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Review Article

Artificial Intelligence and Applied Machine Learning for Climate Change

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Abstract

Artificial Intelligence (AI) is believed to have significant potential use in tackling. Through the use of relevant data to build an algorithm, machine learning primarily aims to automate human help in terms of applied climate change. A subset of artificial intelligence (AI), machine learning focuses on the development of systems that can learn from past data for climate change in the platform of AI. There is great interest in how the growth of artificial intelligence and machine learning may affect global GHG emissions. Here, we introduce a systematic framework for describing the effects of machine learning (ML) on environmental gas emissions, encompassing three categories computing computing-related impacts, immediate impacts of applying ML, and system-level impacts. Using this framework, we identify priorities for impact assessment and climate change scenario analysis and suggest policy levels for better understanding and multiple shaping of the effects of ML on climate change mitigation. In this review paper, we combine AI and machine learning procedures. Also, we are used to this review paper of applied ML for multiple climate change regression. Climate change. This paper explores the connections between AI and climate change research as a whole and its usefulness in climate change adaptation efforts in particular. Using a systematic review of the literature on applications of AI for climate change adaptation and a questionnaire survey of a multinational and interdisciplinary team of climate change researchers, this paper shows the various means via which AI can support research on climate change in diverse regions and contribute to efforts towards climate change adaptation. Through the use of relevant data to build an algorithm, machine learning primarily aims to automate human help in terms of applied climate change. A subset of artificial intelligence (AI), machine learning focuses on development.

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1. INTRODUCTION

1.1 Artificial Intelligence in Climate Change Research

Artificial Intelligence (AI) is the discipline dedicated to the research and development of mechanisms and applications of AI systems. Machine learning (ML) and artificial intelligence (AI) increasingly influence lives, enabled by significant rises in processor availability, speed, connectivity, and cheap data storage, advancing transport delivery, medical and health, and climate change systems. There is a growing realization that climate change impacts are not an isolated threat; instead need more. Recent advancements in AI have demonstrated promising uses for enhancing climate modeling and prediction, improving environmental monitoring, streamlining disaster response mechanisms, optimizing resource management, advancing

renewable energy systems, implementing adaptive strategies, and enabling evidence-based policies.

AI has the potential to revolutionize climate and environmental research, but much of its research remains disconnected from real-world action and implementation. This review emphasizes the importance of ethically grounded, adaptable AI systems for tackling climate and environmental challenges, integrating AI with traditional knowledge systems, and empowering communities for localized decision-making. Artificial intelligence (AI) offers powerful tools for assessing, predicting, and mitigating climate change risks by leveraging data, sensing technologies, and learning algorithms. It performs calculations and forecasts, enabling informed actions to reduce the impacts of climate change. Additionally, AI enhances understanding of climate change effects across different geographical regions, providing valuable insights for targeted adaptation strategies (Amiri et. al., 2024;) [21].

The integration of AI and ML in climate science is a significant advancement in understanding and addressing climate change challenges. These technologies improve climate predictions, aid in mitigation and adaptation, and drive data-driven, sustainable solutions for a more resilient future.

2. Artificial Intelligence and Machine Learning for Climate Change

AI and its subset of machine learning have drawn significant attention in recent years. The influence of such technology on human life has increased due to improved connectivity, data storage, and processor speed. AI is frequently used in many sectors such as health and transport (Hunting Ford *et al*., 2019); renewable energies (He *et al*., 2021); education (Shaikh *et al*., 2021); construction industry (Abioye *et al*., 2021); ocean dynamics (Zhao *et al*., 2021); environmental quality control.

AI is revolutionizing climate change by providing innovative solutions for monitoring, mitigation, and adaptation. It improves weather forecasting, predicts extreme events, and models climate patterns. AI-powered sensors track deforestation, emissions, and ocean health, optimizing energy consumption and contributing to effective climate policies. Climate scientists use various methods to assess climate change, including complex models, historical data analysis, field studies, remote sensing, and statistical analysis. Advanced AI-ML methods are crucial for understanding climate change, enabling informed decisions, resilient urban planning, and resource optimization for a sustainable future (IPCC 2023) [31].

The Asian continent is crucial in climate change studies due to its diverse ecosystems, agriculture-dependent population, and rapid urbanization, making it a microcosm of global effects. Kumar *et al*. in 2024, conducted a pioneering case study to explore the connections between climate change and vector-borne diseases in South Asia, with a focus on Bihar, a state in northern India. Their research evaluated the potential of artificial intelligence and machine learning in supporting urban climate change adaptation and promoting sustainable development.

AI and machine learning (AI-ML) are being utilized globally to support climate change adaptation. In Australasia, AI-ML enhances wildfire management, environmental monitoring, and public engagement through tools like the "Citizen Science App." In Europe, it aids in predicting extreme weather, managing sea-level rise, mitigating urban heat islands, and improving energy efficiency. North and South America benefit from strong technological infrastructure, highlighting global disparities in AI-ML access. Small islands use AI-ML to tackle water scarcity and agricultural challenges, while polar regions provide critical data for climate modeling and understanding carbon dynamics, contributing to global mitigation strategies (Srivastava, & Maity, 2022) [30].

Responsible Artificial Intelligence (RAI) holds significant potential for promoting ethical and sustainable technology use across various development activities. It emerges as a powerful tool for climate change adaptation and mitigation efforts. This article introduces a theoretical RAI framework designed to support climate action by enabling more accurate climate data forecasting and interpretation. By enhancing energy efficiency and reducing greenhouse gas emissions, RAI can play a critical role in driving effective and responsible climate solutions (Kang and Nam 2024) [29].

Machine learning models have become valuable tools in assessing the impacts of climate change, particularly water scarcity and its effects on agriculture. Yang *et al*. (2016) [23] utilized Model Tree Ensembles, specifically Random Forests (RF), to evaluate the impact of drought across various climatic systems, offering insights into how water scarcity affects different regions. In the context of agricultural productivity, Azzari *et al*. (2017) [26] and Burke and Lobell (2017) [27] applied Convolutional Neural Networks (CNN) and Gaussian Process (GP) Regression to estimate crop yields from satellite data. These advanced techniques provide accurate, data-driven predictions, aiding in climate impact assessments and informing strategies for climate adaptation and food security.

Artificial intelligence techniques are increasingly used to analyze the influence of climate factors on environmental processes. Buckland *et al*. (2019) [24] employed Artificial Neural Networks (ANN) to investigate how climate drivers affect sand deposition in semi-arid regions, providing deeper insights into landform changes influenced by climatic variations. In hydrology, Ghiggi *et al*. (2019) [25] utilized Random Forest (RF) algorithms to create a long-term, globally consistent runoff dataset. This dataset is essential for assessing hydrological trends and variability, offering a robust foundation for understanding the impacts of climate change on global water resources.

3. AI in mitigation of Climate change and SDG

AI plays a crucial role in climate change mitigation by optimizing energy consumption and integrating renewable energy sources. It can analyze real-time data from smart grids, reduce waste, and enhance the reliability of wind turbines and solar panels. AI is crucial in monitoring and reducing carbon emissions, analyzing data from sources like satellite imagery and industrial sensors, and promoting a circular carbon economy through carbon capture technologies. AI enhances climate models and predictions by analyzing historical data and real-time

observations, enhancing projections, and providing timely information for disaster preparedness and response. Satellite-based remote sensing and AI algorithms enable systematic Earth surface monitoring, identifying deforestation hotspots, illegal mining, and land use changes, and collecting high-resolution data for precise environmental monitoring in hazardous areas (Olawade *et al.*, 2023; Kamalov *et.al.*, 2023) [22, 20].

4. METHODOLOGY

This paper seeks to identify the nexus between AI and climate change adaptation in a sample of countries known to be investing resources in AI for various climate change adaptation purposes primarily based on a systematic literature search that was implemented, adapting the model used by Leal Filho *et al*. (2019) [8]. The following data collection and analysis steps were conducted sequentially: Identify data sources; select pieces of pertinent literature; perform critical evaluation of studies;

5. CONCLUSION

This research has tried to analyze the connections between AI and climate change adaptation. One of the main findings from the study is that respondents from North America and South America are already extensively applying and utilizing DTs and AI as tools to increase climate change adaptation. This was evidenced by the high levels of optimism as indicated by 80% of respondents from North America and 75% from South America agreeing that these tools are essential, hence being frequently used.

AI and ML are crucial tools in combating climate change, enabling precise climate modeling, predicting extreme weather events, and optimizing resource management. They enhance understanding of climate systems, monitoring deforestation, and managing renewable energy. However, ensuring equitable access, ethical considerations, and interdisciplinary collaboration is essential for their full potential.

Artificial Intelligence and Applied Machine Learning are poised to significantly contribute to climate change mitigation. As they process complex datasets, they can make accurate climate predictions and develop adaptive strategies like precision agriculture and energy grid optimization. AI-driven climate models and autonomous monitoring systems will enhance real-time decision-making and resource management. However, ethical AI frameworks are needed to ensure responsible use, transparency, and equitable access. Collaboration between governments, industries, and academia is crucial for maximizing AI and ML's potential.

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