Chapter 18
AI and Machine Learning in Carbon Sequestration: Transforming Climate Mitigation Strategies

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ABSTRACT

Carbon sequestration plays a crucial role in mitigating climate change by capturing and storing atmospheric carbon dioxide in various natural and engineered systems. The chapter Advanced Systems for Monitoring Carbon Sequestration explores state-of-the-art technologies and methodologies for tracking, quantifying, and verifying carbon sequestration in terrestrial, oceanic, and geological reservoirs. It provides an in-depth analysis of remote sensing, geospatial modeling, sensor networks, and AI-driven analytics that enhance the accuracy and efficiency of monitoring processes. Additionally, the chapter discusses the integration of satellite imagery, LiDAR, eddy covariance flux towers, and soil carbon measurement techniques. The role of blockchain and data transparency in carbon credit verification is also examined. By

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addressing challenges such as data uncertainty, cost-effectiveness, and scalability, the chapter highlights future directions for advancing monitoring frameworks to support global carbon management strategies.

1. INTRODUCTION

1.1 Background

Climate change is one of the most pressing global challenges, driven by excessive greenhouse gas emissions, particularly carbon dioxide (CO2). Industrial activities, deforestation, and fossil fuel combustion have significantly increased atmospheric CO2 levels, contributing to global warming and environmental instability (IPCC, 2021). Carbon sequestration, which involves capturing and storing CO2, is a key strategy to mitigate climate change effects and achieve carbon neutrality. Traditional carbon sequestration methods, including biological, geological, and chemical processes, have shown promise but require further enhancement to improve efficiency and scalability.

Artificial Intelligence (AI) and Machine Learning (ML) have emerged as powerful tools in environmental sustainability, providing data-driven solutions to optimize carbon sequestration. AI can analyze vast amounts of data, predict sequestration potential, and enhance carbon capture processes, making it an essential component in modern climate change mitigation strategies (Zhao et al., 2022).

1.2 Problem Statement

Despite advancements in carbon sequestration techniques, several challenges persist, including inefficiencies in monitoring, prediction, and optimization of sequestration sites. Traditional methods lack real-time adaptability, leading to suboptimal CO2 capture and storage. The application of AI and ML in this domain remains underutilized, primarily due to data limitations, computational constraints, and regulatory barriers (Goodrich et al., 2020). This research aims to bridge this gap by exploring AI-driven approaches to enhance carbon sequestration efficiency and effectiveness.

1.3 Objectives

The primary objectives of this study are: