Asian Journal of Research in Agriculture and Forestry

Volume 9, Issue 1, Page 10-16, 2023; Article no.AJRAF.95711
ISSN: 2581-7418

The Impact of Decreasing Forest Areas on Increasing Global Temperatures

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/AJRAF/2023/v9i1192

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/95711

Original Research Article

Received: 21/10/2022
Accepted: 28/12/2022
Published: 16/01/2023

ABSTRACT

Forests act as a producer of oxygen which is essential for the survival of living things. Degradation of forest areas causes the extinction of various species. It creates a greenhouse gas effect that impacts global warming, triggering regional climate change. This study aimed to determine the effect of decreasing forest area on increasing the annual average temperature in the world. The data used in this study are world forest area data and world average yearly temperature during the 1990-2020 period, with the addition of carbon emission data as a control. The analytical method uses Ordinary Least Square (OLS). The results obtained in this study, namely a decrease in every 1 km^2 of forest area, will have a positive impact on increasing the annual average temperature. There was a significant influence in 1990-2010 with an increase in the country's average temperature of 0.0037225^oC. An increase in carbon emissions of 1 ppm increases temperature by 1.046833^oC. The results of this study illustrate that the reduction in forest area increases temperature, which triggers global climate change. Particular policies are needed from the government to maintain forest sustainability so that the ecosystem is maintained.

Keywords: Forest areas; rising temperatures; global warming; carbon emissions.

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1. INTRODUCTION

Forests are the world's lungs, with their role as a producer of oxygen for the survival of living things and as an absorber of carbon dioxide [1]. Forest areas are estimated to have been degraded by as much as two billion hectares worldwide, and the degradation of forest areas poses a significant threat to biodiversity [2,3]. The decreasing forest area certainly causes the extinction of various types of species which causes different impacts, including the greenhouse gas effect [4].

The greenhouse effect can be interpreted as an increase in the Earth's temperature. The rise in the Earth's temperature is caused by the trapping of long-wave (infrared) sunlight by greenhouse gases. Greenhouse gases are in the troposphere, the layer of the atmosphere on the surface of the Earth up to a radius of 10 km into space. Rising temperatures can cause global warming [5]. Global warming is a form of ecosystem imbalance on Earth due to increasing the average temperature of the atmosphere, sea, and land on Earth. Over the last hundred years, the average temperature at the Earth's surface has increased by 0.74 ± 0.18°C. The increase in the average temperature of the Earth's surface occurs due to increased greenhouse gas emissions, such as; carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride in the atmosphere. These emissions are mainly generated from the process of burning fossil fuels (petroleum and coal) as well as due to deforestation and forest burning [6]. Global warming is a problem that is increasingly being experienced and felt by all people in the world, marked by increasing temperatures that are getting hotter. Erratic weather conditions are also signs of global warming. This global warming originates from various human activities that cause carbon emissions with the resulting impact, namely the greenhouse effect, which also has long-term effects on life and is required to reduce activities that can damage forests or activities that can cause emissions. The increasing temperature or global warming phenomenon occurs almost worldwide, negatively impacting the environmental sustainability index [7].

Forest loss due to the reduction in forest area results in many negative environmental impacts, including greenhouse gas emissions. Emissions due to forest loss are reported to be as high as 20% on a global scale [8,9], whereas Harris et al. [10] show that forest loss in the tropics alone accounts for 7 to 14% of total global CO_2 emissions.

Forests can provide temperature regulation services by lowering local temperatures and reducing the urban heat island effect. Several studies have focused on how to realize better or improve the cooling function of urban forests but have not considered it from a supply and demand perspective. The development of the rate of deforestation by looking at the implications and efforts of countries to reduce deforestation which of course has a good impact on reducing emissions or global warming. The level of deforestation is a problem that requires a strategy to reduce it [11,12]. So this research focuses on the impact of decreasing forest area on increasing average temperature worldwide.

Many studies have reviewed the issue of global warming and the importance of forest areas. However, it is still limited in analyzing the linkage of the reduction in the world's forest areas to increasing global temperatures. This research will obtain the effect of forest area degradation on the increase in temperature.

2. METHODOLOGY

The data used in this study is temperature data taken from world bank data (https://datacatalog.worldbank.org) for the period 1990-2020. Meanwhile, forest area data was taken from The Food and Agriculture Organization of the United Nations (FAO) for the same period (https://www.fao.org). The method used in this study is the Ordinary Least Square (OLS) method. The Ordinary Least Square method uses multiple regression analysis to determine the effect of independent variables on dependent variables. The Ordinary Least Square process will produce the best estimate compared to other methods if all the classical assumptions are met. In this study, the independent variable used was the forest area, while the dependent variable was the annual average temperature. This study will also add a control variable, namely carbon emissions. To test the relationship between increasing temperature, forest area, and carbon emissions, a regression model was formed. The models that will be formed in this research are:

$$temperature\ increase = \alpha + \beta_1 X forest\ area + \beta_i X_{carbon\ emission} + \varepsilon$$

3. RESULTS AND DISCUSSION

Based on the regression calculations for the last 30 years, information is obtained that a 1 km2 of forest area reduction in the previous 30 years will increase the country's average temperature by 0.0000514^{o}C. In the last 20 years, information was obtained that a decrease of 1 km^2 of forest area in the previous 20 years would increase the country's average temperature to 0.0000284 ^{o}C. This result is also in line with conditions in the last ten years that a reduction of 1 km^2 of forest area in the previous ten-year period will have an impact on increasing the country's average temperature by 0.0001263 ^{o}C. Whereas in the last five years, a decrease of 1 km^2 of forest area in the previous five-year period will have an impact on increasing the country's average temperature by 0.0000188^{o}C.

Table 1. The effect of forest areas on the increase in average temperature in the last 30 years

```
. reg tr9020 kh9020, r

Linear regression                               Number of obs     =        192
                                                F(1, 190)         =       7.64
                                                Prob > F          =     0.0063
                                                R-squared         =     0.0016
                                                Root MSE          =     7.9395

------------------------------------------------------------------------------
             |               Robust
      tr9020 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      kh9020 |  -.0000514   .0000186    -2.76   0.006    -.000088   -.0000147
       _cons |   4.273715   .5890445     7.26   0.000    3.111808    5.435622
------------------------------------------------------------------------------
```

Table 2. The effect of forest areas on the increase in average temperature in the last 20 years

```
. reg tr0020 kh0020, r

Linear regression                               Number of obs     =        192
                                                F(1, 190)         =       4.46
                                                Prob > F          =     0.0360
                                                R-squared         =     0.0008
                                                Root MSE          =     6.2362

------------------------------------------------------------------------------
             |               Robust
      tr0020 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      kh0020 |  -.0000284   .0000134    -2.11   0.036    -.0000549   -1.88e-06
       _cons |   3.380572   .4611882     7.33   0.000     2.470865    4.290278
------------------------------------------------------------------------------
```

Table 3. The effect of forest areas on the increase in average temperature in the last ten years

```
. reg tr1020 kh1020, r

Linear regression                               Number of obs     =        192
                                                F(1, 190)         =       3.83
                                                Prob > F          =     0.0518
                                                R-squared         =     0.0007
                                                Root MSE          =     32.989

------------------------------------------------------------------------------
             |               Robust
      tr1020 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      kh1020 |  -.0001263   .0000645    -1.96   0.052    -.0002536    1.02e-06
       _cons |    7.10839   2.437192     2.92   0.004     2.300961    11.91582
------------------------------------------------------------------------------
```

Table 4. The effect of forest areas on the increase in average temperature in the last five years

```
. reg tr1520 kh1520, r

Linear regression                               Number of obs     =        192
                                                F(1, 190)         =       2.62
                                                Prob > F          =     0.1071
                                                R-squared         =     0.0006
                                                Root MSE          =      4.958

------------------------------------------------------------------------------
             |               Robust
      tr1520 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      kh1520 |  -.0000188   .0000116    -1.62   0.107    -.0000417    4.11e-06
       _cons |   .6929374   .3661779     1.89   0.060    -.0293588    1.415234
------------------------------------------------------------------------------
```

Spatial temperature pattern in 2020 by categorizing into categories based on color patterns. The first category is the temperature between 0^o -1 ^{o,} with a total of 46 countries. The second category has a temperature range of 12 ^{o} -22 ^{o} in as many as 48 countries. The third category with a temperature range of 23^o-26^o with a total of 60 countries. The fourth category with a temperature range of 27^o -29^o in as many as 39 countries. The 59 countries were not identified due to the unavailability of temperature data for these countries.

In the 1990-2020 period, information was obtained that the significant increase in temperature was caused by a decrease in forest area in the previous period and an increase in carbon emissions. A reduction of 1 km^2 of forest area during 1990-2010 resulted in an increase in the country's average temperature by 0.0037225^oC in the last ten years. Besides that, an increase in carbon emissions of 1 ppm increases temperature by 1.046833^oC.

Global temperatures have been increasing gradually as the rate of warming of gases in the atmosphere has skyrocketed over the past three decades. In 2015, the world's average temperature rose 1^oC for the first time. The increase is above the temperature growth rate after the pre-industrial era. That year, the Climate Agreement in Paris, France, which was signed by many countries, targeted every government to hold the increase in global average temperature at 1.5 degrees Celsius. [13].

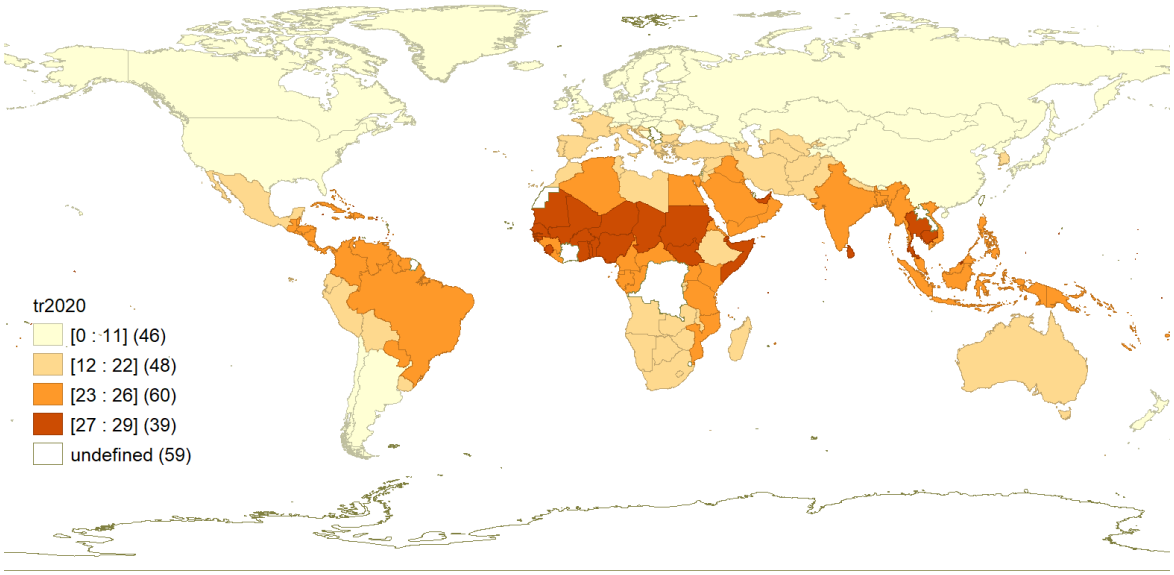

Fig. 1. Spatial patterns of temperature in 2020

Table 5. The effect of forest area on the increase in average temperature and carbon emissions for the period 1990-2010

Linear regression

Number of obs	= 177
F(2, 174)	= 4.92
Prob > F	= 0.0083
R-squared	= 0.0210
Root MSE	= 34.068

tr1020	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
kh9010	-.0037225	.0014888	-2.50	0.013	-.006661	-.0007839
Co1118	1.046833	.4754249	2.20	0.029	.1084913	1.985176
_cons	3.045148	2.160865	1.41	0.161	-1.219732	7.310028

Industrial development and energy consumption using environmentally unfriendly technologies, especially in developing countries, have increased greenhouse gas emissions. Using fossil energy will increase the concentration of greenhouse gases, especially carbon dioxide (CO2). CO2 gas has the second most significant contribution to global warming, around 56%, while CH4 contributes 18% and N2O contributes about 6% [2]. The high concentration of CO2 in the atmosphere causes global warming due to greenhouse gases. Based on calculations for recent years, it can be concluded that the contribution of CO2 to global warming reaches more than 60% [14].

The forest contains tropical forest types rich in flora and fauna, as well as other natural resources, including minerals and coal. Protected and conservation forest areas have long stored mining materials that have become the target of investors. The phenomenon that occurs and cannot be avoided is the emergence of several companies that carry out mining activities in protected forest areas. However, there are many regulations prohibiting open pit mining in

protected forest areas. This prohibition is also supported by mining companies that only think about their economic benefits because many companies do not think wisely and sustainably about natural conditions for the community [15].

Forest fires may be a phenomenon with environmental impacts. Forest fires have a severely destructive effect on very shallow and fragile soils, resulting in a loss of soil fertility and productivity [16] and ultimately causing complete erosion of the soil horizon, leaving bedrock outcrops exposed to the atmosphere [17].

If global temperature increases, the sea level will rise due to the melting of glaciers and icebergs in the polar regions, resulting in higher sea levels. In addition, it can allow for extreme weather events that will bring about more severe storms, dry seasons, floods, hurricanes and other weather phenomena that directly impact human social and economic life. The rapid increase in temperature will mean for ecosystems to adjust, and many types of plants and animals will disappear. Humans will also face various difficulties, such as impacts on agriculture, water supply, and forestry [18].

Various efforts are needed to tackle global warming, both from the side of society and policymakers. People need to change their lifestyles which can unwittingly lead to an increase in temperature. Besides that, the role of the government as a regulator is required to regulate governance so that community activities can be held appropriately.

4. CONCLUSION

Based on the results obtained in this study, it can be concluded that the decrease in forest land area impacts increasing global air temperatures. The influence was quite significant in 1990-2010, with an increase in the country's average temperature of 0.0037225^{o}C. An increase in carbon emissions of 1 ppm increases temperature by 1.046833^{o}C. The results of this study illustrate that the reduction in forest area increases temperature, which triggers global climate change. The speed of temperature increase will impact agriculture, water supplies, and forestry in the sustainability of ecosystems. Various efforts are needed to tackle global warming, both from the side of society and policymakers.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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