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6. Carbon Footprint: An Assessment on its Impact and Prospective Implication

Rashmi Sharma

Department of Physics,
Govt.T.C.L.PG.College,
Janjgir (C.G.), India.

Manendra Mehta

Department of Physics,
Govt.E.R.R.PG. Science College,
Bilaspur (C.G.), India.

Lokeshwar Patel

Department of Physics,
Govt.L.P.P. College,
Sarangarh (C.G.), India.

Abstract:

Today in a sustainable development society, Greenhouse gases such as sulfur dioxide, nitrogen dioxide, and carbon dioxide have been identified as the main reasons for global climate change, and these reasons received significant global attention. Among these gases, carbon dioxide is considered one of the prominent greenhouse gas (GHG) and the main component contributed to GHG, which motivated researchers to explore carbon reduction and mitigation strategies. ***The total amount of emission of greenhouse gases (including carbon dioxide) generated by our actions*** *is expressed as their carbon footprints. The assessment and methodologies for carbon footprint calculations are still evolving, and it is emerging as a significant tool for greenhouse gas management. Several researchers have worked in this domain that identifies the cause of carbon emission and also reported and implemented the carbon mitigation and reduction strategies. The present study focuses on the concept, major sources of carbon emissions, calculations, and reduction of carbon footprints. Furthermore, this also describes the schemes to reduce carbon emissions and provides the basis for future assessment of carbon capture and utilization processes.*

Keywords: *Carbon footprint, Greenhouse Gas, Carbon dioxide.*

6.1 Introduction:

In a sustainable development society, the concept of sustainability is based on economic, environmental, and social dimensions. The concept of sustainability in the world means a Green World that can be free from pollution. One of the green world assessments is the

carbon footprint [1-3]. A carbon footprint is the total amount of greenhouse gas emissions (including carbon dioxide and methane), that are generated by our actions. In other words, **the carbon footprint is the number** of emissions of carbon dioxide (CO_2) associated with all the activities of a person (e.g., building, corporation, country, etc.). It also includes direct emissions, such as processes involved from fossil-fuel combustion in manufacturing, heating, and transportation, as well as emissions required to produce the electricity associated with goods and services consumed. Recent research studies on the low-carbon issue focused on emissions accounting and reduction, carbon emissions trading platform, carbon tax, and carbon emission policy [4-7] have made a lot of interest and achievements. The carbon footprint and its evolution are one of the most basic and crucial research in low-carbon research studies.

The main causes of greenhouse gas emissions are human activities (fossil fuel usage in electricity and other byproducts of manufacturing), which increase the earth's temperature due to the absorption of the earth's atmosphere [8]. The significant parameter that affects such activities may include climate changes, such as extreme precipitation and acidification, and the warming of oceans. Since the start of the Industrial Revolution in the 1820s, Climate change has come into existence. Due to humans' heavy reliance on fossil fuels, energy usage, and constant deforestation, the amount of greenhouse gas continuously increases in the atmosphere, which makes reducing a greenhouse gas footprint harder to achieve [9].

Figure 6.1: Different Sources of Carbon Footprint

6.2 Concept of Carbon Footprints:

The carbon footprint is a measure of human demand on the Earth's ecosystems and originates from the concept of ecological footprint, which was developed by William E. Rees and Mathis Wackernagel in the 1990s. It is one of the standardized measures of demand for natural capital, and to regenerate that may be contrasted with the planet's

ecological capacity. It represents the amount of biologically productive land and sea area which is used to supply the resources to be consumed by the human population and assimilate the associated waste. Carbon footprint is one of the ways to indicate the family of footprint indicators, which also include ecological footprints, water footprints, and land footprints [10]. A concept given by Wiedmann *et al.*: the carbon footprint is the standard measure of the total amount of carbon dioxide emissions directly and indirectly caused by an activity or accumulated over the life stages of the product. At present condition, the carbon footprint is a measure of carbon dioxide emissions [11-12]. Carbon dioxide is one of the greenhouse gases (GHG), and the main component contributed to GHG, which is around 30%, followed by CH4 and N2O [13-14]. The amount of GHG expressed by carbon dioxide or Global Warming Potential (GWP). That is a combination of a GHG impact based on radiation power and the length of time GHG is in the atmosphere [15].

6.3 Knowledge of India's Carbon Footprint:

The increasing contribution of India to global emissions strengthens the need of understanding the underlying drivers of its emissions and how these are subject to change in response to future economic, social, and policy changes. Since 1970, Kanemoto et al estimated that India's carbon footprint has increased sevenfold [16]. According to the analysis by IEA (2019), between 2017–18 India's carbon emissions also grew at a higher rate (4.8%) than China (2.5%), the USA (3.1%), and the EU (-1.3%) [17].

Different consumption patterns for food [18], transport [19], and energy use [20] are the important estimated factor of household carbon footprints in India and remains limited on several parameters. Firstly, the carbon emissions of Indian households have mainly been analyzed within a municipal or national context, omitting analysis of emissions embodied in imported goods and services upon which the country is reliant [21]. Second, household-level carbon foot printing is often confined to specific consumption

sectors, potentially underestimating their total CF [22]. Third, global, multi-sectoral CF assessment of Indian households is only observed for a few cities, preventing identification of critical policy priorities for emissions abatement by city and region [23-25].

The basis of the Carbon Footprint assessment affected a system of integrated economic and environmental accounts which enables the allocation of production activities, and their associated carbon emissions to final consumption sectors, through complex and globalized supply chains. The evaluation of household carbon emissions within a consumption-based accounting framework depends on two main reasons. First, in contrast to production-based carbon accounting, consumption-based carbon foot printing captures supply-chain-wide emissions associated with household spending and allocates responsibility for national imports and exports accordingly.

Such an allocation is an important parameter for an Indian context due to its substantial exports which are not driven by consumption habits across its population [26]. Second, consumption-based accounting captures indirect emissions associated with household consumption activities which estimated to account for 85% of household carbon footprints in India [27].

6.4 Types of Carbon Emission:

The concept of carbon emission scopes was introduced by the Greenhouse Gas Protocol (GHG Protocol). The GHG Protocol is one of the most widely used international accounting tools for government and business leaders to measure, quantify and understand greenhouse gas emissions (GHG). Different emission scopes aim to improve transparency and provide utility for different types of organizations, different types of climate policies, and business goals. These are also useful for making different GHG accounting and reporting methods [28].

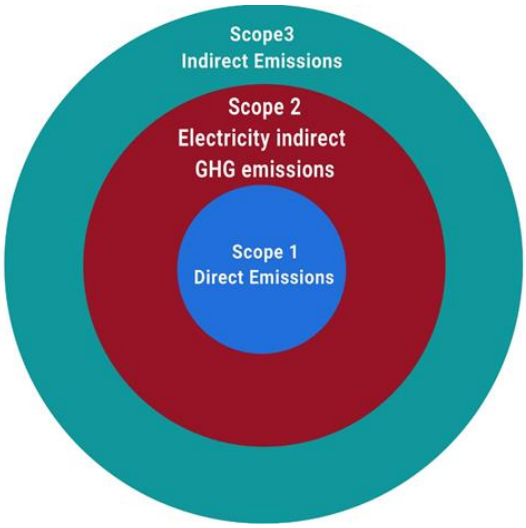

Figure 6.2: Scope 1, 2, and 3 Direct and Indirect Emissions

- **Scope 1: Direct Emissions:**

Direct GHG emissions occur from such sources, owned or controlled by the company, for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.; emissions from chemical production in owned or controlled process equipment. This does **not** account for the direct CO2 emissions from the combustion of biomass.

- **Scope 2: Electricity indirect GHG emissions:**

Scope 2 accounts for GHG emissions from the generation of purchased electricity, steam, and heating/cooling consumed by a company. These emissions physically occur where there is the facility of generation of electricity, steam, and cooling or heating. But as a user of the energy, the consuming party is still responsible for the emission of greenhouse gases that are being created.

- **Scope 3: Indirect Emissions:**

Scope 3 Emissions are optional category emissions sources that are not owned and not directly controlled by the reporting company. However, these emissions are the

consequences of the company's activities. This is usually considered to be the supply chain of the company, so emissions are caused by vendors within the supply chain, outsourced activities, and employee travel and commute.

6.5 Calculation of Carbon Footprint:

An individual's, nation's, or organization's carbon footprint can be measured by undertaking a GHG emissions assessment[29], a life cycle assessment, or other calculative activities indicated as carbon accounting. Once the size of a carbon footprint is known, a strategy can be developed to reduce those factors that affect the GHG emissions, for example, technological developments, energy efficiency improvements, consumption strategies, better processes, and product management changes Green Public or Private Procurement (GPP), carbon capture, carbon offsetting, and others [30].

Several free online carbon footprint calculators exist for the calculation of personal carbon footprint [31-32] including a few supported by publicly available peer-reviewed data and calculations including the University of California, Berkeley's Cool Climate Network research consortium, and Carbon Story [33-35]. The carbon footprint calculation for industry, product, or service is a complex task. The industry uses the tool Life-cycle assessment (LCA), where carbon footprint may be one of many factors taken into consideration when assessing a product or service. The International Organization for Standardization has a standard called ISO 14040:2006 that has the framework for conducting an LCA study [36] and the ISO 14060 family of standards provides further refined tools for monitoring, reporting, quantifying, and validating or verifying GHG emissions and removals [37]. The average carbon footprint for an individual one in the United States is 16 tons, it is the maximum percentage in all over the world. Generally, the normal carbon footprint is closer to 4 tons. To avoid the global 2℃ rise temperatures, per year the normal global carbon footprint should be drop by 2 tons in 2050.

In developed countries, transportation and household energy constitute the largest component of an individual's carbon footprint. During the first decade of the 21st century, approximately 40 percent of total emissions in the United States were from primary and secondary sources. The primary source included the emission over which an individual has direct control, whether the secondary source included the emissions associated with the consumption of goods and services. It can be used to account for diets that contain meat in higher quantity, and foods that can transport through long distances and require to produce a greater amount of energy and nutrients than vegetables and grains. The manufacturing and transportation of consumer goods are an additional supplier to the secondary carbon footprint. For example, greenhouse gas is emitted from **burning gasoline, driving, burning oil or gas for home heating, or using electricity generated from coal, natural gas, and oil.** Greenhouse gas emission varies among individuals depending on a person's location, habits, activities, and personal choices. A variety of tools exist for calculating the carbon footprints for individuals, businesses, and other organizations. The most commonly used methodologies include the Greenhouse Gas Protocol, from the World Resources Institute and the World Business Council for Sustainable Development, and ISO 14064, a standard developed by the International Organization for Standardization which particularly deals with greenhouse gas emissions.

6.6 Schemes to Reduce Carbon Emissions:

The UK is committed to the Kyoto Protocol – an international treaty that considers climate change and adopts an urgent approach to reducing its greenhouse gas emissions (GHG). These include a collective emission of six important greenhouse gases (GHGs) namely carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), set of perfluorocarbons, and hydrofluorocarbons by at least 5.2% as compared to 1990 level during the period 2008–2012 [38]. The gases covered under the Kyoto protocol are referred collectively to as "Kyoto gases" [39].

The emissions of carbon dioxide and other GHGs into the atmosphere, are often associated with the burning of fossil fuels, like natural gas, crude oil, and coal. Although this emission is injurious to the environment, so carbon offsets can be purchased to reduce these effects. The goal of the Kyoto Protocol is to provide the option to those countries upholding UNFCC to execute methods of setting targets to control and measure the production of greenhouse gases within the country.

Kyoto Protocol aims to provide countries upholding the UNFCCC (United Nations Framework Convention on Climate Change) the option to execute methods of setting targets to control and measure the production of greenhouse gases within the country. This Protocol defines legally binding targets and timetables for cutting the GHG emissions of industrialized countries that ratified the Kyoto Protocol. Accordingly, from an economic or market point of view, one has to distinguish between a *mandatory market* and a *voluntary market.* Typical for both markets is the trade with emission certificates:

- Certified Emission Reduction (CER)
- Emission Reduction Unit (ERU)
- Verified Emission Reduction (VER)

During the Kyoto Conference in 1997, the agreement to reduce GHG emissions was established for stabilizing the gases concentration in the atmosphere. In 2012, this agreement was signed by a total of 192 countries, with an average of 5% compared to the 1990 level. If a country failed to fulfill its reduction target, surpassing the assumed rate, then those countries were forced to buy allowances from countries that have not consumed theirs. Therefore, the mandatory market was built for carbon certificates.

6.7 Factors Affecting Green House Emission (GHG):

The energy industry is one of the main factors that cause the burning of fossil fuels to generate GHG emissions in the atmosphere, so to diminish carbon emissions, enterprises in this area must effectively adopt some technologies and involved themselves in shaping the carbon trading mechanism to be used. Some specialists believe that the market for trading carbon emissions can be a beneficial demarche both for companies and the planet in the long term since it is an efficient and rapid method for emissions reduction in the energy industry [40]. Aichele et al. argue that due to the emergence of carbon leakage, increasing the emissions generated by imports, and carbon emissions reallocation, the Kyoto Protocol has been ineffective or possibly even environmentally harmful [41].

Another cause contributing to GHG emissions is soil pollution, particularly through massive deforestation [42]. To reduce GHG emissions steps forwarded by Romania such as Joint Implementation (JI) projects, in collaboration with other states, to achieve the technology transfer for GHG decreasing and energy efficiency, improvement of environmental quality, and biodiversity conservation. JI projects consist of: the construction of Combined Heat and Power CHP units; use of the low-carbon fuels in industrial equipment and energy production; promotion of non-conventional energy; methane recovery from urban landfills; reducing greenhouse emissions in the sector of agriculture, energy and transport; activities for afforestation and/or reforestation of degraded land [43].

6.8 Impact and Effects:

The carbon footprint harms our environment in many ways: It is the main reason for human-induced climate change, which can contribute to urban air pollution, leads to toxic acid rain, adds to coastal and ocean acidification, and worsens the melting of glaciers and polar ice. That's why Co2 emissions are the main cause of contribution to global warming and climate change and can significantly cause critical impacts and consequences for humans and the environment. The CO2 emissions behave like a blanket in the air, trapping heat in the atmosphere and warming up the Earth [44]. Thus, this layer prevents the Earth from cooling and raises global temperatures. The 2030 Climate and Energy Framework states that approximately 27 percent of energy should be obtained from sustainable energy sources hence productivity and energy efficiency should be increased by 27% [45]. However, there are major challenges in finding the sources of low productivity and efficiencies in sustainable energy.

6.9 How to Reduce Carbon Footprint?

Individuals and corporations can go through several steps to reduce their carbon footprints and thus contribute to global climate mitigation. One can reduce Carbon footprints through improving energy efficiency and changing lifestyles and purchasing habits. Estimated energy consumed by devices in standby mode accounts for 5-10% of residential energy use. So, unplug the electronic devices which are not in use or plug them into a power strip and turn the power strip off. Switching one's energy and making use of public transportation, such as buses and trains, have an impact on primary carbon footprints, and can reduce an individual's carbon footprint when compared with driving. Always purchase items with a comparatively low carbon footprint. Some of the manufacturers have started assessing and publishing their products' carbon footprints. Low carbon technology such as renewable and sustainable energy technologies is an efficient technical strategy for reducing carbon dioxide emissions. It is one of the technologies that has a minimal output of GHG emissions into the environment, specifically for CO2 emissions [46].

6.10 Conclusions:

The carbon footprint is the standard method to measure the total amount of greenhouse gases emitted at the time of the manufacturing, processing, and retailing of consumer goods. All over the world, Carbon pricing initiatives are spreading and planning to implement carbon pricing schemes, with a fairly uniform distribution between emission trading

systems and carbon taxes. The main objective is to maintain our environment green and sustainable for this, **the major sources of emissions of greenhouse gases are to be identified.** Since carbon footprint has a significant impact on our environment, damage wildlife, affect human health and retard economic growth. One individual can take several steps to reduce greenhouse gases and control the carbon footprint by using sustainable energy sources, switching to energy-efficient appliances at home, avoiding waste, etc. There is one better option to reduce the carbon footprint of human activities is to **Reduce, Reuse, Recycle, and Refuse**. Then only we would able to get clean air, water, and food for ourselves and also for the next generations yet to come.

6.10.1 Questions for Review:

- What are main component of greenhouse gases and how it affects the environment?
- Define carbon footprint and important estimated factor of carbon footprints in India.
- Define Kyoto protocol scheme and mandatory market for carbon certificate.
- How the carbon footprint is harmful for our environment and how we can reduce it?

6.10.2 Questions for Discussion:

- What are the factors of green house gases affecting our environment and explain its different sources?
- How we can implement carbon footprint schemes, with a fairly uniform distribution between emission trading systems and carbon taxes?
- How individual ones or organization can measure their carbon footprint?
- What is the better way of reduction of carbon footprint?

6.10.3 Exploring Issues:

As it is discussed in 1997 during the Kyoto Conference, the agreement was established to reduce GHG emissions and balance the concentration of gases in the atmosphere. In 2012, this agreement was signed by 192 countries, with an average of 5% compared to the 1990 level. It is mentioned in the agreement that if a country is failed to fulfill its reduction target, surpassing the assumed rate, then all those countries were forced to buy allowances from countries that have not consumed theirs, and after the mandatory market of carbon, certificates came into existence. So, to reduce carbon emissions and save the environment, human health, and biodiversity, each country should follow the guideline of the above agreement.

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