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Assessment of the Link between CO_2 $emissions and Socio-Economic Indicators

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Abstract. *This article examines the intricate relationships between carbon dioxide (CO2) emissions and key socio-economic indicators across various sectors. Utilizing different statistic methods, we scrutinize the interdependencies between air emissions and indicators such as Gross Domestic Product (GDP), education, life expectancy, pesticide use, recycling rates, agricultural production, net income, and tourism. Our analysis reveals a complex panorama where economic growth, indicated by GDP, agricultural output, and tourism, exhibits a strong positive correlation with CO2 emissions, suggesting that economic activity is a significant driver of environmental impact. Intriguingly, life expectancy also correlates positively with emissions, potentially reflecting the dual facets of industrial development, which, while boosting living standards and healthcare, concurrently increases environmental burdens. Conversely, educational attainment shows a negligible correlation, hinting at the potential for decoupling intellectual capital from carbon output. Through a robust statistical approach, this study underscores the multifaceted linkages between emissions and socio-economic health, highlighting areas for policy intervention and sustainable development strategies to balance economic advancement with environmental stewardship.*

Keywords: air emissions, correlation, network, statistic, socio-economic indicators.

Introduction

The interaction between CO_2 emissions and different socio-economic indicators has become a topic of increasing interest in the context of sustainable development. Understanding the relationship between CO_2 emissions and indicators such as Gross Domestic Product (GDP), life expectancy, nights spent in tourist accommodation, recycling rate, education participation rate and pesticide use in agriculture is crucial both for decision makers, as well as for researchers. This research paper aims to provide a comprehensive analysis of the link between CO_2 emissions and these key indicators in the context of sustainable development. Understanding these relationships is essential for formulating effective strategies for continued economic growth without having a negative impact on the environment.

Economic growth and industrialization have led to increased greenhouse gas emissions. Economic growth is also closely related to higher GDP, but depends on a number of factors such as technological advances, energy consumption patterns and government policies.

DOI: 10.2478/picbe-2024-0218

Examining the relationship between CO_2 emissions and recycling rates provides insights into the effectiveness of waste management systems, resource efficiency and circular economy practices. In this sense, education becomes essential in understanding the impact on the environment, so understanding the link between the rate of participation in education and emissions helps to identify opportunities for sustainable development.

Furthermore, greenhouse gas emissions may have broad implications for social indicators such as life expectancy as the public health consequences of climate change and pollution become more apparent. The impact of tourism on the environment can be measured by nights spent in tourist accommodation units, this sector playing a significant role in understanding the carbon footprint and its contribution to overall emissions.

The use of pesticides in agriculture is closely related to greenhouse gas emissions, as pesticide production and application contribute to both CO_2 emissions and other environmental concerns. Analyzing the relationship between these indicators contributes to the understanding of the environmental impact of Agricultural practices, at the same time being able to increase the potential for more sustainable approaches.

By deepening the links between CO_2 emissions and these various indicators, this research paper aims to contribute to the deepening of knowledge on sustainable development, policy interventions and environmental management. The findings will assist policy makers in formulating evidence-based strategies and guiding decision-making processes towards a more sustainable and equitable future.

Literature review

Global environmental problems are caused by the increasing level of damage humans are doing to the planet. These include economic activities, irrational and wasteful uses of nature, overpopulation, urbanization, wars and armed conflicts. Humans cause CO_2 by burning fossil fuels, coal, oil, and natural gas (Li et al., 2023). The role of carbon dioxide (CO_2) in the life of the biosphere is primarily to support the photosynthesis process carried out by plants (Sphak et al., 2022).

People's health and well-being through increasing life expectancy, improving mortality rates and supporting labor productivity contribute greatly to national income. Infrastructure development consumes energy and releases carbon dioxide at various stages of the construction process (Li et al., 2023). Also, human activities such as agricultural deforestation, commercial activities, fossil fuel burning and land use changes due to population growth contribute significantly to the increase in greenhouse gas emissions (Yoro et al., 2020). These emissions are closely related to energy consumption, economic growth and the environment, as they have serious effects on climate change and pollution, with negative effects on human health (Drăcea et al, 2020, Noja et al, 2023). In a study by Li et al (2023) in which they traced the link between CO_2 emissions, energy consumption, life expectancy and GDP in the top five carbon-emitting countries (China, USA, India, Russia and Japan), reported a weak correlation with mortality and life expectancy in Japan and Russia.

In the context of achieving the goal of the work, the link between CO_2 emissions and waste recycling rates was followed. Carbon dioxide is a greenhouse gas that has an impact on climate change and implicitly on global warming. In some studies, the value of CO_2 emissions relative to the entire waste management process (collection, treatment, recycling and waste disposal) was analyzed to better understand the consequences on the environment and it was found that recycling represents the greatest CO_2 savings (of in Barrera and Hooda, 2016). Recycling helps reduce CO_2 emissions in several ways such as energy conservation, waste decomposition, production, etc.

Raw materials represent the key resource for each state. Many materials, such as plastic and aluminum, require the extraction and processing of raw resources that lead to significant CO_2 emissions (Mongo et al., 2022). Recycling reduces the demand for these raw materials, thereby reducing the associated CO_2 emissions from extraction, transport and processing activities. Recycling materials can also lead to significant reductions in production-related CO_2 emissions. By using recycled materials, manufacturers can save energy and reduce emissions associated with the manufacturing process. Recycling reduces the need to extract raw materials and manufacture products from scratch, as recyclables are perceived as key enablers for carbon-neutral solutions for the waste management value chain (Tenhunen-Lunkka et al., 2023). Producing goods from recycled materials generally requires less energy compared to making them from resources.

Regarding the operations to which the waste is subjected, in the stage of their storage at the landfills and their discovery, the most methane gas is released, which contributes to climate change. By sorting them correctly and recycling waste instead of sending it to landfills, less waste accumulates, reducing the volume of methane emissions (Lian et al., 2020).

However, in some studies the causality analysis did not reveal a significant interaction between the recycling rate and CO_2 emissions, but in the long term recycling tends to lead to a decrease in CO_2 emissions, so the emphasis of the recycling process is expected to make a significant contribution to environmental sustainability (Bayar et al., 2021). Therefore, a higher recycling rate directly correlates with lower CO_2 emissions. By promoting recycling and increasing recycling rates, we can effectively mitigate the impact of CO_2 emissions on climate change and contribute to a more sustainable future.

The connection between CO_2 emissions and nights spent at tourist accommodation units can be explained by the energy consumption and waste generation associated with these units.

Tourist accommodation units such as hotels, resorts and lodges require significant amounts of energy for heating, cooling, lighting, water heating and for operating various facilities such as air conditioning, swimming pools and spas (MacAskill et al., 2023). The energy used in these units is often derived from fossil fuels, which release CO_2 emissions when burned. The more nights spent at such establishments, the higher the energy demand and subsequently the higher the associated CO_2 emissions. Hotels are one of the largest energy consuming facilities with high energy costs (Cingoski & Petrevska, 2018). Also, large amounts of water are consumed in these units for various purposes. Treatment and distribution and even heating of water contribute to energy consumption.

Tourist accommodation establishments generate substantial amounts of waste, including food waste, packaging materials and other discarded items (Lee & Huang, 2023). The management of this waste, such as transport to landfills or incineration plants, contributes to CO_2 emissions. In addition, inefficient waste management practices can lead to the release of methane, a potent greenhouse gas, from the decomposition of organic waste in landfills.

Emissions of CO_2 related to nights spent at tourist accommodation units are not limited to the operation of the units themselves. Emissions from transportation to and from these accommodations are also a significant factor. Tourists traveling by car, plane or other forms of transport contribute to CO_2 emissions by burning fossil fuels.

In conclusion, the increase in tourism development and tourists' arrivals directly affects the quality of environment through increased energy consumption, water use, waste generation and transport-related emissions, all of which contribute to total CO_2 emissions (Ibnou-Laaroussi et al., 2020).

It is essential for the tourism industry to adopt sustainable practices, including energy-efficient technologies, waste reduction measures and sustainable transport options, to minimize the environmental impact and reduce CO_2 emissions associated with overnight stays in tourist accommodation.

The relation between CO_2 emissions and Gross Domestic Product (GDP) is a complex relationship, being influenced by factors such as industrialization, energy consumption, technological advances, economic structure and political measures (Sikder et al., 2022). While higher economic growth has historically been associated with increased emissions, efforts to decouple emissions from GDP growth are being made through technological innovation, a transition to cleaner energy sources, and legislation. Achieving a sustainable and low-carbon economy requires balancing economic development with emission reduction strategies.

According to the specialized literature, there are different types of approaches and hypotheses related to the relationship between economic growth and environmental pollution. Thus, Mitić et al, (2023) examine the causal relationship between CO_2 emissions, economic growth, available energy and employment for a group of eight South-Eastern European countries from 1995 to 2019, showing bidirectional causality in the long run short between CO_2 emissions and employment and between available energy and employment. According to Zhang and Cheng (2009), economic growth is independent of both energy consumption and CO_2 emissions.

The results of some studies show that CO_2 emissions have increased statistically significantly with economic growth (Alam et al., 2016; Heidari et al., 2015). Onofrei et al. (2022) suggest the existence of a long-term cointegrating relationship between growth and CO_2 emissions in EU countries, and the DOLS method indicates a statistically significant effect of economic growth on CO_2 emissions, revealing that, on average, a 1% change in GDP leads to a 0.072 change in CO_2 emissions. Per capita income has also been found to contribute to CO_2 emissions, confirming that in the early stage of development, the need for higher incomes and lack of awareness of environmental issues lead to air quality degradation (Zoundi, 2017). Thus, higher income levels lead to increased demand for environmental protection and underline the need to design environmental policies capable of reducing emissions during periods of economic growth (Onofrei et al., 2022).

Economic growth is closely related to industrialization: As GDP increases, especially in developing countries, there is often a corresponding increase in industrial activity, production, and energy consumption. Many industries rely heavily on fossil fuels such as coal, oil and natural gas, which release significant CO_2 emissions when burned. However, economic growth and industrialization have a positive impact on CO_2 emissions in the short term, but economic growth has been achieved at the cost of environmental damage (Lee, 2018).

Economic growth generally leads to increased energy demand for the power industry, transportation and households (Lee, 2018; Churchill et al., 2021). Fossil fuels still dominate the global energy mix, and their combustion is a major source of CO_2 emissions. Therefore, as GDP increases, energy consumption tends to increase, leading to higher CO_2 emissions.

Higher levels of GDP often facilitate technological advances and innovations. These advances can help improve energy efficiency, reduce emission intensity, and promote cleaner energy sources (Ajmi et al., 2015).

In addition, the structure of an economy can influence its CO_2 emissions. As economies transition from low-tech to medium- and high-tech manufacturing industries, energy intensity and

CO_2 emissions associated with GDP tend to decrease (Avenyo & Tregenna, 2022). Service sectors generally have lower energy and emissions requirements compared to heavy industry or manufacturing.

Government policies, environmental regulations and international agreements have a significant impact on CO_2 emissions and GDP (Aguilar-Hernandez et al. 2021). Policies that incentivize cleaner energy sources, promote energy efficiency, and set emission reduction targets can influence the emissions-GDP relationship (Hailemariam & Erdiaw-Kwasie, 2022). International agreements such as the Paris Agreement aim to limit the increase in global temperature by reducing emissions, while taking into account the economic capacities and stages of development of different countries.

Pesticides are widely used in agricultural production to prevent or control pests, diseases, weeds, and other plant pathogens in an effort to reduce or eliminate yield losses and maintain high product quality. The link between CO_2 emissions and pesticide use in agriculture can be understood in the context of agricultural practices and their impact on the environment. Pesticides are synthetic chemicals and are associated with increased carbon emissions, primarily due to their production and secondly to their application techniques. The use of pesticides can lead to undesirable ecological effects. Increasing pesticide applications by farmers leads to higher energy consumption and CO_2 emissions associated with pesticide production and application, thus recommending the use of less intensive agricultural techniques (Chataut et al., 2023).

It is important to note that the relationship between CO_2 emissions and pesticide use may vary depending on several factors, such as agricultural practices, crop types and regional differences (Cech et al., 2022). However, efforts to minimize pesticide use through sustainable agricultural practices can help reduce carbon emissions in the agricultural sector.

Methodology

In order to analyze the network and correlation between CO_2 emissions and other indicators, we have chosen different statistic methods, like descriptive statistic, linear regression, Bayesian network analysis.

Descriptive statistics aim to summarize the central point, known as the measure of central tendency, and the distribution range, referred to as dispersion, within a set of data. Variance is one common measure used to quantify the extent of dispersion (Fisher &Marshall, 2009).

Network analysis is a powerful tool that enhances our comprehension of the intricate web of connections between various elements within a system (Hevey, 2018).

Regression analysis serves as a statistical method to understand how variables are related, particularly identifying cause-and-effect connections. The primary goal of univariate regression is to explore the link between a single independent variable and a dependent variable, and to express this association through a linear equation that models their relationship (Uyanık & Güler, 2013).

The dataset was systematically compiled utilizing the Eurostat database, incorporating data from all 27 member states of the European Union for the period extending from 2010 to 2020. The JASP software, an open-source and complimentary statistical package, was used for the execution of all aforementioned methods.

The indicators are integral to understanding various environmental and economic factors and their interrelation with CO_2 emissions. Table 1 outlines the selected indicators, including their respective symbols, units of measurement, and source.

The aim of this paper is to identify the most important sector that impact air emissions. In order to find that we have been selected different indicators from economics, social, and environmental sector.

The hypotheses of this article are articulated as follows:

Hypothesis 1 There exists an indirect relationship between social life and air emissions.

Hypothesis 2 The economic sector has a significant impact on air emissions.

Hypothesis 3 There is a strong direct correlation between the environmental sector and air emissions.

Table 1. Legend of indicators

Nr. crt.	Indicators	Symbol	Unit of measure	Source
1	Air emissions accounts by NACE Rev. 2 activity - Carbon dioxide	*Air_emissions*	Tone	Eurostat
2	Participation rate in education and training (last 4 weeks), from 18 to 64 years	*EDU*	%	
3	Gross domestic product at market prices	*GDP*	Million euro	
4	Recycling rate of municipal waste	*RRMW*	%	
5	Pesticide use in agriculture	*PEST*	Kilogram	
6	Nights spent at tourist accommodation establishments	*Tourist_accommodation*	Number	
7	Mean equivalised net income	*Net_income*	Euro	
8	Life expectancy	*Life_expectancy*	Year	
9	Circular material use rate	*CMUR*	%	
10	Production value at basic price - Agricultural indicator	*Production_agr*	Million euro	

Source: Authors' own research.

Results and discussions

The statistical summary provides a snapshot of the central tendency and dispersion of the data. Each indicator has a count of valid entries, ranging from as few as 43 for "Circular material use rate (CMUR)" to 297 for several other indicators. This suggests a complete dataset for most indicators, except CMUR and "Pesticide use in agriculture (PEST)" which have a significant number of missing entries. Some indicators exhibit instances of non-reporting, with PEST showing 254 unreported values and CMUR with 43. These gaps in data are attributable to the non-submission of relevant information by certain nations within the timeframe of 2010 to 2020.

The average value across the valid data points is provided for each indicator. For instance, the mean for "Gross Domestic Product (GDP)" is approximately 79.68 million euros, and the mean for "Air emissions" is about 9.6 x 10^6 tones.

Standard Deviation reflects the variability or spread of the data around the mean. A larger standard deviation indicates more spread out data. For instance, "Recycling rate of municipal waste (RRMW)" has a standard deviation of 13.73%, indicating variability in the recycling rates across the observations.

Based on the means and standard deviations, it seems there's a substantial variation in the values of the indicators, which is typical in macroeconomic and environmental data. The large range in the minimum and maximum values also indicates significant variability within each indicator, which could be due to differences between countries, changes over time, or both.

	EDU	GDP								
Valid	297	297	297	297	43	297	293	297	297	295
Missing	0	0	0	0	254	0	4	0	0	2
Mean	16.652	457477.796	79.680	8.545	298371.265	$9.600\times10^{+7}$	34.566	14538.661	16373.478	$8.900\times10^{+7}$
Std. Deviation	7.464	724966.616	2.876	6.225	499412.823	$1.373\times10^{+8}$	15.611	19747.941	9694.728	$1.306\times10^{+8}$
Minimum	6.600	6815.800	73.100	1.200	1838.000	$1.316\times10^{+6}$	4.100	121.090	2324.000	$1.517\times10^{+6}$
Maximum	38.600	$3.474\times10^{+6}$	84.000	29.000	$2.027\times10^{+6}$	$7.028\times10^{+8}$	70.300	78139.890	43687.000	$4.712\times10^{+8}$

Source: Authors' own research.

Analyzing part and partial correlation (Table 3.) between air emissions and others indicators we can see that EDU (Education) seems to have a slightly negative association with the dependent variable when controlling for other factors, as indicated by the negative partial correlation. GDP (Gross Domestic Product) shows a strong positive partial correlation, suggesting a significant association with the CO2 emissions when the effects of other variables are accounted for. CMUR (Circular Material Use Rate) and PESTICIDE both show very weak correlations with the CO2. RRMW (Recycling Rate of Municipal Waste) and Production_agr (Production Value at Basic Price - Agricultural Indicator) show a small but positive relationship with the dependent variable. Net_income (Mean Equivalised Net Income) and Tourist_accommodation (Nights Spent at Tourist Accommodation Establishments) both show a negative association with the dependent variable, with tourist accommodation showing a notably stronger negative correlation. Life_expectancy (Life Expectancy) has a positive partial correlation, but it's relatively low, suggesting a weaker association with the dependent variable compared to GDP.

Table 3. Part And Partial Correlations

Model		Partial	Part
H_0	EDU	-0.187	-0.061
	GDP	0.772	0.386
	CMUR	0.043	0.014
	PESTICIDE	-0.196	-0.064
	RRMW	0.163	0.053
	Net_income	-0.266	-0.088
	Tourist_accommodation	-0.460	-0.165
	Life_expectancy	0.139	0.045
	Production_agr	0.257	0.085

Source: Authors' own research.

The heat map (Figure 1.) shows us the value of the correlation coefficient between different indicators. Thus, from the heatmap below, we can discern the following relationships between air emissions and other indicators:

There is a very strong positive correlation with air emissions, indicating that as the Gross Domestic Product increases, air emissions typically increase as well. This can be due to more industrial activity, energy production, and transportation that often accompany economic growth.

The correlation between air emissions and life expectancy is moderately positive, suggesting a relationship where higher air emissions are associated with higher life expectancy.

While this may seem counterintuitive, it may reflect the fact that countries with more developed economies (hence higher emissions) often have better healthcare systems and standards of living that contribute to longer lives.

A strong positive correlation between air emissions and pesticide use indicates that higher pesticide use in agriculture is associated with higher air emissions. This may be related to agricultural practices that contribute to greenhouse gas emissions.

The correlation is moderately positive between air emissions and Recycling Rate of Municipal Waste (RRMW), which could imply that as recycling rates increase, air emissions also increase. This might reflect better waste management in more industrialized nations, which also produce more emissions.

There is a moderate positive correlation, suggesting that higher production values in agriculture are associated with higher air emissions, possibly due to mechanization and increased activity in the agricultural sector.

There is a moderate negative correlation for net income, implying that higher net incomes may be associated with lower air emissions. This might be interpreted as higher-income areas potentially investing more in cleaner technologies and having stricter environmental regulations.

The correlation for tourist accommodation is moderately positive, suggesting that an increase in tourist activity, possibly requiring transport and energy use, might lead to higher air emissions.

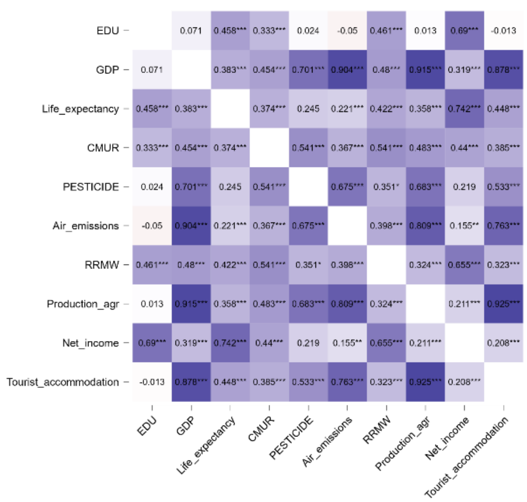

Figure 1. Heat map
Source: Authors' own research.

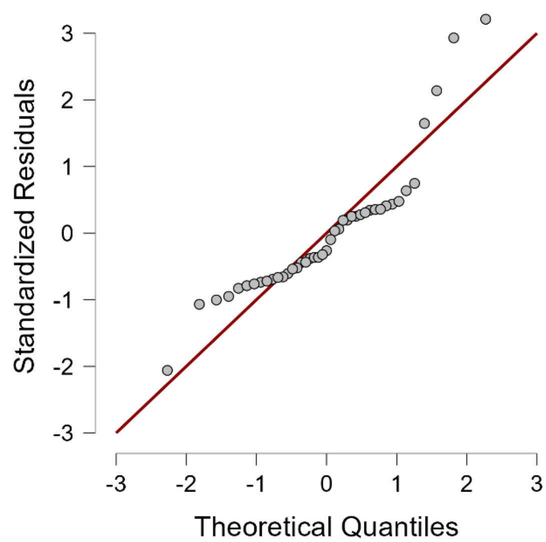

Figure 2. Q-Q Plot Standardized Residuals
Source: Authors' own research.

The Q-Q plot (Figure 2.) suggests that the residuals are approximately normally distributed. However, there are some points at both ends of the plot that deviate from the line. Overall, while there is some deviation, particularly at the tails, the Q-Q plot suggests that the assumption of normality is not strongly violated. This deviation may be due to the lack of data for certain indicators, the very large gaps between countries due to different levels of development.

Further we analyzed the network between air emission with selected indicators (Figure 3.). Air Emissions is the central node in the network, suggesting it is the primary indicator of interest. Gross Domestic Product (GDP) has a strong positive correlation with Pesticide Use and Production in Agriculture, suggesting that higher economic output is associated with increased use of

DOI: 10.2478/picbe-2024-0218, pp. 2594-2608, ISSN 2558-9652 |
Proceedings of the 18th International Conference on Business Excellence 2024

pesticides and agricultural production, both of which can contribute to higher CO_2 emissions. Circular Material Use Rate (CMUR) shows a negative correlation with Pesticide Use and Air Emissions, implying that a higher rate of recycling and reuse of materials is associated with lower use of pesticides and emissions, which aligns with sustainable practices. Recycling Rate of Municipal Waste (RRMW) is negatively correlated with Air Emissions, which is expected as more effective recycling can reduce waste-related emissions. Education (EDU) has a strong negative correlation with Air Emissions, which could suggest that better education leads to higher environmental awareness and possibly the adoption of practices that reduce emissions.

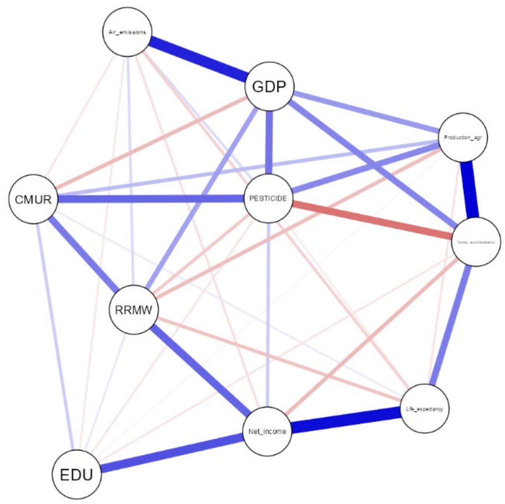

Figure 3. Network analysis

Source: Authors' own research.

Centrality plot (Figure 4.) offers insights into the relative importance and influence of each indicator within the network, based on various centrality measures. Air emissions have a negative score (-1.118) for betweenness, which suggests that within this network, air emissions do not often act as a bridge between other indicators. This indicate that air emissions are not a central node through which the effects of other variables are mediated. The negative score (-1.385) for air emissions in closeness centrality indicates that it is relatively isolated and not closely connected to all other nodes in the network. This could mean that changes in air emissions are not immediately or directly related to changes in other indicators, or it may require more 'steps' to influence or be influenced by changes in other nodes. Air emissions have a negative score (-1.228) in strength centrality as well. This means that the sum of the weights of the edges connected to air emissions is low, implying that it doesn't have strong direct correlations with many indicators in the network. The negative score (-0.984) for Expected Influence suggests that air emissions are not expected to have a significant influence on the network based on the current connections and the importance of its neighbors.

In summary, the centrality analysis suggests that air emissions are not central to the network based on the data and relationships modeled. This could imply several things depending on the context of the network analysis: the other variables in the network may not have a strong direct influence on air emissions, or vice versa; air emissions might be influenced by factors not included in this network; the impact of air emissions on other indicators may be more complex and not captured by direct relationships.

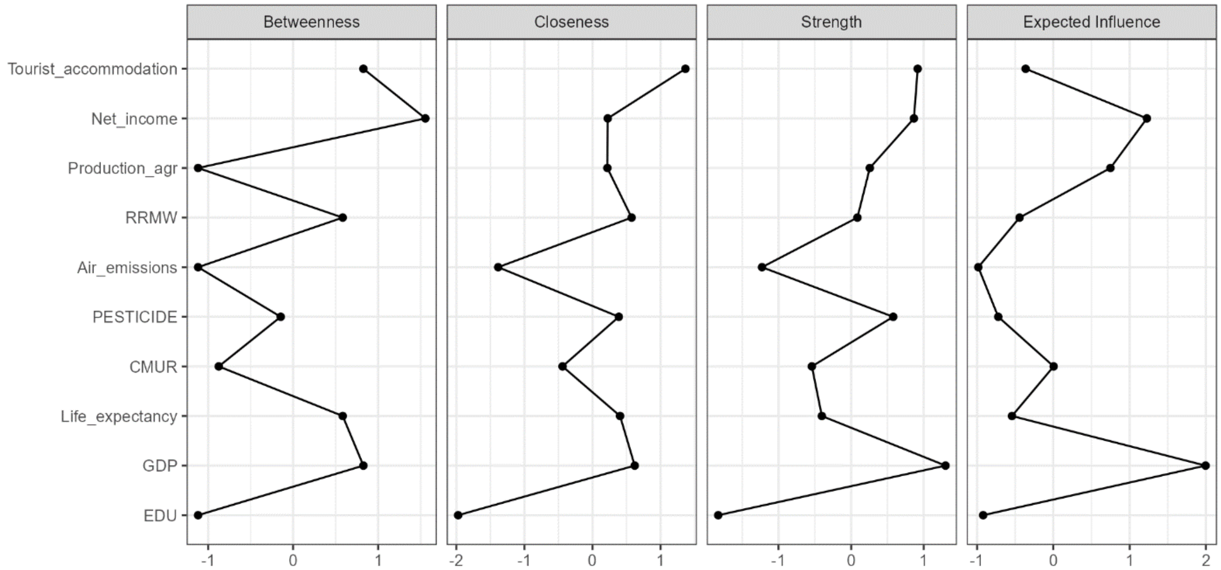

Figure 4. Centrality plot

Source: Authors' own research.

Covariance matrix (Table 4.) shows the covariance between pairs of variables in terms of air emissions. The covariance between air emissions and education is positive, suggesting that they tend to increase together. The positive covariance indicates that higher GDP might be associated with higher air emissions, which is a commonly understood relationship since economic activity often leads to increased emissions. There is a positive covariance with life expectancy, which might seem counterintuitive because we typically expect more emissions to correlate with lower life expectancy due to health impacts. However, this could reflect a more complex relationship, where countries with higher life expectancy also have higher industrial activity and thus emissions, or it might be influenced by third variables like healthcare quality and public health policies. Covariance with CMUR, Pesticide Use, RRMW, Net Income, Tourist Accommodation, and Agricultural Production tell us how each of these variables moves with air emissions. For instance, if the covariance between air emissions and recycling rate (RRMW) is negative, it suggests that when recycling rates go up, emissions go down, or vice versa.

Table 4. Coefficients Covariance Matrix

		EDU	GDP	CMUR	PESTICIDE	RRMW	Net_income	Tourist_ accommodation	Life_ expectancy	Production_ agr
H_0	EDU	$2.946\times10^{+12}$	952737.164	$-8.625\times10^{+10}$	$8.183\times10^{+6}$	$-4.911\times10^{+11}$	$-8.317\times10^{+8}$	144105.979	$-1.936\times10^{+12}$	$-7.043\times10^{+8}$
	GDP		1318.954	$2.311\times10^{+7}$	-600.935	$-1.119\times10^{+7}$	-11239.718	-4.682	$4.770\times10^{+7}$	-7679.392
	CMUR			$3.728\times10^{+12}$	$-1.766\times10^{+7}$	$-7.379\times10^{+11}$	$-1.419\times10^{+7}$	45456.709	$-1.928\times10^{+12}$	$-1.070\times10^{+9}$
	PESTICIDE				1098.084	$-1.022\times10^{+6}$	2848.897	5.588	$-2.982\times10^{+7}$	-27847.322
	RRMW					$1.028\times10^{+12}$	$-8.105\times10^{+8}$	-105907.133	$2.580\times10^{+12}$	$8.402\times10^{+8}$
	Net_income						$3.535\times10^{+6}$	194.894	$-9.090\times10^{+9}$	-519566.910
	Tourist_ accommodation							0.089	$-1.211\times10^{+6}$	-428.008
	Life_expectancy								$4.767\times10^{+13}$	$4.416\times10^{+9}$
	Production_agr									$3.313\times10^{+6}$

Source: Authors' own research.

The Pearson's correlation matrix shows the correlation coefficients (Pearson's r) between different variables, along with their respective p-values which indicate the statistical significance of the correlations. The correlation of education with Air_emissions is very weak and negative (-0.050), and not statistically significant (p = 0.389). This suggests no clear relationship between education levels and air emissions based on this data. There is a very strong and statistically significant positive correlation of GDP with Air_emissions (0.904, p < .001), indicating that as GDP increases, air emissions tend to increase as well, which is common as economic activity typically drives up energy use and emissions. There is a positive correlation of life expectancy with Air_emissions (0.221, p < .001), which is statistically significant. This indicates a relationship where higher air emissions are associated with higher life expectancy. This could be due to many factors, such as higher emissions being a byproduct of industrial activity that also contributes to a higher standard of living and better healthcare. The positive correlation of CMUR (Circular Material Use Rate) with Air_emissions (0.367, p < .001) is statistically significant, suggesting that higher rates of material recycling and reuse are associated with higher emissions. This might seem counterintuitive but could be due to more developed economies having both higher recycling rates and higher emissions. Pesticide shows a strong and statistically significant positive correlation with Air_emissions (0.675, p < .001), indicating that higher pesticide use is associated with higher air emissions. This could reflect the intensity of agricultural activity that often correlates with increased emissions. There is a moderate and statistically significant positive correlation between RRMW (Recycling Rate of Municipal Waste) with Air_emissions (0.398, p < .001), suggesting a relationship where increased recycling is associated with higher emissions, which may reflect a complex interaction between waste management practices and industrial emissions. Production_agr (Agricultural Production) and Tourist_accommodation show a very strong and statistically significant positive correlation with Air_emissions, indicating that higher agricultural production and tourism activity is associated with higher air emissions. Net_income has a weak but statistically significant positive correlation with Air_emissions (0.155, p = 0.007), suggesting that there is a slight tendency for higher net incomes to be associated with higher emissions.

Table 5. Pearson's Correlations

Variable		EDU	GDP	Life_expecta	CMUR	PESTICI	Air_emissi	RRM	Production_	Net_inco	Tourist_accommo
1. EDU	Pearso	—									
	p-	—									
2. GDP	Pearso	0.07	—								
	p-	0.22	—								
3.	Pearso	0.45 **	0.38 **	—							
	p-	< .0	< .0	—							
4. CMUR	Pearso	0.33 **	0.45 **	0.374 ***	—						
	p-	< .0	< .0	< .001	—						
5. PESTICIDE	Pearso	0.02	0.70 **	0.245	0.54 **	—					
	p-	0.88	< .0	0.114	< .0	—					
6. Air_emissions	Pearso	-	0.90 **	0.221 ***	0.36 **	0.675 ***	—				
	p-	0.38	< .0	< .001	< .0	< .00	—				
7. RRMW	Pearso	0.46 **	0.48 **	0.422 ***	0.54 **	0.351 *	0.398 ***	—			
	p-	< .0	< .0	< .001	< .0	0.021	< .001	—			
8. Production_agr	Pearso	0.01	0.91 **	0.358 ***	0.48 **	0.683 ***	0.809 ***	0.32 **	—		
	p-	0.82	< .0	< .001	< .0	< .00	< .001	< .0	—		
9. Net_income	Pearso	0.69 **	0.31 **	0.742 ***	0.44 **	0.219	0.155 **	0.65 **	0.211 ***	—	
	p-	< .0	< .0	< .001	< .0	0.158	0.007	< .0	< .001	—	
10.	Pearso	-	0.87 **	0.448 ***	0.38 **	0.533 ***	0.763 ***	0.32 **	0.925 ***	0.208 **	—
	p-	0.82	< .0	< .001	< .0	< .00	< .001	< .0	< .001	< .00	—

* p < .05, ** p < .01, *** p < .001

Source: Authors' own research.

Conclusion

This paper has analyzed the direct and indirect relationships between CO2 emissions and various economic, social and environmental indicators.

Thus, we can conclude that Participation rate in education and training can influence environmental awareness and policy-making, potentially affecting CO2 emissions, but not crucially. Economic growth measured by GDP often correlates with energy use and hence CO2 emissions, but the nature of this relationship can vary depending on the energy mix of a country. Higher recycling rates can reduce CO2 emissions by lessening the need for raw material extraction and processing. Agricultural practices can have significant environmental impacts, including on CO2 emissions, through the use of fertilizers and pesticides. Tourism can affect CO2 emissions through increased transport and energy consumption. Income levels can impact CO2 emissions through consumption patterns and energy usage. While more indirect, life expectancy can be a general indicator of a country's development and public health, which may have complex interactions with CO2 emissions. Circular material uses rate (CMUR) indicates the reuse of materials within the economy. Higher rates can suggest a move towards a circular economy, potentially reducing CO2 emissions. Production value at basic price could relate to how agricultural practices and their scale affect CO2 emissions, considering factors like land use, cultivation methods, and livestock management.

The p-values indicate that almost all of these correlations are statistically significant, except for the correlation with Education. The strong correlations with GDP, Agricultural Production, and Tourist Accommodation suggest that economic activities in these areas are closely linked with air emissions. However, it's important to note that correlation does not imply causation, and further analysis would be required to determine the underlying causes of these relationships.

In conclusion, the first and second hypotheses have been substantiated. Evidence indicates an indirect correlation between education, life expectancy, and air emissions, as well as a pronounced direct correlation between the economic sector and air emissions. Conversely, the third hypothesis has not been validated; the findings reveal a correlation between environmental factors and air emissions, albeit a negligible one.

The limit of these research may be the indicators that we elected. For future research, scholars may opt to select distinct indicators from these sectors and examine additional connections among them.

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