.

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Appendix 1 The Correlation Between Climate-Related Spending and Agriculture GRDP Growth in Lampung Province

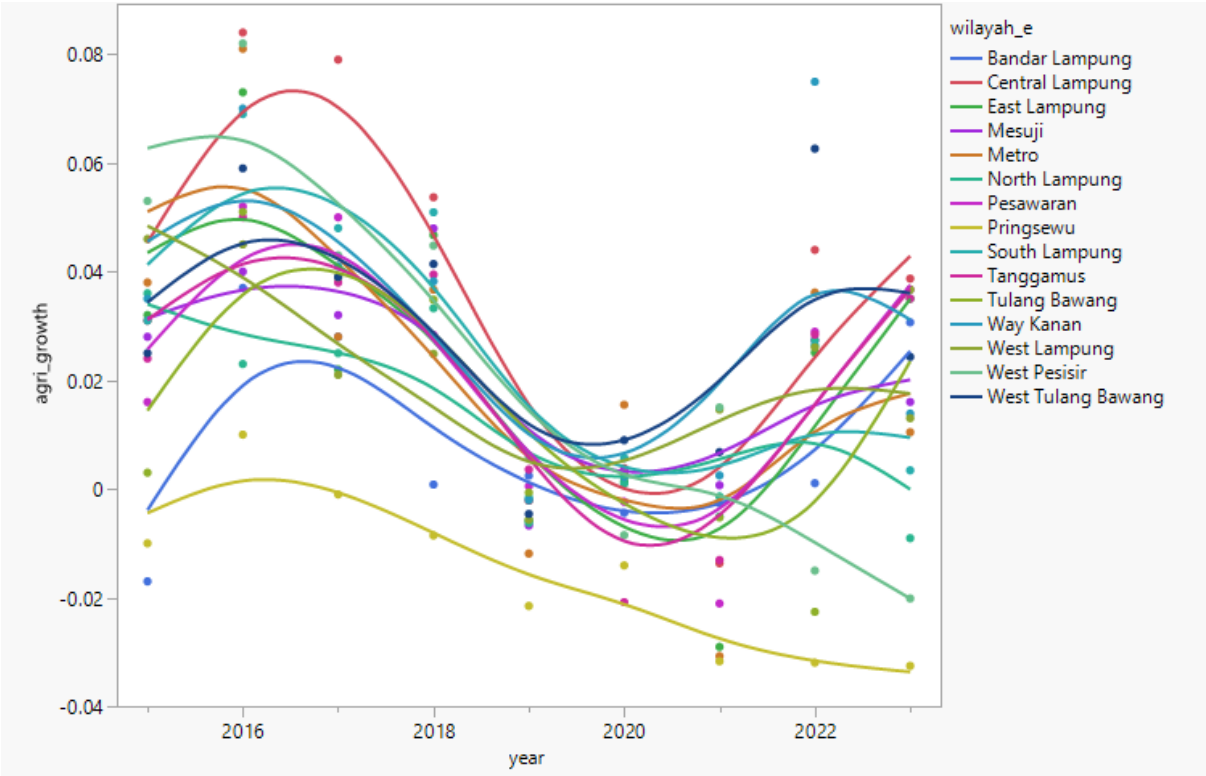
Dependent Variable: Agriculture Local GRDP Growth

Term	OLS(1)	OLS(2)	OLS(3)
Intercept	0.0216522	0.0218643	0.0217496
D(Ln climate.spending)	0.0102301		
D(Ln infra)		0.0206517	
D(Ln non.infra)		-0.001322	
D(Ln irrigation)			0.0247105
D(Ln fertilizer)			-0.006896
D(Ln rainfall)	0.0195711	0.0189054	0.0183895
land	1.53E-07	1.54E-07	1.53E-07
dummy covid	-0.034091	-3.38E-02	-3.33E-02
Observations	135	135	135
R-squared	0.375539	0.397768	0.399999
Durbin Watson Stat.*	1.6152057	1.6958749	1.7336225

Source: JMP Pro 17

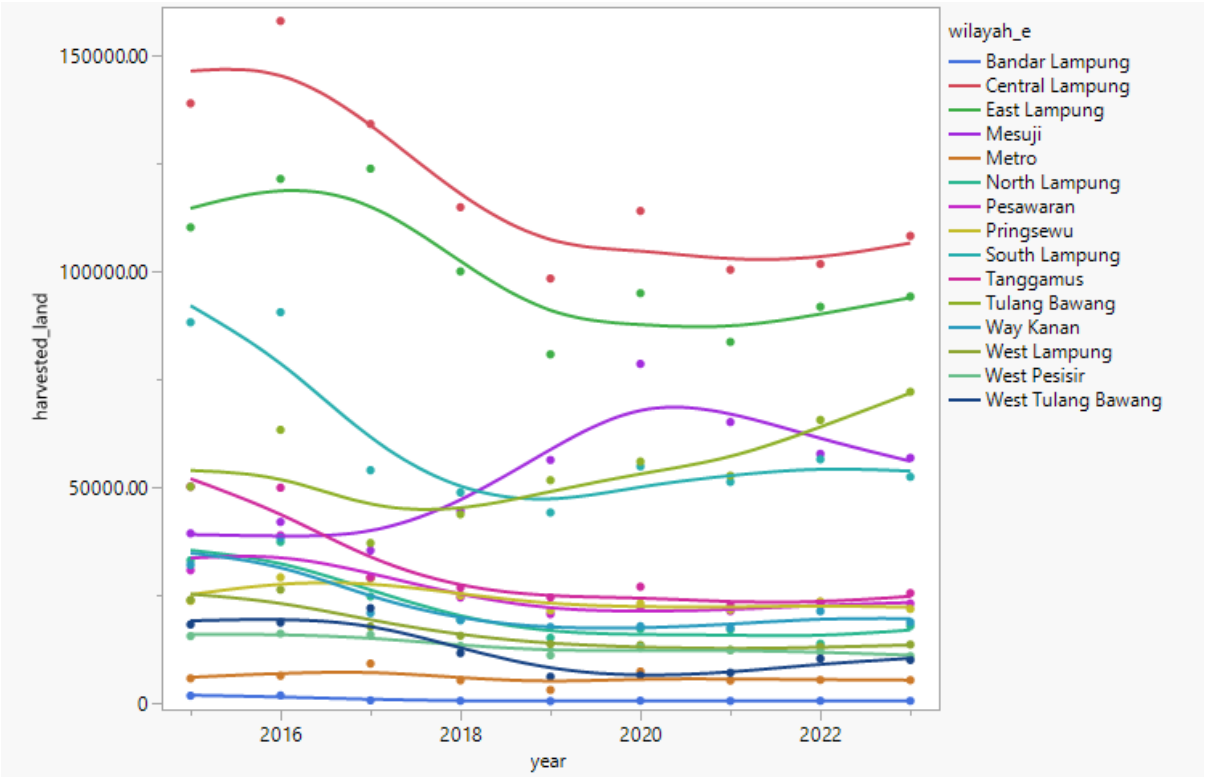
Nore: The Durbin-Watson statistics (1.615, 1.696, 1.734) fall within the acceptable range of 1.5 to 2.5

Appendix 2 Agricultural GRDP Growth by Region in Lampung Province (2015-2023)



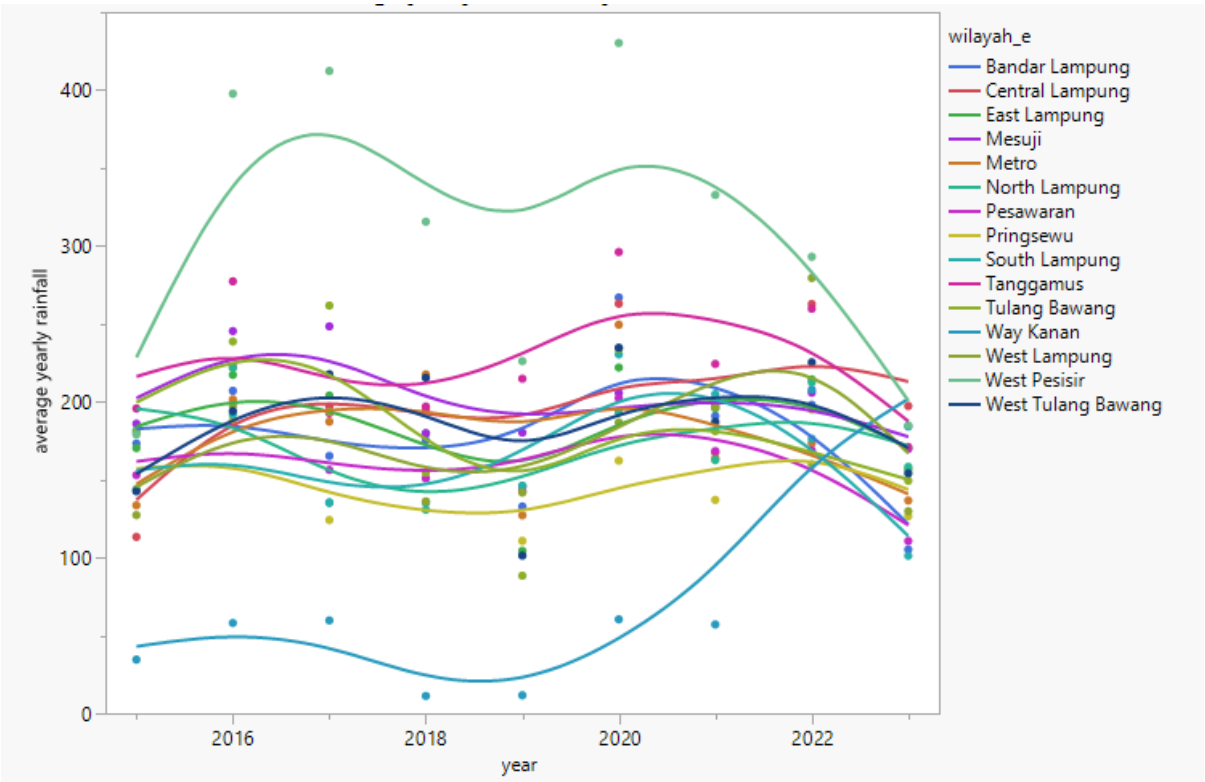
Source: Data analysis by the authors

Appendix 3 Trends in Harvested Land Area (ha) by Region in Lampung Province (2015-2023)



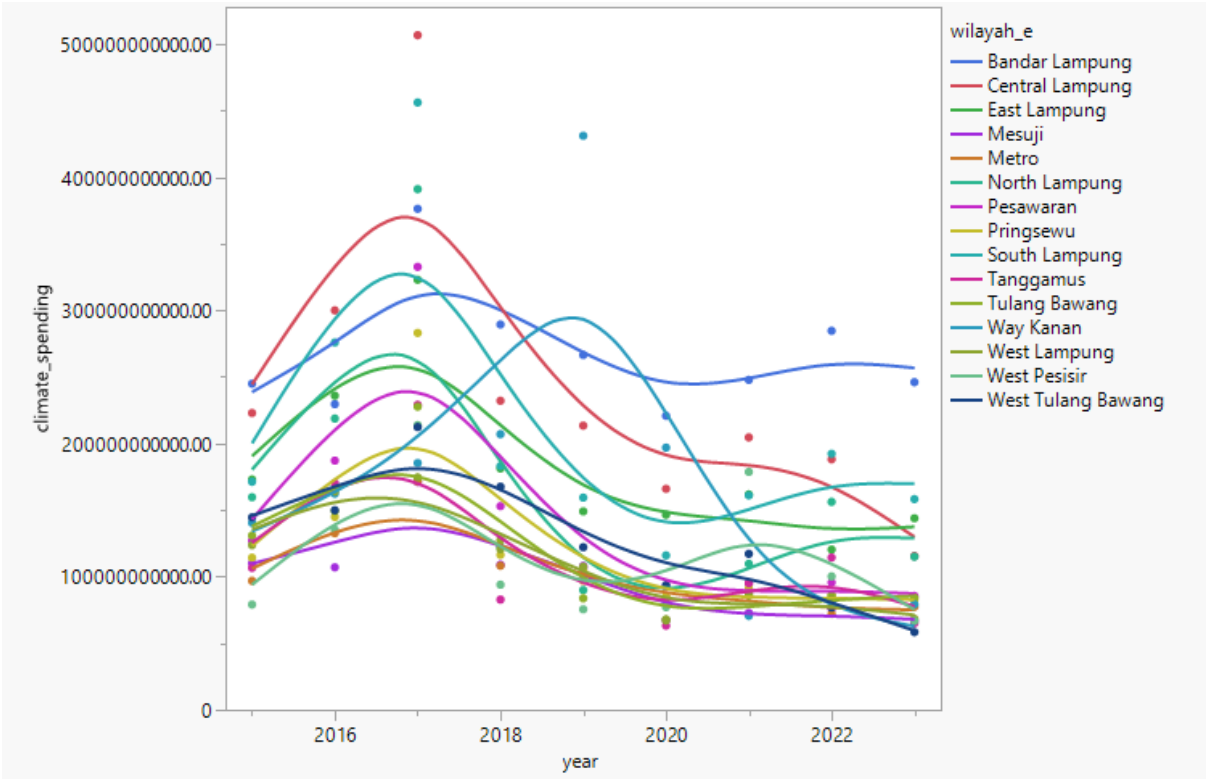
Source: Data analysis by the authors

Appendix 4 Average Yearly Rainfall (mm) by Region in Lampung Province (2015-2023)



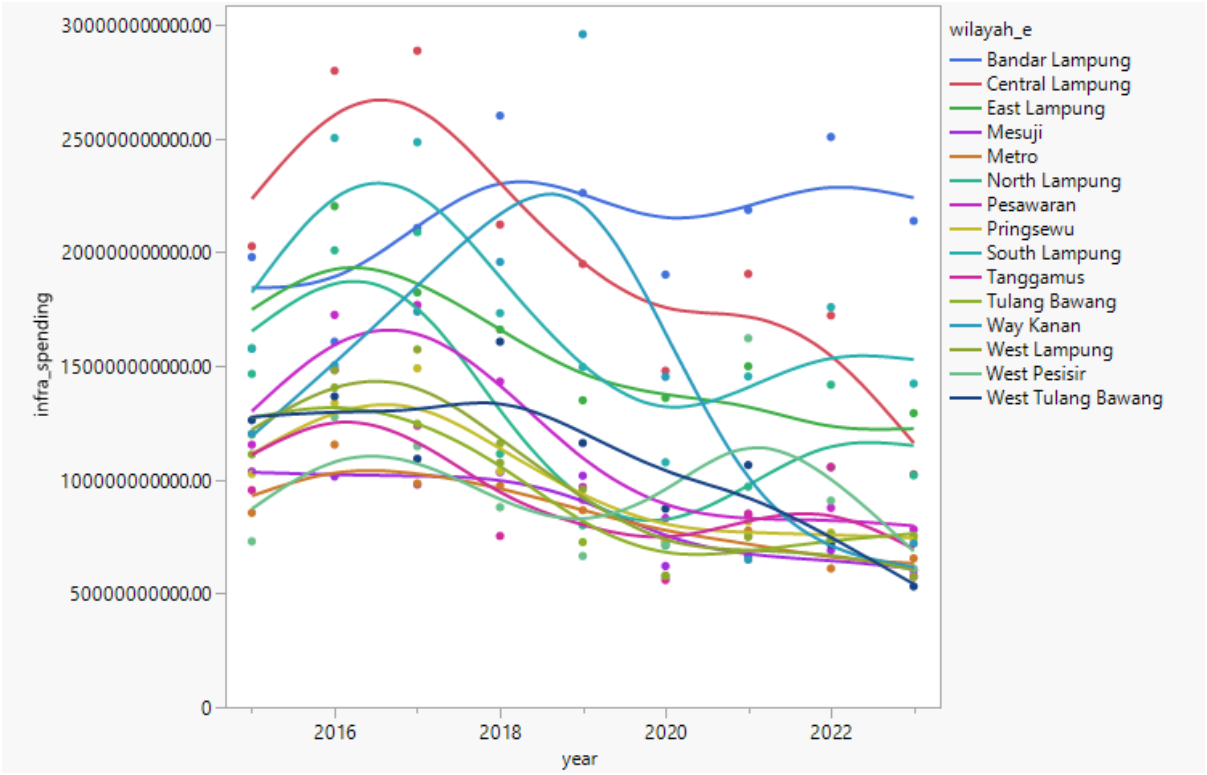
Source: Data analysis by the authors

Appendix 5 Climate Spending (Rp) by Region in Lampung Province (2015-2023)



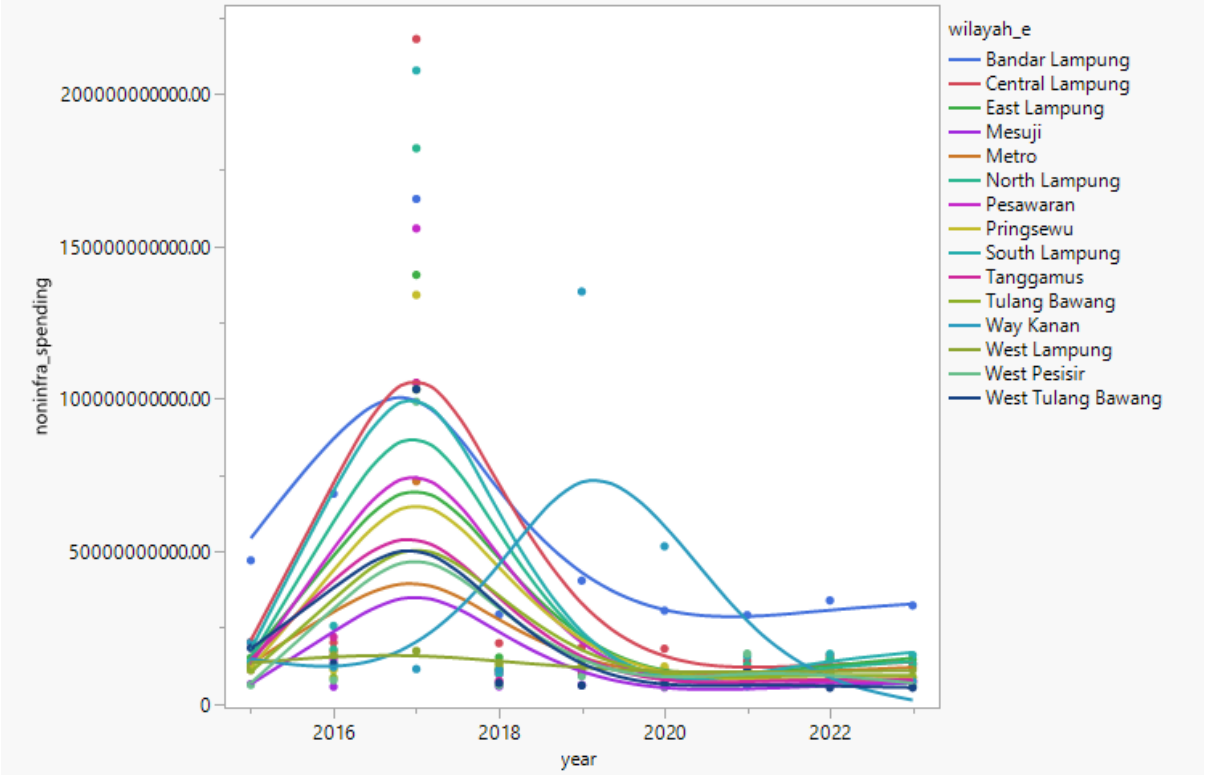
Source: Data analysis by the authors

Appendix 6 Infrastructure Climate Spending (Rp) by Region in Lampung Province (2015-2023)



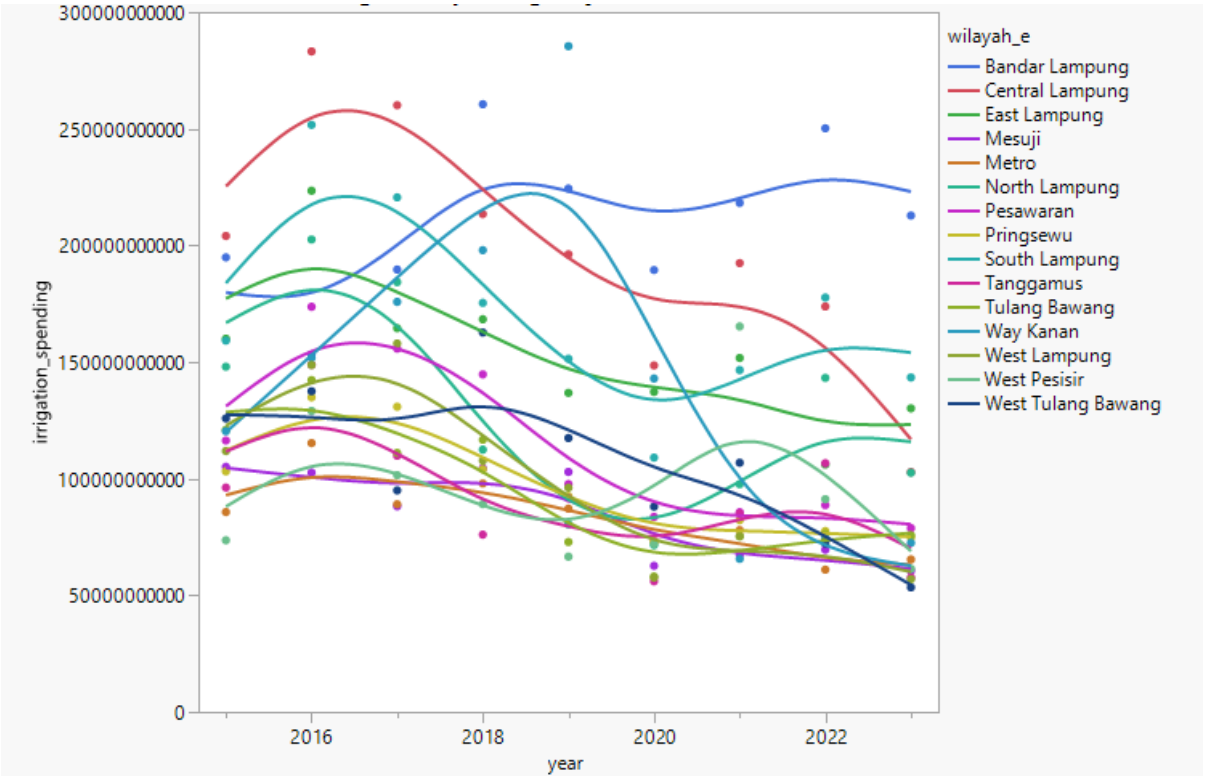
Source: Data analysis by the authors

Appendix 7 Non-Infrastructure Climate Spending (Rp) by Region in Lampung Province (2015-2023)



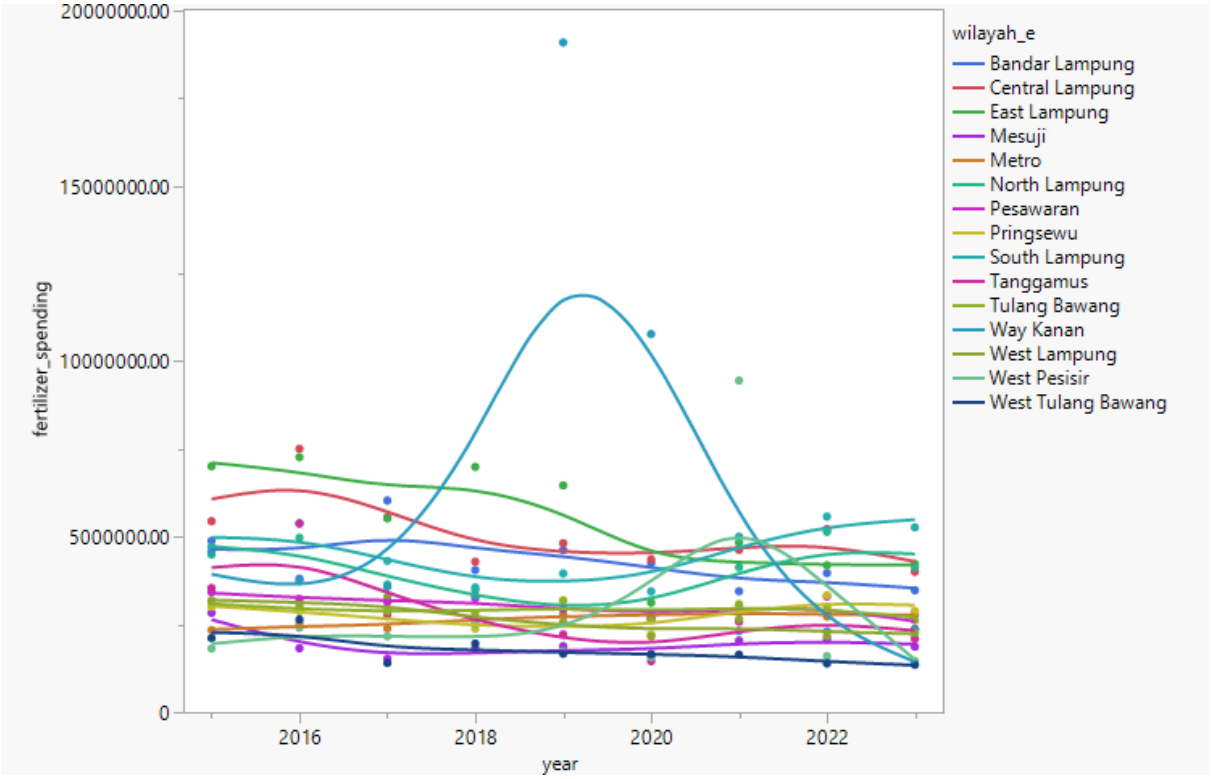
Source: Data analysis by the authors

Appendix 8 Irrigation Spending (Rp) by Region in Lampung Province (2015-2023)



Source: Data analysis by the authors

Appendix 9 Fertilizer Spending (Rp) by Region in Lampung Province (2015-2023)



Source: Data analysis by the authors