Dean&Francis
ISSN 2959-6157

Research for Global Carbon Emissions Influence Factor and Sustainable Reduction

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Abstract:

Today, carbon emission pollution is particularly serious. Greenhouse gases are produced all the time in every part of people's lives, which directly leads to catastrophic global warming. Controlling carbon emissions is related to the fate of the entire earth, and countries around the world need to study the most effective and lowest-cost emission reduction methods as soon as possible. In this regard, this article comprehensively reviews the factors affecting global carbon emissions and analyzes the rising trend of carbon emissions in recent years. The article focuses on the mechanisms of major sources of carbon emissions such as transportation, urbanization, and industrial production, and their impact on the environment. The study found that the combustion of fossil fuels produces a large amount of carbon dioxide emissions and forest reclamation is the main reason for the increase in greenhouse gas concentrations, which directly leads to climate change. In addition, the article also analyzes the potential impact of urbanization. This article emphasizes the importance of reducing carbon emissions through global cooperation, technological innovation, and policy intervention to promote sustainable development.

Keywords: Carbon emissions, economic growth, population urbanization, environmental pollution, industrial production

1. Introduction

Global climate change is a result of the world economy's growth and the ongoing rise in carbon emissions. Global carbon emissions have been increasing since 2020, with energy producing the largest daily average emissions, which can reach 40 Gt [1]. Scientists note that the survival and sustainable development of both humans and nature are significantly impacted by extreme weather events—such as high temperatures, heavy precipitation, and natural disasters—caused by carbon emissions. Serious crises for endangered creatures have been exacerbated by issues including forest dieback, abrupt changes in ocean circulation, and the Antarctic ice sheet collapsing. To avoid irreversible disasters on the earth, countries need to study strategies, specify corresponding strategic plans and take effective measures,

ISSN 2959-6157

and people must also do something.

Countries all over the world place a high value on the development of carbon emissions to support biodiversity and the peaceful coexistence of humans and nature [2]. China, for instance, has set up a national carbon emissions trading market. Businesses are incentivized to lower their carbon emissions through the carbon emission quota trading mechanism. China has also aggressively encouraged the use of renewable energy sources and progressively decreased its reliance on fossil fuels that are not renewable. In recent years, researchers have gradually turned their attention from the conventional domains of industry, agriculture, and transportation to new factors that influence carbon emissions, such as urbanization, industrial production, and economic development and transportation [3]. For example, Wang et al. analyzed China's energy consumption structure through an energy flow model and provided ways to improve energy efficiency in different fields [4].

Transportation carbon tracking and new energy control are two examples of carbon reduction strategies that can effectively reduce emissions to a certain extent in the economic and transportation sectors. However, they may also have an impact on people's daily lives and come with significant costs and limitations. Effectively reducing carbon emissions while maintaining economic and transportation development should be the ultimate objective; this is still a long research road for all nations.

The Kuznets curve, energy flow diagram, and combined time series analysis of current carbon reduction initiatives and their limitations are some of the analytical techniques used in this paper. To suggest an efficient route for reducing emissions and serve as a guide for future sustainable development, this study will thoroughly examine international collaboration, technology advancement, and legislative intervention.

2. The Mechanisms and Current Situation of Carbon Emissions

2.1 Mechanisms of Carbon Emissions

Fossil fuel burning and changes in land use, especially extensive deforestation, are the primary sources of carbon emissions. Burning coal, oil, and natural gas releases carbon dioxide (CO_2), the primary component of greenhouse gases, which can directly cause climate change and an increase in global temperatures.

The main consequences of carbon emissions can be seen in the increasing frequency of extreme climate events including heat waves, floods, and sea level rise. About 18% of species are predicted to be in danger of going extinct if global temperatures increase by 2°C, according to the Intergovernmental Panel on Climate Change's (IPCC) 2014 "Impacts, Adaptation, and Vulnerability: Regional Aspects" report [5]. Furthermore, carbon emissions worsen air pollution, particularly in cities, which raises the risk of cardiovascular and respiratory illnesses. According to the World Health Organization, diseases linked to air pollution claim the lives of 7 million people worldwide each year. According to the International Monetary Fund (IMF), climate change costs the world economy between 1% and 2% annually [6, 7].

2.2 Current Status of Carbon Emissions

Based on data from the Global Carbon Budget, Figure 1 shows the trend of per capita carbon emissions from 1999 to 2020. The vertical axis shows per capita carbon emissions (in billion tons), while the horizontal axis shows the year (in years). Figure 1 shows that there is a general increase trend in the tons of carbon emissions per person. There is a significant difference in greenhouse gas emissions between nations, with those with higher incomes and larger populations generating more. China and the US are the two countries that contribute most to the concentration of CO_2. However, some oil-rich countries, like Bahrain and Qatar, actually have the greatest per capita carbon emissions [8, 9].

Electricity, ground transportation, industry, home consumption, domestic and international aviation, and other variables are the primary drivers of greenhouse gas emissions. The transportation and electricity sectors contribute the most to these domains' carbon emissions, particularly because of the world economy's growing energy demand, which exacerbates the problem of environmental pollution and carbon emissions.

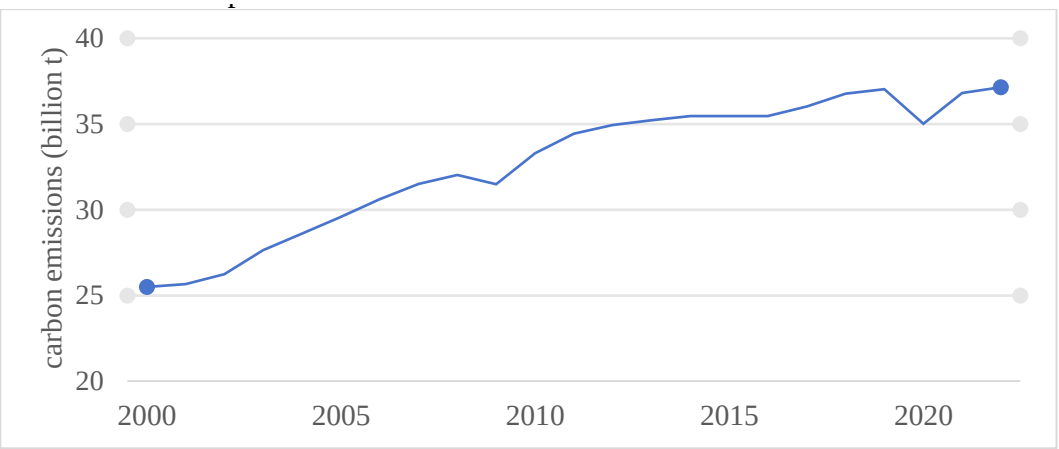

Fig. 1 Line chart of annual total carbon dioxide emissions and change trend (Photo/Picture credit: Original).

3. Factors Affecting Carbon Emissions

3.1 Economic Development and Transportation

The Kuznets curve, also known as the inverted U-shaped curve that Kuznets devised to explain the relationship between national economic development and carbon emissions and personal per capita income (GDP per capita), was the first to reflect the impact of economic development on carbon emissions. The positive relationship between the economy and carbon emissions has been satisfied in recent years, as variations in global carbon emissions essentially follow the Kuznets curve. For instance, the COVID-19 pandemic in 2019 and the SARS outbreak in 2008 both contributed to economic slump and the loss of employment as a result of infectious diseases. Both GDP per capita and carbon emissions fell precipitously and to their lowest points in the following years (2009 and 2020), before picking up their growth pattern again in 2010 and 2021. This pattern is consistent with the first feature of the Kuznets curve, which states that environmental pollution is relatively low in countries with low levels of economic development, increases with per capita income, and the degree of environmental degradation rises with economic growth [10].

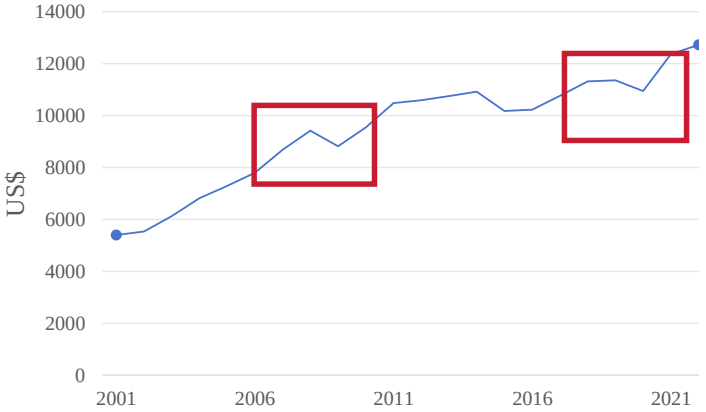

Figure 2 shows the trend of world per capita GDP from 2003 to 2023, showing significant fluctuations between 2009 and 2020 [11]:

ISSN 2959-6157

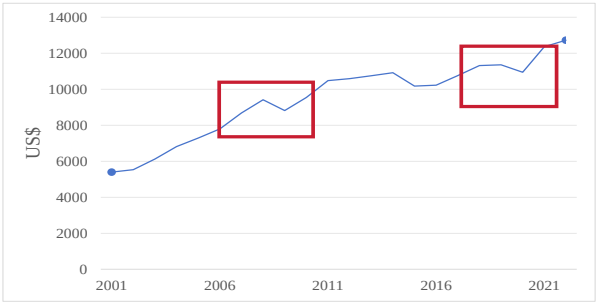

Fig. 2 Trend chart of world carbon emission data from 2001 to 2022 (Photo/Picture credit: Original).

With the advancement of science and technology in many nations and the post-epidemic economic recovery, trade and tourism have gradually expanded in recent years, encompassing both private automobiles and public transportation. Energy consumption has increased as a result of these forms of transportation's heavy reliance on fossil fuels. The International Energy Agency's 2021 study states that about 24% of carbon emissions worldwide are caused by the transportation sector [12]. This demonstrates that the transportation system and global energy structure are crucial for reducing carbon emissions.

Shomik and Tatiana pointed out that transportation is one of the fastest-growing sources of carbon emissions [13]. In 2017, transportation accounted for 23% of energy-related carbon emissions, equivalent to 7.3 gigatons of global carbon dioxide emissions in 2013, an increase of 60% compared to 1990. Among them, road transportation is one of the fastest-growing modes of total transportation carbon emissions [14]. Due to the large amount of carbon dioxide and carbon monoxide produced by burning fossil fuels, the transportation industry has become one of the most serious greenhouse gas emission sectors [15].

As shown in Figure 3, according to the data on the proportion of transportation type relative to total carbon emissions, it can be seen that the proportion of road transportation has increased year by year [15]:

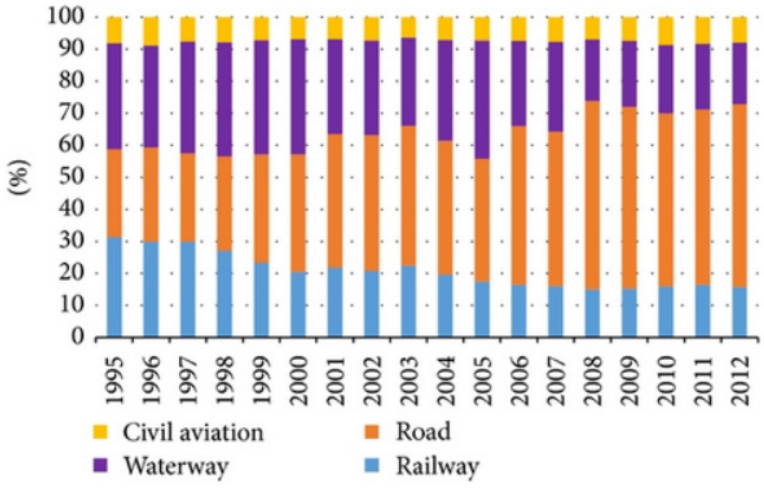

Fig. 3 Carbon emission ratio of transportation (Photo/Picture credit: Original).

According to Shomik and Tatiana, carbon emissions from emerging markets will triple by 2050 if people do not take decisive action and enact pertinent regulations to reduce carbon emissions from environmentally friendly transportation, which could account for as much as 70% of emissions [16]. In addition to escalating the already strong global greenhouse impact, this phenomenon will increase the frequency of extreme weather events and climate anomalies.

3.2 Population Urbanization

There is a complex relationship between population urbanization and carbon emissions. Studies have shown that as the population migrates from rural areas to cities, the initial urbanization is accompanied by a large amount of infrastructure construction and industrialization, and the increased demand for housing, infrastructure, and energy usually leads to further increases in carbon emissions [17]. Tian Jianguo and Wang Yuhai used the spatial panel Durbin model to calculate and study that the lag of population urbanization behind land urbanization will also lead to the dispersion of public facilities, which is not conducive to the reduction of carbon emissions [17]. In general, the world's population urbanization and carbon emissions are currently positively correlated.

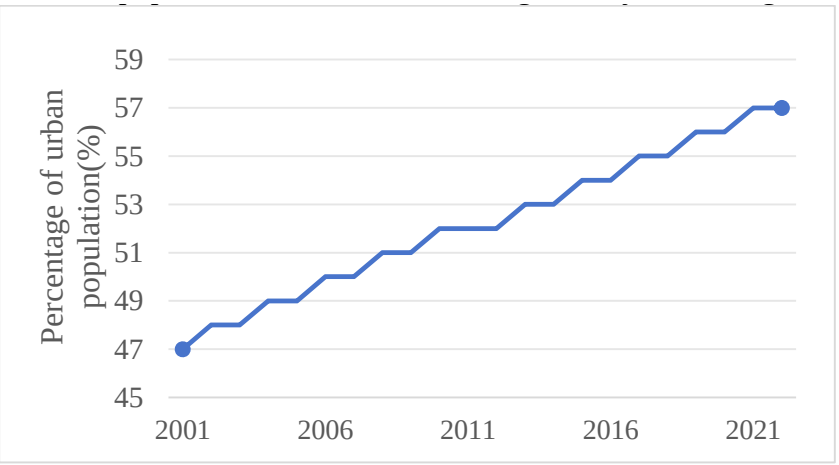

Figure 4 shows that the population urbanization rate is gradually increasing [18].

Fig. 4 Data chart of world urban population proportion (Photo/Picture credit: Original).

Green buildings, sustainable development ideas, and more effective urban management techniques, however, can successfully lower energy use and carbon emissions as the degree of urbanization rises. Urbanization and carbon emissions have an inverse U-shaped link, according to Chinese research. When urbanization increases, carbon emissions first rise but then progressively fall once they reach a certain threshold [19].

The carbon cycle will also be impacted by the sort of people. One of the primary features is aging. Their per capita carbon emissions are comparatively modest since their level of demand and economic activity is lower than that of young people. Age alone has the potential to cut global carbon emissions by 20% over time. Conversely, pertinent research has demonstrated a negative correlation between age and greenhouse gas emissions. Carbon emissions will rise in tandem with productivity. Even while aging lowers carbon emissions, society's productivity is being driven by some new factors. When combined with the global average birth rate and aging, population type has a growing effect on lowering carbon emissions. However, the rate at which population type lowers carbon emissions is faster than the current increase rate of carbon emissions brought on by economic expansion. Current carbon emission data barely shows this development, which is potential.

Therefore, when promoting urbanization, the government should focus on promoting low-carbon urbanization through innovative technologies and policy guidance. Take China as an example. As the world's largest carbon emitter, its urbanization process has led to a significant increase in carbon emissions. However, through policies to promote the application of green cities and energy-efficient technologies, the growth trend of carbon emissions has begun to slow down [19].

Figure 5 shows China's total carbon emissions data. The growth rate of carbon emissions has begun to slow down in the past 10 years [20]:

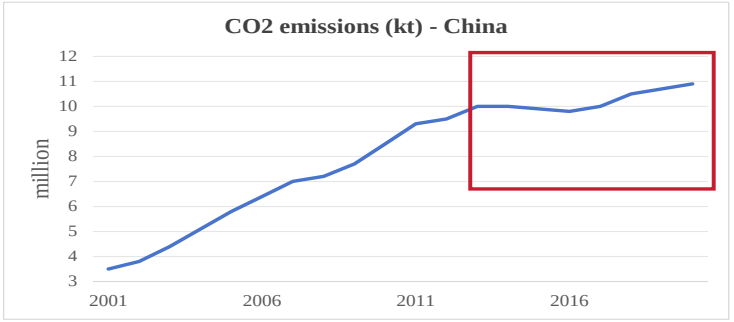

Fig. 5 Total carbon emission data of China (Photo/Picture credit: Original).

3.3 Industrial Production

The steel, cement, chemical, and petroleum refining industries are the primary contributors to worldwide carbon emissions, accounting for about 30% of global emissions, according to data from the International Energy Agency (IEA). The production process of these businesses uses a lot of fossil fuels, and they emit a lot of greenhouse

ISSN 2959-6157

gases, including carbon dioxide [21]. As an illustration, the GCCA notes that the combustion of fossil fuels and the unavoidable chemical reactions that occur during the cement manufacturing process result in approximately 0.9 tons of carbon dioxide being produced for every ton of cement produced. Furthermore, the carbon emissions from the worldwide steel industry make up roughly 7–9% of global emissions. Except for the impact of SARS in 2009 and the impact of COVID-19 in 2019, industrial production has shown positive growth. These industries are often the pillars of development in various countries, but they are also the focus of carbon emission reduction.

Figure 6 shows the growth rate of world industrial production, which is positive except for the years when individual infectious diseases occurred [22].

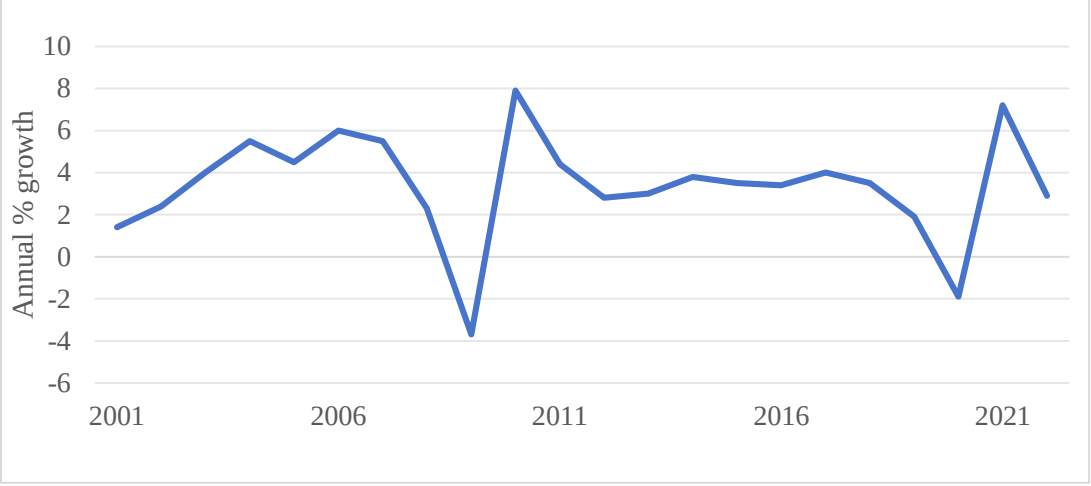

Fig. 6 Growth rate of world industrial production (Photo/Picture credit: Original).

Using the Kaya model in conjunction with the Tapio model, Wang Wenxiu, Yao Qiu, and others found that the secondary industry is the largest contributor to carbon emissions, accounting for up to 85% of total emissions. The tertiary and primary industries follow in order of contribution [23]. Therefore, the key to lowering industrial carbon emissions is innovation and the development of technological advancements such as encouraging the use of renewable energy, increasing energy efficiency, and implementing carbon capture and storage technology (CCS) [24].

More and more nations and businesses are looking into green industrialization routes to reduce carbon emissions as a result of the increased awareness of environmental issues worldwide. For instance, over the last ten years, the European Union has cut carbon emissions in the industrial sector by 20% by implementing more energy-efficient techniques in industrial operations (EEA). However, there are still a lot of obstacles in the way of global industrial emission reduction. Technical and budgetary limitations, for instance, make it challenging to implement green technology on a big scale in underdeveloped nations. To encourage emission reduction in the global industrial sector, international cooperation and knowledge transfer are essential.

4. Solutions

The global problem of carbon emissions requires a coordinated response and solution from multiple parties. The following will discuss specific strategies for emission reduction from three levels: countries, enterprises and individuals, and experts.

4.1 National Aspects

As policymakers and energy managers, countries play a core role in emission reduction. To effectively control carbon emissions, the United Nations points out that the energy sector is the key to carbon emission reduction. The most effective method will be to use renewable energy, such as wind and solar energy, to replace heavily polluting natural gas and coal. Promote the transformation of the energy structure and increase the use of renewable energy to reduce dependence on fossil fuels [25]. Secondly, the government can guide enterprises and individuals to reduce carbon emissions through economic and other promotional means. For example: carbon tax - a certain tax is imposed on each ton of carbon dioxide emitted, increasing the cost of carbon emissions and encouraging enterprises to find more environmentally friendly production methods. Carbon trading - enterprises can trade carbon emission rights in the market through carbon quota trading. At the same time, it is also important to promote and improve

green transportation, encourage electric vehicles, public transportation, bicycles, and walking, and reduce carbon emissions in transportation from people's daily travel methods. At the same time, the government should guide emission reduction by issuing policies such as carbon tax and carbon trading, and even provide subsidies to encourage the public to participate in carbon emission reduction [26].

4.2 Enterprises and Individuals

Enterprises should actively adopt green technologies, improve energy efficiency, and reduce carbon emissions in the production process. For example, enterprises can reduce energy consumption by improving and improving the automation and intelligence of process flows. In addition, the use of clean energy to replace traditional energy is also an important direction. Enterprises need to use environmentally friendly materials and lead a green and environmentally friendly corporate culture. The industrial sector can improve and upgrade carbon capture, utilization, and storage technologies, shift the focus from industrial production to industrial emission reduction, and promote low-carbon industry. At the same time, enterprises can simultaneously promote an environmental culture within the enterprise, by reducing unnecessary business trips saving office electricity consumption, and encouraging employees to reduce their carbon footprint in their daily work. People should also actively adopt green travel methods in their lives and refuse to use disposable plastic products.

4.3 Experts and Scientific Research Institutions

To thoroughly implement the effective implementation of relevant emission reduction measures, it is necessary to establish an expert research group. If the country and the world want to focus on controlling carbon emissions, they need to invest in research and upgrades, make practical plans and strictly supervise their implementation to truly achieve carbon reduction rather than simply calling for and listing feasible measures. Experts can enable countries and companies to more accurately understand emissions through real-time monitoring and analysis of carbon emission data, and evaluate the effectiveness of relevant policies. At the same time, more efficient carbon capture and storage technology is being developed.

5. Conclusion

This paper analyzes the carbon emission problem from multiple perspectives, including the relationship between economic development and carbon emissions, the impact of transportation and industrial production, and the contribution of population urbanization to carbon emissions. Through the discussion of carbon emission mechanisms and the analysis of global data, the results show that the trend of carbon emissions has gradually slowed down in the past 10 years, but the overall level is still very high, and environmental pollution is still one of the serious problems facing mankind. Carbon emissions will lead to global climate rise, major natural disasters, and extreme weather, which seriously threaten human life and health. The world's total carbon emissions have been on an upward trend in the past 50 years, among which energy has contributed the most, most of the energy structure transformation has not been achieved at present, and traditional fossil energy still seriously pollutes the environment. With the continuous development of the economy and the improvement of technology in recent years, the world's demand for transportation has increased, making transportation one of the sectors with the most serious air pollution. Population-type changes have a certain mitigating effect on carbon emissions, but the rate is far less than the rate of increase in carbon emissions, and the problem of air pollution still requires practical action.

This is not only related to the living environment of human beings but also to the survival of ecosystems human beings and the earth. Countries around the world should work together as a human community to solve the problem, study the measures that need to be implemented by different departments and implement them, and achieve carbon emission reduction to the greatest extent to improve the ecological environment and humanity itself. To formulate effective plans, such as developing and promoting low-carbon technologies, and promoting energy transformation. To ensure the continued decline in carbon emissions, statistical research on the efficiency of relevant emission reduction measures and carbon emission rates will be carried out in the future to ensure that the amount of carbon reduction will be greater than the amount of carbon emissions, and the emission reduction measures of various departments will be more strictly supervised and evaluated. Through global cooperation and technology sharing, we will jointly respond to the challenges of climate change and hope to achieve negative growth in carbon emissions to the greatest extent.

References

[1] CarboMonitor. Global real-time carbon data. 2024.

[2] Li Q, Chen J, Zhang P. Study on carbon emission characteristics and its influencing factors of energy consumption in Sichuan Province, China. Environmental Economics and Management, 2024.

ISSN 2959-6157

[3] Zhou D, Chen B, Li J, Jiang Y. China's economic growth, energy efficiency, and industrial development: Nonlinear effects on carbon dioxide emissions. Research article, June 1, 2024.
[4] United Nations. Seeking a liveable climate: Net zero commitments must be backed by credible actions. Climate Action Report, 2022.
[5] Hu J, Wu J, Zhao C, Wang P. Challenges for China to achieve carbon neutrality and carbon peak goals: Beijing case study. 2021.
[6] IPCC. Climate change 2014. 2014.
[7] World Health Organization. Ambient (outdoor) air pollution. Fact sheet, 19 December 2022.
[8] International Monetary Fund. The IMF and climate change. Economic Research, 2024.
[9] Global Carbon Budget. Annual CO2 emissions. 2021.
[10] Lee K, Li J, Wadhwa D. From climate science to global action: Who contributes most to global greenhouse gas emissions? Data blog, 11 October 2023.
[11] Kelly. Economics in Dual Carbon: Environmental Kuznets Curve. Shanghai, January 27, 2022.
[12] World Bank. GDP per capita (current US$). 2023.
[13] IEA 50. Global energy review 2021. April 2021.
[14] Mehndiratta S, Peralta Quiros T. Follow the moving carbon: A strategy to mitigate emissions from transport. Research article, 10 January 2017.
[15] Li W, Li H, Zhang H, Sun S. The analysis of CO2 emissions and reduction potential in China's transport sector. Research article, 19 January 2016.
[16] IEA 50. Global energy & CO2 status report 2019. March 2019.
[17] Mehndiratta S, Peralta Quiros T. Follow the moving carbon: A strategy to mitigate emissions from transport. Research article, 10 January 2017.
[18] Tian J, Wang Y. The impact of China's population urbanization lag on carbon emissions. Urbanization Research, 2019.
[19] World Bank. Urban population (% of total population). 2023.
[20] World Bank. Total greenhouse gas emissions (% change from 1990). 2012.
[21] World Bank. CO2 emissions (kt) - China. 2023.
[22] IEA 50. Global energy-related CO2 emissions, 1990-2021. 20 April 2021.
[23] World Bank. Industry (including construction), value added (annual % growth). 2023.
[24] Wang W, Kuang Y, Huang N, Zhao D. Empirical research on decoupling relationship between energy-related carbon emission and economic growth in Guangdong Province based on extended Kaya identity. Research article, 23 March 2014.
[25] Ritchie H, Roser M. CO2 emission. Environmental Research, January 2024.
[26] United Nations. Seeking a liveable climate: Net zero commitments must be backed by credible actions. Climate Action Report, 2022.