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APPLICATION OF AI IN CLIMATE CHANGE RESEARCH- A SYSTEMATIC REVIEW

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ABSTRACT

Beyond reasonable concern, Artificial Intelligence (AI) has the potential to optimize activities, increase efficiency, and improve the accuracy and efficacy of societal predictions and likelihoods. The most promising applications of this technology may not be related to civil liberties or the social fabric, but rather to addressing technical challenges beyond human capacity. Climate change is a difficult issue that requires significant changes to our transportation, construction, agriculture, water resources, and energy sectors. While AI is being utilized to enhance climate change estimates and implications, there has been limited research on its usage. The recent debate has prompted calls for more uniformity and transparency in the processes used to synthesize climate change research. Here, an analysis of systematic literature review approaches in the application of AI in climate change research is presented.

KEYWORDS: ***Climate Change, Artificial Intelligence, PRISMA, Systematic Review***

1. INTRODUCTION

Climate change is one of the most daunting issues faced by the world today. It is an emergency that spans globally.The United Nations defines climate change as 'long-term shifts in temperatures and weather patterns' (UN, n.d).

Every aspect of our lives has already been impacted by climate change, resulting in rising temperatures, floods, droughts, food scarcity, declining health, and many more. Researchers and environmental experts worldwide have given focus on addressing the climate crisis. The result is a matrix of adaptation issues that is uncertain, intricate, and rapidly shifting(Helmrich & Chester, 2020), which the conventional climate change adaptation tools and techniques are not ready to address.

The increasing severity of climate change challenges has led to the promotion of Artificial Intelligence (AI) as a viable answer for solving the challenges of climate change. AI can help mitigate climate change by improving the prediction of extreme weather events(McGovern et al., 2017), keeping track of nuclear energy production to use in future estimation of energy industry(Woo, 2019), along with considering it as a major source of mitigating global warming(Woo, 2023), address climate change using energy sector(Stein, 2020), promoting sustainability through natural resource management and designing resilient cities(Chen et al., 2023), tracking the river flow levels, lake water variations, rainfall, ground water levels etc. which are crucial components in tackling climate change can be monitored using various AI tools (Secci et al.,2023; Behfar, Booij and Nourani, 2024; Jian et al.,2024; &Abbaszadeh et al.,2025).

AI has the potential to address the issue of climate change in part by using online resources to generate timely suggestions based on precise climate forecasts. With the escalating availability of new data streams and analytical tools, AI has new opportunities to address climate change. Although AI has been used in climate change science, its applications have mostly been confined to mitigation, impact, and climate change modelling (Huntingford et al., 2019; Jones, 2017; Schmidt and McQuade, 2013; &Rolnick et al., 2022). Concisely, AI has the potential to redefine how we approach climate change mitigation by delivering new tools and insights that will help us achieve a more sustainable future.

Here, the study reviews contemporary research and the application of AI in minimizing the adverse effects of climate change. The study is designed to address the specific uses of AI and AI-based techniques in mitigating climate change.

1. DESIGN AND METHODS

A systematic literature review gathers all pertinent information that meets the predetermined eligibility criteria to address a research question. It identifies, evaluates, and interprets all relevant research on a topic, issue, or research question(Kitchenhan, 2004). The PRISMA model has been adopted in the study, an approach derived from health care research in which clinical practice guidelines and information are needed to aid clinical decision-making within a predetermined methodological framework(Moher et al.,2015). This method can help researchers summarise existing literature through a rigorous, precise, and transparent stepwise procedure(Mulrow et al.,2009). The final research topic for a new study to address the gap identified in the literature can be justified by a more systematic literature review(Tranfield, Denyer & Smart, 2003). Interest in the study of the application of AI to various climate change studies also offers an initial assessment of the significance of this literature gap. In this context, employing a methodology based on systematic literature review provides an assessment of the relevance of this gap.

Literature published from 2019 to 2025 has been examined that delves into the different approaches of AI in climate change science. The literature was identified by query keywords in the title, abstract, and keywords from

the Web of Science Database. Table 1 below presents the criteria, eligibility, and exclusion strategies for the retrieved data.

Table 1- Criteria for Data Retrieval

Database	Web of Science Database and Dimensions AI
Inclusion & Exclusion Criteria	Only publications having the search terms in the title, abstract and keywords; Only publications in English; 2019-2025
Publication Type	Review Article, Article, and Editorial Material
Bibliometric Software	VOSviewer

Following PRISMA guidelines, literature that includes books, conference reports, and articles in languages other than English has been excluded. Only research articles and review literature written in the English language and relevant to the study, which can be accessed in full text, are included in the examination. VOSviewer, an online application, maps words into clusters representing a research theme.

The detailed process resulted in a final sample size of 41 literature for in-depth analysis. The sort-out literature were analysed to discuss general information, methodology and implications. The PRISMA flowchart is given in Figure 1. The sampled literature was read in its entirety, and the information was tabulated (Table 1). This study will provide significant insights into answering typical research questions (RQs) raised in the literature review.

RQ1: What is the year-wise research productivity trend in the application of AI in climate change research?

RQ2: What are the leading nations in the research field?

RQ3: What are the major research areas in the application of AI in climate change research?

RQ4: What are the major themes for research on the application of AI in climate change research?

RQ5: What considerations exist in the implementation of AI in the domain?

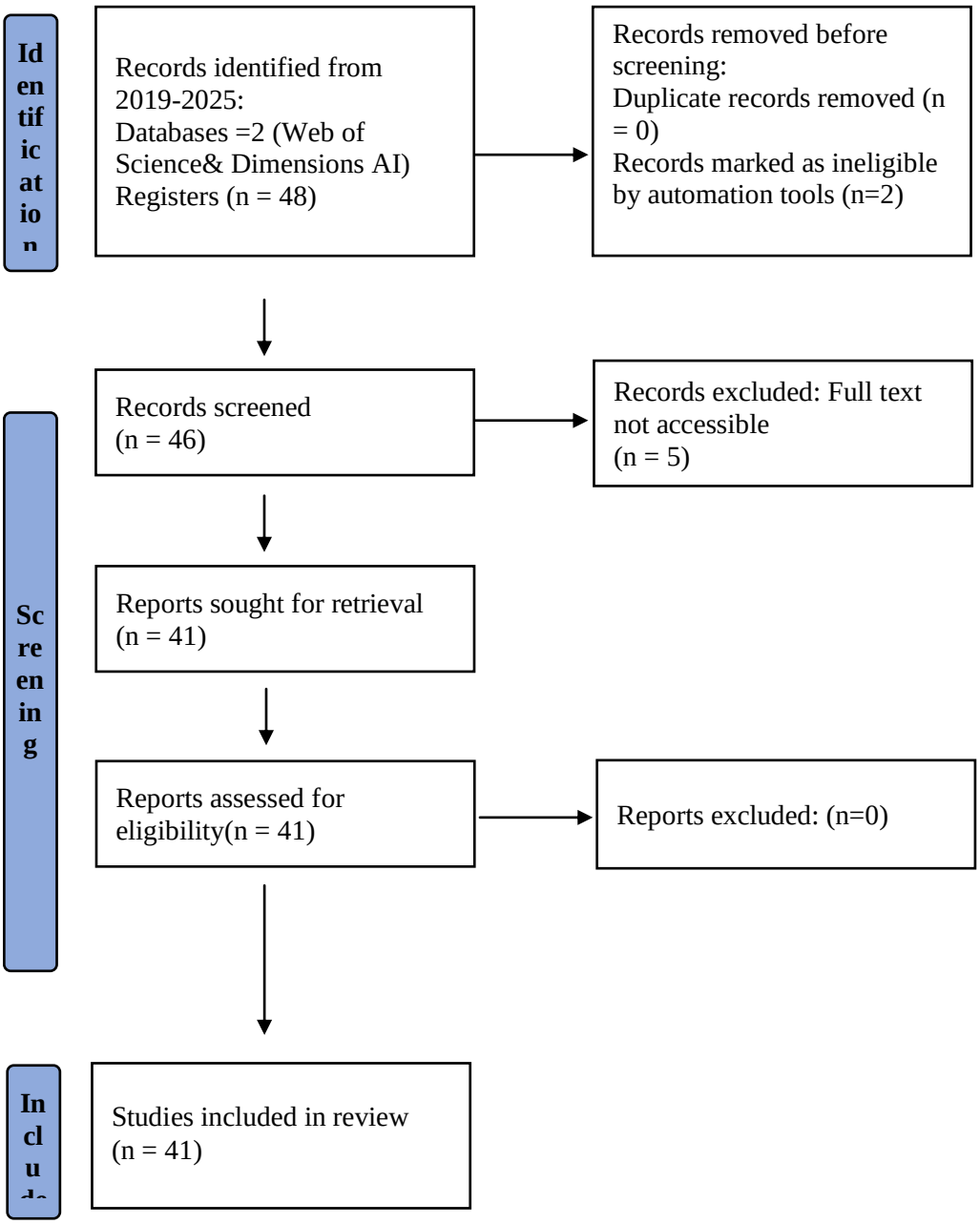

Figure 1: PRISMA flow diagram for systematic literature reviews

2. LITERATURE AND INFORMATION SOURCES

Table 2 depicts the summary of the literature included in the study. It put on view the various research methods and analyses employed for the research being conducted. It shows the status of methods explicitly and puts forth their research implications.

Table 2- Summary of Systematic literature review articles on application of AI in climate change research indexed in Web of Science

Source	Title	Research Method	Analysis	Data Source	Methods Explicit	Implications
Woo, TH. (2019)	Artificial Intelligence-based modelling for global warming analysis incorporated with the nuclear energy productions	Quantitative	Co-relational	Review Article	Yes	For the reliability of the nuclear energy productions incorporated with a neural networking algorithm, the AI-induced Machine Learning is used for future estimation of energy industry
Woo, TH. (2023)	Artificial Intelligence(AI) based analysis for global warming mitigation of non-carbon-emitting nuclear energy productions	Quantitative	Co-relational	Review Article	Yes	Applying AI-based quantifications, Nuclear energy is considered a major source of global warming mitigations
Stein, AL (2020)	Artificial Intelligence and climate change	Qualitative	Descriptive	Review Article	No	Using the energy sector to demonstrate the potential promise and drawbacks, the enhanced use of AI to address climate change has been discussed
Cheong, SM., Sankaran, K. & Bastani, H.	Artificial Intelligence for Climate Change	Qualitative	Descriptive	Review Article	No	Identify the limited use of AI in addressing climate

(2022)	Adaptation					change adaptation and highlight the value of AI in adaptation choices and implementation
Kaack, L.H. et al. (2021)	Aligning Artificial Intelligence with climate change mitigation	Qualitative	Descriptive	Review Article	No	Assessed and prioritized research and data needs for shaping the effects of AI and Machine Language on climate change mitigation
Filho, WL. Et al. (2022)	Deploying Artificial Intelligence for Climate Change adaptation	Quantitative	Co-relational	Review Article	Yes	AI can contribute to global effects in better understanding and handling of climate change challenges
Singla, C. et al. (2023)	Artificial Intelligence-based approach to study the impact of climate change and human interventions on groundwater fluctuations	Quantitative	Experimental	Article	Yes	Depletion of groundwater in Central Punbal is addressed using AI-based approach like Artificial Neural Network (ANN) and Multiple Linear Regression (MLR) models
Chen, L. et al. (2023)	Artificial Intelligence-based solutions for climate change: A Review	Qualitative	Descriptive	Review Article	No	Promotion of sustainability can be done through the application of AI in natural resource management and the design of resilient cities
Rodriguez-Delgado, C.	Wave energy assessment under	Quantitative	Case Study	Article	Yes	Taking into account the effects

&Bergillos, RJ. (2021)	climate change through Artificial Intelligence					of climate change, the Artificial Neural Network(ANN) and Delft 3D model serve as a useful tool to assist engineers, managers, and policy-makers in the selection of the most promising locations for wave energy facilities
Luccioni, A. et al. (2021)	Using Artificial Intelligence to visualize the impacts of climate change	Qualitative	Descriptive	Review Article	Yes	The AI climate impact visualizer has been developed to represent images and accessible information regarding the science behind climate change
Levy, O. and Shahar, S. (2024)	Artificial Intelligence for climate change Biology: From data collection to predictions	Qualitative	Descriptive	Article	No	The convergence of AI, big data, and ecological science is crucial for addressing the 21st century global environment challenges
Taddeo, M. et al. (2021)	Artificial Intelligence and the climate emergency: Opportunities, challenges, and recommendations	Qualitative	Descriptive	Editorial Material	No	In the interest of an equitable and sustainable future, the researchers and policymakers are required to act to ensure the impact of the AI tool, to develop effective responses to the climate emergency,

						is as positive as possible
Mascareno, A. (2024)	Contemporary visions of the next apocalypse: Climate change and Artificial Intelligence	Qualitative	Descriptive	Article	No	Apocalyptic eschatology encourages a ritualistic response in the present to avoid explaining the intricate causalities behind AI and climate change
Ballestar, MT., Martin-Haguno, M. and Sainz, J. (2022)	An Artificial Intelligence analysis of climate change influencers' marketing on Twitter	Quantitative	Correlational	Article	Yes	AI and natural language processing were applied to scrutinize the sentiment of messages of Thunberg and Gates, thus resulting in the different and unconnected strategies to deliver their messages to their followers
Amiri, Z., Heidari, A. and Navimipour, NJ. (2024)	Comprehensive survey of Artificial Intelligence technologies & strategies for climate change mitigation	Mixed	Descriptive	Article	No	A new perception on the effectiveness and reliability of Deep Learning methods has been provided in addressing challenges on climate change
Podrecca, M. et al. (2024)	Artificial Intelligence for climate change: A Patent Analysis in the manufacturing sector	Quantitative	Correlational	Review Article	No	Bring forth the current state of AI technologies in addressing and mitigating global climate change in

						the manufacturing sector, and lay out a viewpoint for future development
Nguyen, H. et al. (2024)	Misrepresentation or inclusion: promises of generation Artificial Intelligence in climate change education	Quantitative	Correlational	Article	No	Potential and challenges of using generative AI, including Large Language Models (LLMs) to depict the corresponding perspective
Huntingford, C. et al. (2019)	Machine Learning and Artificial Intelligence to aid climate change research and preparedness	Qualitative	Descriptive	Article	No	Machine Learning and AI will enhance forecasting across time scales and adopt this information to support the decision
Leal, W. and Gbaguidi, GJ. (2024)	Using Artificial Intelligence in support of climate change adaptation Africa: Potential and risks	Qualitative	Descriptive	Editorial Material	No	Outlines the benefits and drawbacks of using AI in agriculture and also emphasizes the need for clear regulatory frameworks for AI deployment
Mohamed, K. and Shen, JD. (2024)	Exploring the potential for incorporating Artificial Intelligence in Highway Resilience to climate change	Qualitative	Descriptive	Article	No	Discussed the potential applications of AI, Machine Language and big data availability in highway resilience to climate change
Garrett, KA. et al. (2022)	Climate Change effects on pathogen emergence:	Qualitative	Descriptive	Review	No	Reviewed machine-learning applications in

	Artificial Intelligence to translate big data for mitigation					plant pathology and developed strategies to make the most of these tools in digital agriculture
Secci, D. et al. (2023)	Artificial Intelligence models to evaluate the impact of climate change on groundwater resources	Quantitative	Correlational	Article	Yes	Using historical records of groundwater levels, temperature and precipitation, along with regional climate projections, AI models are used to investigate the effects of climate change on groundwater resources
Shaamala, A. et al. (2024)	Algorithmic green infrastructure optimisation: Review of artificial intelligence-driven approaches for tackling climate change	Mixed	Correlational	Review Article	Yes	Consolidate the understanding of AI-driven green infrastructure optimisation, particularly for tackling climate change
Bird, LJ., Bodeker, GE. and Clem, KR. (2023)	Sensitivity of extreme precipitation to climate change, inferred using Artificial Intelligence, shows high spatial variability	Mixed	Correlational	Review Article	No	Presented an approach using AI model to evaluate extreme precipitation change with climate
Chakraborty, D. et al. (2021)	Scenario-based prediction of climate change impacts on building cooling energy consumption with Explainable	Quantitative	Correlational	Article	Yes	Explore the impacts of climate change on the cooling energy consumption in buildings and

	Artificial Intelligence					predict the long-term cooling energy consumption using Explainable AI (XAI)
Pimenowa, S., Pimenowa, O. and Prus, P. (2024)	Challenges of Artificial Intelligence development in the context of energy consumption and impact on climate change	Mixed	Descriptive	Review Article	No	Identifies areas for further research, striving minimum negative impacts and maximizing its contribution to sustainable development in the energy consumption of AI
Dominguez-Rodriguez, A. et al.(2023)	Measurement scales of mental health related to climate change: A scoping review protocol using Artificial Intelligence	Qualitative	Descriptive	Review Article	Yes	Organises the available evidence to understand the state of the art of the effect of climate change on mental health
Qerimi, Q. and Sergi, BS. (2022)	The case for global regulation of carbon capture and storage and Artificial Intelligence for climate change	Mixed	Correlational	Article	Yes	Highlighted the emerging trend towards an international regulatory framework that aims to include Carbon Capture and Storage (CCS) within the scope of credible solutions for climate change mitigation
Elkiran, G. et al. (2021)	Impact of Climate Change on hydro-climatological parameters in North Cyprus: Application of Artificial	Quantitative	Correlational	Article	Yes	Impact of climate change on hydro-climatological parameters has been explored using AI-based

	Intelligence-based statistical downscaling models					future forecasts and statistical downscaling
Behfar, N., Booij, MJ. And Nourani, V. (2024)	Assessing rainfall runoff models for climate change: Simple and differential split-sample tests for conceptual and Artificial Intelligence models	Quantitative	Correlational	Article	Yes	The use of model ensemble techniques integrating AI and Deep Learning models can escalate the performance of rainfall-runoff modeling in climate change
Coeckelbergh, M and Saetra, HS. (2023)	Climate change and the political pathways of AI: The technocracy-democracy dilemma in light of Artificial Intelligence	Qualitative	Descriptive	Article	No	The impact of AI on politics and democracy has been discussed by setting them in a technocracy-democracy dilemma using the concept of critical junctures
Tian, PL. et al. (2024)	Exploring the effects of climate change and urban policies on lake water quality using remote sensing and explainable Artificial Intelligence	Quantitative	Diagnostic	Article	Yes	Demonstrate the long-term contribution of climate change and urban policies in propelling lake water variations
Janizadeh, S. et al. (2024)	Impact of climate change on future flood susceptibility projections under shared socioeconomic pathway scenarios in South Asia using Artificial Intelligence	Quantitative	Correlational	Article	Yes	Perception on effects of climate change on flood susceptibility in South Asia has been strengthened and offers a tool for assessing and managing flood risks in the region

	algorithms					
Alibudbud, RC. Et al. (2024)	Artificial Intelligence in the era of planetary health: insights on its application for the climate change-mental nexus in the Philippines	Qualitative	Descriptive	Review Article	No	Explores the probability of dangers posed by the climate crisis on mental health by AI
Gaska, K. et al. (2023)	Artificial Intelligence methods for analysis and optimization of CHP cogeneration units based on Landfill biogas as a progress in improving energy	Quantitative	Correlational	Article	Yes	Presented an advanced model for the production of fuel mixtures in the production of fuel mixtures in the context of energy use in a combined heat and power (CHP) unit
Bui, MT., Yanez-Godoy, H. and Elachachi, SM. (2024)	Assessment of the implications and challenges of using Artificial Intelligence for urban water networks in the context of climate change, when building future resilient and smart infrastructure	Qualitative	Descriptive	Review	No	Assessed the implications of AI, specifically, machine learning in transforming urban infrastructures into smart cities by integrating geotechnical modelling and experimental building methods
Hauser, OP. (2025)	Climate change, Intergenerational fairness, and the promises and pitfalls of Artificial Intelligence	Qualitative	Descriptive	Article	No	Examine how applying AI to intergenerational dilemmas might foster fairness and cooperations
Abbaszadeh, M. et al. (2025)	Harnessing Artificial Intelligence for streamflow predictions under	Quantitative	Correlational	Article	Yes	Compared different timelines to assess the effects of climate change on

	climate change scenarios in arid region					river flow levels in the Minab river basin, thus giving insights to local organizations and authorities for water resource management
Sander, B. (2025)	Confronting risks at the intersection of climate change and artificial intelligence: The promise and perils of rights-based approaches	Qualitative	Descriptive	Article	No	Draws attention towards the risks and issues that are associated with relying on AI to combat climate change
Bag, S. et al. (2025)	Utilizing Artificial Intelligence for stakeholder engagement and social innovation in addressing climate change: A conceptual framework and future research agenda	Qualitative	Descriptive	Article	Yes	Highlights AI's impact on social engagement, in line with diffusion theory, emphasizing the importance of highlighting AI's positives to accelerate adaptation
Laaribya, S. and Alaoui, A. (2025)	Spatio-temporal trends and climate change impacts on land cover dynamics in Talassemtane National Park (Morocco) using Artificial Intelligence and Google Earth Engine	Quantitative	Descriptive	Article	Yes	Highlights the effectiveness of using remote sensing and special algorithm methods to monitor vulnerable ecosystems, thus emphasizing the urgent need for adaptive management solutions to mitigate the impact of climate change

						on Talassemtane National Park (TNP)

3. REPORTING RESULTS AND DISCUSSION

3.1. General Analysis

Figure 2 depicts the number of publications between 2019 and 2025, where all the documents were published before June 2025. In this latest scenario of climate change mitigation, there is an increase intervention of AI in the field. The year 2024 marks the highest productive year, with 14 publications out of 41, followed by 2023 with 8 publications. By the end of 2025, there a possibility of increase in number of literatures in the research field. This answers the RQ1.

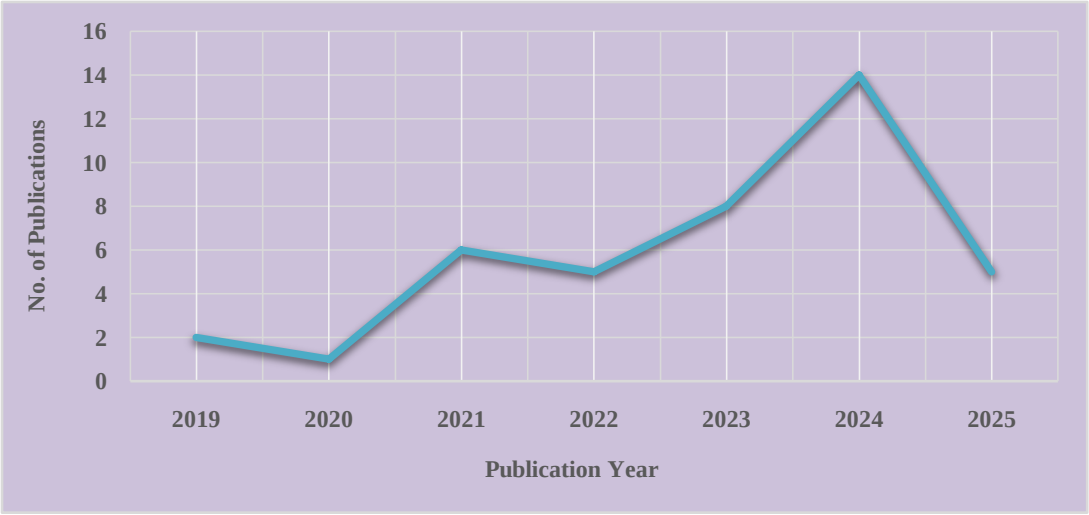

Figure 2: Publication Trend

Observing table 2, USA leads in the contribution of researchers working in the field, followed by England, India, Iran and Peoples Republic of china. This Answers the RQ2.

Table 3: Top 5 productive countries

Rank	Country	No. of Publications	Percentage
1	USA	10	24.39 %
2	England	6	14.63 %

3	India	4	9.75%
4	Iran	4	9.75%
5	Peoples Republic of China	4	9.75%

The intervention of AI in climate change research are immense. It encompasses many research areas in diverse fields. Answering RQ3, Table 3 outlines the top research areas, where Engineering and Environmental Sciences, Ecology, are the top research areas, followed by Energy fuels, Water resources, and Business Economics.

Table 4: Top 5 Research Areas

Rank	Research Area	No. of Publications	Percentage
1	Engineering	11	26.82 %
2	Environmental Sciences Ecology	11	26.82 %
3	Energy Fuels	6	14.63%
4	Water Resources	6	14.63%
5	Business Economics	4	9.75%

3.2.Theme Analysis

To answer RQ4, a theme analysis has been conducted using VOS viewer. Figure 3 represents the resulting clusters and further discusses the derived themes below.

Cluster 1: AI intervention in climate change and sustainability

As AI continues to prevalent in our daily lives, concerns have been raised about the threats it poses to privacy, security, due process, and democracy itself. Despite these legitimate concerns, AI has the potential to optimise activities, improve accuracy and increase efficiency of many aspects of society that rely on predictions and likelihoods. Thus, the most promising applications of AI may not be related to the social fabric of our society or civil liberties, but to those complex technical issues that are beyond human capacity. There are critical trade-offs corresponding with an increased use of AI to address climate change. Its benefits can be used to reduce emissions of Greenhouse Gas (GHG), and can be further utilized in agriculture, commercial, residential, and transportation sectors(Stein, 2020).

AI can effectively utilize real-time information in data-scarce environments and enable decision-making, adapt to heterogeneous populations, and promote effective synergies and trade-offs by employing transfer, reinforcement, supervised, and multi-model learning. The Ability to comprehend what and how we are adapting to climate change within the complex, dynamic system in which adaptation strategies are developed will lead to the effective management of the climate crisis (Cheong, Sankaran, and Bastani 2022).

Assessing and shaping the impact of AI on climate mitigation demands collaboration across research, policy, and industry. However, the impact of AI on present and future Greenhouse gas (GHG) emissions remains uncertain. Using systematic framework for deploying AI, especially Machine Language (ML) impact on GHG emission,

research and data needs for impact assessment and scenario analysis can be assessed and identify important policy levers(Kaack et al.,2022).

AI can greatly detect water-related management issues. There is also a great deal of anxiety about the potential risks posed by AI concerning humanity and an existential threat to civilization. However, when due care is taken, global efforts to better comprehend and handle the numerous challenges related to a changing climate may benefit from the application of AI(Filho et al.,2022).

Being a major threat, climate change is already harming natural and urban systems resulting in global economic losses. AI has the potential to address these problems, in part by integrating internet resources to generate timely recommendations based on accurate climate change predictions. AI technologies have been utilised by 70% of the global natural gas industry to intensify reliability and accuracy of weather prediction. Combining smart grids and intelligent transport systems with AI can optimize power systems' efficiency and reduce carbon dioxide emissions. Moreover, sustainability can be further advanced by the application of AI to manage natural resources and build resilient cities(Chen et al.,2023).

According to the United Nations (UN) and World Economic Forum (WEF), manufacturing sector constitute a major cause of climate change. Manufacturing industries contribute to the unsustainable consumption of natural resources i.e. massive use of energy, raw material, and water, which contributes to the depletion of Earth's natural resources, which leads to ecological imbalances(Bhatia, Jakhar and Dora, 2022). AI plays several roles in the larger clean-tech innovation scene and urges policymaker to take synergies into accounts. Managers can use information to develop technology portfolios and alliances, considering technological evolution(Podrecca et al.,2024).

Generative AI (GenAI) technologies like Large Language Models (LLMs), can efficiently synthesize and generate new teaching and learning resources. Climate justice can be represented by potential leveraging LLMs within a science communication curriculum. Climate justice addresses the sociocultural, racial and environment dimensions of climate crisis, emphasizing local impacts and unequal vulnerability (Schlosberg & Collins, 2014). Without a diverse, intersectional, and culturally sustaining perspective, GenAI may perpetuate educational and societal inequalities(Nguyen et al.,2024).

Green Infrastructure (GI) is a fundamental building block which promotes sustainability and vibrancy to cities by contributing numerous benefits such as water, air quality, cooling, greening and control carbon emissions. The use AI technologies for GI optimization is considered a potent strategy. However, a knowledge deficit remains in the field of AI-driven GI optimization for climate change mitigation. GI optimization goes beyond technological improvement and necessitates thoughtful integration into the urban fabric, ensuring GI not only improves environmental quality but also contributes to accessibility and social fairness(Shaamala et al.,2024).

Application of AI and Machine Learning (ML) has become a crucial tool in combating climate change and enhancing energy efficiency, and its implementation in mitigating the impact of climate change and energy efficiency leads to dual nature. Where AI facilitates sustainable solutions, operation of Large Language Models (LLMs) involves high energy consumption, jeopardizing the carbon neutrality efforts(Pimenowa, Pimenowa& Prus, 2024).

Vulnerability to climate catastrophes has substantial consequences on psychological well-being. 44 million people could fall into extreme poverty due to the adverse impacts of climate change on human health(Jafino et al.,2020).The situation has heightened mental health symptoms such as post-traumatic stress, depression, and anxiety, which lead to the emergence of new terminologies like 'solastalgia' (Albrecht et al.,2007), 'climate anxiety' (Clayton,2020), 'eco-anxiety' (Usher, Durkin and Bhullar, 2019), and 'ecological grief'(Comtesse et al.,2021). to make visible the emotional distress caused by environmental degradation.

Carbon Capture and Storage, a global effort to limit carbon dioxide emissions, when combined with wind, solar, and nuclear energy and emerging technologies, plays a vital role in decarbonizing industrial processes, thus reducing mitigation costs significantly(IPCC,2014). A relatively new and developing area for the wider use of carbon capture and storage technology includes more advanced AI options, in order to enhance the likelihood of achieving global climate goals and thus stabilizing global temperature(Qerimi& Sergi, 2022).

AI may considerably aid in improving decision-making processes related to climate change, as existing approaches have proven insufficient and arguably prone to getting stuck(Saetra, 2020). On the other hand, allowing AI decide without human oversight or control is far riskier since it threatens core principles from the very start(Coeckelbergh&Saetra, 2023).

Although the intersections of AI and climate change have been recognized, the focus has typically been on AI's potential to improve societal responsiveness to the climate crisis, with particular attention placed to its ability to assist decision-makers in better anticipation, mitigate and adapt to climate change(Schutze, 2024). Relying on AI technologies to solve the climate crisis is also fraught with a range of interrelated hazards and issues(Sander, 2025).

Regional sea-level change, melting ice, coastal impacts, weather and climate extremes, carbon feedbacks in the climate system, water for food baskets of the world, climate sensitivity, and near-term climate prediction are a few of the many issues that fall under the umbrella of grand challenges of climate research. The management scholars have recognized climate change as a societal grand challenge and integrated it with national policies, plans, and strategies (George et al.,2016; Bag et al.,2024).

Cluster 2: Climate Prediction using AI

The severity of climate change's threat to people and the environment is frequently not addressed by the public. To mentally simulate this dispute, one must understand the long-term repercussions of complex issues like climate change by representing the concrete picture of our own activities. These possible images of future risks from climate change and extreme events may be used to influence the perception of climate risk and public opinion(Luccioni et al.,2021).

Several studies have already demonstrated the induced adjustments caused by climate change in animal behaviour, phenology, and distribution(Thomas et al.,2004). The thoughtful use of AI in tracking animal data and interpreting microclimates enhances our ecological models' precision and scope while also strengthening conservation tactics and contributing to a more robust framework for biodiversity in the face of environmental change globally(Levy & Sahar, 2024).

The advantages of AI in land use and agriculture can outweigh the risks by encouraging co-operation, guaranteeing equitable access, and promoting suitable practices. This will assist farmers' communities in overcoming the many challenges and risks they are currently facing(Leal &Gbaguidi, 2024).

Changes in the frequency and intensity of Extreme Precipitation Events (EPSs) are among the most damaging climatic risks and are of major concern to society (Vander &Bintanja, 2021; Sebastain et al.,2019). An AI-based method, Convolutional Neural Network (CNN) can incorporate with learning the statistics of EPEs along with climate covariate, to determine the sensitivity of extreme precipitation to climate change(Bird, Bodekar&Clem, 2023).

eXplianable Artificial Intelligence (xAI), a novel data-driven AI model, can analyse how climate change effects on the cooling energy consumption and predict long-term energy usage. By leveraging the power of significant, and reliable predictions and insights, it will enable stakeholders and decision makers to contemplate and prepare for possible future energy change scenarios. It will also establish the groundwork for mitigation strategies for sustainable development and climate-resilient adaptation (Chakraborty et al.,2021). Lake water quality is also significantly impacted by urban policy and climate change, particularly in rapidly developing regions. xAI can be used in determining the comprehensive impacts that vary over time. It also illustrates how urbanizations and climate change have a long-term impact on lake water variations, with implications for fostering beneficial social, economic, and environmental relationships(Jian et al.,2024).

Downscaling models such as Artificial Neural Networks (ANNs) and Multiple Linear Regression (MLR) can be employed to estimate future precipitation and temperature, which further could be used in policy-making, as well as climate change adaptation and water resource management(Elkiran et al.,2021).

Runoff prediction and simulation are crucial for planning and managing watershed sustainability. However, frequency, timing, and intensity of extreme weather events are exacerbated by climate change and human activities, complicating the development and use of precise and computationally effective hydrological models(Tongal& Booij, 2018). It is of great importance to consider various AI modelling techniques to accurately predict runoff in hydrological systems under climate change scenarios (Behfar, Booij,& Nourani, 2024).

The frequency, duration, spatial extent, and timing of flood events are all expected to be impacted by climate change, thereby making them more hazardous and prevalent. There are several AI algorithms that can be employed to predict and advance understanding of how climate change affects flood susceptibility, and also provide an essential tool for analysing and managing flood risk in the region(Janizadeh et al.,2024).

Decisions involving water resource management require precise information for groundwater levels. The main reasons for groundwater depletion can be identified using Artificial Neural Network (ANN) and Multiple Linear Regression (MLR) models, thereby assisting policymakers in obtaining suitable outcomes (Singla et al., 2023).

River flow levels are also affected by climate change, and it is likely to observe more consequences in the future. Using an AI model like the Canadian Earth System Model (CanESM5), the impact of climate change on precipitation and temperature dynamics in river flow can be analysed. These insights are essential for local governments and organizations to manage water resources effectively (Abbaszadeh et al.,2025).

Cluster 3: Machine Learning to aid Global Warming

Machine Learning (ML) can be used to predict the reliability of nuclear energy generation in the future, incorporating game theory and a neural network method. Nuclear power, as a key non-carbon production energy source, would be created using regenerative energy rather than fossil fuels like oil and gas. In other words, nuclear energy has the potential to reduce global warming caused by carbon-based fuels(Woo, 2019). Nuclear energy can be compared to traditional energy sources such as oil and coal, which have high carbon emissions. AI algorithms mimic organic neurons through mathematical calculations, similar to how a robot's intelligence works (Woo, 2023).

The utilization of Machine Learning on climate change extends beyond reducing greenhouse gas emissions and improving energy efficiency. Many AI approaches can be employed to explore various climate change mitigation techniques. This provides a good roadmap for future research on climate change mitigation with AI approaches (Amiri, Heidari &Navimipour, 2024). Machine Learning algorithms can also help tele-connection identification and AI can expand on the climate connections that have been found to offer better warnings for impending weather phenomena, such as extreme events(Huntingford et al.,2019).

Several potential users that could benefit from Machine Learning/AI tools, like geo-hazard programs, geotechnical asset management, and probalistic damage evaluation could be take on the challenges with managing the highway geotechnical features and frameworks to get the capacity for adaptation(Mahamed & Shen,2024).

AI has the potential to enhance global capacity building by providing disease diagnostics and management recommendations on farmers' phones, as well as personalized training for plant pathologists based on current risks. Collaborating internationally to integrate data and modes will help develop more effective responses to climate change (Garrett, 2022).

Satellites imaging, combined with AI, particularly Machine Language and cloud-based systems like Google Earth Engine (GEE), has transformed the way environmental monitoring is undertaken, making it feasible to evaluate enormous areas over long periods of time(Amani et al.,2020). This will eventually help in providing convincing evidence of the substantial effects of climate change and escalating environmental stress(Laaribya& Alaoui, 2025).

Cluster 4: Monitoring Climate Change with Neural Networks

Among the most essential challenges that society should face in the upcoming years and decades, the development and use of renewable energies is one of the most confronting in the current scenarios of climate change. Wave energy is limited in development compared to other renewable energies(Brussels Commission,2007). Artificial Neural Network (ANN) model has the potential to assess the wave energy availability in long term which may assist managers, policymakers and engineers in determining the most viable region for wave energy projects, considering the effects of climate change(Rodriguez-Delgado &Bergillos, 2020). Artificial Neural Network (ANN) models can be used to assess how climate change effects ground water resources by analysing historical temperature, precipitation and ground water levels, along with regional climate projections (Secci et al.,2023).

The above discussion answers to RQ5, where considerations in the implementation of AI in the domain existed.

4. DISCUSSION AND CONCLUSION

The study gives essential theoretical insights into the intervention of AI in climate change research, as well as practical implications for addressing the issue. It advocates for enhanced awareness, transparency, and responsibility in addressing the use of AI in climate change and promote good environmental practices in the field. The study reviewed the factors and repercussions of AI involvement in combating climate change globally. After conducting a thorough review of the literature, a narrow sample of relevant papers that addressed the issue from the perspectives of the direct environmental effects of AI applications in climate change as well as their indirect social and economic effects.

AI is transforming climate action by improving climate modelling, optimizing renewable energy, increasing energy efficiency in buildings and transportation, and enabling precision agriculture through the analysis of massive data for monitoring emissions, resource management and better predictions, ultimately assisting with mitigation, adaptation and disaster response, despite challenges in existing data gaps and energy use. AI technology have considerable promise to cut greenhouse gas emissions. For example, AI can help optimize energy consumption and distribution, reduce energy waste and locate emission hotspots in industrial operations. Similarly, AI systems may evaluate transportation data to improve route planning and traffic flow, resulting in lower fuel use and emissions. Early warning systems can be strengthen by forecasting extreme weather occurrences like floods, droughts and hurricanes, enabling dynamic disaster risk management. AI can help with sustainable water usage, biodiversity conservation, and land restoration activities, when combined with satellite images. In conclusion, the outcomes of the study shed light on how academic conversations have evolved. These findings have the potential to inform future research on AI intervention in climate change mitigation, as well as cross-disciplinary approaches.

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