



The Impact of Carbon Credits on Climate Change Mitigation

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Abstract: This paper assesses the performance of carbon credit systems in realizing global climate change mitigation goals, notably under the auspices of the Kyoto Protocol and the Paris Agreement. It responds to a relevant research deficit relating to the effectiveness of carbon credits in reducing greenhouse gas emissions and the subsequent effects on climate change. The goals involve investigating the economic advantages that carbon credit schemes can provide to developing nations, for example, generating income and employment, which could improve their acceptance of such schemes. The approach entails a detailed examination of current carbon trading schemes, determining difficulties like implementation of complexities and market failures while evaluating equity issues between developed and developing nations. Key conclusions are that although carbon credit can generate economic growth and sustainability, the main constraints make their effectiveness unlikely without better policy and regulatory instruments. The report focuses on lessons and best practices for future projects to create more efficient and fairer climate measures. The implications highlight the necessity for strong policies to provide favourable conditions for carbon credit trading and to make significant contributions towards worldwide emissions reduction targets.

Keywords – Carbon Credits, Climate Change Mitigation, Kyoto Protocol

I. INTRODUCTION

Among the challenges to be faced in the 21st century, climate change is perhaps the most daunting, with anthropogenic greenhouse gas emissions coming from fossil fuel burning, deforestation activities, and industrial processes being the key drivers. The Inter Government Panel on Climate Change indicated that the Earth's mean temperatures have risen by around 1.1°C compared to pre-industrial times, and if it were to continue this way temperatures will exceed 1.5°C in the early 2030s. This warning is already leading to rising sea levels, increased frequency and intensity of weather-related events, and the severance of ecosystem and human food systems. Earlier treaties signed in response to climate change include the Kyoto Protocol and the Paris Agreement, both calling for massive emissions cuts. On the other hand, carbon credit is a market mechanism applied in a specific way to make reductions and achievements in sustainable development. Carbon credits offer these entities the opportunity to offset their emissions by funding projects that prevent, reduce, or sequence GHG emissions in some other locations. These projects

may range from developing renewable energy infrastructure, reforestation projects, or energy-efficient technologies. The

Kyoto Protocol in 1997 put a mark on the introduction of carbon credits through the establishment of market forms like Clean Development Mechanism (CDM), Joint Implementation (JI), and Emissions Trading Systems (ETS), commonly known as Cap-and-Trade. These mechanisms are designed to provide flexibility and cost effectiveness

pathways for achieving emissions reduction targets while promoting sustainable development. Since then, carbon credits schemes have been expanded in both regional and national carbon markets, such as the European Union Emissions Trading System (EUETS), the California Cap-and-Trade Program, and the China Emissions Trading System. The role of carbon credits in climate change mitigation is examined in this paper, including their effectiveness, challenges, and scaling-up potential for global climate action. The work reviews carbon trading mechanisms, their economic and environmental impacts, and the regulatory enforcement process on how they are permitted to function. It, therefore, supplements the theoretical framework available in literature and case studies with its analysis into the strengths and weaknesses of these systems. Generally, through its findings, the paper maintains that carbon credits have been instrumental in reducing emissions, however, it is only in the presence of rigorous monitoring, transparency, and equity in

distribution that any hope of success is found for such emissions reduction systems. The paper concludes with recommendations to ensure carbon credit systems are adapted to have a better impact on climate change mitigation. The function of carbon credits in mitigating

greenhouse gas emissions. Carbon credits are now important instrument in international efforts to reduce greenhouse gas emissions. Through mechanisms like the Clean Development Mechanism (CDM) and Joint Implementation (JI), developed countries can invest in emission reduction activities in developing or transition economies and be rewarded with carbon credits. For example, India's Bagepalli Biogas Project, supported under the CDM, provided rural homes with biogas disaster that minimized emissions and indoor air pollution for more than 5,000 households. The Netherlands-sponsored project on Reforestation of Degraded Land in Romania sequestered carbon dioxide while restoring the biodiversity of the land. Such experiences corroborate the potential of carbon credits in assuring verifiable emissions reductions, while fostering sustainable development. There are, however, serious concerns regarding the effectiveness of credits that depend on their ability to provide added value, that is emissions were reduced in addition to anything that would have occurred in the baseline case absent a carbon credit subsidy. It has been argued that some projects, like large hydroelectric dams, do not meet this provision and thus qualify the

validity of credits. There are several issues to be dealt with in this paper: how far do carbon credits contribute towards reducing carbon emissions, how feasible are they, and what can be done to challenge such issues as additionality and transparency? The carbon credit systems bear heavy economic and environmental implications. They create economic incentives to clean up operations. For example, The EU Emissions Trading System has garnered investments into renewable energy and energy efficiency, cutting power sector emissions by over 20% since its inception in 2005. Similarly, other efforts such as the California Cap-and-Trade Program raise more than \$16 billion for clean energy initiatives, again proving that carbon market hold great potential for advancing climate policy without developing a New Deal-style approach for economic

development. Environmentally, carbon credit projects typically had biodiversity conservation, cleaner air, and better livelihoods for local people as co-benefits. Projects such as Bagepalli Biogas Project infused the additionality concept beyond reducing emissions levels, it translated into better health by replacing dirty woodstoves with clean biogas. However, there are other issues in carbon credit systems, like carbon leakage, where emissions are brought to jurisdictions with less stringent regulations, and double counting. It looks at the carbon credit schemes' economic and environmental impacts as well as their strong and weak points. Carbon credit systems suffer from a plethora of challenges. Thrust into the spotlight, perhaps it is the matter of additional, i.e., with these projects, emissions reductions would not have materialized the carbon credits do not finance them. For example, the Bujagali Dam Project in Uganda displaced over 8,000 people and caused vast amount of environmental degradation for carbon credits, raising serious concerns about its additionality and equity. In addition, the low level of transparency and accountability among the carbon credit markets has raised fears of green washing, where firms make exaggerated claims of the environmental effectiveness of their carbon offsets. Equity is paramount in this as the returns from carbon credit projects usually do not spread

the benefits fairly. The local populate will not benefit significantly from income or social gains, while rich nations will rely on carbon credits to excuse a lack of cuts at home. These use case studies to illustrate the success and challenges of carbon credit systems. The Bagepalli Biogas Project, India, and Reforestation of Degraded Land, Romania, advocate

the power of carbon credits to realize emissions reductions along with sustainable development. Furthermore, the European Union Emissions Trading System (EUETS) and California Cap-and-Trade Program ably demonstrate the performance of cap-and-trade systems by leveraging investments in renewable energy and emissions reductions. Such case

analyses offer a platform where the mechanisms, execution, and impacts of carbon credit systems become intelligent. The future of the carbon credit system is all about keeping pace with newer innovations and trends.

The corporate social responsibility-induced growth of the

voluntary carbon markets will be one of the major drivers of ramping up climate action. Emerging technologies such as blockchain and artificial intelligence must push the efficiency and transparency of carbon credits markets in this respect. Bundling carbon credits together with nature-based solutions such as reforestation or carbon removal technologies such as direct air capture should be crucial as well as for achieving net-zero conditions by the year 2050. Therefore, this paper is going to discuss the emerging trends and their implications for carbon credit systems.

II. OBJECTIVE

1. To analyse the role of carbon credits in reducing greenhouse gases.
2. Evaluate the effectiveness of carbon credits in achieving climate mitigation targets set by international agreements like the Kyoto Protocol and Paris Agreement.
3. Explore the financial benefits of carbon credit projects for developing countries, including revenue generation.
4. To identify the challenges and limitations of carbon credit mechanisms

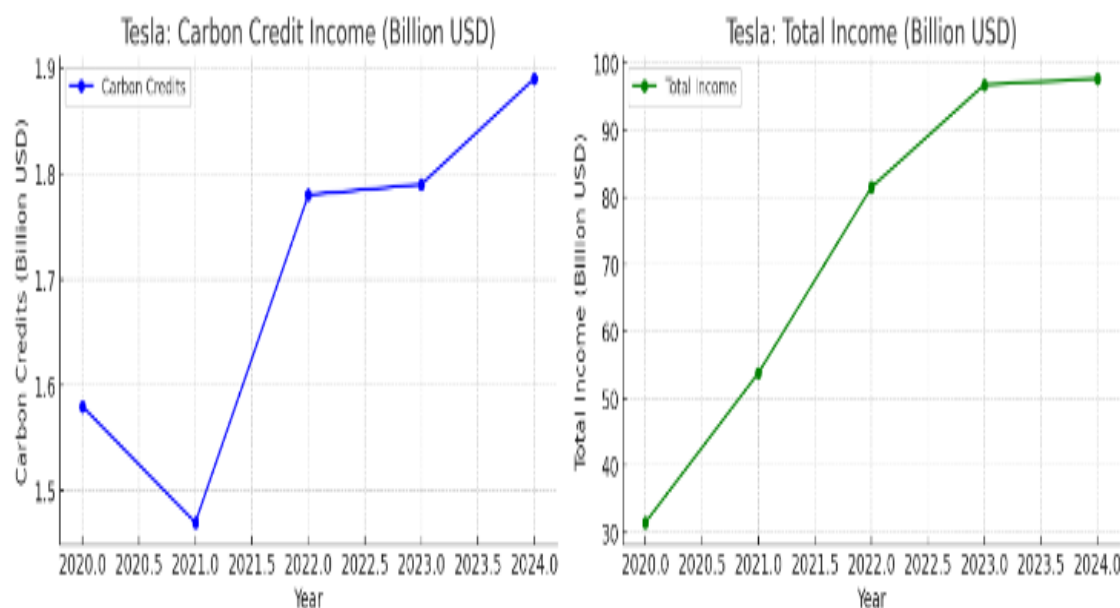
III. LITERATURE REVIEW

Carbon credit has emerged as a critical instrument in the global fight against climate change, operating within leading worldwide systems like Kyoto Protocol and Paris Agreement. Their efficiency has, however, stimulated huge debate among scientists. West and others (2020) have also posed some significant questions regarding carbon credit measurement in their research on REDD+ projects in the Brazilian Amazon, with their finding that methods currently being used can overestimate the actual contribution to decreased deforestation and emissions reductions. That scepticism is repeated by Rosenbloom et al. (2020), who postulate that while carbon pricing encourages emission reductions, it may not go far enough to induce the type of systemic change needed to decarbonize. The economic impacts to developing nations are opportunities and challenges alike. Oyedepo (2012) highlights the benefits, acknowledging that carbon credit schemes can bring necessary revenue and employment opportunities in developing nations. However, Rosenbloom et al. (2020) highlights the complexity of carrying out REDD+ activities, the establishment of governance and the empowerment of local stakeholders. They note the thin line between global climate targets and action at the local level, particularly where deforestation is a concern in such an area. Methodological problems still beset carbon accounting, namely the measurement of biogenic carbon in building materials, as per Portner et al. (2023). Their article sets out to ascertain the urgent necessity for normalized accounting methods in a bid to instil trust in carbon credits. The same echoes by Huwei et al. (2023), whose study of California's carbon offset program revealed likely over-crediting issues that effectively reduce the climate benefit of the program. The linked nature of climate change, biodiversity, and social issues requires the application of an integrated approach. Sills et al. (2014) points out the reality that carbon credit should be viewed as one component of an overall strategy towards climate change mitigation and not individually. This perception is more suitable when determining the overall implications of carbon credit program on ecosystem services and community well-being. Experience with international carbon markets is enlightening. Badgley et al. (2021) analyses the environmental integrity and governance problems of previous carbon markets and draw valuable lessons for the design of future carbon credit systems under the Paris Agreement. Their research emphasizes the importance of robust design and monitoring mechanisms to ensure actual emission reductions. In the future, there will be various knowledge gaps that need to be filled by the research community. The exaggeration reported to be associated with carbon credit calls for more sophisticated methods of assessment. The future research agenda should involve the explanation of standard carbon accounting methods, particularly for bio-based products as well as for forest projects. In addition, analysis of the socioeconomic impacts of carbon credit schemes within developed countries and their integration with other policy institutions can provide critical insights to policymakers who are attempting to balance economic and environmental objectives. The overall literature testifies that while carbon credits are an important tool in preventing climate change, their effectiveness largely depends on proper implementation, proper quantification, and integration with larger sustainability initiatives. Since the world is still grappling with climate change, improving carbon credit systems and making them more sophisticated is an important task for researchers, policymakers, and practitioners.

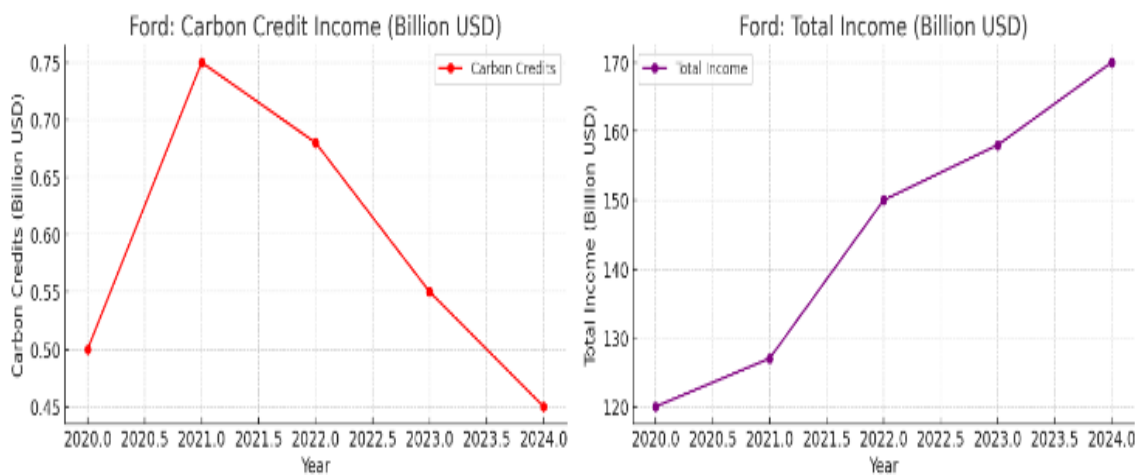
IV. ANALYSIS

Name of the company	2024		2023		2022		2021		2020	
	Carbon Credit (CC) USD	Total Income (TI)	CC	TI	CC	TI	CC	TI	CC	TI
Tesla	1.89	97.7	1.79	96.8	1.78	81.5	1.47	53.8	1.58	31.5
Ford	0.45	170	0.55	158	0.68	150	0.75	127	0.50	120
NALCO	-4.60	1.61	0.85	1.74	1.46	1.71	0.98	1.71	0.84	1.08

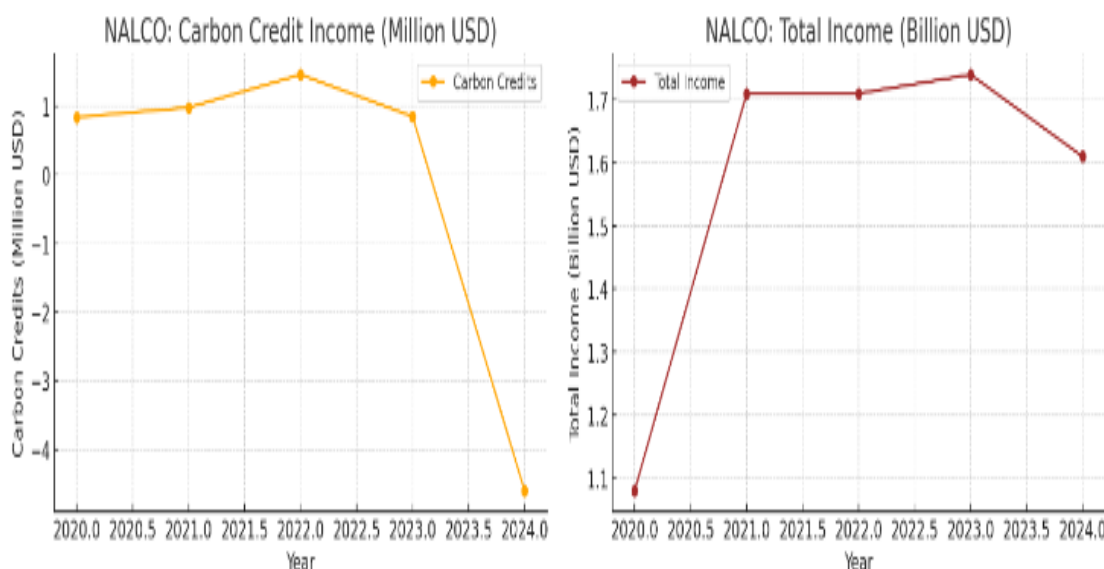
Tesla:



From 2020 to 2024, Tesla's carbon credit revenue jumped from 1.58 billion to 1.89 billion. From the statistics, Tesla's substantial proceeds from selling its carbon credit to other manufactures of cars that do not comply with pollution standards put it in enviable position in the Ev sector. More generated carbon credits are an indicator of Tesla's healthy EV production and sales. Tesla's total revenue grew rapidly from 31.5 billion in 2020 to 97.7 billion in 2024. This proves Tesla's rapid growth in the EV market, expanded production capacity, and high demand for all its vehicles. Most of Tesla's revenues are derived from its main business, the sale of cars and energy products, although carbon credits also earn a lot, but only account for 1.9% of revenue of Tesla as of 2024. On the other hand, it is that Tesla's carbon credit is a spinoff of its core business, while it is also worth more due to its success in the EV space. To that extent, the reality is that as more automobile manufacturers transition to electric vehicle models, their carbon credits may not add up in the long term.

Ford:

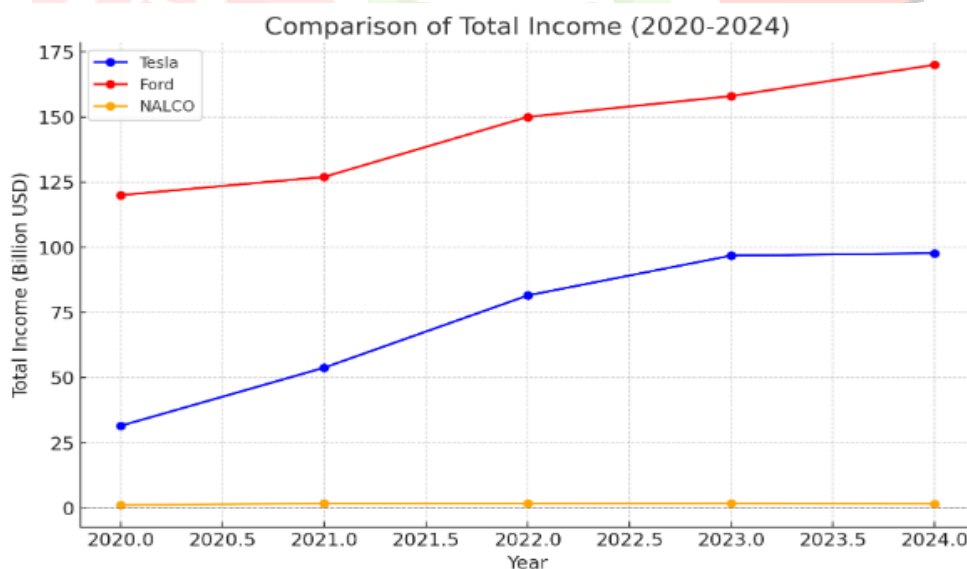
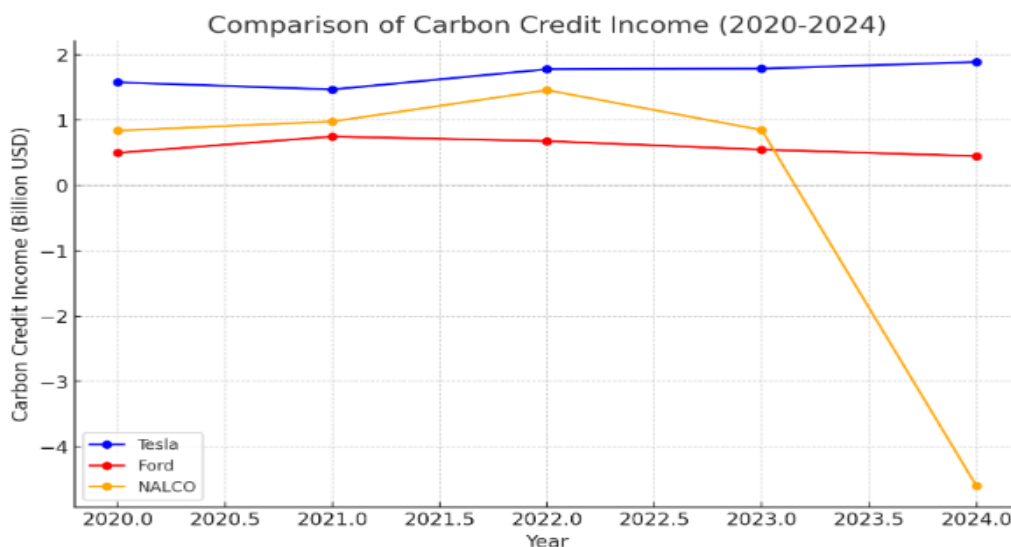
From 2020 to 2024, Ford's carbon credit revenue fell from 0.50 billion to 0.45 billion. The decline might suggest that Ford continues to reduce emissions and as a result, the number of credits, or it could indicate that there is regulatory pressure to limit Ford's ability to generate or buy credits in the carbon markets. This decline means that either Ford is decarbonizing, which is why emissions credits are becoming less relevant to long-term planning, or Ford is subject to some regulatory compulsion to limit the number of credits it can purchase or produce. Overall, Ford is moving towards more electrified vehicles, which would mean there are fewer carbon credits available. Ford reports that it has sold more carbon credit, increasing revenue from 120 million in 2020 to 170 million in 2024 consistently. The reason Ford is making a concerted effort to join the ranks of electric cars and other green technologies is an obvious indication of its status in the traditional auto business. Sales alone constitute a considerable share of Ford's actual revenue, while credits represent only a negligible fraction of the firm's total revenue. Ford has made significant strides in reducing its emissions, perhaps through investments in EVs or clean technology, as evidenced by its decreasing carbon credits revenue. However, its revenue from carbon credit falls far short of matching its overall revenue.

NALCO:

Consequently, most of NALCO's carbon credits were irregular, falling sharply from more than 0.85 billion in 2023 to -4.60 billion in 2024, while a typical hitch appeared in the negative for 2024. These other indicators,

which would have foreseen that NALCO would be buying carbon credits instead of selling them to neutralize its emissions, could largely be attributed to mounting regulatory pressures or increasing operations of the firm. Before 2024, NALCO's revenue from carbon credits had changed very little from 0.84 billion in 2020 to a high of 1.46 billion in 2022. NALCO's overall revenue is stable, between 1.08 billion in 2020 and 1.74 billion in 2023 before dipping to 1.61 billion in 2024. These clearly and unmistakably indicate that NALCO's core business is essentially stagnant and that its revenue from carbon credit or expenses has a more significant effect on the bottom line. Concerns would have been raised by NALCO's control or regulatory requirements for the same. By accepting this claim for capital investment, NALCO will be compelled to either enhance operational efficiency or invest in greener technology.

Comparative Analysis:



Tesla vs Ford vs NALCO:

Since Ford's carbon credit revenues are decreasing in this sector, Ford is decreasing its dependence on these credits, presumably because of its electric vehicle initiatives (like the Mustang Mach-E and F-150 lighting). NALCO's carbon credit revenue is a lot less than what Ford and Tesla make together, and the fact that it will be negative in 2024 shows how hard it has been for NALCO to control emissions. As compared to Tesla and Ford, NALCO is not shown to be concentrated on increasing its core business, but rather the application of

carbon credits might be an added reason for diluting the company's poor financial performance. This information shows other trends in the growth of EV manufacturing with less requirements of carbon credits. These companies are making money since they can provide carbon credits. Big, established car manufacturers such as Ford would take longer to cut that dependence because they have already invested heavily in existing technologies.

V. CONCLUSION:

The research encapsulates significant details regarding carbon credits' ability to curb climate change while identifying their limitations. Overall, the research proves that carbon credits are a viable tool for curbing climate change, their efficacy depends on their wise application and understanding of complicated dynamics. The most notable aspects are outlined in the research. First, if well implemented and regulated, carbon credit can be an extremely effective weapon in the fight against climate change. Second, these systems have economic and environmental implications that need to be properly weighed. The research focuses on the impact of carbon trading on stakeholders, including industry players and policymakers, and provides practical guidance for making informed choices. Notably, the report does not shy away from addressing challenges. The research reveals several shortcomings of the existing system of carbon credits, especially concerning attaining objectives defined by global accords such as Paris Agreement and the Kyoto Protocol. The key observation concerns the issue of equity, i.e., relative inequity between developed and developing countries, and it is marked by comparatively more equitable implementations. The study also investigates the convergence of nature-based solutions, carbon removal technologies, and carbon credit mechanisms. Convergence between the two is essential to realize net-zero emissions by, and it is indicated that there should be a more joined-up approach to climate action. The study finds that carbon credits are still a useful weapon against climate change but will be successful depending on resolving implementation issues, fairly sharing benefits, and incorporating them into comprehensive climate strategies.

VI. FINDINGS AND SUGGESTIONS:

1. Emphasizes the global climate commitment fulfilment function of carbon credits (e.g., Kyoto Protocol, Paris Agreement).
2. Offers proof of contributions to worldwide climate goals.
3. Interprets the mechanisms of carbon trading, commenting on potential economic and environmental impacts.
4. Regards successful experiences like the EU Emissions Trading System (EU ETS) and California Cap-and-Trade Program
5. View challenges associated with equity of benefit sharing between developed and developing countries
6. Calls for strong policies to establish effective carbon credits systems with greater transparency
7. Recommends associating carbon credits with natural solutions and carbon removal technologies for achieving the 2050 net-zero target

8. Recommends cross-sharing of the best practices among successful carbon credit schemes to inform future deployments
9. Affirms that carbon credits are facilitators of desired climate outcomes

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