


Chapter 2

Advancing Environmental Modeling: Integrating AI, Big Data, and Predictive Analytics for Sustainable Solutions

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ABSTRACT

Environmental modeling has a major importance in analyzing the changes in the environment, climate, and resource allocation. The current environmental models with the use of new technologies such as AI, machine learning, big data, and IoT improves the precision of climate change predictions, emissions, protection of species, and prevention of calamities. These models use data and information generated in real-time and computer models to arrive at policy recommendations. However, there are some limitations like data uncertainty, computational complexity, and the gaps

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between the existing and implemented policies that reduce their efficiency. Future research needs to address the issues of combining different types of AI, continuous monitoring of the AI-driven processes, and sharing of AI models due to the concerns related to the accessibility and accuracy of the results. At the international level, the development of environmental modeling hence requires interventions from interdisciplinary fields as the policy frameworks.

1. INTRODUCTION

1.1 Background and Motivation

Environmental modeling has become very important in analyzing and solving environmental problems as they are today. It is the methodology based on formula, algorithms, and approaches for modeling of environmental occurrences [Zhong et al 2021]. By using models, the researchers, policymakers or other professionals within the industry can predict the trends and risks associated with sustainability for evaluating and designing strategies. Environmental modeling is important since it focused on portraying the real-world systems in a systematic manner. These models include the climate change models, air and water quality models, species distribution models, disaster models as well as land-use planning models [Wu et al 2022]. The simulation capacity allows the decision-makers to try policies and measure resource costs and risks before going to the field and implementing the actions. Computational models are used in a number of capacities in environmental systems. Environmental processes are relatively complex and active mostly under the influence of factors such as weather changes, human interference, and acts of nature. Traditional methods of observation are rather restricted in the sense that they do not capture the whole picture of such systems. Thus, computational models fill this gap by reflecting a large amount of data from remote sensing, sensor networks, GIS and real-time monitoring. These models help the scientists to forecast the future changes in the environment and the possible effects that may be associated with the changes. The development of the environmental modeling has been influenced by four factors, namely; computational power, artificial intelligence and lastly data analytics. Advanced technologies such as machine learning and deep learning coupled with the cloud computing systems have enhanced better and more accurate forecast of the environment [Lakumarapu et al 2024; Subha et al 2024]. Due to this, environmental modelling has gone beyond being a research topic to being an important tool in decision making in government departments, global organizations, private sectors and non-governmental organizations. However, there are some issues that have been seen to affect environmental modeling, these

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