A study on economic growth related carbon dioxide damage and forest area damage across the world, for the period of 2012 to 2013.

1. Research Question:

What is the impact of forest area percentage and carbon dioxide damage on the adjusted net national income per capita across different countries from 2012 to 2013?

In an era where environmental sustainability and economic stability are increasingly intertwined, understanding the impact of natural resource management on national income is crucial. This analysis focuses on the relationship between forest area percentage and carbon dioxide damage, as well as their effects on adjusted net national income per capita across various countries during the years 2012 and 2013. For the study, the "World Bank Database" was utilized.

The motivation for researching this topic stems from the growing discourse surrounding environmental issues in the news and social media. As climate change and deforestation continue to dominate global conversations, it is imperative to understand the economic implications of these environmental challenges. By analyzing the interplay between forest conservation and economic indicators, I hope to contribute valuable insights that can inform policy decisions and promote sustainable practices.

The findings from this research could hold societal benefits, as they can guide the development of effective policies that promote sustainable practices while fostering economic growth. Furthermore, by raising public awareness of the critical link between environmental health and economic prosperity, we can encourage collective action towards conservation efforts.

2. Methods:

2.1 Samples:

In the used dataset there are 198 observations for each of the studied variables (forest area percentage, CO2 damage, and adjusted net national income per capita) for the years 2012 and 2013. These observations represent the number of countries, involved in the world bank data. 247 countries are available in total, but with missing data for at least one of the variables. To ensure further processing, these values have been cleaned out.

2.2 Measures:

The "Forest Area Percentage" represents the percentage of land area that is covered by forests in a given country for the years 2012 and 2013. It is an important indicator of a country's natural resources and environmental health. Forests play a crucial role in carbon sequestration, biodiversity conservation, and providing ecosystem services. A higher percentage of forest area may indicate better environmental management practices and can contribute positively to economic stability by supporting industries such as tourism and timber. This measure ranges from 0% (no forest cover) to nearly 98.4%, highlighting the the large global diversity of the forest coverage across all considered countries.

The Carbon Dioxide Damage quantifies the economic damage associated with carbon dioxide emissions in a country for the years 2012 and 2013. It reflects the costs incurred due to environmental degradation and health impacts related to CO2

emissions. Understanding CO2 damage is vital for assessing the economic implications of environmental policies and practices. Countries with higher CO2 damage may face greater economic challenges, which can affect their adjusted net national income.

The Adjusted Net National Income per Capita accounts for the depreciation of natural resources and the effects of environmental degradation. It provides a more accurate picture of a country's economic well-being by considering sustainability. This measure is crucial for understanding how environmental factors, such as forest area and CO2 damage, influence economic performance. A higher adjusted net national income per capita suggests better economic health and sustainability practices. This measure ranges from approximately 140 to 78,000, again showing the large spread over the countries.

The measures were not binned any further for the analysis.

2.3 Descriptive Statistics:

The following table provides an overview of all variables and their descriptive statistics.

Table 1: Descriptive statistics of the chosen variables

	FOREST_AREA _PCT_2012	FOREST_AREA _PCT_2013	CO2_DAMAGE_ 2012	CO2_DAMAGE_ 2013	ADJ_NAT_ GPA_2012	ADJ_NAT_ GPA_2013
Count	198	198	198	198	198	198
Mean	31.716	31.703	0.483	0.491	10389.064	10750.837
STD	22.633	22.639	0.371	0.379	14401.763	14837.418
Min	0.000	0.000	0.048	0.051	140.283	154.823
25 %	12.411	12.438	0.239	0.247	1246.590	1351.589
50 %	30.923	31.111	0.347	0.359	4189.441	4424.458
75 %	45.988	46.132	0.633	0.646	11192.652	11851.326
Max	98.355	98.331	2.509	2.485	78441.338	80588.455

Forest Area Percentage (2012 and 2013): The mean forest area percentage is around 31.7%, with a standard deviation of approximately 22.6%. This indicates a wide variation in forest area across countries.

CO2 Damage (2012 and 2013): The mean CO2 damage is around 0.48 to 0.49, with a standard deviation of approximately 0.37. This suggests that there are countries with significantly higher CO2 damage.

Adjusted Net National Income per Capita (2012 and 2013): The mean adjusted net national income per capita is around 10,389 to 10,751, with a large standard deviation, indicating significant income disparity among countries.

To gain a visual overview over the data, histograms were created for each variable (see figure 1).

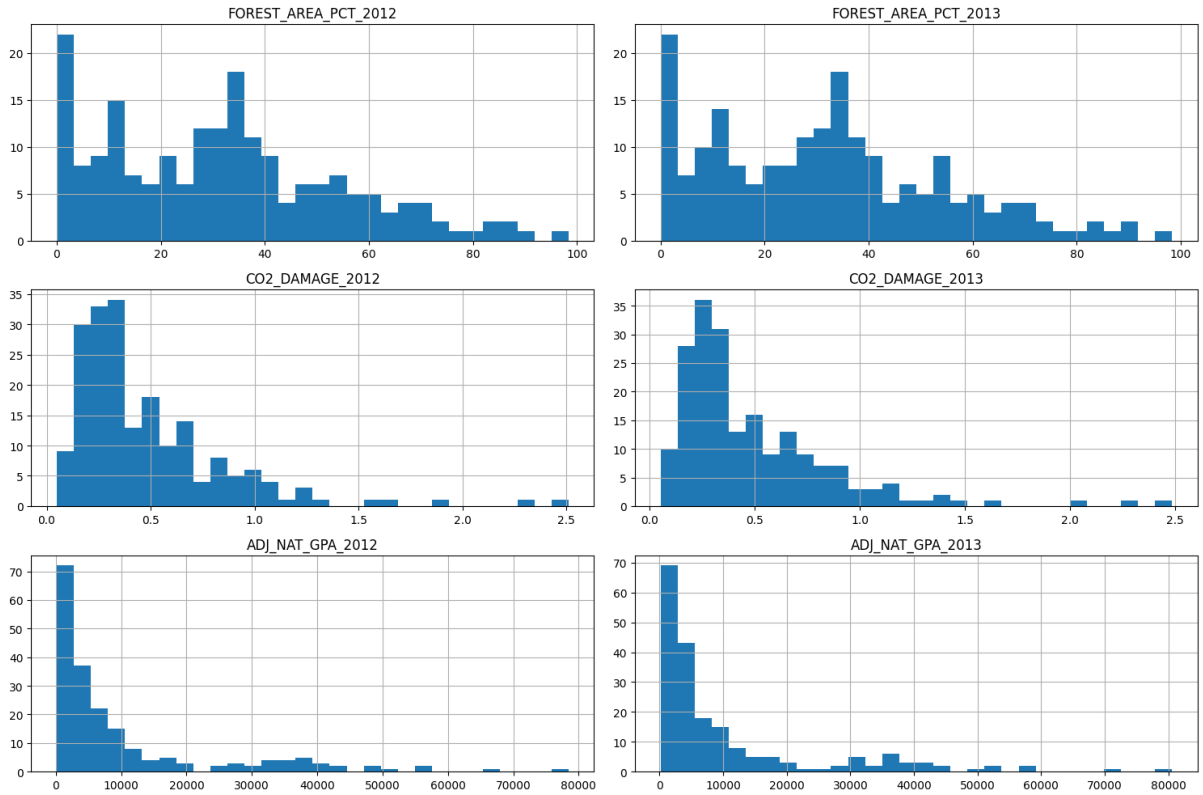

Figure 1: Visualization of statistics for each of the parameters in histograms.

2.4 Analyses:

In the following, the approach in context of the research topic is described. To understand the strength and direction of the relationships between the variables, a correlation matrix is created. In the next step, a multiple regression is performed, to check for statistical significance among the variables. In the last step, a linear regression to forecast the 2013 data based on the 2012 data is being performed, to model the relationship between the independent variables (forest area percentage and CO2 damage) and the dependent variable (adjusted net national income per capita).

3. Evaluation:

3.1 Correlation Matrix:

To evaluate the strength and direction of the relationships between the variables, a correlation matrix was created (see figure 2).

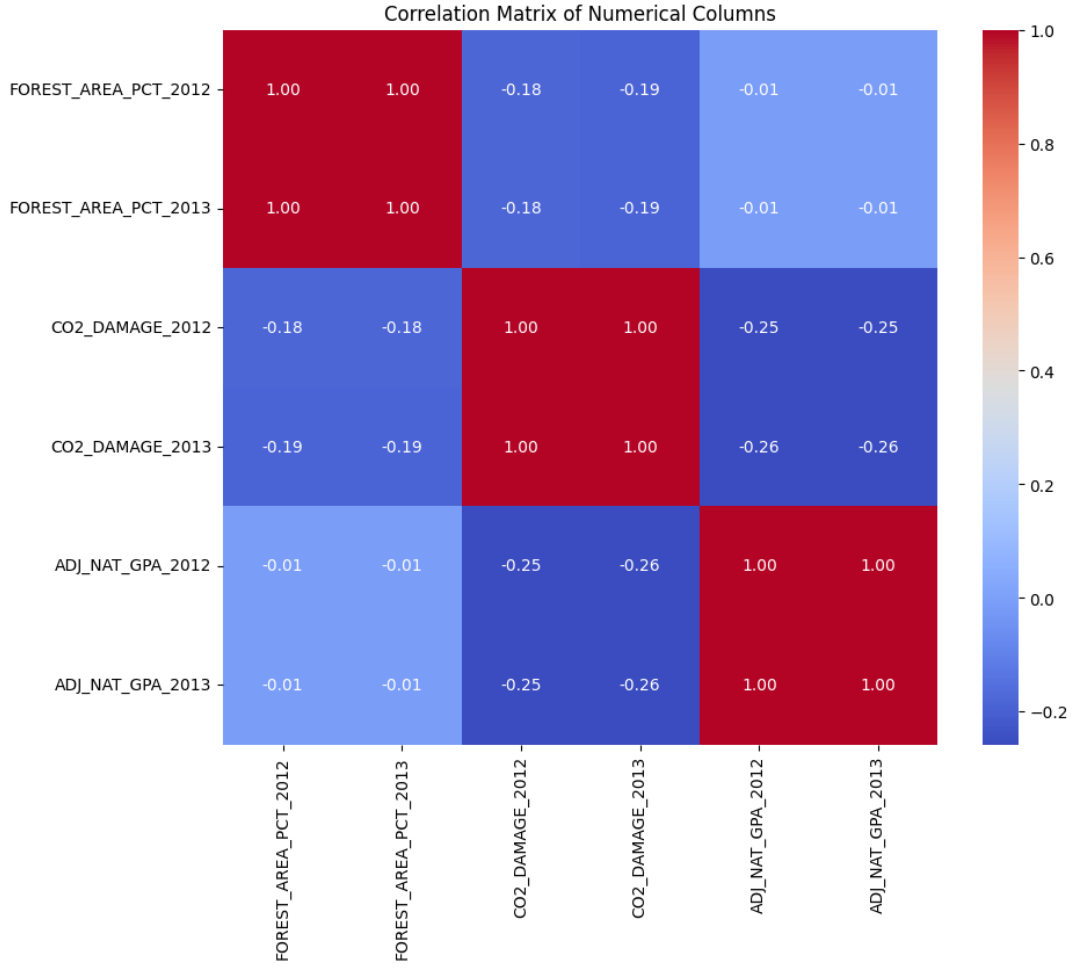

Figure 2: Correlation matrix of the parameters

The variables *CO2_DAMAGE_2012* and *FOREST_AREA_PCT_2012* have a correlation of -0.183780, suggesting a weak negative correlation. This means that as CO_2 damage increases, the forest area percentage tends to decrease slightly.
The correlation factor between *Adjusted Net National Income per Capita 2012* and *CO_2 Damage 2012* is -0.25 as well as -0.26 for the respective values of the year 2013, indicating a moderate negative correlation. This indicates, that with increasing *Adjusted Net National Income per Capita,* the CO_2 damage slightly decreases.
Nevertheless, there seems to be no correlation between the *Adjusted Net National Income per Capita* and the forest area for both years.

Concluding the above findings, the matrix suggests that forest area percentages are stable over the two years measured. Further, CO_2 damage appears to have a weak negative relationship with forest area percentages, indicating that higher CO_2 damage may be associated with lower forest area percentages. The adjusted national GPA shows a strong consistency between the two years.

3.2 Multiple Linear Regression:

A multiple linear regression was performed to check for statistical significance among the variables. The results were separated for both years of observation, 2012 (see figure 3) and 2013 (see figure 4). The CO_2 damage was chosen as the dependent variable and the dependence of the *Forest Area Percentage* as well as the *Adjusted Net National Income per Capita* was analyzed.

Multiple Regression Results for 2012

OLS Regression Results

Dep. Variable:	CO2_DAMAGE_2012	R-squared:	0.099
Model:	OLS	Adj. R-squared:	0.090
Method:	Least Squares	F-statistic:	10.74
Date:	Wed, 23 Apr 2025	Prob (F-statistic):	3.76e-05
Time:	10:05:42	Log-Likelihood:	-73.671
No. Observations:	198	AIC:	153.3
Df Residuals:	195	BIC:	163.2
Df Model:	2		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.6486	0.047	13.760	0.000	0.556	0.742
FOREST_AREA_PCT_2012	-0.0030	0.001	-2.739	0.007	-0.005	-0.001
ADJ_NAT_GPA_2012	-6.587e-06	1.75e-06	-3.764	0.000	-1e-05	-3.14e-06

Omnibus:	117.385	Durbin-Watson:	2.246
Prob(Omnibus):	0.000	Jarque-Bera (JB):	744.147
Skew:	2.258	Prob(JB):	2.57e-162
Kurtosis:	11.355	Cond. No.	3.32e+04

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 3.32e+04. This might indicate that there are strong multicollinearity or other numerical problems.

Figure 3: Results of the multiple linear regression for 2012.

The regression model for 2012 has an R-squared value of 0.099, indicating that approximately 9.9% of the variability in CO_2 damage can be explained by the independent variables included in the model. The F-statistic is 10.74 with a p-value of 3.76e-05, suggesting that the overall model is statistically significant.
The coefficient for the forest area percentage is -0.0030, indicating that as the percentage of forest area increases, CO2 damage decreases, and this relationship is statistically significant (p = 0.007). The coefficient for *Adjusted Net National Income per Capita* 2012 is -6.587e-06, suggesting a negative relationship with CO_2 damage, which is also statistically significant (p = 0.000)

The regression model for 2013 has an R-squared value of 0.103, indicating that approximately 10.3% of the variability in CO2 damage can be explained by the independent variables included in the model. The F-statistic is 11.20 with a p-value of 2.49e-05, suggesting that the overall model is statistically significant. The coefficient for *Forest Area Percentage 2013* is -0.0032, indicating that as the percentage of forest area increases, CO_2 damage decreases. This relationship is statistically significant (p = 0.005). The coefficient for *Adjusted Net National Income per Capita* 2013 is -6.629e-06, suggesting a negative relationship with CO_2 damage, which is also statistically significant (p = 0.000).

Multiple Regression Results for 2013

OLS Regression Results

Dep. Variable:	CO2_DAMAGE_2013	R-squared:	0.103
Model:	OLS	Adj. R-squared:	0.094
Method:	Least Squares	F-statistic:	11.20
Date:	Wed, 23 Apr 2025	Prob (F-statistic):	2.49e-05
Time:	10:05:46	Log-Likelihood:	-77.402
No. Observations:	198	AIC:	160.8
Df Residuals:	195	BIC:	170.7
Df Model:	2		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.6634	0.048	13.806	0.000	0.569	0.758
FOREST_AREA_PCT_2013	-0.0032	0.001	-2.816	0.005	-0.005	-0.001
ADJ_NAT_GPA_2013	-6.629e-06	1.73e-06	-3.830	0.000	-1e-05	-3.22e-06

Omnibus:	111.931	Durbin-Watson:	2.216
Prob(Omnibus):	0.000	Jarque-Bera (JB):	637.099
Skew:	2.174	Prob(JB):	4.53e-139
Kurtosis:	10.637	Cond. No.	3.43e+04

Notes:

[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

[2] The condition number is large, 3.43e+04. This might indicate that there are strong multicollinearity or other numerical problems.

Figure 4: Results of the multiple linear regression for 2013.