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Original Research

How Much is the Cost to Reduce the Incidence Rate of Infectious Diseases Through Reforestation? (Case Study on Pulmonary TB under Global Warming Scenario)

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Abstract

Background: Nowadays, pulmonary tuberculosis (TB) is still a major global cause of death. Indonesia is a country with a high burden of the disease and is ranked second as a contributor to tuberculosis in the world after India, China, the Philippines, and Pakistan [1] along with the phenomenon of deforestation [2] and global warming [3]. Forest restoration and reforestation are considered cost-effective nature-based solutions for climate change adaptation and mitigation to remove carbon dioxide from the atmosphere, provide habitat for species and balance temperatures.

Methods: There is no research data on the contribution of the economic value of reforestation to reduce the incidence rate of infectious diseases especially for TB, which is very important for mitigating against the global warming. This research was conducted to determine the economic value of ecosystem services as compensation for the reforestation program. This research was carried out in Lampung Province from April to October 2021, using Landsat imagery series 2009, 2012, 2015, 2018, and 2019 to detect forest cover.

Results: The study's findings show that every 2ºC increase in temperature increases the incidence of pulmonary tuberculosis by 1.5 per 10,000 population, or 3,770 cases cover class that has a significant effect on the incidence of pulmonary TB is temperature, state forests, community forests, bare land, and rice fields.

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Conclusions: The valuation of forest environmental services in Lampung Province with human capital through pulmonary tuberculosis medical cost approach techniques for forest mitigation costs is IDR 20.113.458.000 /year.

Keywords: economic compensation, global warming, reforestation

Introduction

Global warming is an important issue that occurs as a result of economic activities that are carried out without paying attention to environmental impacts that have caused an increase in average global temperature in recent years [4]. Recent reports on forests by the United Nations Food and Agriculture Organization (FAO) and the United Nations Environment Program (UNEP) have emphasized the negative impact of deforestation on human health [5]. Health development is essentially an investment in social and economic development that aims to maintain the health of all people as well as increase awareness, willingness, and ability to achieve the highest degree of public health in Indonesia, which is an effort of all components of the nation [6]. The conversion of forests into commodities can affect several ecosystem functions, such as carbon sequestration, disruption of soil and water conservation, and changes in temperature. To date, most research on the impact of rising temperatures on society has focused on the effects of extreme heat events on vulnerable populations. [7]. The United States Centers for Disease Control and Prevention (CDC) provides several warnings about the consequences of global warming causing changes to the world's climate which can cause outbreaks of infectious diseases to spread to areas where they are not commonly seen (Lindahl et al. 2015). Pulmonary TB is an infectious disease of the Mycobacterium tuberculosis bacteria that attacks the lungs and is able to survive at low temperatures, between 4ºC-70ºC, for a long time. In Southeast Asia, a meta-analysis showed that the increasing prevalence of vector-borne diseases such as dengue fever or chikungunya and pulmonary TB was associated with land conversion, including forest, plantation, land clearing, agriculture, etc [8].

Tuberculosis remains the leading single cause of death worldwide, with the majority of new cases occurring in low- and middle-income countries. The World Health Organization (WHO) Global TB Report in 2019 highlighted that there are still large and persistent gaps in the detection and treatment of pulmonary TB. According to [9], 142,000 people (253 per 100,000 population) fell ill with TB in 2018, of whom 40,000 (28%) were people living with HIV. However, only 75,828 people with TB were notified overall, leaving 47% of people still unreached by national TB services. Indonesia is a country with a high burden of tuberculosis and is ranked second as a contributor to tuberculosis in the world after India, China, the Philippines, and Pakistan. Lampung Province, which consists of 14 regencies/cities, has natural conditions in the highlands and lowlands, and coastal areas are potential areas for the spread of infectious pulmonary TB disease. Forest restoration and reforestation are considered as cost-effective nature-based solutions for climate change adaptation and mitigation to remove carbon dioxide from the atmosphere, provide habitat for species and balance temperature [10]. Therefore, reforestation is also very important in reducing the impact of deaths from cases of pulmonary TB and pneumonia in the Lampung area, which increases every year due to land changes. The objectives of this study were (a) to determine the contribution of forest ecosystems to the control of pulmonary TB disease and (b) to evaluate the role of forests in providing environmental services for the control of pulmonary TB disease.

Material And Method

Study Area

This research was conducted at the Forest Resources Inventory Laboratory, University of Lampung accompanied by fieldwork to validate the interpretation result of satellite imagery covering Lampung Province (Fig. 1) started from April to October 2021.

Material Obtainment and Preparation

The tools used in this research include computer hardware and software, as well as stationery. The hardware used is a notebook, a global positioning system (GPS), and a digital camera. The software used is geographic information system (GIS) software, Minitab 16, and Microsoft Office 2016. The materials used include Landsat imagery of capture 2009, 2012, 2015, 2018, and 2019 respective. Landsat imagery data collection methods are carried out by downloading on the situs of www.earthexplorer.usgs.gov. While other data were obtained by collecting from relevant agencies, namely the Central Statistics Agency of Lampung Province, the Lampung Provincial Forestry Service, and the Lampung Provincial Health Office.

Data Analysis

The analytical method used is multiple linear analysis. A multiple linear analysis method is used to determine the linear relationship between two or more

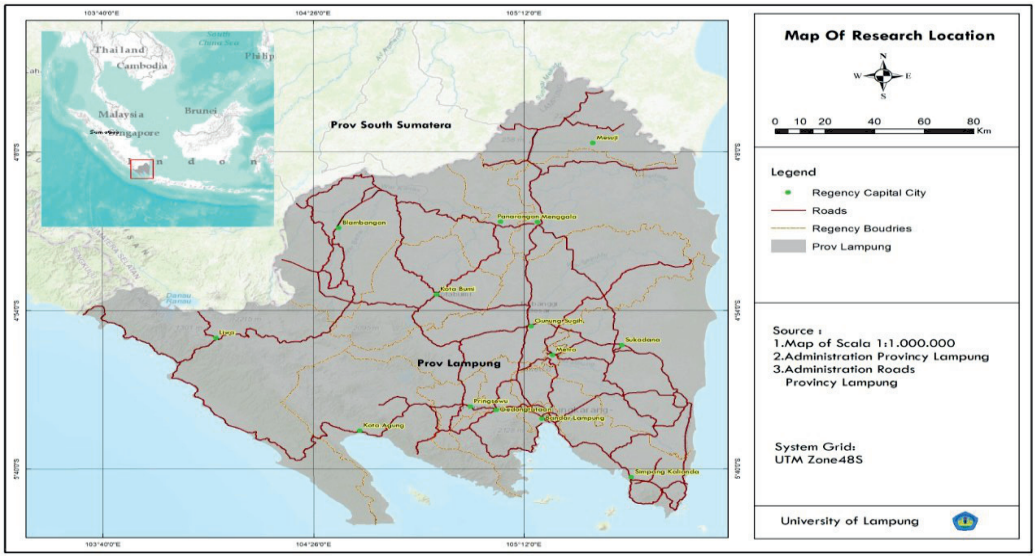

Fig. 1. Research Location in Lampung Province.

independent variables (X) and the dependent variable (Y). The following is a model of multiple linear analysis:

$$[Y]_{it} = \beta_0 + \beta_1[TEMP]_{it} + \beta_2[STWF]_{it} + \beta_3[POPF]_{it} + \beta_4[BAR]_{it} + \beta_5[PLNT]_{it} + \beta_6[SETTL]_{it} + \beta_7[MFARM]_{it} + \beta_8[RICE]_{it} + \beta_9[URBN]_{it} + \beta_{10}[PHC]it + \beta_{11}[HPS]it + e_{it} \quad (1)$$

The working hypothesis as the following:

$$H0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = 0 \quad (2)$$

$$H1: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq \beta_8 \neq \beta_9 \neq \beta_{10} \neq \beta_{11} = 0 \quad (3)$$

The variables, symbols in the model, units, data sources for response variables and predictors are presented in Table 1.

Hypothesis Testing

Hypothesis testing is part of inferential statistics, which aims to draw conclusions about a population based on data obtained from a population sample. At the same time, the F test was conducted to determine the effect of the independent variable on the dependent

Table 1. Variables, symbols in the model, units and scores, data sources.

No	Variable	Symbol	Unit and Score	Data source
1	Pulmonary Tuberculosis Incidence Rate	$[Y]_{it}$	Per 10,000 inhabitants	Lampung Provincial Health Office
2	Temperature	$[TEMP]_{it}$	^{o}C	Meteorology Climatology and Geophysics Agency Lampung
3	State Forest	$[STWF]_{it}$	% of total provincial area	Landsat image interpretation accompanied by terrestrial ground check
4	People's Forest	$[POPF]_{it}$		
5	Bare land	$[BAR]_{it}$		
6	Plantation	$[PLNT]_{it}$		
7	Settlement	$[SETTL]_{it}$		
8	Mixed Farm	$[MFARM]_{it}$		
9	Rice field	$[RICE]_{it}$		
10	Urban Area	$[URBN]_{it}$		
11	Public health center	$[PHC]_{it}$	Per 10,000 inhabitants	Lampung Provincial Health Office
12	Health Professionals Services	$[HPS]_{it}$		

Table 2. Tariffs for Pulmonary Tuberculosis Healing Services at Public Hospital (INA-CBG's).

No	INA-CBG code	Pulmonary Tuberculosis Severity	Healing Service Charge (IDR)		
			Class 3	Class 2	Class 1
1	J-4-17-I	Mild	5,421,900	6,506,300	7,590,700
2	J-4-17-II	Moderate	6,492,900	7,791,500	9,090,000
3	J-4-17-III	Severe	8,520,600	10,224,700	11,928,900

Source: Minister of Health Regulation Number 52 of 2016.

variable. The t-test was used to test whether the independent variable had a partial effect on the dependent variable. The significance level used in this study was 10%. The coefficient of determination test is intended to determine the percentage or percentage of total variation of the dependent variable explained by the independent variable. The equation used is multiple regression, so the value used is R-squared. Testing the parameters of the multiple linear regression equation was carried out using Minitab 16.

Determination of the Value of Environmental Services for Health Fee Charge

In 2004, Law Number 40 concerning the National Social Security System (SJSN) was issued. This law mandates that social security is mandatory for all residents, including the National Health Insurance through a Social Security Administering Body treatment costs for pulmonary TB are recorded by tracing secondary data from the Minister of Health's Regulation Number 52 of 2016 concerning Health Service Standard Tarifs in the Implementation of the Health Insurance Program. Based on the cost of the Indonesian-Case-Based Groups Tariff or INA-CBG Tarif, which is the amount of claim payment by BPJS (People Cooperative for Healthcare Insurance) Health to Advanced Level Referral Health Facilities for service packages based on disease diagnosis groupings and procedures, the standard INA-CBG rates for Regional Government Hospital A 2 are presented in Table 2

Model Simulation as an Environmental Services Valuation Approach

In this simulation, the concept of the economic valuation method uses a market price approach, which can be done through a human capital approach. This is conceptually very relevant to public health, and an appropriate human capital approach is the

Table 3. Pulmonary Tuberculosis Incident Rate (IR/10,000 population) of the 14 districts/cites of Lampung Province.

No	County/City	Year				
		2009	2012	2015	2018	2019
1	West Lampung	2.82	6.27	5.90	6.48	9.21
2	Tanggamus	7.77	5.38	9.98	12.13	14.09
3	South Lampung	7.07	9.26	11.98	22.29	22.67
4	East Lampung	3.76	6.80	0.96	12.86	12.15
5	Central Lampung	5.50	6.87	5.77	22.48	10.23
6	North Lampung	8.87	7.08	8.78	11.66	15.95
7	Way Kanan	7.83	11.23	12.17	13.97	16.80
8	Tulang Bawang	10.65	8.89	4.61	22.86	15.21
9	Pesawaran	4.93	5.35	9.45	11.13	12.24
10	Pringsewu	0.00	8.05	5.58	9.92	16.24
11	Mesuji	0.00	4.71	7.51	19.03	15.33
12	West Tulang Bawang	0.00	5.71	6.99	17.04	16.91
13	Bandar Lampung	11.48	13.24	20.33	23.25	22.86
14	Metro	7.12	7.77	14.38	23.37	30.76

Source: Lampung Provincial Health Office Profile (Processed by Authors).

medical expense or medical billing approach. This maintenance fee will be used as a reference in assessing the environmental services of the Pulmonary TB forest. Forest assessments can be calculated using changes in environmental impacts as measured by land changes using a human resources approach under the 2012 Minister of Environment Regulation on Guidelines for Economic Assessment of Forest Ecosystems.

Results And Discussion

Pulmonary Tuberculosis Pain Rate in Lampung Province

Globally, in 2017, pulmonary TB cases were the highest in the Southeast Asia and West Pacific regions, namely 62% and 25% of the African region. Indonesia and 7 other countries are the biggest contributors to pulmonary TB cases. This happens because Indonesia has big problems in dealing with pulmonary TB disease (Mathofani and Febriyanti, 2020).

Indonesia is ranked 2nd with the highest TB sufferers in the world after India, while Lampung Province is in the 11th highest rank for pulmonary TB cases, with an average of 135 cases per 100,000 population each year (Ministry of Health, 2020). Table 3 provides data for pulmonary TB sufferers of children under five in Lampung Province by district/city in 2002, 2009, 2015, 2018, and 2019 with an Incident Rate (IR) of 10,000 people.

Land Cover in Lampung Province

The use of Landsat imagery is needed to identify district/city land cover in Lampung Province in 2009, 2012, 2015, 2018, and 2019. The land cover classes identified are state forest, community forest, vacant land, plantations, settlements, mixed agriculture, rice fields, and others. Land use change continues to occur along with the development process. Table 3 will explain the average percentage of land covered area in Lampung Province in 2009, 2012, 2015, 2018, and 2019 whereas the series of land used change depicted ed in Fig. 2.

Linear Regression F Test

The F test in this study was carried out to see the effect of all independent variables, namely land changes and temperature, together on the dependent variable of pneumonia. Based on the results of the F-regression test, it was found that the p-value was 0.000, which means that land changes greatly affect the increase in the number of pulmonary TB diseases with a confidence level of up to 99%, which can be proven by the data. These results also show that all independent variables have the possibility of missing only 0.000 or only 1 incident per 10,000 population.

Multiple Linear Regression T Test Against Dependent Variables

The results of the T test were carried out to see the influence of each independent variable of land change on the dependent variable of pulmonary TB disease. The results of the T test on multiple linear regression can be seen in Table 4 as follows.

Description S = Standard Error of Estimate (SEE)
R-Sq = R Square (Coefficient of Determination)
R-Sq (Adj) = Adjusted R Square
(Coefficient of Determination)

The relationship among the independent variable (X) and the dependent variable (Y) in the regression:

$$[Y\_TB]_{it} = -4{,}61 + 0{,}7708\,[TEMP]_{it} - 18{,}98\,[STWF]_{it} - 43{,}31\,[POPF]_{it} - 203{,}06\,[BAR]_{it} + 0{,}39\,[PLNT]_{it} + 6{,}74\,[SETTL]_{it} + 7{,}987\,[MFARM]_{it} + 20{,}24\,[RICE]_{it} + 3{,}769\,[URBN]_{it} - 6{,}979\,[PHC]_{it} + 0{,}11533\,[HPS]_{it}$$

In the data processing in Table 4, the value of R-Sq, or the resulting determinant coefficient, is 71,7%. This value indicates that the diversity of the incidence of pulmonary TB disease can be explained by the model, while the remaining 28,3% is explained by other variables outside the model. The variables that have a significant effect on the incidence of pulmonary TB disease from the results of Table 4 above are temperature, state forests, community forests, bare land, and rice fields.

The Influence of Temperature and Land Change on the Incidence of Pulmonary Tuberculosis in Lampung Province

The Relationship between Temperature and the Incidence of Pulmonary Tuberculosis

Based on air hygiene guidelines, the temperature that meets the requirements is 18-30ºC [11]. Temperature is a risk factor for pulmonary TB because Mycobacterium tuberculosis cannot survive in hot temperatures or in high sunlight. According to research conducted by [12], people who live at high temperatures are 4.66 times more likely to develop pulmonary TB, compared to people who live at lower temperatures. The T test and the coefficient of determination in Table 4 state that the temperature has a p-value of 0.063, which means that the data has a confidence interval of 90%. The value of the coefficient is 0,7708, which explains that every 1ºC increase in temperature will increase the incidence of pulmonary TB disease by 0,7708 events per 10,000 population in Lampung Province. In line with research conducted by [13], temperature greatly influences the increase in the incidence of pulmonary TB disease.

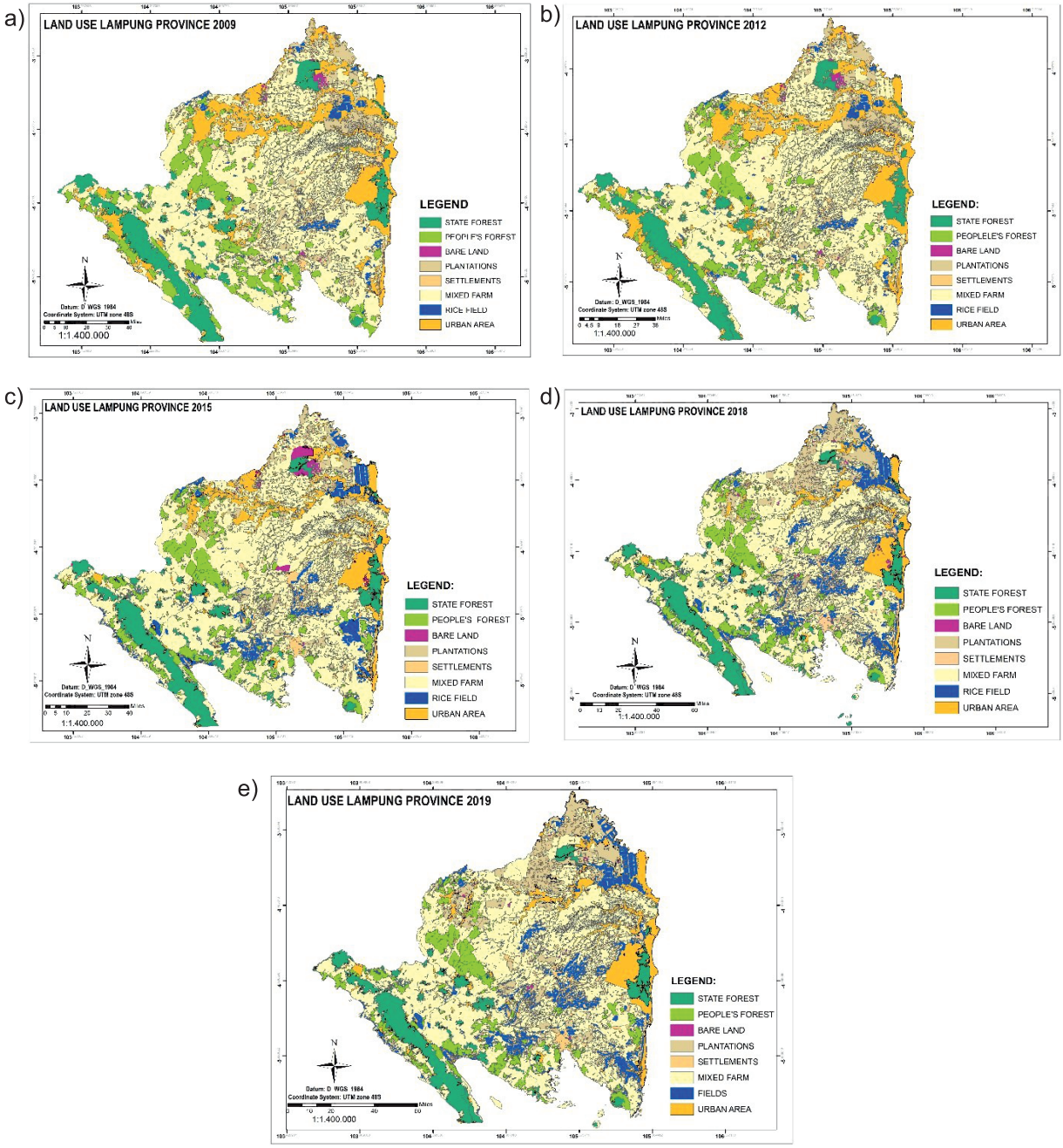

Fig. 2. Land use of Lampung Province (Source Landsat Interpretation accompanied by field ground checking of a) 2009, b) 2012, c) 2015, d) 2018, and d) 2019 after [5].

This is due to the presence of temperature, which plays a very important role in the growth of Mycobacterium tuberculosis bacilli, where the growth rate of these bacilli is determined based on the temperature of the air that is in the surroundings.

The Relationship between State Forests and Pulmonary Tuberculosis Incidence

According to research conducted by [14], the conversion of forests to other land causes climate change, which causes global warming. Climate variations in the form of temperature, rainfall, and others have a mutually influential relationship with the increasing incidence of pulmonary TB in Indonesia. After further investigation, it turned out that this was influenced by climate change, which directly or indirectly affected the incidence and severity of respiratory infections by influencing the vector and the host immune response [15, 24]. Based on the results of the T test and the coefficient of determination in Table 4, there is a significant relationship between state forests and the incidence of pulmonary TB in Lampung Province, with a p-value of 0.095.

Table 4. The results of the optimization of the model parameters of the effect of land use changes on Pulmonary Tuberculosis morbidity.

Predictor	Symbol	Coef.	SE Coef.	T	P
Constant	-	-4.61	13.51	-0.34	0.734
Temperature	$[TEMP]_{it}$	0.7708	0.4060	1.90	0.063
State Forest	$[STWF]_{it}$	-18.98	11.19	-1.70	0.095
People's Forest	$[POPF]_{it}$	-43.31	11.83	-3.66	0.001
Bare Land	$[BAR]_{it}$	-203.06	70.99	-2.86	0.006
Plantation	$[PLNT]_{it}$	0.39	10.99	0.04	0.971
Settlement	$[SETTL]_{it}$	6.74	14.85	0.45	0.652
Mixed Farm	$[MFARM]_{it}$	7.987	7.408	1.08	0.285
Rice Field	$[RICE]_{it}$	20.24	10.64	1.90	0.062
Urban Area	$[URBN]_{it}$	3.769	6.289	0.60	0.551
Public health Center	[PHC]it	-6.979	7.087	-0.98	0.329
Health Professionals Services	[HPS]it	0.1153	0.08813	1.31	0.196
S = 4,92378	R-Sq = 71.7%		R-Sq(adj) = 66.3%		

Data Source: Research Results (2021). Note: *i* = county, *t* = year

The average state forest has a coefficient value of -18.98, which means that every 1% increase in the average state forest land will succeed in reducing the incidence of pulmonary TB by 18.98 events per 10,000 population in Lampung Province. Table 4 shows that state forests have decreased in area over the last ten years. This is also the cause of the increase in pulmonary TB in Lampung Province. The imbalance of the ecological system is a factor in the increasing incidence of pulmonary TB.

The Relationship between Community Forests and the Incidence of Pulmonary Tuberculosis

In addition to providing financial benefits, community forests have the potential to provide environmental services to reduce carbon dioxide (CO_2). The existence of community forest management is carried out intensively so as to create a good ecological condition, so that microclimate conditions are also maintained. Based on the T-test and the coefficient of determination in Table 4, it is stated that community forests have a p-value of 0.001, which means that the data has a confidence interval of 99% and has a significant relationship. The coefficient value of community forest is -43.31, which means that if the area of community forest increases by 1%, it will reduce pulmonary TB disease by 43.31 events per 10,000 population in Lampung Province. These results are in line with research conducted by [16] where community forests have a mutually influential relationship to the increase in the incidence of pulmonary TB in Lampung Province with a p-value of 0.040 and a coefficient of -1.0314, indicating that any increase in 1% of community forest area in each district/city will reduce the risk of TB incidence by 1.0314 events per 100,000 population.

The Relationship between Bare Land and the Incidence of Pulmonary Tuberculosis

Bare land or vacant land is closely related to space that is less balanced in its ecological management. According to research by [17], the increase in bare land is caused by land conversion, which is usually carried out by burning, so that it greatly triggers the incidence of respiratory tract diseases. Based on the results of the T test and the coefficient of determination in Table 4, it is stated that bare land has a p-value of 0.006, which means that the data has a confidence interval of 99% and has a significant relationship. The coefficient value of bare land is -203,06, which means that if the area of open land increases by 1%, it will reduce pulmonary TB disease by 203,06events per 10,000 population in Lampung Province. This result is inversely proportional to the research conducted by [18] that found bare land has no effect on other infectious diseases such as the incidence of malaria.

The Relationship between Plantation and the Incidence of Pulmonary Tuberculosis

Based on the results of the T test and the coefficient of determination in Table 4, it is stated that the plantation land has a p-value of 0.971, which means that the plantation land does not have a significant relationship with the increase in pulmonary TB cases in Lampung Province. The coefficient value of the plantation is 0.39, which means that if the area of

the plantation increases by 1%, it will increase pulmonary TB disease by 0.39 events per 10,000 population in Lampung Province. Research by [19] explains that the high rate of oil palm planting carried out in the future by plantations by converting forests in South Sumatra will cause the risk of an increase in the incidence of pulmonary TB due to smog.

The Relationship between Settlements and the Incidence of Pulmonary Tuberculosis

Poor residential environmental conditions can be seen from the low number of people who can access clean water services, sewage, garbage disposal, inadequate housing conditions, and unhealthy liquid waste disposal [20]. High population growth and reduced residential land cause various problems that often occur in urban areas. One of the problems that commonly occurs is the quality of the residential environment. Based on the results of the T test and the coefficient of determination in Table 4, the settlement has a p-value of 0.652, which means that the data does not have a significant direct relationship to the increase in disease. The coefficient value of the settlement is 6.74, which means that if the area of the settlement increases by 1%, it will increase pulmonary TB disease by 6.74 events per 10,000 population in Lampung Province. The results of this study are inversely proportional to the research of [11] that showed settlements have a significant relationship with the incidence in Seluma Regency with a p-value of 0.002. This is due to the high level of residential density that is not healthy, because in addition to causing a lack of oxygen consumption Also, if one of the family members is infected with an infectious disease, it will be easily transmitted to other family members.

The Relationship between Mixed Farm and the Incidence of Pulmonary Tuberculosis

According to research by [21], the agricultural sector releases Green House Gas (GHG) emissions into the atmosphere in a significant amount, namely in the form of CO_2, CH_4, and N_2O. CO_2 is mostly released from microbial decomposition processes, burning plant litter, and soil organic matter. Based on the results of the T test and the coefficient of determination, Table 4 states that mixed farming has no significant effect on the incidence of pulmonary TB disease in Lampung Province with a p-value of 0.285. Settlement has a coefficient value of 7.987, which means that every 1% increase in residential land will increase pulmonary TB disease by 7.987 events per 10,000 population in Lampung Province. The situation in developing countries is not found to have a lot of waste and disease on agricultural land but often has various toxic wastes discharged directly into the soil, water, and air from industrial processes, paper production, tanning, mining, and unstable forms in industry, which trigger the development of microbes that cause pulmonary TB. Along with the problem of acute poisoning, the accumulation of exposure to various combinations of chemicals and toxins in the human body can be a factor in the presence of pulmonary TB disease.

The Relationship between Rice Field and the Incidence of Pulmonary Tuberculosis

Pollutants in the rice fields can reduce lung function, making the lungs more vulnerable. Because of the low resistance of the lungs to this infection, if there is an infection with Mycobacterium tuberculosis, it is likely that farmers will suffer from pulmonary TB [22]. Based on the results of the T test and the coefficient of determination in Table 4, the rice fields have a p-value of 0.062, which means that the data has a confidence interval of 90% and has a significant relationship. The coefficient value of rice fields is 20.24, which means that if the area of rice fields increases by 1%, it will increase pulmonary TB disease by 20.24 events per 10,000 population in Lampung Province.

The Relationship between Urban and the Incidence of Pulmonary Tuberculosis

Based on the results of the T test and the coefficient of determination, Table 4 states that urban areas have no significant effect on the incidence of pulmonary TB disease in Lampung Province with a p-value of 0.551. Urban has a coefficient value of 3,769, which means that every 1% decrease in urban land will reduce pulmonary TB disease by 3,769 events per 10,000 population in Lampung Province. The role of the variable [D1_URBN] is that although it has no significant effect on the incidence of malaria in Lampung Province (p-value = 0.818), it has a coefficient value of -0.73, thus it can be explained that people who live in areas with city status have a lower potential for contracting the disease. Pulmonary TB from people who live in areas with district status in Lampung Province. Urban areas are indeed the main risk areas for the spread of pulmonary TB, but the facilities and distance to health centers are much better than those in rural areas.

The Relationship between Health Services and the Incidence of Pulmonary Tuberculosis

The factor of health facilities/facilities influencing changes in behavior of pulmonary TB patients is a reciprocal relationship that is interrelated because if the health facilities or facilities provided to pulmonary TB patients are good, the behavior changes of patients will be even better. In other words, pulmonary TB patients will diligently go to health services if the health facilities or facilities are run properly. Based on the results of the T test and the coefficient of determination,

Table 4 states that health services in the form of the number of public health center and the number of midwives and nurses have no significant effect on the incidence of pulmonary TB disease in Lampung Province, with p-values of 0.329 and 0.196, respectively. The coefficient value of each health service variable is -6979 and 11533, which means that every 1% increase in service facilities will reduce pulmonary TB disease by 6979 and 11533 events per 10,000 population in Lampung Province. The high number of cases of pulmonary TB patients was caused, among others, by non-compliance with treatment programs and uneducational treatment programs.

Development of Adaptation Scenarios to Lessen the Global Warming through Simulation of Environmental Services Valuation Approach

The concepts of thresholds, tipping points, and regime shifts dominate today's ecological frameworks that aim to understand ecosystem responses to global change. A threshold corresponds to the level of environmental stresses that create discontinuities in the ecosystem's response to these stresses [23]. Anticipating when, and under what conditions, threshold violations may occur is important for sustainable environmental management. In Indonesia, in general, the global warming adaptation program has a close relationship with the forestry and energy sectors, although it is possible that it is also related to other sectors such as agriculture, transportation, and industry. An example of a global warming adaptation program is forest rehabilitation so that it can help with climate change by nature. In contrast to climate change mitigation, climate change adaptation programs focus more on strengthening community infrastructure facilities to reduce the impact of climate change. An example of a climate change adaptation program is repairing forests in anticipation of various diseases [8].

Based on Table 4, the variables that have a significant effect on the incidence of pneumonia are temperature, state forest, community forest, open land, plantations, and urban areas. The following is a simulation of the valuation of environmental services from temperature, state forests, and community forests. The coefficient value of the regression equation for temperature is 3.157 and the total population of Lampung is 8.85 million (BPS, 2021). In Table 2, previously explained about the cost of treatment for pulmonary TB disease, in this simulation the average cost of treatment for mild pulmonary TB is Rp. 6,500,000/patient, namely the tariff for regional 2 (Minister of Health Regulation #58 of 2016). This was also decided based on the ability of the people in Lampung Province who have an average income of Rp. 1,000,000–Rp. 2,500,000 per month according to the average monthly net income of informal workers and main occupations in Lampung Province (BPS, 2021). To eliminate pneumonia, a simulation will be used using forest reforestation costs of 58 million for the entire population of Lampung Province, amounting to 8,850,000 people with an area of 3,357,600 ha. Tables 5 below contain the simulation results of the increase in the incidence of pulmonary tuberculosis per temperature increase of 0.25ºC to the upper limit of global warming of 2.0ºC and simulations of the effects of changes in state forests and people's forests.

The results of Table 5 above show that in order to suppress the increase in the incidence of pulmonary TB caused by changes in temperature, it is necessary to suppress cases by 1.5/10,000 population, or about 1363 people in Lampung Province. It costs up to IDR. 25.868.000.000. The simulation in Table 5 above explains that to negate the increase in pulmonary TB by each temperature increase, a state forest area of 0.07% or 241.117 Ha is required, which can be calculated using the cost of reforestation in state forests of IDR 13.984.811.000. The results of the simulation of the valuation of environmental services above can be seen that it is necessary to reforest state forests by up to 0.07% and people's forests by 0.03% to suppress the 2ºC average annual temperature increase, which if allocated to mitigation costs, can reach IDR 6.128.647.000. The mitigation costs themselves are obtained from the sum of the maintenance costs and the costs of reforestation in state forests and community forests. A maintenance fee of IDR 20.113.458.000 is required for the reforestation of 241.117 hectares of state forests and 105.666 hectares of community forests to eliminate the increase in the incidence of pulmonary TB disease that the value of the environmental services is only for pulmonary TB, not for infectious diseases as well as for malaria, Dengue Hemorrhagic Fever (DHF), pneumonia etc.

Conclusion

The conclusion of this study is that this study proves that there is a real effect of land cover change on the incidence of pulmonary tuberculosis. Every 2ºC increase in temperature increases the incidence of pulmonary tuberculosis by 1.5 per 10,000 population, or 1363 cases. cover class that has a significant effect on the incidence of pulmonary TB is temperature, state forests, community forests, bare land, and rice fields. The valuation of forest environmental services in Lampung Province with human capital through pulmonary tuberculosis medical cost approach techniques for forest mitigation costs is IDR 20.113.458.000 /year.

Abbreviations

CDC: Centers for Disease Control and Prevention; FAO: Food and Agriculture Organization; GHG: Green House Gas; GIS: geographic information system; GPS: global positioning system; IR: Incident Rate; R-Sq:

Table 5. Simulation of the impact of rising temperatures and changes in state forest land and people's forests on the severity of Pulmonary Tuberculosis patients.

Variable	Global Warming Scenario	Pulmonary Tuberculosis Increasement	Total Incidence of Pulmonary Tuberculosis	Total Cost for healing
	°C	Person/per 10 Thousand Population	Total People	IDR§
Temperature	0.25	0.2	170	3.233 .000.000.
	0.50	0.4	341	6.467.000.000.
	0.75	0.6	511	9.700.000.000.
	1.00	0.8	681	12.934.000.000.
	1.25	1.0	852	16.167.000.000.
	1.50	1.2	1,022	19.401.000.000.
	1.75	1.3	1,193	22.634.000.000.
	2.00	1.5	1,363	25.868.000.000.
Locus	Reforestation acreage that needed at location of: [a] State Forest, or else at [b] people's Forest to negate increasement as the impact of global warming for each scenario above			Reforestation costs to negate Pulmonary Tuberculosis correspond to the global warming scenario at both locations
	%	Ha		IDR§ (Million)
[a] State Forest	0.01	30,073		1,744,254,000
	0.02	60,324		3,498,768,000
	0.03	90,397		5,243,022,000
	0.04	120,470		6,987,275,000
	0.04	150,721		8,741,789,000
	0.05	180,794		10,486,043,000
	0.06	211,044		12,240,557,000
	0.07	241,117		13,984,811,000
[b] People's Forest	0.004	13,179		764,395,000
	0.01	26,436		1,533,286,000
	0.01	39,615		2,297,681,000
	0.02	52,794		3,062,075,000
	0.02	66,051		3,830,967,000
	0.02	79,230		4,595,361,000
	0.03	92.487		5,364,252,000
	0.03	105,666		6,128,647,000

Source: Research results (2021). § Note: 1USD= IDR 14,500

R Square; R-Sq (Adj): Adjusted R Square; SEE: Standard Error of Estimate; TB: Tuberculosis; UNEP: United Nations Environment Program; WHO: World Health Organization.

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Conflict of Interest

We do not have any conflict of interest on this research result.

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