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The Effectiveness of Personal Carbon Trading for Sustainable Urban Development in Developing Nations: An Overview

Amita Shandilya[1,*], Vivek Agnihotri[2]

Abstract

In recent decades, humankind has evolved much more rapidly than the ages. This evolution resulted in tremendous technological advancement and massive planetary degeneration. Enormous greenhouse gas emissions have resulted from the quick increase in energy and fossil fuel consumption patterns brought on by technological breakthroughs. Eventually, the scenario contributed to rising per capita carbon emissions manifolds, especially in highly populated cities. Reduced per capita carbon footprints are the goal of a number of initiatives being implemented to address this problem, including taxation, incentives, policy recommendations, etc. Personal Carbon Trading (PCT) is an innovative approach to fostering sustainable urban development by assigning individual carbon allowances and enabling citizens to trade emissions credits. The notion encourages urban dwellers to lessen their carbon footprints while raising awareness of climate change by fusing financial incentives with environmental responsibility. Cities can promote a culture of accountability and teamwork by putting PCT mechanisms in place, enabling people to take an active role in sustainability initiatives. This study examines the potential of personal carbon trading to enhance urban sustainability, analysing its implications for local economies, social equity, and behavioural change. The efficiency of PCT in lowering greenhouse gas emissions and encouraging low-carbon alternatives is demonstrated by case studies from early adopters. A thorough summary of PCT's contribution to the accomplishment of urban sustainability objectives is given, together with a discussion of obstacles like legal frameworks, public acceptance, and technology requirements. Finally, this study examines PCT and its useful approach to aligning individual conduct with broader climate objectives, improving the sustainability and resilience of the urban environment.

Keywords: Personal carbon trading (PCT), carbon footprints, GHG, carbon credit, developing nations, sustainable development

***Author for Correspondence**
Amita Shandilya
E-mail: amitashan01@gmail.com

[1]Research Scholar, Department of Architecture and Planning, National Institute of Technology, Raipur, Chhattisgarh, India
[2]Assistant Professor, Department of Architecture and Planning, National Institute of Technology, Raipur, Chhattisgarh, India

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INTRODUCTION

Sustainability aims to restore the interaction between the two most intricate systems on Earth: human civilizations and the natural world [1]. The goal of this idea is to prevent instability or destruction by promoting mutual benefit through the alignment of human progress with Earth's ecological system. Climate change caused by people is one of the most notable instances of this mismatch. Among various environmental concerns, one of the most urgent sustainability challenges is climate change and its effects on the planet's rising temperature. Prominent scientists and activists like Al Gore have drawn attention to the worldwide

threats posed by climate change since the early 1990s. Rising sea levels, more frequent and powerful hurricanes, widespread flooding, prolonged droughts, increased rates of species extinction, and a reduction in the world's food supply are all predicted by many experts and are now happening as the planet's average temperature rises.

Climate change has been attributed to human activity, particularly increases in energy use and greenhouse gas (GHG) emissions. Greenhouse gases are released when fossil fuels are used to power gasoline-powered vehicles, generate electricity from coal, and carry out other related tasks. The concentration of greenhouse gases in the atmosphere has increased by 30% since industrialization as a result of these efforts [1].

Four major variable greenhouse gases that are especially vulnerable to human activity have been discovered by researchers: Methane (CH_4), nitrous oxide (N_2O), carbon dioxide (CO_2), and chlorofluorocarbons (CFCs). The primary greenhouse gases released into the atmosphere are carbon dioxide, nitrous oxide, methane, and fluorinated gases [2].

The planet's temperature is controlled by the atmospheric buildup of greenhouse gases. Besides negatively influencing the environment, ecology, and the health of people, plants, and animals, these gases are responsible for global climate change. International forums and intergovernmental panels have tackled climate change through pilot initiatives, though no efficient solution has yet been devised. This study aims to understand the various mechanisms implemented to reduce environmental footprints and combat climate change as part of efforts towards a sustainable future. The efficiency of personal carbon trading for sustainable urban growth in underdeveloped countries such as India is the specific emphasis of the study.

The study explores the literature background on climate change and carbon market regulations, global and Indian emission scenarios, worldwide strategies and their comparison, challenges in adopting personal carbon trading in emerging economies, and concludes with final thoughts.

LITERATURE REVIEW

Earth's resilience and stability rely on the nine planetary limits, six of which have been crossed by humans. Climate change, freshwater change, bio geochemical flows, land system change, biosphere integrity, and novel entities. This demonstrates the critical need to reassess our impact on the environment and the need for international cooperation in resolving these serious problems.

Defining Safe Limits and Understanding Planetary Boundaries

Planetary borders are comparable to vital indicators of human health, such as blood pressure. The risk of generating irreversible environmental problems grows as planetary boundaries are crossed, much as the risk of heart disease is increased by hypertension. The framework for planetary boundaries was presented in 2009 and is a dynamic system that outlines the safe ecological bounds that mankind should operate inside. This paradigm has to change to reflect our growing understanding of Earth's complex systems and human effect [3].

Boundaries Violated and Their Repercussions

- *Atmospheric carbon dioxide concentration:* Significant climate change is being caused by the current level of 417 ppm, which is more than the safe limit of 350 ppm.
- *Land system change:* With only 60% of the original forest cover remaining, compared to the intended preservation of 75%, significant effects on land systems are evident.
- *Biosphere integrity:* Millions of plant and animal species are in grave danger as the extinction rate has risen to 100 per million species-years, much above the safe limit of 10.
- *Freshwater change:* Limits for both green (plant-accessible) and blue (surface and groundwater) water supplies have been surpassed, adversely affecting ecosystems.

- *Biogeochemical flows:* Safe limits for nitrogen and phosphorus flows have been exceeded, leading to severe consequences for biodiversity and water quality.
- *Novel entities:* Threats notably aerosol loading, ocean acidification, and stratospheric ozone depletion have been introduced as a result of the crossing of the global threshold of zero for novel things [4].

All planetary boundary breaches are linked to energy usage and emission patterns. To address these, the approach must shift from merely determining problems to active regeneration. This entails lessening environmental impact and boosting the usage of renewable energy. This shift requires an understanding of consumption and emission patterns.

METHODOLOGY

The comprehensive research on personal carbon trading to obtain urban sustainability comprises a secondary data collection method to understand the consumption and emission pattern by qualitative analysis and its implications for local economies, social equity, and behavioural change through the comparative regulatory framework of personal carbon trading. Examining global solutions for increasing

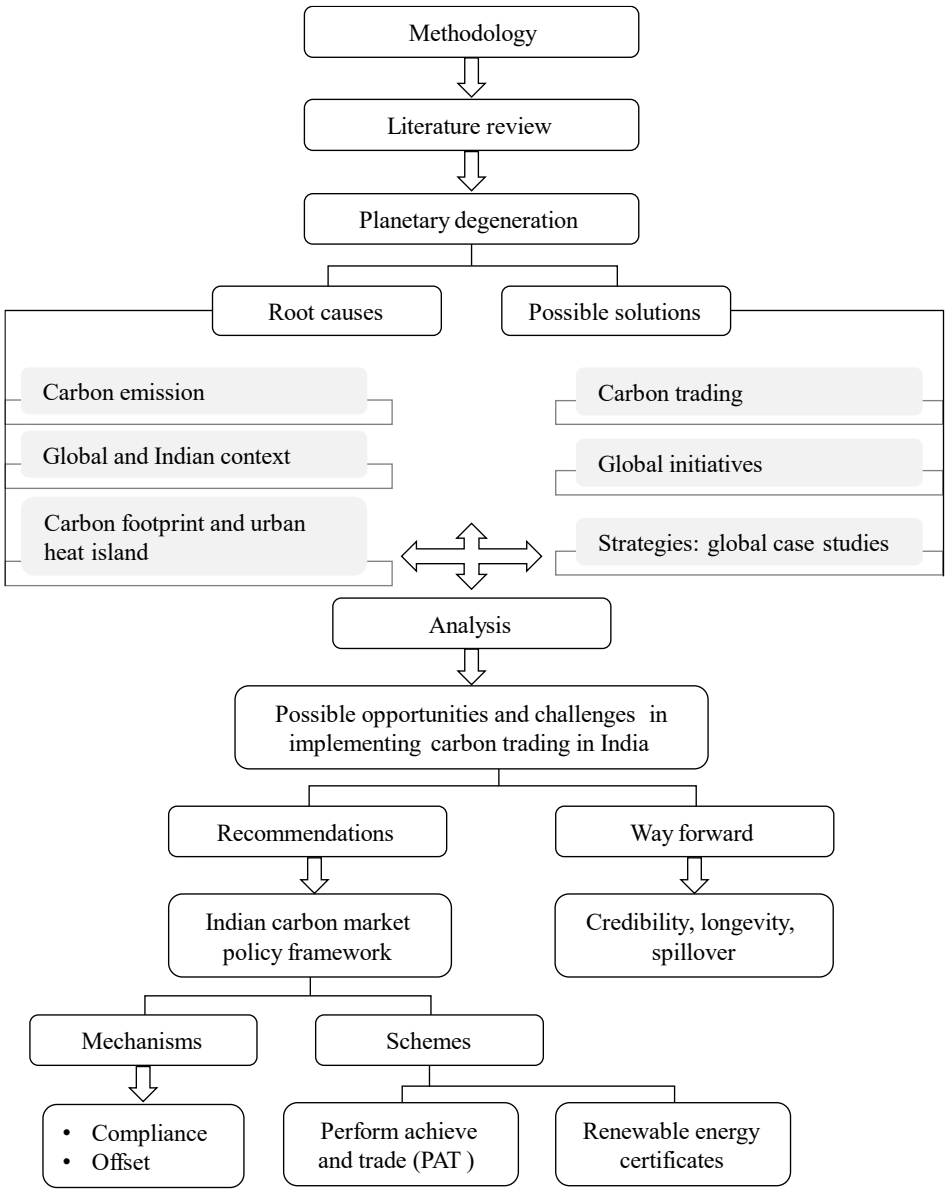

Figure 1. Methodology.

carbon emissions and their adopted tools based on schemes and policies for creating effective and transparent mechanisms involves addressing public acceptance challenges and technological requirements. To accomplish the broader climatic objectives, the research makes sure that effective policy suggestions adhere to the aforementioned action-oriented techniques that involve individual actions with workable solutions (Figure 1).

CARBON EMISSION

The primary cause of the current climate shift is human-induced emissions of greenhouse gases. Carbon dioxide and methane are released into the atmosphere as a result of burning fossil fuels, producing steel, cement, and polymers, and growing food for human use [5].

Reform is required in the food, industrial, and energy sectors to lower emissions and address energy poverty. Clean energy is now more widely available thanks to advancements in technology and the declining costs of solar, wind, and batteries, but quick decarbonisation requires political backing. Many countries have effectively lowered their emissions, demonstrating that low-carbon growth is achievable without following a high-carbon path, even when emissions are rising in some sectors [6].

Global Average Temperature

The mean temperature worldwide compared to a reference point, as shown in Figure 2, is the mean value from 1961 to 1990. Since then, average temperatures have increased by more than 0.8°C. With 1850 temperatures being about 0.4°C colder than the baseline, it can be seen an overall increase in temperature of almost 1.2°C over pre-industrial periods. Global warming has not affected everyone in the same way. The Northern Hemisphere has warmed more than the Southern Hemisphere. Furthermore, there has been an especially strong warming at the poles. In some locations, the temperature has risen by over 5°C. This change is mostly the result of human emissions. Aerosols have cooled the global climate, and the role of natural variability has been negligible [7].

Per Capita CO_2 Emissions

Fossil emissions are the amount of carbon dioxide (CO_2) emitted from the burning of fossil fuels and during direct industrial processes like the production of cement and steel. Fossil CO_2 emissions include those from flare, cement, steel, coal, oil, and gas. Vegetation, soil erosion, land use change, and deforestation are not taken into account, as shown in Figure 3. Fossil emissions of the United States lead the world in carbon dioxide (CO_2) emissions with 14.9 t, followed by China and world emission (8 t), the United Kingdom (4.7 t), and India (2 t) [8].

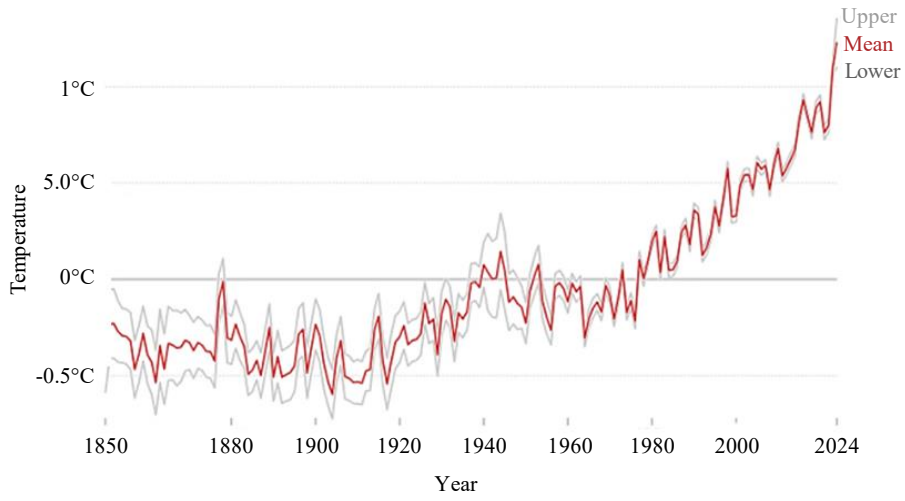

Figure 2. Global average temperature.
(Source: Global Carbon Budget 2023).

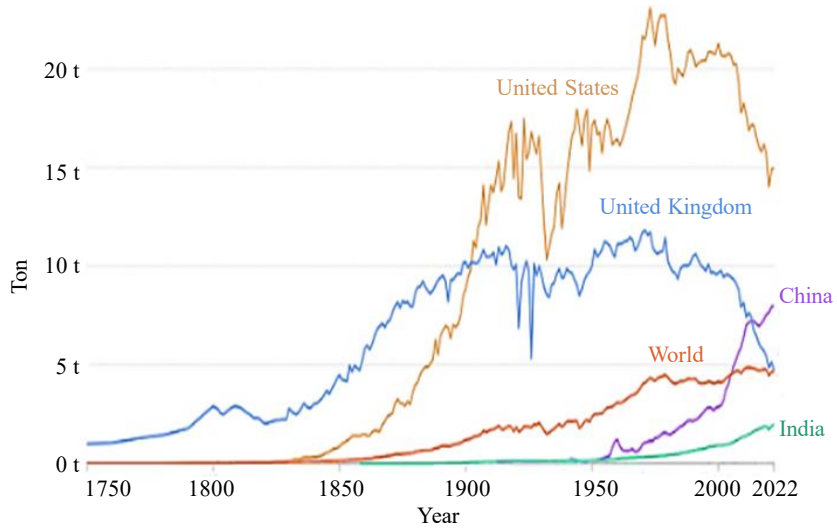

Figure 3. Per Capita CO_2 emissions.
(Source: Global Carbon Budget 2023)

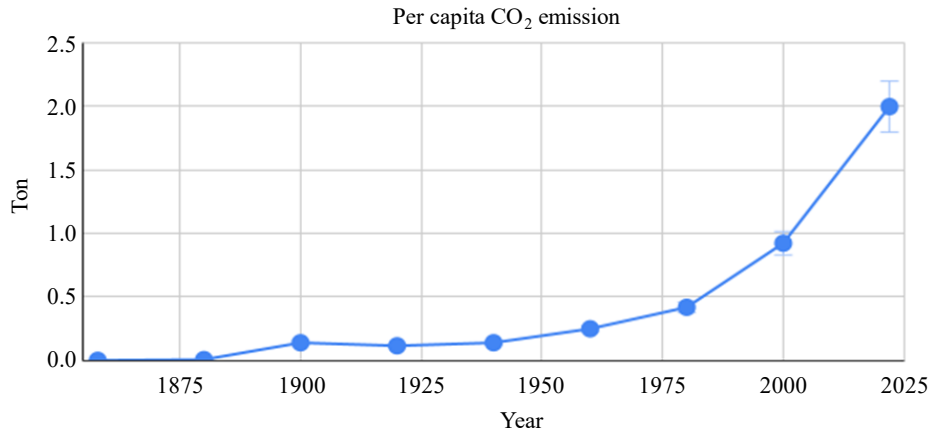

Figure 4. Average person CO_2 emission.
(Source: Global Carbon Budget 2023)

How Much CO_2 Does the Typical Indian Emit Per Person?

A standard method for comparing nations' climate change contributions is through annual emissions estimates, as shown in Figure 4. However, this statistic often reflects variations in global population sizes. To understand the average person's impact, a per capita emissions analysis is more appropriate.

CO_2 Emissions from Fossil Foils and Land Use Change

China has the most absolute changes between 1850 and 2022, as Figure 5 illustrates. Additionally, the United Kingdom has the fewest absolute changes in land use. Because of industry and the usage of fossil fuels, the United States and the United Kingdom have seen the biggest absolute changes in emissions. In contrast, China and India have experienced directly increased variations in 2022 [8].

India: What is the Country's Annual CO_2 Emissions?

The "production" or "territorial" emissions, that is, emissions from burning fossil fuels or making cement inside a nation's borders, are the basis for these numbers. Traded goods emissions (consumption-based emissions) are not taken into account. CO_2 emissions, in contrast to overall greenhouse gas emissions, the Figure 6 focuses only on CO_2 emissions. As presented in the Figure 4 per capita, population size largely influences annual emissions [8].

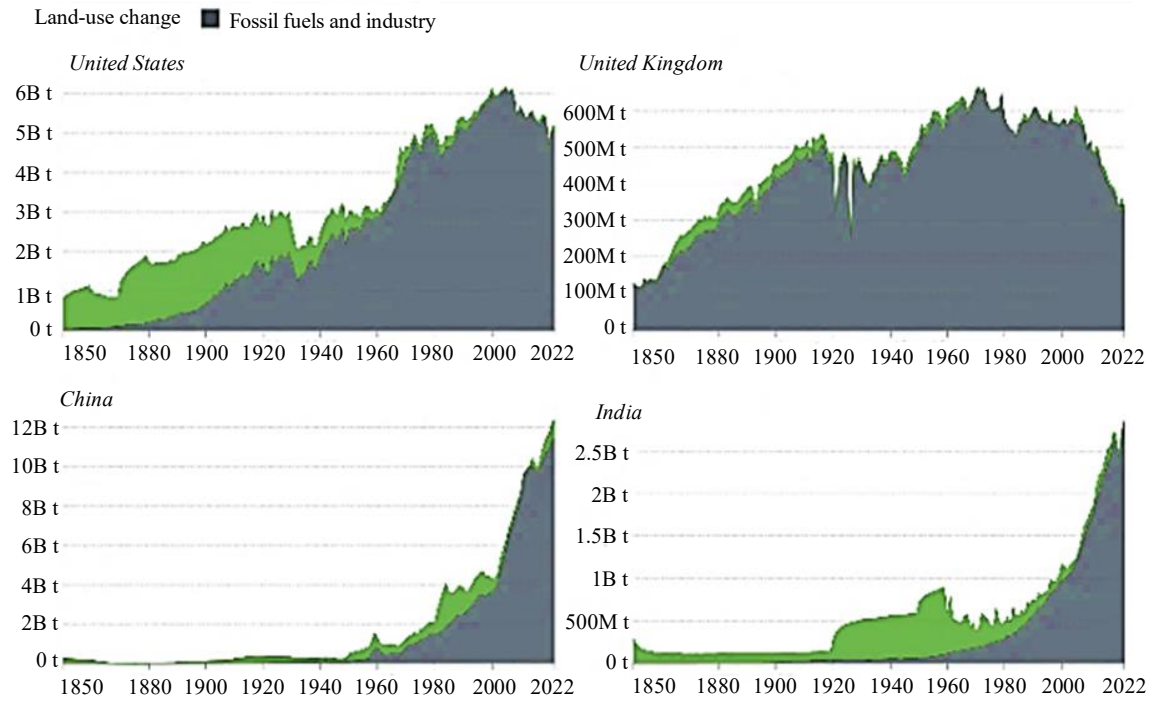

Figure 5. Annual CO_2 emissions from fossil foils and land use change.
(Source: Global Carbon Budget 2023)

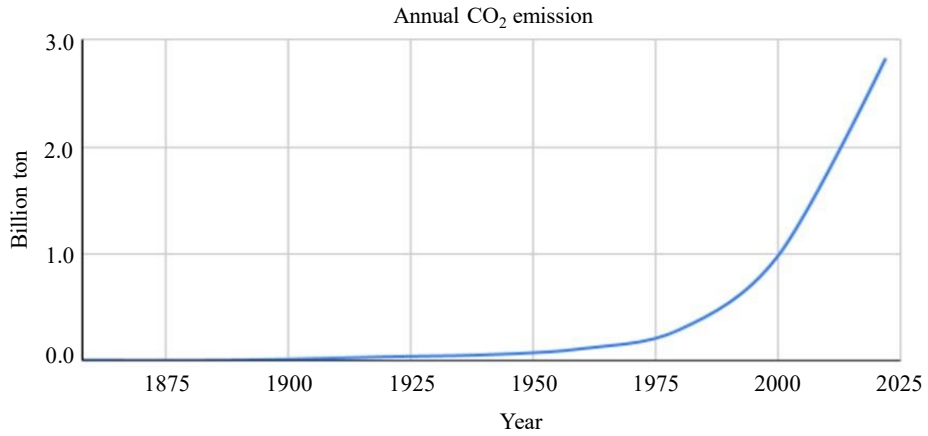

Figure 6. Annual CO_2 emissions.
(Source: Global Carbon Budget 2023)

Carbon Footprints and Urban Heat Islands

Since 2022, carbon footprint emissions have surged to previously unheard-of heights, reaching the startling milestone of 37.1536.8 billion tonnes. According to forecasts, emissions increased by 1.1% in 2023 and peaked at 37.55 mega tonnes of CO_2, setting a new record for world emissions. In light of this concerning number, it needs to comprehend the causes and mechanisms behind these high emissions. It may gain a more concentrated understanding of carbon emissions and consider ways to modify and lessen the impact of these detrimental emissions by looking at the nations with the most significant carbon footprints. In order to determine which 10 nations, have the most significant carbon emissions, this study will concentrate on the most recent data. Investigation reveals the main causes, which range from significant industrialisation and population expansion to fossil fuels including coal, gas, and oil. An examination of the measures being taken by these nations, including their "net zero" policy and other official pledges has been done [9].

Evaluation of the carbon footprint of every nation by 2024 has examined the primary reasons for emissions for each of the top five nations to gain insight into what propels some of them to the top of this list [8]. The United States, China, and India are the top three nations in terms of CO_2 emissions in 2021 and 2022, according to data from the Global Carbon Project and the World Population Review. Their large population and industrial activity make this not surprising. However, the list of CO_2 emissions per capita is drastically different. According to this data, managing the environmental impact of populous nations continues to be challenging [10].

The situation becomes much direr when one looks at emissions per capita, as smaller countries such as Qatar and Palau record disproportionately high figures because of their substantial use of fossil fuels in energy production and industry while having lower populations. Optimising and reducing our environmental impacts can be made possible by having a better grasp of what needs to change. A clearer understanding of what needs to change can enable us to adjust and reduce our environmental impact. Countries with the highest total emissions globally play a crucial role in this effort.

The Indian Context

India has one of the largest carbon footprints, emitting 2.8 billion tons of CO_2, as shown in Table 1. In India, the main sources of carbon emissions are power plants and agriculture. One of the least eco-friendly energy sources is coal, as has been acknowledged. Furthermore, agriculture is the second-largest source of emissions, contributing to global warming, due to methane from livestock and rice paddies. However, the nation's emissions have also increased due to burning crops and increasing the use of artificial fertilisers [9].

Climate warming and urban heat islands raise temperatures close to the surface. Fewer studies examine how urban climate change is influenced by global warming, even though many studies focus on urban heat islands in large cities. Land use, urban shape, weather, terrain, emissions from human activity, and the thermal and optical characteristics of city materials are important variables [11].

Urban warming harms a city's energy, environmental, and social equilibrium. The most significant effect is linked to a notable rise in both the peak and overall demand for power, particularly for cooling. Simultaneously, urban warming is linked to a rise in the concentration of urban pollutants, including tropospheric ozone, which exacerbates outdoor thermal comfort conditions, heightens health and mortality issues, and considerably expands the urban ecological footprint. The degree of urban overheating, the type and characteristics of the structures in question, and the local microclimate all influence how much of an energy impact urban warming has [12].

Table 1. Top 10 highest carbon emitting countries.

Rank	Country	Million tons of CO_2	Percentage of world Co_2 emission
1	China	12,667	32.88%
2	United States of America	5,057	12.60%
3	India	2830	6.99%
4	Russia	2032	4.96%
5	Japan	1083	2.81%
6	Indonesia	729	1.80%
7	Iran	691	1.78%
8	Germany	673	1.75%
9	Saudi Arabia	663	1.66%
10	South Korea	636	1.53%

(Source: Global Carbon Project and World Population Review 2022)

Urban warming can lower the need for heating while frequently increasing the requirement for cooling. Numerous research looks at these effects in a variety of building types and climates, but comparisons are difficult due to various classifications and techniques. In order to properly evaluate the energy impact of urban warming, standardised worldwide indicators are required [7].

GLOBAL INITIATIVES TO REGULATE THE CARBON MARKET

Recognizing the obligations and difficulties that each nation faces in the battle against climate change becomes easier when we understand the carbon footprints of various countries. Fortunately, we can determine the locations that need major changes to have a substantial impact on the world by concentrating on the top emitters. With the use of renewable energy sources, this analysis promotes and educates action for a more sustainable future.

Governments are adopting various solutions to address increasing carbon emissions. Many of these significant emitters are investing in renewable energy to save costs, and increase wind energy, boosting their expenditures on solar panels and other renewable sources [13].

International agreements such as the Paris Agreement, Kyoto Protocol, and Glasgow Climate Pact have set up frameworks for countries to adopt carbon credit (CC) trading systems in order to lower greenhouse gas emissions. One of the first nations to adopt cap-and-trade policies was the United States, which has created several state and local carbon credit programs to encourage companies to lessen their environmental effect.

In 1997, a global pact known as the Kyoto Protocol came into force with the intention of reducing greenhouse gas emissions by issuing carbon credits. Industrialised and developing nations committed to cut their emissions in line with predefined targets under the UN Framework Convention on Climate Change through the Kyoto Protocol, which presently has 192 signatories.

In 2015, 196 parties signed the *Paris Agreement*, which encourages emissions trading and establishes environmental guidelines. The goal of this agreement is to restrict global warming to less than 2°C (3.6°F) beyond pre-industrial levels by the end of the 21st century by reducing greenhouse gas emissions.

In order to tackle global warming, *the Glasgow Climate Pact*, which was agreed at the UN Climate Change Conference in Glasgow (COP26) in November 2021, intends to incentivise nations to support projects that protect forests and develop green energy infrastructure. Through the use of offset credits, this carbon credit agreement will enable member nations to make significant progress towards their emission targets.

Personal carbon trading (PCT), is a cutting-edge and innovative mitigation technique for the home and personal transportation industries. PCT, which might account for over 40% of the country's carbon emissions, encompasses various downstream cap-and-trade programs. These programs seek to reduce societal carbon emissions by involving individuals in the process. This policy is distinctive because it incorporates social, psychological, and economic mechanisms to induce behaviour change, offering a comprehensive strategy for reducing personal emissions from energy use [14].

Personal carbon emissions refer to the carbon emissions that are directly caused by the use of energy for household purposes, transportation, or related services. This focus combines emissions from residential and transportation sectors, often considered separately. Calculating carbon emissions from energy and gasoline used in cars and homes is straightforward, although accounting for public transport, flying, or sailing emissions is more complex [15].

This definition of personal carbon emissions excludes indirect emissions from goods and services people purchase, primarily due to the difficulty in calculating them. Establishing carbon labels for

embodied emissions is complicated, and very few products currently have them. Therefore, popular measurements of human "carbon footprints", which typically attempt to account for embodied emissions, have different boundaries than "personal carbon emissions" [1].

In developed nations, energy consumption and individual carbon emissions typically account for a significant fraction of total emissions. For instance, human carbon emissions in the UK account for about 42% of overall emissions. These are attributed to the following: personal travel (29%), holiday air travel (12%), other travel (2%), appliances (9%), space heating (30%), water heating (10%), lighting (4%), and cooking (3%). Preliminary data suggest that personal emissions account for a comparable share of national totals in Denmark and Ireland [16]. In the United States, 38% of the country's provided energy comes from personal transportation and residential consumption. While individual carbon emissions from personal sources are negligible on their own, they collectively add up to a significant amount [17]. Reducing emissions through altering the energy-use decisions and behaviours of millions of people is still an unfulfilled policy issue.

DIFFERENT CARBON TRADING STRATEGIES

Implementing innovative technology and renewable energy sources, reducing the energy consumption of outdated equipment, planting trees, and altering management techniques are all ways to prevent climate change. These measures can range from simple adjustments, like redesigning a cook stove, to complex projects, such as creating the blueprint for a new city. Global initiatives include everything from advanced subway systems to bike lanes and walkways [18].

Reducing climate change presents numerous policy challenges. It is essential to reduce carbon emissions quickly and steadily across all economic sectors. To prevent the average global temperature from exceeding a 2°C increase, certain nations have pledged to significantly lower their emissions [19]. Major reductions in the emission levels seen in developed countries are implied by the strategies covered in Table 2.

Table 2. Schemes to combat personal carbon trading.

Scheme	Description	Benefits	Challenges
TEQs (Tradable Energy Quotas)	The UK developed it to address peak oil and climate change. Covers the whole economy. Sets a carbon emission cap, with 40% allowances free to individuals and 60% sold to other users. Transactions are electronic.	Encourages carbon reduction; market-based	Implementation complexity; monitoring
Cap and Share (C&S)	Developed for the Irish economy. National carbon cap set by an independent committee. Adults receive certificates for an equal share of emissions, sold to fossil fuel companies.	Simple concept; public engagement	Requires robust regulation; economic impact
Tradable Consumption Quota	National carbon emissions cap. Free per capita allocation. Carbon labels on products. Individuals and companies trade emissions quotas to offset carbon use.	Direct consumer involvement; transparency	Development needed; complex enforcement
PCA (Personal Carbon Allowances)	Proposed in the UK for personal travel and home energy. National cap on emissions. Free per capita allowances for energy use, traded in a carbon market.	Promotes personal responsibility; equity	Requires tech integration; acceptance
Household Carbon Trading	Considered in California. Sets yearly carbon cap for households. Allowances allocated per household via utility providers. Deductions based on energy use. Full trading of allowances.	Household-level control; reduces emissions	Utility involvement; compliance checks
Tradable Transport Carbon Permits	Suggested in France for private transport. Emissions from private vehicles capped. Free allowances for individuals. Allowances offset CO_2 equivalent of fuel, electronically traded.	Targets transport emissions; accessible	Varying individual needs; system management

(Source: Personal Carbon Trading: An Overview Climate Policy)

LOCAL AND GLOBAL SCENARIO

The United Kingdom has established a legally mandated goal to cut its overall national greenhouse gas (GHG) emissions by 80% by 2050. It is consequently necessary to reduce emissions by more than 4% annually until 2050, which is a much faster rate of change than has been accomplished in the past [20].

The EU's ambitious climate change initiatives over the past three decades have resulted in a more than 31% reduction in emissions from 1990 in 2022. The primary causes of this reduction are the rise in renewable energy consumption and the fall in the use of fossil fuels with high carbon contents. Economic structural changes and improvements in energy efficiency also made it easier to achieve these goals [21].

Future targets: More significant objectives are set for the future, with 2030 targeting a net 55% decrease below 1990 levels and 2050 aiming for climate neutrality. Encouraging the switch from fossil fuels to clean, renewable energy will necessitate even greater emission reductions. This involves stopping deforestation, managing land sensibly, and conserving the environment to balance greenhouse gas emissions with their absorption in soil, oceans, and forests. The EU cannot act alone, as it only contributes 6% of global emissions. International cooperation is vital for effective climate change mitigation [21].

International cooperation is ensured by the Paris Agreement and the United Nations Framework Convention on Climate Change (UNFCCC) in order to combat climate change and ensure a sustainable future.

Carbon Markets

Carbon markets, which enable the exchange of carbon credits to lower emissions, are one method of pricing carbon emissions. These marketplaces offer financial incentives to reduce pollution or boost energy efficiency. For example, an industrial facility that exceeds pollution regulations can receive credits, which can be sold to another unit struggling to meet the requirements, enabling both to comply with standards [22].

- *Compliance markets:* Regulated by national, regional, and global policies. Governments issue permits or allowances to entities based on their emission levels.
- *Voluntary markets:* Emitters (businesses, private citizens, etc.) purchase carbon credits to offset emissions. Activities like afforestation produce these credits by lowering CO_2 levels in the atmosphere [23].

CHALLENGES OF CARBON CREDITS IN INDIA

India's Carbon Credit Opportunities and Difficulties

India presents a number of carbon credit prospects, however there are significant obstacles to be addressed (Figure 7). The ignorance of businesses and organisations regarding carbon credits is a significant barrier. Because of this, it is challenging for them to find and use carbon reduction techniques that can result in carbon credits [24].

The intricate and time-consuming procedure of obtaining carbon credits presents another difficulty. For businesses and organisations to make sure their carbon reduction efforts meet international standards, they must go through rigorous verification and validation procedures. Carbon credits offer India a substantial chance to lower its carbon footprint and encourage sustainable activities in spite of these obstacles [25].

Popular Methods for Producing Carbon Credits in India

In India, waste-to-energy programs, energy efficiency initiatives, and renewable energy projects are the most popular ways to produce carbon credits. Nonetheless, several challenges need to be overcome to guarantee the nationwide adoption of carbon credits. India has the potential to take the lead in the global effort to use carbon credits to prevent climate change if the proper regulations and incentives are put in place [26].

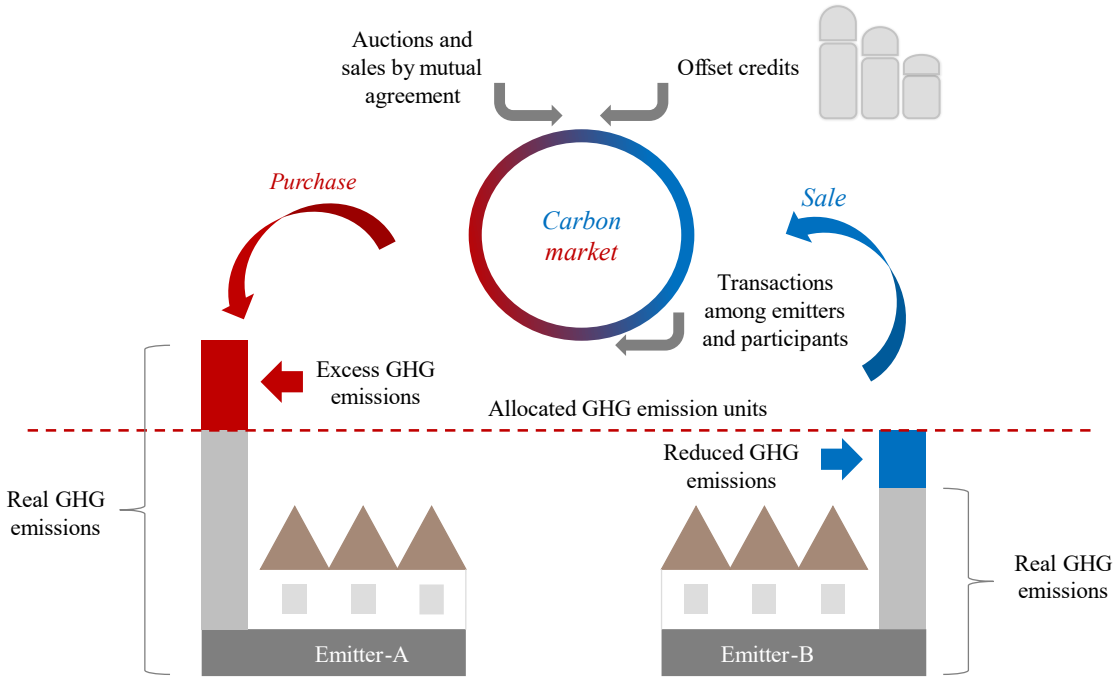

Figure 7. Carbon credits.
(Source: Ministry of the Environment, the Fight Against Climate Change, Wildlife and Parks)

India's Role in Mitigating Climate Change

India is a major contributor to global greenhouse gas emissions and is vital to the fight against climate change. India has created a lot of chances for carbon credits because of its dedication to lowering its carbon footprint and accomplishing its sustainable development goals [27]. Projects using renewable energy, including wind and solar, are common ways to produce carbon credits. There is a big chance to create carbon credits with clean energy since the Indian government wants to build 175 GW of renewable energy capacity by 2022 [28].

Waste-to-Energy and Energy Efficiency Initiatives

Energy efficiency projects can also generate carbon credits. The Bureau of Energy Efficiency (BEE) in India introduced the Perform, Achieve, and Trade (PAT) initiative, which encourages companies to lower their carbon footprint and increase energy efficiency. Carbon credits could potentially be produced via waste-to-energy initiatives like biomass and biogas. These initiatives contribute to clean energy production, trash reduction, and improved sanitation [29].

Resolving Complications

Despite the opportunities, several obstacles must be overcome. Lack of knowledge and comprehension of carbon credits among companies and organisations is a major problem that makes it challenging to find and carry out pertinent projects. The laborious and time-consuming procedure of acquiring carbon credits presents another difficulty because it needs to be rigorously verified and validated in order to fulfil international requirements [24].

International Collaboration

It is necessary to reduce global greenhouse gas (GHG) emissions by 25 to 50% this decade in order to limit warming to 2°C, and ideally no more than 1.5°C. As part of the 2015 Paris Agreement, nearly 170 nations have committed to updating their nationally determined contributions (NDCs) every 5 years. Openness in the institutional and financial framework is essential for carbon market transactions, according to the UNDP, which also emphasises that “emission reductions and removals must be real and aligned with the country's NDCs” for carbon markets to be functional [27].

DISCUSSION AND CONCLUSION

Greenhouse gas emissions are increasing daily in the modern period, which presents serious problems for nations like India. These pollutants, which damage the ozone layer and fuel climate change and global warming, are mostly caused by human activity. Meeting emission reduction goals necessitates widespread involvement in mitigation initiatives and a thorough grasp of these problems.

Social and economic systems were significantly altered by the Industrial Revolution, which also brought fossil fuels like coal, gas, and oil. Renewable energy sources were used by societies before this. Technology was improved by industrialisation, but the environment suffered and people's quality of life declined. To address these issues, carbon trading must be encouraged.

Personal Carbon Trading (PCT) offers a viable mechanism for aligning individual actions with broader climate objectives, contributing to urban resilience and sustainability. Carbon trading agreements should mandate compliance from significant emitters and direct resources accordingly.

Indian companies have experience with the execution of voluntary (offset) initiatives like CDM (Clean Development Mechanism) and comparable instruments, as well as compliance markets like PAT-ESCerts (Perform Achieve and Trade) and RECs (Renewable Energy Certificates). India has the second-highest number of CDM projects registered worldwide. More than 106 million tonnes of CO_2 emissions have been avoided by Indian units under the PAT plan since 2015 and through June 2024 [30].

Although compliance-based tools have forced organisations to take mandatory measures, voluntary actors have been rewarded for their extra work. Credits or certificates were given to the entities in both situations as payment for their increased savings. As a result, the nation has enough knowledge and capability to enable a fully functional domestic carbon market structure.

The development of a strong National Framework for the Indian Carbon Market (ICM) via a trustworthy national carbon credit electronic platform is underway. By valuing their additional efforts to reduce greenhouse gas (GHG) emissions, this framework seeks to assist and complement different organisations working on programs to decarbonise the Indian economy.

To provide a comprehensive approach to decarbonising the economy, the Indian Carbon Market Framework comprises two essential mechanisms: the Compliance mechanism, which attempts to address emissions from its industrial and energy-using sectors, as well as the Offset mechanism, which incentivises non-compliant firms to take voluntary steps to reduce their GHG emissions.

A dependable national carbon credit electronic platform is being used to create a strong National Framework for the Indian Carbon Market (ICM). This framework seeks to assist and support different organisations that are working on programs to decarbonise the Indian economy by pricing their additional actions towards reducing greenhouse gas (GHG) emissions.

Way Forward

Establishing the credibility and quality of carbon credits must be the top priority. Quality consists of three key elements: credibility, longevity, and spillover benefits.

- *Credibility*: Trustworthy carbon credits that have been validated by respectable organisations, have the required paperwork, and can be readily and openly tracked.
- *Durability:* The carbon credit's level of permanence.
- *Spillover effects:* Extra advantages to the environment or society that are ascribed to the carbon credit.

Additionally, the global push for carbon pricing and India's aggressive reforms of the carbon market are essential milestones in the direction of a sustainable future that may develop a strong market that

reduces climate change while promoting innovation and economic progress, if we take these issues head-on and guarantee the integrity and quality of carbon credits. Incentives and legislation pertaining to carbon credits could propel India to the forefront of the world market in terms of reducing climate change and advancing sustainable practices.

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