Carbon Footprint and Climate Change: A Global Perspective

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OPEN ACCESS

Keywords

Carbon Footprint, Climate Change, Global Warming, Greenhouse Gases, Wood

How to cite this article:

Soumya, B., Pranaswi, D., Jhansi, K. and Ramya, P. 2025. Carbon Footprint and Climate Change: A Global Perspective. *Vigyan Varta* 6(4): 164-167.

ABSTRACT

Climate change is a critical global challenge, primarily driven by greenhouse gas (GHG) emissions from human activities. Among these gases, carbon dioxide (CO_2) is a significant contributor to global warming. The concept of a carbon footprint quantifies the total GHG emissions associated with various activities, making it an essential tool for assessing environmental impact. This study explores carbon footprint calculation methods, emission trends, and potential reduction strategies. A key focus is carbon capture and utilization (CCU) within the chemical industry, which offers a pathway toward carbon neutrality. Additionally, national emission trends highlight fossil fuel dependency and the need for alternative energy sources. Strategies for reducing carbon footprints at both organizational and individual levels include the adoption of renewable energy, energy-efficient technologies, sustainable material choices, and improved waste management. Understanding and mitigating carbon footprints is crucial for fostering a sustainable future and combating climate change effectively.

INTRODUCTION

Climate change is one of the most pressing challenges of the 21st century, and its root cause is closely linked to human activities that release greenhouse gases (GHGs) into the atmosphere. Among the primary GHGs, carbon dioxide

(CO_2) stands out as a key contributor to global warming. The **carbon footprint** refers to the total amount of carbon dioxide and other greenhouse gases emitted by human activities, typically measured in terms of tons of CO_2-equivalents (CO_2e). Understanding and reducing carbon footprints is crucial for mitigating the impacts of climate change.

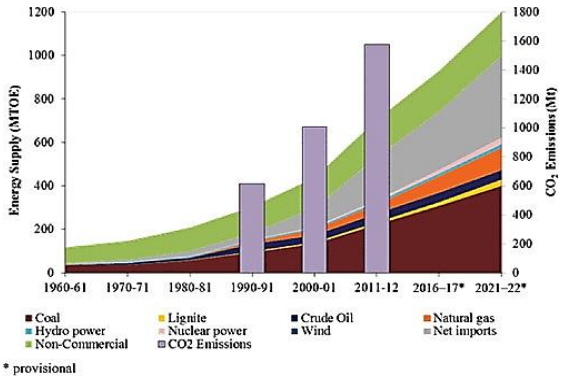
Significance:

Carbon dioxide (CO_2) is a key driver of climate change when released into the atmosphere. However, it can also serve as a carbon source for chemical production through carbon capture and utilization (CCU). This study provides a global assessment of CCU's technical potential to mitigate climate change within the chemical industry. Using an engineering-level model that accounts for 75% of current greenhouse gas (GHG) emissions, we analyze how large-scale CO_2 utilization could transform the sector and reduce emissions. Our findings indicate that CCU could enable a carbon-neutral chemical industry, reducing reliance on fossil resources. However, this transition would require significantly increased material flows and a substantial supply of low-carbon electricity (Kätelhön *et al*., 2019).

National emission trends

The Planning Commission provides data on India's primary energy supply over the years, highlighting coal as the dominant fuel, a trend expected to continue (Figure 1). The combustion of fossil fuels contributes significantly to CO_2 emissions, whereas biomass energy is considered carbon-neutral, and renewable sources along with nuclear power are classified as zero-carbon. The total energy supply accounts for both domestic production and imports of various fuel types, with CO_2 emissions calculated based on these values (Garg *et al*., 2017).

Figure 1: Trends of primary energy supply, by fuel, in Mtoe and CO_2 emissions (Mt).



Carbon Footprint Calculation

A carbon footprint quantifies the greenhouse gases (GHGs) emitted into the atmosphere due to human activities such as transportation, energy consumption, industrial processes, and deforestation. These emissions are typically measured in carbon dioxide equivalent (CO_2e) units, which account for the varying warming potentials of different GHGs. To accurately assess a product or service's environmental impact, every stage of its life cycle must be considered from raw material extraction to disposal. This approach, known as a "cradle-to-grave" study or life cycle assessment (LCA), provides a comprehensive evaluation of factors such as GHG emissions, air pollution, water consumption, and energy use. Also referred to as "GHG accounting" or "environmental LCA," this method calculates the emissions generated or embedded at each phase of a product's existence. Various standards and guidelines are available to facilitate this process (Çelekli & Zariç, 2023).

Carbon Footprint Reduction

Reducing carbon footprints is crucial for both organizations and individuals. Various strategies can be implemented to minimize greenhouse gas (GHG) emissions and contribute to a more sustainable future.

❖ **Organizations**

Many businesses are leading the way in carbon footprint reduction through environmental policies and strategic actions. Organizations can develop a carbon management plan, set realistic reduction targets, and implement measures to achieve them. By adopting energy-efficient technologies, optimizing resource use, and investing in renewable energy, businesses can significantly lower their emissions.

❖ **Carbon Footprints of Wood and Other Materials**

Different materials have varying carbon footprints based on the energy required for raw material extraction and manufacturing. Materials such as plastic, metal, and concrete have positive carbon footprints due to their high energy demands. In contrast, wood has a negative carbon footprint because trees absorb and store carbon dioxide during growth. The emissions associated with harvesting, transporting, and processing wood are minimal compared to the total amount of carbon stored within it. This means that even after accounting for energy use in processing, wood remains a sustainable choice that reduces overall GHG emissions when compared to non-wood alternatives (Kumar *et al*., 2014).

Reducing one's carbon footprint means minimizing greenhouse gas emissions, which can be achieved through various lifestyle changes. Using renewable energy, adopting energy-efficient appliances, and cutting down on meat and dairy consumption are effective ways to lower emissions. Choosing public transportation, walking, or biking instead of driving, as well as practicing recycling, further contributes to a smaller carbon footprint. Waste management also plays a key role in reducing greenhouse gas emissions. Organic waste in landfills decomposes and releases methane, a powerful greenhouse gas, and incinerating waste can also produce methane. However, recycling and composting help reduce landfill waste and methane emissions. Additionally, producing materials through recycling and composting generally results in a lower carbon footprint than manufacturing new materials. Adopting sustainable waste management practices is essential for cutting emissions and combating climate change.

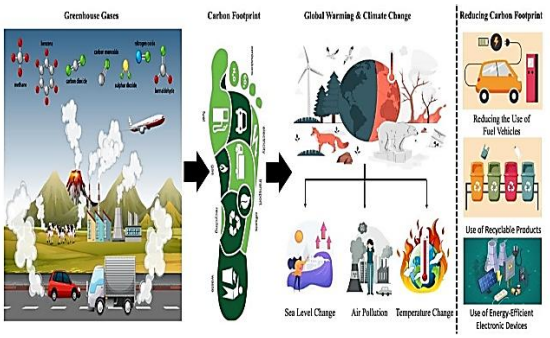


Figure 2: Carbon footprint context path (Source: Celekli & Zariç, 2023)

CONCLUSION

Advancing the methods for evaluating environmental impacts is essential for effectively addressing climate change and safeguarding the health of our planet. By developing more thorough and consistent systems for measuring carbon footprints and expanding the scope of assessments to include a wider range of environmental factors, we can gain a deeper understanding of the true ecological cost of human activities. The integration of more comprehensive data, interdisciplinary approaches, and innovative technologies will enable more accurate and reliable environmental assessments. These efforts are not only crucial for reducing greenhouse gas emissions but also for mitigating broader environmental issues such as biodiversity loss, resource depletion, and pollution. In the end, these actions will play a pivotal role in reducing the negative effects of climate change, promoting sustainability, and ensuring a healthier and more resilient planet for future generations.

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