Research Article
Volume 16:1, 2026

Journal of Civil and Environmental Engineering

ISSN: 2165-784X Open Access

The Role of Clean Development Mechanism and Carbon Credits in Mitigating Climate Change

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Abstract

Climate change is one of the most pressing global challenges, driven by the rising concentration of greenhouse gases from fossil fuel combustion. Its consequences of rising sea levels, shifting weather patterns, and an increasing frequency of extreme events demand urgent action. Transitioning to renewable energy, conserving resources, and adopting sustainable practices are imperative to address this crisis.

The Kyoto Protocol, an international treaty established by the United Nations, introduced mechanisms such as carbon credits and the Clean Development Mechanism (CDM) to reduce global emissions. Carbon credits create a market-driven approach by allowing companies to offset their greenhouse gas emissions through tradable allowances, incentivizing emission reductions. The CDM further enables industrialized nations to invest in sustainable projects in developing countries, earning carbon credits while fostering environmental and economic benefits for local communities.

This study examines the functioning and significance of carbon credits and the CDM, exploring their market dynamics and the evolution from the Kyoto Protocol to the Paris Agreement. It highlights the environmental and economic benefits of carbon credits, the business opportunities they present, and the critical role of sustainable practices in combating climate change. By analyzing these mechanisms, the study underscores their potential to drive meaningful global action toward a low-carbon, sustainable future.

Keywords: Carbon credits • Carbon offset • Clean Development Mechanism (CDM) • Greenhouse gas emissions reduction • Kyoto protocol • Sustainable development

Introduction

Climate change encompasses long-term modifications to the climate that accumulate over decades, centuries, or even extended periods. It is predominantly the result of the combustion of fossil fuels (e.g., coal, oil, and natural gas), dramatically increasing the concentration of greenhouse gases in the Earth's atmosphere [1,2]. These gases, which contain heat, are warming the Earth and the oceans, leading to various consequences, including increased sea levels, altered ocean currents, changes in rainfall, dissolving snow and ice, more severe heat events, fires, and droughts. The expected effects are predicted to continue and, in some cases, intensify, influencing human health, infrastructure, forests, agriculture, freshwater resources, coasts, and marine ecosystems [3].

Existing approaches to climate change mostly center around mitigating greenhouse gas emissions through various measures. Important strategies are shifting to sustainable energy sources such as wind and solar power, encouraging energy conservation in residential and industrial settings, improving public transportation infrastructure, and implementing environmentally friendly farming methods. Initiatives are currently being implemented to save and rehabilitate forests and seas, which serve as crucial reservoirs for carbon. In conjunction with global collaboration and legislative modifications, minimizing plastic use and consumption is imperative for achieving a substantial influence [4].

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Received: 30 December, 2024, Manuscript No. JCDE-24-157167; **Editor assigned:** 03 January, 2025, PreQC No. JCDE-24-157167 (PQ); **Reviewed:** 18 January, 2025, QC No. JCDE-24-157167; **Revised:** 02 Febrsuary, 2026, Manuscript No. JCDE-24-157167 (R); **Published:** 09 February, 2026, DOI: 10.37421/2165-784X.2026.16.642

Without actively pursuing strategies to mitigate these emissions, there will be no viable alternative to avert the impending annihilation of the world. The emergence of the Kyoto Protocol was a response to the perilous consequences of climate change, aiming to find a solution.

The purpose of this study on the fundamentals of carbon credits is to understand their meaning, market workings, and entry procedures for the clean development mechanism, and regulatory framework.

The Kyoto Protocol, established under the United Nations Framework Convention on Climate Change (UNFCCC), is an international agreement aimed at reducing Greenhouse Gas (GHG) emissions. Greenhouse gases in Earth's atmosphere absorb and emit radiation in the thermal infrared range, significantly contributing to the greenhouse effect and increasing the planet's temperature. The main greenhouse gases include water vapor (36-72%), carbon dioxide (9-26%), methane (4-9%), nitrous oxide (3-7%), ozone, and Chlorofluorocarbons (CFCs). This underscores the pressing necessity for coordinated global initiatives aimed at controlling and reducing emissions to effectively mitigate the impacts of climate change [5]. Despite the varying heating impacts of these gases, Carbon Dioxide (CO_2) is used as the standard for measurement purposes. Consequently, emissions are quantified in units representing one tonne of CO_2 or its equivalent (CO_2e) for other gases. These gases, known collectively as the 'Kyoto Basket', contribute to global warming by impacting the atmosphere and leading to an increase in temperature. The Kyoto Protocol was originally established in 1997, but it came into effect in 2005. A total of 192 countries agreed to the Kyoto Protocol, which was subsequently succeeded by the Paris Agreement. This also represented a change in climate strategy, with the Paris Agreement promoting wider involvement and establishing more adaptable, nationally determined objectives for emission reductions [6]. The main concepts of the Kyoto Protocol focus on carbon emissions and carbon credits.

A carbon footprint is a calculation of the total quantity of carbon dioxide and other greenhouse gases released by a country, corporation, organization, individual, or other responsible party [7,8]. The concept of carbon footprint is commonly recognized and utilized by businesses and nations to quantify their carbon emissions and develop strategies for reduction. This approach also facilitates the establishment of sustainability goals and the monitoring of advancement over time. Carbon credits are transferable certificates that allow the holder, whether an entity or a country, the right to emit a designated amount of carbon dioxide and its equivalents. Carbon credit symbolizes a decrease of one ton of carbon dioxide [9].

Under the Kyoto Protocol, countries that accepted the agreement were allocated emission goals for specified periods and were required to engage in carbon trading if their emissions exceeded the prescribed limit. Nations classified as Annexures 1 and 2, or economically developed nations, are allocated individual targets, which they are expected to meet. The Kyoto Protocol mandates that nations establish their policies and actions to address the issue of climate change and regularly report on their efforts to mitigate its effects. The agreement is structured around annexes and imposes more demanding emission reduction objectives on wealthy nations, as they are widely acknowledged to have greater responsibility for the high levels of greenhouse gas emissions in the atmosphere, in contrast to underdeveloped countries.

Materials and Methods

Kyoto Protocol

The Kyoto Protocol has three mechanisms that help states in achieving their carbon reduction targets.

Figure 1 shows the flexibility mechanisms established by the Kyoto Protocol to help countries meet their carbon reduction targets. These mechanisms include the International Emission Trading Mechanism, which permits countries to buy and sell emission allowances among themselves. Additionally, the Clean Development Mechanism (CDM) allows industrialized nations to invest in sustainable development projects in developing countries, enabling them to earn carbon credits in return. Joint Implementation (JI) encourages countries to work together on emission reduction projects and share the resulting carbon credits. These mechanisms aim to provide countries with flexible and cost-effective ways to reduce global emissions and combat climate change.

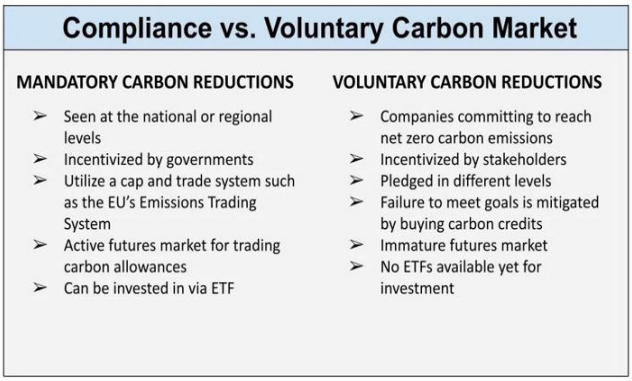

Figure 1. Kyoto Protocol flexibility mechanism.

Paris Agreement

The Paris Agreement, which replaced the Kyoto Protocol in 2015, was adopted by 196 nations during the UN Climate Change Conference in Paris. The goals were originally set for 2020. The primary objective of the agreement is to limit the increase in the global average temperature to well below 2°C above pre-industrial levels while striving to restrict the temperature rise to 1.5°C. This emphasizes the urgent need for coordinated global actions to combat climate change and reduce greenhouse gas emissions through Nationally Determined Contributions (NDCs) and regular progress assessments.

It also involves limiting greenhouse gas emissions from human activities to the levels that trees, soil, and nature can naturally absorb, known as 'Net Zero,' by the years 2050 to 2100.

The Paris Agreement decisively champions the commitment of wealthier nations to provide financial support to less developed countries. This funding is essential for implementing impactful climate change initiatives and facilitating a robust transition to renewable energy sources. This agreement empowers each country to establish its emission reduction targets, with mandatory updates every five years to strengthen their commitments. The framework is designed to drive a global transition to sustainable energy solutions while ensuring robust support for climate resilience in vulnerable regions.

Understanding the carbon market and carbon credits

Organizations and individuals actively harness energy in their daily activities and business operations. When sourced from fossil fuels like oil, coal, and gas, this energy unequivocally contributes to the release of carbon and other Greenhouse Gases (GHGs) into the atmosphere. This is a crucial factor in the causes of climate change. Carbon markets play a vital role in carbon trading or 'offsetting', empowering businesses and individuals to take responsibility for their unavoidable emissions. By investing in approved programs that effectively reduce greenhouse gas emissions globally, they actively contribute to combating climate change and making a positive environmental impact.

Compliance *vs.* voluntary carbon market: Carbon markets can operate under two main frameworks as shown in Figure 2. voluntary or compliance schemes/mandatory. The key difference between them is that the voluntary market is unregulated. To ensure the quality and legitimacy of carbon credits traded in the voluntary market, internationally recognized standards, such as the Gold Standard, are used for oversight and authentication.

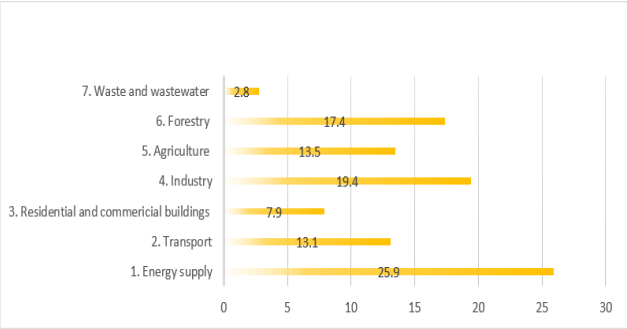

Figure 2. Compliance *vs.* voluntary carbon market.

Carbon credits: Carbon credits allow the owner to emit a specified amount of carbon dioxide or other Greenhouse Gases (GHGs). Each credit permits the release of one ton of carbon dioxide or its equivalent in other GHGs. Sometimes, carbon credits are referred to as carbon offsets. They also provide a financial mechanism that encourages reductions in emissions since entities can trade credits. This trading incentivizes lower emissions through market-driven solutions.

Carbon credit serves as an essential component of a cap-and-trade program. Companies involved in pollution are granted allowances that enable them to continue their polluting activities but within a gradually decreasing limit. These companies can sell any surplus credits to others who need them, which provides a strong motivation for private enterprises to reduce carbon emissions. If an individual's emissions exceed the predetermined limit, they are required to purchase additional credits. Additionally, individuals can earn revenue by selling any surplus permits they possess and by lowering their emissions.

Technological advancements, regulatory modifications, and market demand all impact the carbon credit market. The major players are governments, verification entities, buyers, and project developers. The market is notable for its versatility, which includes a range of trading platforms, such as compliance markets and voluntary markets, as well as different types of credits, like voluntary emission reductions and certified emission reductions. This variety enables participants to engage in emissions trading based on either regulatory obligations or voluntary commitments, promoting a diverse and adaptable approach to carbon management. Figure 3 represents the contribution of different sectors to greenhouse gas emissions. The energy supply sector is the largest contributor at 25.9%, followed by the industrial sector at 19.4%. The transport sector is responsible for 13.1%, while agriculture contributes 13.5%.

The forestry sector is responsible for 17.4% of emissions. Residential and commercial buildings have a lower impact at 7.9%, and waste and wastewater contribute the least at 2.8%. This data highlights the significant role of energy supply and industry in greenhouse gas emissions, while sectors like waste and wastewater have a minimal impact. This highlights the need for targeted strategies to reduce emissions in high-impact sectors for significant progress in lowering global greenhouse gas levels.

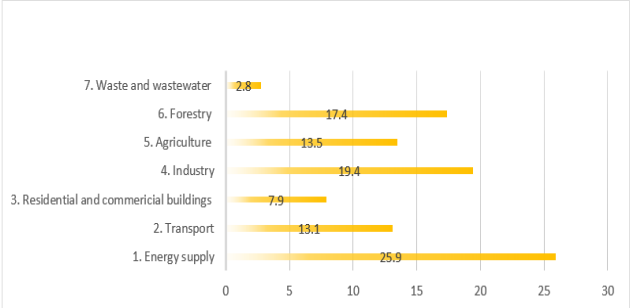

Figure 3. Sectors can work with carbon credits.

In Figure 4, it shows the complex network of participants involved in a trading exchange system. On the left side, various entities such as banks, individuals, NGOs/governments, consultants, Annexure 2 countries, and others feed into the trading exchange. The trading exchange serves as a central hub, interacting with banks, brokers, traders, and intermediary services to facilitate transactions. These services then connect to the broader market, including buyers and sellers. The right side of the figure shows how the trading exchange connects buyers and sellers, which includes Annexure 1 countries, banks, individuals, consultants, NGOs/governments, and others. This comprehensive structure ensures that all stakeholders, from financial institutions to individual participants, are integrated into the trading ecosystem, allowing for efficient and regulated exchanges.

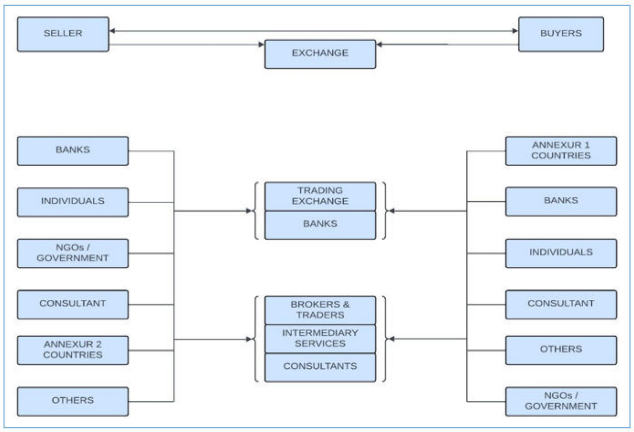

Figure 4. Procedure of carbon credit trading.

Types of carbon credits:

There are two primary types of carbon credits which are shown in Figure 5 Certified Emission Reductions (CERs) and Voluntary Emission Reductions (VERs). CERs are generated through projects that receive approval and verification under established regulatory frameworks, such as the Clean Development Mechanism (CDM) of the Kyoto Protocol. This process guarantees that the emission reductions achieved are of the highest standards. In contrast, VERs are created through voluntary programs, which do not require the same stringent verification as CERs.

This clear distinction emphasizes the differing levels of regulatory oversight and the specific markets each type of carbon credit serves, with CERs operating in compliance markets and VERs in voluntary markets. Moreover, this variety underscores the flexible mechanisms available for organizations to pursue their emissions reduction goals, catering to entities that operate within both regulated and voluntary frameworks.

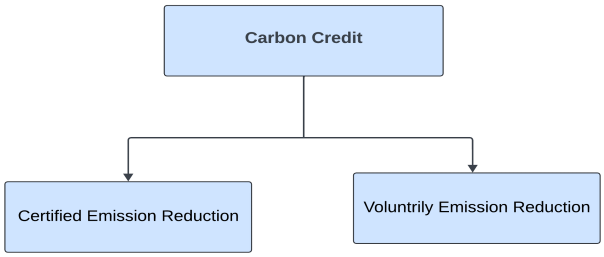

Figure 5. Types of carbon credit.

Trading platforms, market dynamics, and pricing for carbon credits: Trading platforms for carbon credits are essential for facilitating the buying and selling of these credits, helping to reduce greenhouse gas emissions globally. These platforms provide a marketplace for enterprises, governments, and other organizations to exchange carbon credits, which may be required by legal frameworks or pursued voluntarily to mitigate emissions. Prominent trading platforms include the European Union Emissions Trading System (EU-ETS), one of the largest and most established systems, and the California cap-and-trade program, which confidently sets a cap on total emissions while allowing for the trading of allowances. These cap-and-trade systems are highly effective, providing robust economic incentives for emissions reduction while enforcing strict limits on overall emissions.

Also, voluntary platforms like the Verified Carbon Standard (VCS) and the Gold standard cater to entities seeking to voluntarily offset their emissions by investing in projects that reduce or sequester carbon. These trading platforms ensure transparency, standardization, and credibility in the carbon market, promoting global efforts towards climate change mitigation.

The price of carbon credits is influenced by various factors, including supply and demand, regulatory changes, and market sentiment. Principal determinants influencing carbon credit pricing are legislative modifications, technological innovations, economic circumstances, and market attitude. This also illustrates the complexity of the carbon credit market, where external factors like policy shifts and advancements in low-emission technologies can significantly impact pricing trends and influence the overall effectiveness of emissions trading in achieving climate goals. Stricter emission reduction policies or expanded carbon trading schemes can increase demand and drive up prices. Innovations in low-carbon technologies can enhance the supply by making emission reductions cheaper and easier. Economic growth and industrial activity also play a role, as higher production typically leads to higher emissions and a greater need for credits. Investor perceptions and expectations about future regulatory developments and climate policies can significantly impact market prices.

Results and Discussion

Clean Development Mechanism (CDM)

The Clean Development Mechanism (CDM) is a component of the Kyoto Protocol that facilitates the execution of projects aimed at reducing Greenhouse Gas (GHG) emissions in developing nations. The aim of the Clean Development Mechanism (CDM) is to ensure that greenhouse gas emissions are minimized at the lowest possible cost while promoting sustainable development in developing countries. The Clean Development Mechanism (CDM) is a bilateral agreement between two organizations that aims to implement a project that reduces greenhouse gas emissions. The Clean Development Mechanism (CDM) operates as follows: By providing financial support to a project in a developing nation that reduces greenhouse gas emissions, an investor from an industrialized nation or a government of an industrialized nation can offset their emissions. For the reductions achieved, the investor is granted carbon credits that can be applied toward their Kyoto objective. This also facilitates technology transfer and sustainable development in developing countries, creating a mutually beneficial system where both emission reductions and economic growth are supported through international cooperation.

Article 12 of the Kyoto Protocol: Article 12 of the Kyoto Protocol established a framework wherein industrialized nations (known as Annex-I countries) can provide financial assistance to projects in developing countries (known as Annex-II countries) that aim to reduce greenhouse gas emissions. As a result, the industrialized nations are given recognition for their efforts and aid in advancing sustainable development in the developing nations.

Benefits of the CDM for developed and developing countries: The Clean Development Mechanism (CDM) offers significant benefits for both developed and developing countries. For developed countries, the CDM provides a cost-effective way to meet emission reduction targets by allowing them to purchase Certified Emission Reductions (CERs) from projects in developing countries instead of implementing more expensive domestic measures. For developing countries, the CDM attracts foreign investment in sustainable development projects, fostering technology transfer, job creation, and economic growth. These projects typically focus on areas such as renewable energy, energy efficiency, waste management, and reforestation, contributing to overall environmental and socio-economic improvements.

CDM projects: All Annex I countries, except for the United States, approved the Kyoto Protocol in February 2005. The Clean Development Mechanism (CDM) was officially registered on November 18, 2004, and the 2000th initiative was recorded on January 6, 2010. This highlights the rapid adoption and growth of CDM projects as a key mechanism for promoting sustainable development and reducing emissions in developing countries, emphasizing the global commitment to collaborative climate action. As of April 16, 2012, there were a total of 4,005 officially recorded Clean Development Mechanism (CDM) projects. These projects resulted in the authorization of a significant 908,678,320 Certified Emission Reductions (CERs). This data highlights the considerable impact of the CDM in promoting global emission reduction efforts, while also offering environmental benefits and economic incentives for sustainable development in host countries. Each Certified Emission Reduction (CER) is linked to a decrease of 1 tonne of Carbon Dioxide (CO_2).

Under CDM project: Before the implementation of a Clean Development Mechanism (CDM) project, baseline greenhouse gas emissions are determined to accurately represent the existing levels of emissions. This also establishes a benchmark for measuring the actual reductions achieved by the project, ensuring that the emission reductions are real, measurable, and additional to what would have occurred without the project, thereby upholding the integrity of the CDM. Internationally established approaches are utilized to assess the decrease in greenhouse gas emissions resulting from the adoption of new technology. Certified Emission Reductions (CERs) are quantified in metric tons, serving as a benchmark for evaluating the reduction of greenhouse gas emissions. By investing in these initiatives, industrialized nations generate CERs or carbon credits, which encourage the reduction of emissions and promote sustainable development.

CDM project cycle: Figure 6 outlines the step-by-step process for formulating and certifying a Clean Development Mechanism (CDM) project. This process involves several stakeholders, including the Project Developer, the Designated National Authority (DNA), the Designated Operational Entity (DOE), and the UNFCCC Executive Board (EB).

Initially, the project developer conducts a feasibility assessment, which typically takes between 6 to 12 months. After completing the assessment, the developer prepares the Project Design Document (PDD), which details the project's methodology, baseline, and expected emission reductions. This preparation usually takes about 4 months.

Once the PDD is ready, it is submitted to the DNA of the host country for approval. After obtaining approval, the DOE validates the project to ensure it meets all CDM requirements.

This structured and collaborative process ensures the credibility and compliance of CDM projects with international standards, thereby enhancing transparency and accountability in efforts to reduce emissions.

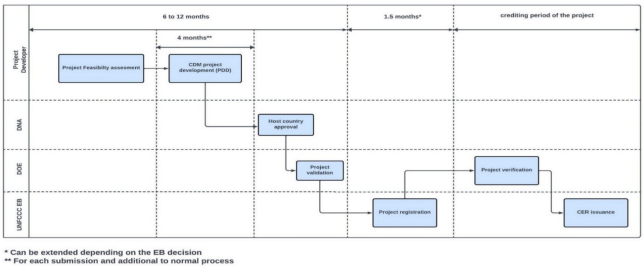

Figure 6. CDM project cycle.

After validation, the project is registered with the UNFCCC Executive Board (EB). This registration process typically takes around 1.5 months, although it may extend based on the EB's decisions. Following registration, the Designated Operational Entity (DOE) conducts regular verifications to confirm the actual emission reductions achieved by the project. Once verification is completed, the UNFCCC EB confidently issues Certified Emission Reductions (CERs) to the project.

This comprehensive process guarantees that every project is thoroughly assessed, validated, and verified before the issuance of CERs. These CERs can then be effectively traded or utilized to meet emission reduction targets. The structured, multi-step approach we employ is crucial for upholding the integrity and reliability of emissions trading, clearly demonstrating the roles and interactions among the various entities involved and establishing a well-defined timeline for the entire process.

Figure 7 explains the types of requests Clarification Request (CL), Corrective Action Request (CAR), and Forward Action Request (FAR) issued by the Designated Operational Entity (DOE) during the verification process of a Clean Development Mechanism (CDM) project, outlining the reasons for each request and the required responses from project participants to address issues and ensure smooth verification.

Explanation of Designated Operational Entity Requests in the Verification Process: Clarification Request, Corrective Action Request, and Forward Action Request

Reason for Request	Response Required by Project Participant to Resolve the Issue
1. Clarification Request The DOE raises a clarification request if the information provided by the project participant is insufficient or unclear and the DOE is unable to establish whether a requirement has been met.	Project participant must modify the project design or provide additional explanations that satisfy the CDM requirements.
2. Corrective Action Request (CAR) A CAR is raised by the DOE if – noncompliance in the monitoring plan or methodology are found in monitoring and reporting, or if the evidence provided to prove conformity is insufficient; – mistakes have been made in applying assumptions, data, or calculations of emission reductions that will impair the estimate of emission reductions; – mistakes have been made in calculating emission reductions; – a FAR raised at the validation stage has not been resolved; or – a risk that emission reductions will not be verified or registered.	Project participant must provide additional explanations to satisfy the DOE's concerns.
3. Forward Action Requests (FAR) In addition to CARs and CLs, the project participant may be required to respond to a FAR that was raised during the validation of the project. During validation, a FAR is raised to highlight issues relating to project implementation that require review during the first verification of the project activity. Any FARs raised during validation will be reviewed by the DOE during the first verification. If they have not been resolved, then the DOE will issue a CAR as part of the verification findings. The CAR will require a response from the project participant, as with any other issues raised during verification. DOEs can also raise FARs during verification for an issue that they want to be dealt with during the next verification period.	Project participant must resolve a FAR request issue prior to verification to avoid being issued with a CAR and delaying the verification process.

CDM = clean development mechanism, DOE = designated operational entity, CL = clarification request.

Figure 7. How to raise a finding?

Verification occurs every two months during the award of time credits, and both the verification and monitoring reports must be publicly accessible. While on-site inspections and engagement with local stakeholders may be part of the verification process, they are not mandatory for all projects. Project operators can select a crediting period of up to 7 years (renewable twice) or a maximum of 10 years (non-renewable). This framework promotes transparency and allows operators to choose a crediting period that aligns with their project's lifecycle and sustainability goals.

Rules for CDM project: Projects need to achieve real, measurable, and long-term emissions reductions. They must go beyond what would happen without the project, ensuring 'additionally'. These projects must align with sustainable development objectives and promote biodiversity conservation and the sustainable use of natural resources.

Major players in CDM: Figure 8 shows the major players in the Clean Development Mechanism (CDM), including project developers, PDD consultants (sometimes in-house), validators (Designated Operational Entity-DOE), the CDM Executive Board (EB), the CDM methodology panel, Designated National Authorities (DNA), CDM credit buyers, NGOs and the interested public (local and international), Annex I and non-annex I countries, and other consultants.

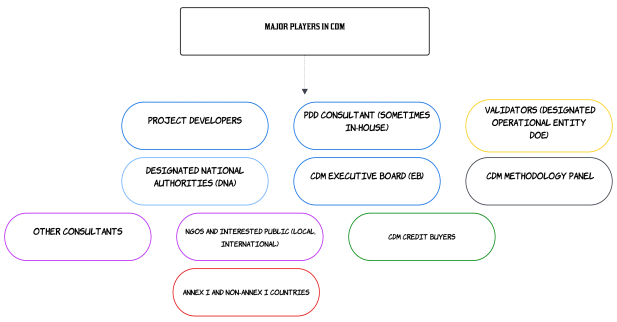

Figure 8. CDM major players.

Benefits and opportunities

Environmental and economic benefits of carbon credits: Carbon credits provide essential environmental and economic advantages by addressing climate change and fostering sustainable development. Carbon credits assign a monetary value to carbon emissions, serving as an incentive for companies and individuals to reduce their greenhouse gas output, contributing to a reduction in overall emissions. Initiatives that generate carbon credits such as those focused on renewable energy, reforestation, and energy efficiency enhance environmental conservation efforts and protect biodiversity.

Economically, carbon credits encourage investment in clean technologies and sustainable practices, drive innovation, and provide financial incentives for companies that successfully exceed their emission reduction targets. Furthermore, trading carbon credits can generate significant revenue for developing countries, thereby supporting their economic growth and development.

Carbon credits, therefore, offer multifaceted benefits. They address the environmental, economic, and social dimensions of sustainability and create pathways for progress at both local and global levels.

Benefits of the CDM for host countries: The CDM provides several key benefits to host countries, particularly developing nations. It attracts foreign investment into emission-reducing projects, injecting vital capital for sustainable development. CDM projects often introduce advanced technologies and best practices that enhance local capabilities. They also generate employment opportunities by implementing and operating these projects, contributing to local economic development. Furthermore, many CDM projects, particularly those focused on renewable energy, improve local infrastructure, benefiting communities and fostering long-term development. This also enhances social and economic conditions in the host regions, as improved infrastructure can create jobs, increase access to clean energy, and support sustainable community growth, reinforcing CDM initiatives' broader positive impact.

Opportunities for organizations and businesses: The carbon credit market and CDM offer numerous opportunities for organizations and businesses. Companies that reduce their emissions below regulatory targets can sell excess carbon credits, generating additional revenue, and providing a financial incentive for adopting sustainable practices. Participation in carbon offset projects and the purchase of carbon credits also enhance a company's Corporate Social Responsibility (CSR) profile, showcasing its commitment to environmental stewardship and sustainability. This can improve a company's reputation and attract environmentally conscious consumers and investors. Engaging in carbon reduction helps businesses differentiate themselves in the market, gaining a competitive edge over less environmentally responsible competitors. It also aids in managing regulatory and reputational risks, allowing companies to stay ahead of regulatory requirements and public expectations and thereby reducing exposure to potential penalties and negative publicity.

Strategic benefits for stakeholders: The strategic benefits of participating in the carbon credit market and the CDM extend to various stakeholders. Governments can leverage carbon credits and CDM projects to meet international climate commitments, reduce national emissions, and stimulate sustainable development. Investors find opportunities in the carbon market with the potential for high returns, particularly as demand for carbon credits rises with stricter emission regulations. Due to CDM projects, local communities benefit from improved air quality, increased employment opportunities, and enhanced infrastructure. Understanding and leveraging these benefits can enhance the effectiveness and profitability of engaging in the carbon credit market and CDM projects.

Challenges and Limitations

While the carbon credit market and the Clean Development Mechanism (CDM) provide numerous advantages, they also face significant challenges and limitations. Verification and demonstrating additionally are often complex and costly, necessitating detailed documentation and third-party validation, which can be particularly difficult in developing countries. Additionally, market volatility driven by regulatory changes, economic conditions, and market sentiment can introduce uncertainty for project developers and investors. Regulatory and policy uncertainty can affect the stability and predictability of the carbon credit market; inconsistent or unclear regulations may deter investment and reduce effectiveness. Accessibility and equity issues arise as small-scale projects and entities in developing countries may struggle with high upfront costs, lack of technical expertise, and limited market reach. Ensuring environmental integrity is crucial to avoiding issues like "carbon leakage," where emissions are reduced in one area but increased elsewhere, and to preventing the exploitation of local communities.

Conclusion

The role of carbon credits and the Clean Development Mechanism (CDM) in mitigating climate change is pivotal in our global efforts to address the escalating environmental crisis. Carbon credits provide a market-based approach to limiting greenhouse gas emissions by assigning a monetary value to polluting costs, thereby incentivizing companies to reduce their carbon footprint. The CDM, as part of the Kyoto Protocol, facilitates sustainable development in developing countries through the investment of developed nations in projects that lower emissions, providing a cost-effective way for these nations to meet their emission reduction targets. This mechanism promotes environmental sustainability and stimulates economic growth and technology transfer in host countries. By creating a financial market for both compliance and voluntary carbon credits, the CDM ensures that emission reductions are measurable, verifiable, and real, thus contributing significantly to global carbon management strategies. As we transition towards the goals set by the Paris Agreement, enhancing the effectiveness of carbon markets and mechanisms like the CDM will be crucial for achieving net-zero emissions and fostering a sustainable future.

Acknowledgment

The author gratefully acknowledges Earthood Company for providing the internship opportunity to work on Clean Development Mechanism and Carbon Offset projects, which have significantly enhanced his understanding and skills in these areas. The author also extends sincere appreciation to Professor Arya V for her invaluable guidance and mentorship throughout this work.

Data Availability

No data, models, or code were generated or used during the study.

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How to cite this article: Ali, Abdullahi Mohamed Sheikh, and Mohamed Omar Mohamed, Ayan Muse Osman. "The Role of Clean Development Mechanism and Carbon Credits in Mitigating Climate Change." *J Civil Environ Eng* 16 (2026): 642.