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INDIA IS POISED TO ACHIEVE ITS ADDITIONAL CO2 SEQUESTRATION COMMITMENTS

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& PROF. G. N. SINHA**

Abstract:

The Paris Agreement, adopted at the 21st Conference of the Parties (COP21) under the United Nations Framework Convention on Climate Change (UNFCCC) in 2015, represents a landmark global effort to address climate change and transition toward a sustainable, low-carbon future. This legally binding accord aims to limit global temperature rise to well below 2°C above pre-industrial levels, with efforts to restrict it to 1.5°C. India, as a signatory, presented its Nationally Determined Contributions (NDC) outlining its climate commitments and ratified the agreement on October 2, 2016.

India's NDC embodies three core targets aimed at balancing economic growth with climate action. First, it aims to reduce the emissions intensity of GDP by 33–35% from 2005 levels by 2030. Second, it commits to increasing the share of non-fossil-based renewable energy in the total installed power capacity to 40%. Finally, it pledges to enhance forest and tree cover to achieve an additional carbon sink of 2.5–3.0 billion tons of CO2 equivalent. These targets underscore India's commitment to sustainable development and global climate goals.

Keywords: Paris Agreement, Nationally Determined Contributions, emissions intensity, carbon sequestration.

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1. Introduction:

India, China and US are some of the major countries emitting Green House Gases (GHSs). Share of other countries are comparatively less. Therefore, rate of economic growth of these countries and use of fossil fuel for energy will have major impact on GHGs and result in global warming. However, India on its part has initiated robust schemes and policy changes that will surely enable the country to achieve net zero emissions by 2070.

The Paris Agreement, adopted at the 21st Conference of the Parties (COP21) in 2015, represents a landmark international accord aimed at combating climate change and ensuring a sustainable, low-carbon future. This legally binding agreement, reached by member countries of the United Nations Framework Convention on Climate Change (UNFCCC), established a global framework for addressing climate risks and mitigating global warming. India, as a key player in the climate change dialogue, presented its Nationally Determined Contributions (NDCs) at the conference, committing to significant climate action.

India ratified the Paris Agreement on October 2, 2016, and pledged to reduce its emissions intensity (CO_2 emissions per unit of GDP) by 33-35% from 2005 levels by 2030. This ambitious commitment forms part of India's broader strategy to mitigate climate change while balancing economic growth and development. The NDCs outlined three core targets: first, reducing emissions intensity; second, increasing the share of renewable energy in the country's overall power generation capacity; and third, enhancing carbon sequestration through the addition of 2.5-3.0 billion tons of CO_2 equivalent (CO_2e) through expanded forest and tree cover.

As of recent updates, India has made significant strides towards these targets, including the installation of over 175 GW of renewable energy capacity by 2023 and a target to achieve 500 GW by 2030. Additionally, forest cover is being expanded through various national and state-level afforestation programs, with India now having over 24% of its land area under forest cover. Despite these advances, meeting these ambitious targets will require sustained effort and international cooperation.

2. India's Nationally Determined Contributions (NDCs)

India's Nationally Determined Contributions (NDCs) under the Paris Agreement reflect the country's commitment to addressing climate change while pursuing sustainable development.

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India ratified the Paris Agreement on October 2, 2016, and presented its NDCs with clear targets aimed at reducing its carbon footprint. One of the primary commitments made by India was to reduce the emissions intensity of its GDP by 33–35% from 2005 levels by 2030 (UNFCCC, 2016). This target highlights India's recognition of the need to decouple economic growth from carbon emissions, ensuring that its industrial and economic development does not exacerbate climate change. Additionally, India emphasized the need to increase its renewable energy capacity, aiming to reach 175 GW of renewable energy capacity by 2022 and 500 GW by 2030, a goal that is critical to reducing the nation's reliance on fossil fuels[1].

Among the key elements of India's NDCs, one of the most ambitious targets is the enhancement of carbon sinks through afforestation and reforestation programs, with a goal of sequestering 2.5–3.0 billion tons of CO2 equivalent (CO2e) through additional forest and tree cover (UNFCCC, 2016). This commitment aligns with India's broader climate action strategy to mitigate the adverse effects of climate change. Forest ecosystems in India play a significant role in carbon sequestration, with the country having around 24% of its land area under forest cover as of 2021 (Forest Survey of India, 2021). The additional carbon sequestration target is expected to be met through large-scale afforestation initiatives, sustainable forest management, and promoting tree plantations across urban and rural areas[2].

India's emissions reduction goals, particularly in the context of CO2 sequestration, are central to the country's efforts to contribute to global climate goals while balancing socio-economic growth. The NDCs not only aim to curb emissions intensity but also seek to increase India's renewable energy share, which has seen rapid expansion in recent years. By 2023, India had already installed over 175 GW of renewable energy capacity, and the target for 2030 remains highly ambitious (Ministry of New and Renewable Energy, 2023). Achieving the sequestration target through enhanced forest cover will be crucial in offsetting emissions from sectors such as agriculture, industry, and transportation. The commitment to these NDCs is a crucial step in India's strategy to contribute to the global effort of limiting global temperature rise to below 2°C, as prescribed in the Paris Agreement, while also promoting sustainable economic growth and environmental preservation[3].

[1] UNFCCC. (2016). *India's Nationally Determined Contribution (NDC) to the Paris Agreement*. Retrieved from https://www.unfccc.int
[2] Forest Survey of India. (2021). *India State of Forest Report 2021*. Ministry of Environment, Forest and Climate Change, Government of India.
[3] Ministry of New and Renewable Energy. (2023). *Annual Report 2022-23*. Government of India

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3. CO2 Sequestration Mechanisms in India

India's forest cover and afforestation initiatives have been central to the country's strategy for enhancing carbon sequestration. The Forest Survey of India (FSI) reported that in 2021, India's total forest cover accounted for approximately 24.62% of its total geographical area, with forest and tree cover together contributing to 80.9 million hectares of land (Forest Survey of India, 2021). These forests act as significant carbon sinks, capturing CO2 from the atmosphere and mitigating the impact of climate change. The Indian government has also launched large-scale afforestation programs like the Green India Mission and the National Afforestation Programme, which aim to increase forest cover by planting millions of trees across the country. These initiatives play a critical role in India's commitment to enhance its carbon sinks by 2.5-3.0 billion tons of CO2 equivalent by 2030 under its Nationally Determined Contributions (NDCs) (UNFCCC, 2016)[4].

Reforestation and agroforestry are also essential components of India's carbon sequestration efforts. Reforestation projects focus on restoring degraded forests and expanding forest cover, particularly in areas that have experienced deforestation due to agricultural expansion or urbanization. Agroforestry, the practice of integrating trees with agricultural crops, helps in sequestering carbon while improving soil fertility and enhancing biodiversity. A report by the Indian Council of Agricultural Research (ICAR) indicates that agroforestry can sequester up to 1.1 billion tons of CO2 equivalent annually (ICAR, 2022). These methods are becoming increasingly significant as they contribute not only to carbon storage but also to food security and rural livelihoods, providing a sustainable way to meet both environmental and socio-economic goals[5].

In addition to these natural sequestration practices, India is also exploring the potential of Carbon Capture and Storage (CCS) technologies to enhance its climate mitigation efforts. CCS involves capturing CO2 emissions from industrial processes and power plants and storing them underground or using them for other purposes such as enhanced oil recovery. While CCS technology is still in its nascent stages in India, early-stage projects are being developed, particularly in sectors like coal-based power generation. A pilot CCS project is being developed by the Indian government in collaboration with international agencies in the Tamil Nadu region

[4] Forest Survey of India. (2021). *India State of Forest Report 2021*. Ministry of Environment, Forest and Climate Change, Government of India.
[5] ICAR. (2022). *Agroforestry for Carbon Sequestration in India*. Indian Council of Agricultural Research.

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(Ministry of Environment, Forest and Climate Change, 2023). This technology, coupled with both natural and artificial sequestration methods, is expected to complement India's broader carbon sequestration goals by directly capturing emissions from major industrial sources and preventing their release into the atmosphere[6].

4. Current Progress in Achieving Sequestration Targets

India's forest cover and carbon sink play a crucial role in the country's efforts to mitigate climate change. According to the India State of Forest Report 2021 by the Forest Survey of India (FSI), India's total forest cover has reached approximately 80.9 million hectares, which constitutes about 24.62% of the country's geographical area. Additionally, India has made significant progress in enhancing its carbon sink, with forests and tree cover collectively storing a substantial amount of CO2. The FSI estimates that India's forests capture around 2.5 billion tons of CO2 annually, contributing significantly to the country's climate mitigation strategies (Forest Survey of India, 2021). This vast forest cover, coupled with efforts to increase it further, plays a pivotal role in helping India achieve its carbon sequestration targets under the Paris Agreement[7].

Progress in afforestation and tree plantation campaigns has been integral to India's strategy to enhance carbon sinks and restore degraded lands. The Green India Mission (GIM), launched in 2014, aims to increase forest and tree cover, restore degraded ecosystems, and enhance biodiversity. As of recent reports, the mission has led to the planting of millions of trees across India, particularly in areas prone to desertification and soil erosion. The mission aims to increase forest and tree cover by 5 million hectares and improve the quality of forests in another 5 million hectares by 2030 (Ministry of Environment, Forest and Climate Change, 2023). Additionally, the National Afforestation Programme (NAP), operational since 1992, has continued to support afforestation and reforestation activities, with the aim of enhancing ecosystem services and increasing carbon sequestration potential[8].

The success of India's afforestation and tree plantation efforts can be seen in several state-level initiatives that have made significant contributions to carbon sequestration. In the state of

[6] Ministry of Environment, Forest and Climate Change. (2023). *Annual Report 2022-23*. Government of India.
[7] Forest Survey of India. (2021). *India State of Forest Report 2021*. Ministry of Environment, Forest and Climate Change, Government of India.
[8] Forest Survey of India. (2021). *India State of Forest Report 2021*. Ministry of Environment, Forest and Climate Change, Government of India.

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Odisha, for instance, the "Green Odisha Mission" has been particularly effective, with large-scale plantation programs covering over 1.5 million hectares of land and contributing to enhanced carbon storage. Similarly, in Himachal Pradesh, the state's "Forest and Tree Cover Expansion Program" has successfully increased forest cover by 2.6% in the last decade through both reforestation and agroforestry practices (Forest Survey of India, 2021). These local initiatives demonstrate the power of targeted, community-driven afforestation efforts in supporting national climate goals.

Nationally, the Green India Mission and the National Afforestation Programme have been the primary drivers behind these afforestation campaigns. The National Afforestation Programme alone has led to the establishment of over 20,000 community-managed forests and the rehabilitation of over 2 million hectares of degraded land (Ministry of Environment, Forest and Climate Change, 2023). These initiatives not only contribute to carbon sequestration but also improve livelihoods, biodiversity, and soil health, aligning with India's sustainable development goals. By 2030, India aims to further expand its forest and tree cover, contributing significantly to its goal of enhancing carbon sinks by 2.5–3.0 billion tons of CO2 equivalent as part of its commitments under the Paris Agreement[9].

5. Challenges and Barriers to Achieving CO2 Sequestration Goals

India faces significant challenges related to deforestation, land degradation, and urbanization, all of which threaten its efforts to enhance carbon sequestration. Deforestation in India has been driven by rapid urbanization, agricultural expansion, and infrastructure development. According to the Forest Survey of India (2021), while the country's forest cover has grown in recent years, forest loss remains a concern, particularly in states like Maharashtra and Madhya Pradesh, where large-scale deforestation for mining and agriculture continues. Moreover, land degradation affects approximately 30% of India's total land area, primarily due to unsustainable farming practices, overgrazing, and soil erosion. Degraded lands significantly reduce the capacity for carbon sequestration, as soils lose their ability to store carbon effectively (FAO, 2021). These issues, combined with the expansion of urban areas, put immense pressure on India's natural ecosystems, reducing the potential for forest regeneration and the enhancement of carbon sinks[10].

[9] Ministry of Environment, Forest and Climate Change. (2023). *Annual Report 2022-23*. Government of India.
[10] Forest Survey of India. (2021). *India State of Forest Report 2021*. Ministry of Environment, Forest and Climate Change, Government of India.

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India also faces several financial, technological, and policy challenges in achieving its carbon sequestration targets. Financial constraints are a major barrier to scaling up afforestation and reforestation initiatives. Despite the government's commitment to tackling climate change, funding for large-scale projects often falls short of what is required to make a substantial impact. Technologically, the country faces difficulties in implementing advanced carbon capture and storage (CCS) technologies, which are still in the early stages of development. Moreover, policy challenges include fragmented land management regulations and inadequate coordination between central and state governments, hindering the effective implementation of climate policies. A report by the National Action Plan on Climate Change (NAPCC) highlights that while India's policies are robust on paper, there is a need for more integrated and enforceable frameworks to enhance the effectiveness of climate action, particularly in forest management and sustainable land use (NAPCC, 2020)[11].

Climate variability presents an additional challenge to India's sequestration efforts. Changes in temperature, rainfall patterns, and the increasing frequency of extreme weather events have a direct impact on the efficiency of carbon sequestration processes. For instance, prolonged droughts in regions like Rajasthan and Maharashtra have led to reduced forest growth and slower regeneration of degraded lands. According to the Indian Meteorological Department (IMD), the country has seen a 1.1°C increase in average temperature over the past century, which could affect the carbon storage capacity of India's forests (IMD, 2022). Additionally, unpredictable weather patterns complicate afforestation efforts, as seedlings are highly sensitive to fluctuating climatic conditions. These factors, along with the projected impacts of climate change, require adaptive strategies that account for changing environmental conditions and integrate climate resilience into carbon sequestration projects[12].

6. Strategies to Accelerate CO2 Sequestration in India

To enhance forest management and improve carbon sequestration in India, it is crucial to strengthen policies that support sustainable forest conservation and restoration. One key policy recommendation is to enforce stricter regulations against illegal logging and encroachment in forest areas. Strengthening forest governance through improved monitoring systems, community involvement, and ensuring the implementation of the Forest Rights Act (2006) can

[11] FAO. (2021). *The State of Land Degradation in India*. Food and Agriculture Organization of the United Nations.
[12] Indian Meteorological Department (IMD). (2022). *Annual Climate Report 2022*. Ministry of Earth Sciences, Government of India.

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prevent land degradation and promote sustainable land-use practices. Additionally, incentivizing the adoption of sustainable forest management practices such as selective logging, agroforestry, and community-led conservation programs can enhance forest health and increase carbon sequestration potential. Programs like the Green India Mission, which aims to increase forest and tree cover, can be expanded with a focus on integrating biodiversity conservation and carbon sequestration objectives (Ministry of Environment, Forest and Climate Change, 2023). The government should also promote research and data-driven decision-making to monitor forest health and carbon stocks, which can guide policy adjustments and implementation[13].

Scaling up renewable energy and sustainable land-use practices is integral to reducing India's carbon emissions and achieving its NDCs. Expanding India's renewable energy sector is a critical step toward reducing reliance on fossil fuels, which are major contributors to greenhouse gas emissions. India has made remarkable progress in this area, with the country reaching 175 GW of renewable energy capacity by 2023, ahead of the 2022 target (Ministry of New and Renewable Energy, 2023). However, India needs to continue expanding its renewable energy capacity, with a target of 500 GW by 2030. To further enhance sustainability, policies encouraging energy efficiency, decentralized energy generation, and the integration of renewables into the national grid should be prioritized. In the agricultural sector, sustainable land-use practices such as no-till farming, organic farming, and conservation tillage can increase soil carbon sequestration and reduce emissions from agriculture, which contributes significantly to India's total carbon footprint. Integrating these practices into national agricultural policies will not only improve soil health but also contribute to India's climate goals[14].

Strengthening international cooperation and funding mechanisms is essential for achieving India's climate objectives, particularly in the context of its ambitious carbon sequestration and renewable energy targets. Global collaboration through platforms like the Green Climate Fund (GCF) and the Clean Development Mechanism (CDM) is crucial in facilitating technology transfer, capacity building, and financial support for large-scale climate action projects. India, as a developing country, faces significant financial and technological barriers in meeting its climate commitments, and international funding plays a vital role in overcoming these

[13] Ministry of Environment, Forest and Climate Change. (2023). *Annual Report 2022-23*. Government of India.
[14] Ministry of New and Renewable Energy. (2023). *Annual Report 2022-23*. Government of India.

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obstacles. In recent years, India has increasingly engaged in climate finance agreements, with bilateral and multilateral partnerships to support sustainable development[15]. The United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement provide a framework for such cooperation, with India leveraging these platforms to attract investment for renewable energy projects and forest conservation programs. Moreover, strengthening public-private partnerships in the clean energy sector can accelerate the deployment of renewable technologies and infrastructure, ensuring that India remains on track to meet its emissions reduction targets while fostering sustainable development.

7. Case Studies and Regional Insights:

Several Indian states have made significant strides in forest conservation and carbon sequestration through successful regional initiatives. In Odisha, for example, the "Green Odisha Mission" has been highly successful in enhancing forest cover and promoting environmental sustainability. By focusing on afforestation in degraded and barren lands, the mission has helped restore over 1.5 million hectares of forest and contributed significantly to the state's carbon sink (Ministry of Environment, Forest and Climate Change, 2023). Similarly, Himachal Pradesh has witnessed considerable success in increasing forest cover through its "Forest and Tree Cover Expansion Program," which has helped restore degraded land and increase forest cover by 2.6% over the last decade. The state's focus on sustainable forest management and agroforestry has contributed to both carbon sequestration and improved local livelihoods (Forest Survey of India, 2021). These state-driven efforts not only help meet India's carbon sequestration targets but also serve as examples of how localized initiatives can be effective in addressing climate challenges[16].

Community-driven afforestation and carbon sequestration projects have played a key role in India's climate action efforts. In many rural areas, local communities have been involved in forest conservation and restoration programs, which have resulted in significant improvements in carbon capture and forest health. The Joint Forest Management (JFM) program, initiated by the Indian government in the early 1990s, has been one of the most successful community-based initiatives. Under this program, local communities are given responsibility for protecting and managing forests, leading to better forest protection and the sustainable use of forest

[15] United Nations Framework Convention on Climate Change (UNFCCC). (2022). *India's Nationally Determined Contribution (NDC) Progress Report*.
[16] Ministry of Environment, Forest and Climate Change. (2023). *Annual Report 2022-23*. Government of India.

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resources. In the state of Madhya Pradesh, for instance, the involvement of local communities in afforestation projects has led to the restoration of thousands of hectares of degraded forest land, enhancing the region's ability to act as a carbon sink (ICIMOD, 2022)[17]. These community-driven approaches not only contribute to environmental sustainability but also provide economic benefits to local populations through improved livelihoods and ecosystem services[18].

The success of these regional and community-based projects provides valuable lessons for scaling up afforestation and carbon sequestration efforts across India. Key best practices that can be replicated include integrating afforestation with sustainable agricultural practices, engaging local communities in forest management, and adopting a participatory approach to decision-making. States like Rajasthan have shown that involving local farmers in agroforestry projects, where trees are integrated into agricultural systems, can increase both carbon sequestration and agricultural productivity (Indian Council of Agricultural Research, 2022). Additionally, fostering strong public-private partnerships and utilizing innovative financing mechanisms can help accelerate the implementation of large-scale projects. The replication of these best practices across India will require strong policy support, adequate funding, and capacity building at the grassroots level, but with these strategies in place, India can significantly enhance its carbon sequestration efforts and meet its climate goals under the Paris Agreement[19].

8. Conclusion

Several Indian states have made significant strides in forest conservation and carbon sequestration through successful regional initiatives. In Odisha, for example, the "Green Odisha Mission" has been highly successful in enhancing forest cover and promoting environmental sustainability. By focusing on afforestation in degraded and barren lands, the mission has helped restore over 1.5 million hectares of forest and contributed significantly to the state's carbon sink (Ministry of Environment, Forest and Climate Change, 2023). Similarly, Himachal Pradesh has witnessed considerable success in increasing forest cover through its

[17] Forest Survey of India. (2021). *India State of Forest Report 2021*. Ministry of Environment, Forest and Climate Change, Government of India.
[18] ICIMOD. (2022). *Community-Based Forest Management in Madhya Pradesh*. International Centre for Integrated Mountain Development.
[19] Indian Council of Agricultural Research (ICAR). (2022). *Agroforestry Practices in India: Enhancing Sustainability and Carbon Sequestration*. ICAR.

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