CO_2 Emissions, Natural Disasters, and Economic Impact: A Case Study of Kerala's Environmental and Socioeconomic Challenges

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Abstract

The result of state development projects in rural and urban regions is the rise in CO_2 Emissions in recent years. The environment, biodiversity, and the state's economic activity are disrupted by the growth of CO_2 emissions. This article discusses how CO_2 emissions and natural disasters have economically impacted Kerala. The secondary data for the analysis was collected from worldwide forest data and yearly disaster management reports in Kerala. This article made use ofregression and forecasting analysis. The key findings revealed a positive link between CO_2 emissions and tree cover loss in Kerala. Furthermore, the 2018-2021 floods caused damage and losses throughout the state. After all, the research indicates that carbon dioxide (CO_2) emissions will rise in the next years, causing environmental problems in society. Furthermore, it will challenge society's economic development and progress.

Keywords: *CO_2 emission, Climate change, Environment, Biodiversity. Kerala flood*

Introduction

The urgent problem of global warming is causing tragedies and drastic transformations across the planet (Abdul Haleem Butt: 2023). With the present global warming that has had several biophysical effects worldwide, climate dissipation was observed to occur more frequently(Yuan: 2021). One of the main causes of global warming is carbon emissions (Mohsen et.al:2022). Both natural and human-made processes can cause carbon emissions. The human causes of carbon emissions include various man-made activities such as cutting down trees, forest fires, burning fossil fuels, producing cement, and natural gas production (Prosperi 2020). The decrease in tree cover also causes increased atmospheric carbon emissions. This creates a break in the natural state of equilibrium. In addition to damaging the ecosystem, these changes inthe atmosphere also exacerbate people's social, economic, and health issues. No city in Kochi hasever seen the unsafe and intolerable circumstances that the year 2023 saw in the smoke. As a result, the Kochi Co-operation experienced financial issues, which led to the homeless status of people living within a 15-km radius and their temporary relocation to other

residences (Malayala Manorama: 2023). Although plants are crucial for lowering carbon emissions in the atmosphere, ongoing deforestation is hastening the development of environmental issues related to carbon missions.

Image:1 Sources of CO_2

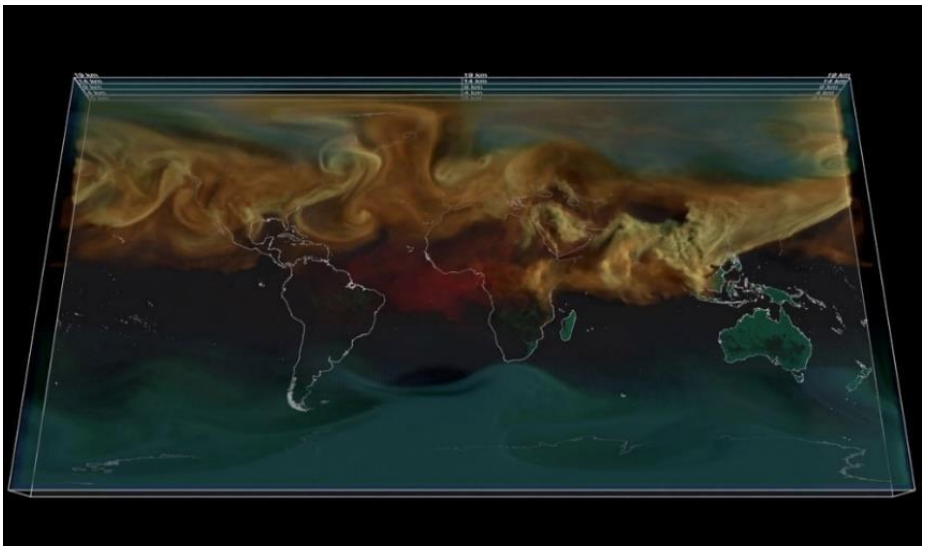

Image 1 depicts the four main sources of CO_2 that contributed to the Earth's atmosphere in 2021: burning biomass in red, fossil fuels in orange, terrestrial ecosystems in green, and the ocean in blue (NASA: 2023). The surface's dots also demonstrate how terrestrial ecosystems, which are depicted in green, and ocean ecosystems, which are depicted in blue, are both absorbing atmospheric carbon dioxide (NASA:2023). The earth's surface and the seas act as global carbon sinks, but certain places can also act as sources occasionally. Kerala's annual emissions growth of 5.73 percent is attributed to energy sector emissions, which persisted until 2017(NASA:2023) Population growth and industrialization also contribute to increased emissions. Urban migration and industrialization increase energy consumption in the transportation, construction, and manufacturing sectors. Limited renewable energy sources are crucial to address the energy sectorand population growth. The purpose of the study is to identify the relationship between CO_2 emissions and the decline in tree cover loss, to compute the sector-wise emission of CO_2 and per-capita emission of CO_2, and lastly, to forecast the future decline in tree cover and CO_2 emissions in Kerala. In addition, this paper considers how the Kerala economy performed in 2018.

Methodology

From the Global Forest Watch (GFW) platform, two time series datasets were obtained (carbon emission and tree cover reduction). Each dataset consists of the past 20 years of information on carbon emission and the tree cover loss from 2001 to 2020. To analyze greenhouse gas emissions between 2005 and 2018, sector-specific CO_2 emissions, as well as CO_2 per capita emissions were used. The following four objectives are addressed by this study.

Analysis of the relationship between CO_2 Emissions and Tree Cover Loss in Kerala

Analysis of Sector-wise contribution of CO_2

Analysis of Per capita net emission of Kerala (2005-2018)

Analysis of the Economic impact of the 2018 Kerala Floods

Results and Discussion

Analysis of the Relationship between CO_2 Emissions and Tree Cover Loss in Kerala

In the modern era, maintaining the balance between ecological preservation and human growth is a challenging issue. Understanding the link between carbon dioxide (CO_2) emissions and the loss of trees has become a crucial concern as the world community works to reduce the harmful consequences of climate change. A remarkable case study for elucidating this complex dynamic is the state of Kerala, located in the densely forested region of southern India and famous for its outstanding biodiversity and beautiful forests. An early investigation of the probable connection between CO2 emissions and Kerala's declining tree cover is provided in thefollowing table.

Table 1

Tree Cover Loss and CO_2 Emission in Kerala

Year	Tree cover loss (Ha)	CO2 Emission (Mt)
2002	1.03	104142
2003	1.78	115734
2004	1.58	418064
2005	1.46	214520
2006	1.88	82572
2007	4.34	239207
2008	3.08	291191
2009	1.05	248951
2010	2.04	34874
2011	4.91	2779
2012	3.79	474939
2013	2.80	450955
2014	3.82	252964
2015	2.71	365146
2016	7.19	309352
2017	9.726	430017
2018	6.27	518328
2019	7.42	534394
2020	6.85	525108

Source: Computed data from Global Forest Watch

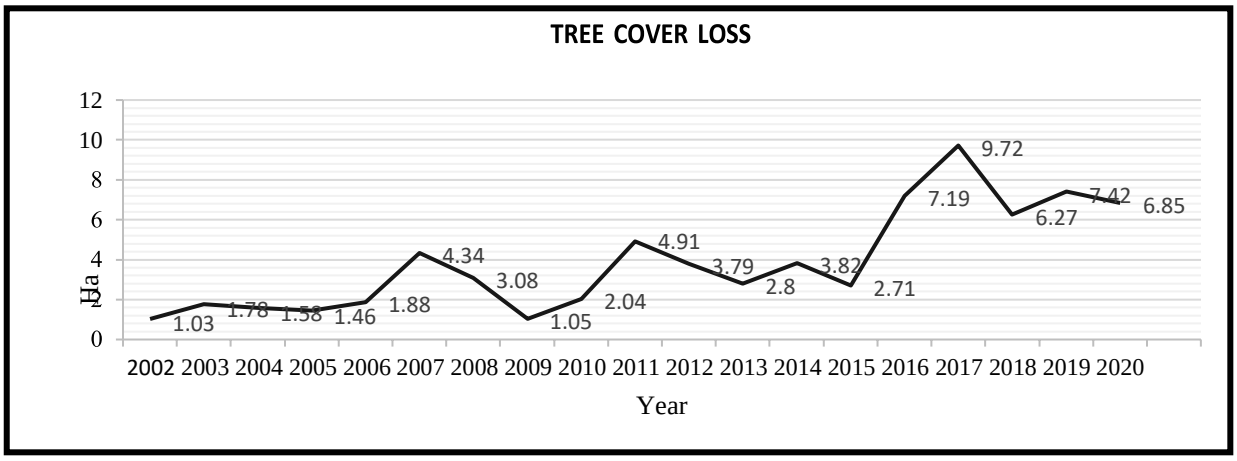

Figure:1

Tree cover loss in Kerala

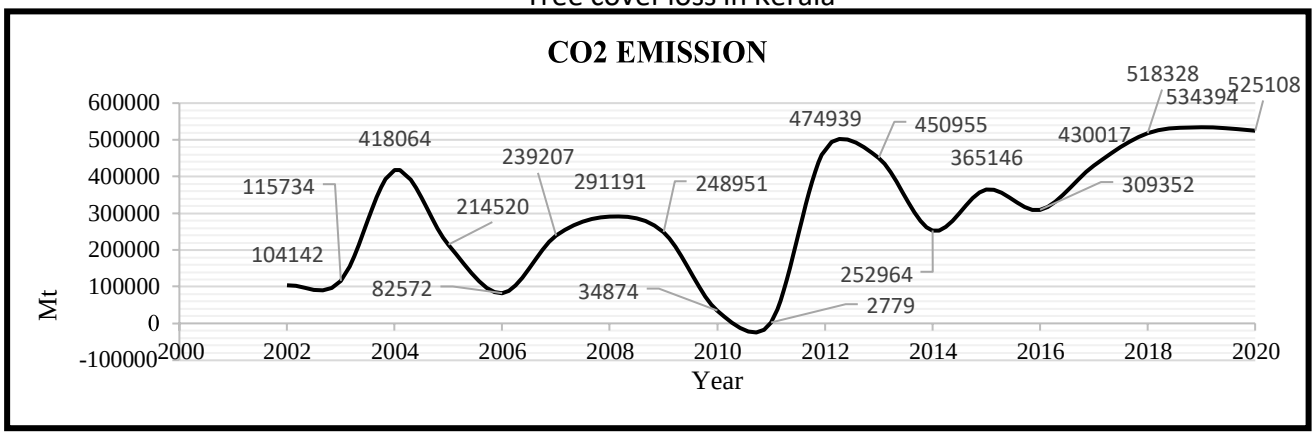

Figure:2

CO_2 emission in Kerala

Table 2:

Summary of Regression result (Tree cover loss and CO_2 emission in Kerala)

	Unstandardized Coefficient		Standardized coefficients		
	B	**Std.Error**	**Beta**	**t-value**	**Significance**
(Constant)	155295.178	64299.209		2.415	.027
Tree cover loss	36115.192	13982.098	.531	2.583	.019

Dependent Variable: Co2 emission

$$Y=a+bx$$

$$Y=155295.178+36115.192x$$

From 2002 to 2020, the Kerala state lost 72.6 kha of tree cover, equivalent to a 2.8% decrease in tree cover since 2000 and 40.8 Mt of CO_2 emissions (Global Forest Watch). In the case of primary tree loss, the trend showed that as of the tree loss, from 2002 to 2020, Kerala had mislaid 3.44 Kha of primary forest, making up 4.8 % of its total tree cover loss in the same period. The total area of humid primary forest in Kerala has decreased by 0.66 % in this period (Global Forest Watch). Both the data showed that most of the tree cover loss and the CO_2 emission in Kerala occurred in 2017, 2018, and 2019. This was a period of tragic rainfall floods and landslides in Kerala. Fossil fuel burning and tree cover loss contribute to increase atmospheric CO_2 generation. Forests absorb excess CO_2 from the atmosphere, causing global warming and contributing to climate issues (Global Forest Watch). According to the regression analysis, Kerala's carbon emissions and tree cover reduction are positively correlated. After the burning of fossil fuels, deforestation which is mostly brought on by the loss of tree cover is the second-largest human-caused source of CO_2 emissions. About 11% of the world's greenhouse gas emissions as of 2018 are attributed to the decrease in forest cover. This has increased because of changes in land use, including logging, cattle grazing, and agriculture (Francisco: 2021) The relationship between CO_2 emissions and decreased tree cover contributes to climate change and raises the possibility of catastrophic natural disasters (Global Forest Watch).

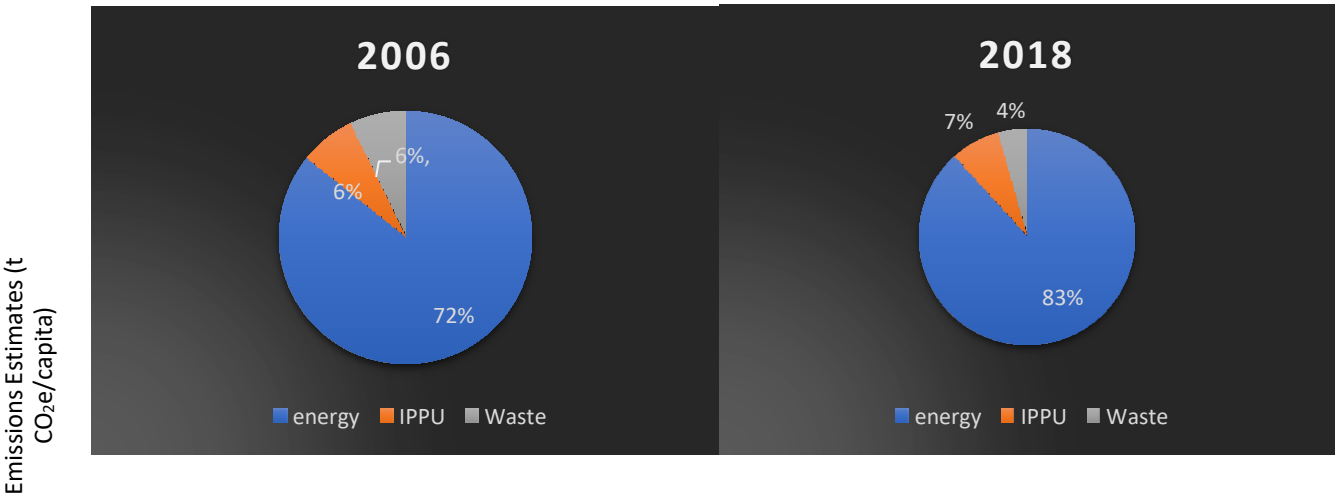

Figure 3
Sector-wise emission of CO_2

(Source: Author's calculation from Global Forest Watch) Note: IPPU-Industrial Processes and Product Use

In contrast to 2006, the energy sector has shrunk from 83% to 72% in 2018, industrial processes and product consumption use (IPPU) have climbed from 6% to 7%, and waste has shrunk from 6% to 4%. The graph depicts the increase in carbon emissions from the cloud industry. While theexpanding need for data centers and cloud computing has increased energy use, better waste management practices like recycling and composting have decreased emissions.

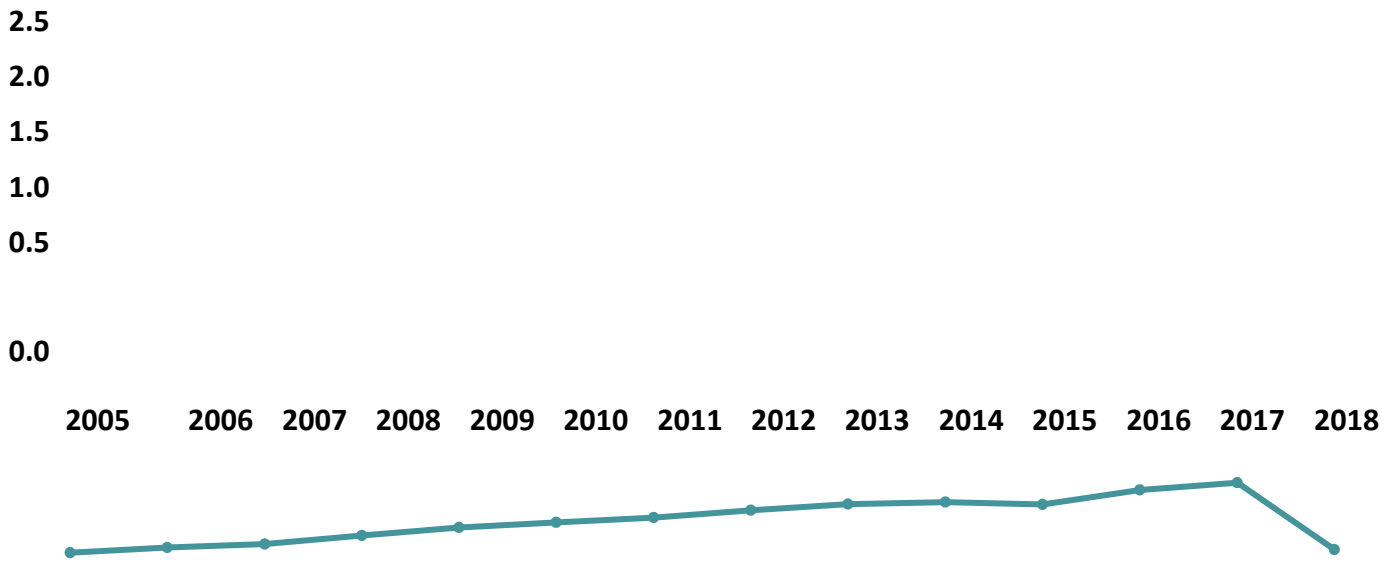

Figure: 4
Per capita Net emission of Kerala (2005-2018)

Source: Analysis of Greenhouse Gas Emissions from 2005 to 2018

Despite having lower per-person emissions than other states, Kerala's emissions increased by 5.31% between 2005 and 2018 **(Vijitha;2007).** This is a result of Urbanisation and industrialization, which raised energy requirements and boosted the usage of fossil fuels, producing more greenhouse gases. Large cities are the source of 75% of greenhouse emissions. **(Dodman:2009)** Urban areas like Calicut, Kochi, and Trivandrum are abundant in developing states like Kerala. Numerous enterprises are present in each city, including Hindustan Organic Chemicals, Bharath Petroleum Company, Travancore Cochin Chemical Ltd., and the Cochin Shipyard. The net release of greenhouse gases into the atmosphere grew year over year as a result of their increased production. One of the most important greenhouse gases in the atmosphere is carbon dioxide (CO_2). **(Aylin:2010**). Fuels are often burned directly, which produces significant CO_2 emissions and dominates the energy industry. About 60% of the world'shuman greenhouse gas emissions are carbon dioxide, which is produced during the energy process. Due to different national energy arrangements, this proportion varies significantly in each country. **(Tayfun:2010**) A fire that erupted on March 2 at the Brahmapuram waste management plant has been fighting hazardous vapors in the coastal Indian town of Kochi. Carbon dioxide, carbon monoxide, methane, and nitrogen dioxide are among the toxic gases that cover the metropolis. **(Rema Abrahm:2023).** The extremely flammable polymers catch fire as a result of a combination of these toxic gases and the methane produced by anaerobic breakdown (**Devika:2023).** In Kochi, the PM_2 and PM_{10} (Particular matter) readings shot up with the fire, raising the air quality indexes to "unhealthy" and "very unhealthy"levels. In the early stages of the fire, the AQI (Air quality index) rose to levels exceeding 320 in the majority of locations, and even 400 in others. The air quality index is currently at 170 andindicates harmful conditions, even afterthe fire has subsided (Reshma Abraham:2023)

Image:2 Brahmapuram fire 2023 march

Economic Impact of 2018 Kerala Floods

Since the start of August, Kerala has been experiencing heavy rainfall and flooding, causing significant damage to properties and displacement of people. The extent of the damage is not yet fully known. The five districts that have been hit the hardest out of the 14 in the state are Idukki, Ernakulam, Kollam, Kottayam, and Pathanamthitta. These districts have a combined population of approximately 11.09 million, which accounts for almost 30% of the total population of the state **(Rucha Ranadive:2018).** There were almost 330 landslides, which led to an expected economic loss of more than INR 31,000 crore **(NDMA:2018).** The floods in 2018 resulted in an economic cost of $3.1 billion. The most notable financial impact was the damage caused to residential and commercial properties, including their contents and motor vehicles, totaling around $2 billion**. (Kavita Chacko 2018**). According to the National Disaster Management Authority's 2018 report, 20774 houses were affected by floods, with 1186 being fully damaged and 19588 being partially damaged. The floods also caused the loss of 361 lives and 775 villages were affected.

Table 3
Economic loss incurred due to the 2018 flood

Sectors	Loess (in Rs crore)
Argo-based industry	1216.5
Financial services	549.1
Hospitals	161.5
Roads and Transportation	656.7
Hotels and shopping complex	161.5
Mining and quarrying	75.4
Real estates ownership	1725.7

Sources: Acquit rating of research

The floods in Kerala in 2018 caused devastating economic damage. Agriculture lost 1,216.5 crore rupees, banking lost 549.1 crore rupees, hospitals lost 161.5 crore rupees, and critical infrastructure lost 656.7 crore rupees. The tourist and retail industries suffered, and real estate was hit the hardest with losses of 1,752.7 million rupees. Initiatives to rebuild and increase resilience are desperately needed to safeguard Kerala's future. Kerala is struggling to make ends meet (Sreekumar;2017). Due to a severe revenue imbalance and debt load, it is unable to finance capital expenditures. After the recent floods, they are now in even more financial trouble, and it'sprobable that they may make less money if the government spends more on relief and recovery. This will lead to an increase in both the fiscal deficit and the shortfall in income. The state could also need to increase its market borrowing in order to cover the costs of the floods (Manisha Sachedev: 2019).

Table 4
Forecasts of CO_2 Emissions and tree cover loss in Kerala

Year	Tree cover loess (Ha)	Co2 emission (Mt)
2024	3.4536	667698
2025	2.7058	697832
2026	1.958	727966
2027	1.2102	758100
2028	0.4624	788233.8

Source: Author's calculation from Global Forest Watch

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Rising CO_2 emissions and increasing tree cover in Kerala have a positive correlation. As a result, it is essential to reduce carbon emissions from industry and transportation and increase forest cover through sustainable practices like afforestation and reforestation to combat climate change both in Kerala and globally. Rising CO_2 emissions and increased tree cover in Kerala have a positive correlation. As a result, it is essential to reduce carbon emissions from industry and transportation and increase forest cover through sustainable practices like afforestation and reforestation to combat climate change both in Kerala and globally.

Externalities Theory Integration

The study matches up with the idea of externalities theory, which talks about how certain actions affect the people directly involved and have wider effects on society and nature. In this situation, the effects that spread out are bad outcomes caused by CO_2 emissions and what comes from them. These bad effects, caused by things like burning fossil fuels and cutting down forests, create problems like climate change and disasters that do not just impact the ones responsible butalso many other people. Because normal market rules do not include the costs that hurt society and the environment, they end up not working well. This is called a market failure. The study's discoveries show that trees also decrease when there is more CO_2 in the air. This points to how harming the environment affects the economy. This connection highlights a big idea in externality theory: We need to change how markets work when actions affect more than just the doer. As CO_2 increases, tree cover loss increases, and this makes problems worse, causing more issues for the environment and the economy. The study examines the severe impact of the 2018 Kerala floods on both nature and the economy. It also predicts the future impact of CO_2 and treesin Kerala while emphasizing the need for immediate action to combat these issues. The study advocates for implementing rules such as carbon pricing to encourage people to be environmentally responsible. When the study uses the idea of externalities, it helps us see how CO_2, floods, and money problems are all tied together. It explains how the market can mess up when people do not think about how their actions hurt others. It says we need to make rules to fixthese problems, like making sure we pay for the bad things we do to the environment. The study reminds us that everyone needs to work together to make sure Kerala's future is good for everyone.

Findings and Recommendations

The study looks at how natural disasters, CO_2 emissions, and their consequences on Kerala's economy are related. It highlights the need for reforestation and sustainable land use by demonstrating a causal link between CO_2 emissions and a decline in tree cover. The necessity forrenewable energy sources is highlighted by the energy sector's contribution to growing carbon emissions, notably the burning of fossil fuels. Urbanisation and industrialization also result in higher CO_2 emissions per person, necessitating extensive measures to manage energy use and lower emissions. The 2018 Kerala floods served as a reminder of the value of readiness for emergencies, resilient infrastructure, and effective disaster management strategies. The research suggests public awareness and education campaigns, reforestation, renewable energy, energy efficiency, integrated disaster management, and sustainable urban planning as solutions to these problems. These programs will boost Kerala's biodiversity and ability to withstand extreme weather and reduce carbon emissions.

Conclusion

This study shows the link between CO_2 emissions, natural disasters, and economic effects in Kerala. It emphasizes the need for environmental conservation and renewable energy sources. Managing energy consumption and promoting sustainable urbanization is crucial for a greener future. Investing in disaster

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preparedness and effective management strategies is essential for economic stability. Collaboration among policymakers, communities, and stakeholders is necessary to address challenges and secure a prosperous future for Kerala.

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