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Investigating climate change and emerging theoretical perspectives: a systematic theoretical review and thematic analysis

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This study aims to review existing studies on climate change theories, as well as other theories from other disciplines, including economics, political science, sociology, management, cultural studies, and psychology that have been used to explain climate change. Furthermore, it seeks to identify emerging theoretical perspectives in climate change research. This study analyzed and reviewed 73 articles and reports on climate change theories and emerging theoretical perspectives using systematic theoretical review and thematic analysis methodologies. Data sources included Science Direct, Taylor & Francis, Emerald, Google Scholar, and Google general. The findings indicate the multidimensional nature of climate change theories, encompassing four primary climate change theories, interdisciplinary theories, and emerging theoretical perspectives. This variation suggests that no single theory can fully explain the complexity of climate change, necessitating an integrated approach. The review revealed that anthropogenic climate change theory dominates the literature, representing 37.5% (12 papers) of the reviewed literature, reinforcing the strong scientific consensus among academics, environmentalists, and policymakers that human-induced greenhouse gas emissions are the primary drivers of climate change. The paper concludes by identifying four critical knowledge gaps. In addition, the findings will be useful for policymakers, industry stakeholders, and educators in developing effective mitigation and adaptation strategies.

KEYWORDS

greenhouse gases, climate change theories, anthropogenic climate change theory, interdisciplinary theories, mitigation and adaptation strategies

1 Introduction

Climate change, considered among the most severe worldwide problems of the 21st century, continues to command global focus among academics, environmentalists, policy makers and international debates in both scientific and political spheres [Ihemeson, 2024; Intergovernmental Panel on Climate Change (IPCC), 2023; Kilicarslan and Dumrul, 2017]. Since the 1990s, the phenomenon has sparked significant concern, primarily due to its adverse long-term effects on agricultural productivity, food security, water resources,

and rural livelihoods [Acaroglu et al., 2023; Intergovernmental Panel on Climate Change (IPCC), 2022]. Climate change is defined as a long-term shift in temperatures and weather patterns attributed directly or indirectly to human activity, as well as natural climate variability that alters the composition of the global atmosphere observed over a comparable period [United Nations Framework Convention on Climate (UNFCCC), 1992].

Climate change is a crucial element of the UN's 2030 Agenda for Sustainable Development, highlighted in SDG 13, which calls for immediate action to combat its effects [Ngarava et al., 2019; United Nations Framework Convention on Climate Change (UNFCCC), 2016]. International efforts like the Paris Agreement aim to cap global warming at "well under" 2°C, preferably 1.5°C, compared to pre-industrial levels [United Nations Framework Convention on Climate Change (UNFCCC), 2015]. However, global temperatures have already risen by ∼1.1°C since that era, leading to more severe and frequent climate disasters [Intergovernmental Panel on Climate Change (IPCC), 2022; World Meteorological Organisation (WMO), 2024]. Forecasts suggest that unless substantial mitigation measures are taken, worldwide temperatures may rise to 4°C by 2100, possibly causing severe and permanent ecological disruptions [International Monetary Fund (IMF), 2022].

Climate change is a deeply social (Gounaridis and Newell, 2024), political (Lee et al., 2024), and cultural issue (Zhai et al., 2024) that cuts across global inequalities [Intergovernmental Panel on Climate Change (IPCC), 2021; Nofirman et al., 2025]. Climate change is attributed to anthropogenic greenhouse gas emissions such as carbon dioxide (CO_2). methane (CH4), nitrous oxide (N_2O), hydrofluorocarbons (HFCS), perfluorocarbons (PFCS), and Sulfur hexafluoride (SF6), which originate from industrial activities and fossil fuel consumption, with developed countries being the predominant contributors [Intergovernmental Panel on Climate Change (IPCC), 2022; United Nations Framework Convention on Climate Change (UNFCCC), 1998]. However, its impacts are distributed unevenly, with the world's poorest and most vulnerable communities bearing the brunt of the consequences [Intergovernmental Panel on Climate Change (IPCC), 2022]. Small Island Developing States (SIDS), low-income nations, and marginalized populations are disproportionately affected by climate-related disasters such as rising sea levels, droughts, extreme weather events, and loss of biodiversity [Bajaj et al., 2025; Gounaridis and Newell, 2024; Intergovernmental Panel on Climate Change (IPCC), 2022; Thomas et al., 2020]. These impacts threaten food and water security, displace populations, and erode traditional cultural and social structures. Importantly, many of these communities have contributed the least to global greenhouse gas emissions, yet they face the greatest risks [Ali et al., 2024; Intergovernmental Panel on Climate Change (IPCC), 2022].

The politics of climate change are deeply entangled in global power dynamics (Jeong and Silverman, 2025; Saeed, 2024). Wealthy countries in the Global North not only have greater historical responsibility for greenhouse gas emissions but also often dictate the terms of international climate policy and finance [Choi et al., 2024; HadŽić, 2024; Intergovernmental Panel on Climate Change (IPCC), 2023]. Trade agreements, transnational supply chains, and extractive economic models led by the Global North often externalize environmental costs onto poorer countries in the Global South (HadŽić, 2024; Hassan, 2024). These economic structures reinforce colonial patterns of exploitation, where natural resources and labor are extracted from the Global South to fuel consumption in the Global North—further entrenching environmental and social disparities [HadŽić, 2024; Intergovernmental Panel on Climate Change (IPCC), 2021; Mercer and Simpson, 2023].

Culturally, climate change challenges long-held identities, practices, and belief systems, especially among Indigenous peoples and traditional communities [Shanaah et al., 2024; World Meteorological Organisation (WMO), 2024]. The loss of land, sacred sites, and customary livelihoods due to climate change is not only an ecological loss but also a profound cultural trauma. These communities, while often most vulnerable, are also repositories of alternative knowledge systems and practices that are essential for building resilient and sustainable futures [Aktürk and Hauser, 2024; Intergovernmental Panel on Climate Change (IPCC), 2022; World Meteorological Organisation (WMO), 2024].

The role of theories in scientific research remains a contentious topic in the production of knowledge (Collins and Stockton, 2018). A theory is a scientifically acceptable set of principles offered to explain a phenomenon. Theories provide frameworks for interpreting environmental observations and serve as bridges between research and education (Schunk, 2012; Suppes, 1974). A theory is defined as a network of concepts and propositions detailing interrelations among various phenomena. A theory explains how phenomena relate to each other, and what can be expected under unknown conditions (Kwasnicka et al., 2016). Theories provide the lenses through which phenomena are understood, predictions are made, and interventions are designed (Collins and Stockton, 2018; Luft et al., 2022).

In the context of climate change, theoretical frameworks are essential for uncovering the underlying power dynamics, cultural contexts, and systemic inequalities that shape its impacts (Boylan et al., 2018; Schweizer et al., 2013). In climate change research, theories are drawn from fields such as environmental science, political ecology, economics, sociology, and communication studies (Billi et al., 2019; Domingues and Teixeira, 2024). The theories help to explain the drivers of climate change, predict its consequences, and propose solutions (Arteaga et al., 2023; Wang et al., 2023). Conducting a systematic theoretical review of climate change is crucial to advancing interdisciplinary integration, guiding future empirical research, and strengthening policy frameworks (Berrang-Ford et al., 2015; Schweizer et al., 2013).

Empirical scientific studies have highlighted several theories of climate change including the carbon dioxide theory of climate change (Plass, 1956), Astronomical theory of climate change (Berger and Loutre, 2004), Milankovitch theory of climate change (Berger, 2009) and greenhouse theory of climate change (Ramanathan, 1988). Furthermore, theoretical literature reviews have been conducted on climate change. For instance; Daddi et al. (2018) conducted a systematic review of the use of organization and management theories in climate change studies. Gumel (2022) conducted a conceptual and theoretical review assessing climate change vulnerability. While the studies have identified some of the theories related to climate change, their primary focus was on vulnerability, organizational, and management theories in climate change studies, rather than on the broader theoretical foundations

of climate change itself. Soler and Marcé (2018) conducted a theoretical review on sustainable companies, addressing climate change. Similar to the study conducted by Daddi et al. (2018), the study by Soler and Marcé (2018) as well as focused on the organization and management theories in climate change studies, specifically in sustainable companies.

Existing reviews have examined various theories of climate change, but none provides a comprehensive synthesis of the emerging theoretical perspectives in climate change research. These perspectives include: social-ecological systems (SES) theory (Hossain et al., 2024; Talukder et al., 2024), planetary boundaries theory (Mathias et al., 2017), complex adaptive systems (CAS) theory (Talukder et al., 2024), climate change justice theory (Baxi, 2016), climate colonialism and degrowth theory (Tornel, 2019), more-than-human & multispecies theory (Tschakert et al., 2021), post-normal science and trans disciplinarity theory (Krauss et al., 2012; Lidskog, 2025), geoengineering governance theories (Baiman, 2025), and narrative and discourse theories (Kulaeva, 2025; Pétursdóttir, 2017), along with their practical implications for addressing climate change. A systematic and comprehensive analysis of climate change theories is still urgently needed, one that incorporates these emerging theoretical perspectives, clearly differentiates between the various theories, and strengthens both their conceptual foundations and practical policy applications. Furthermore, theories from other disciplines, including economics, political science, sociology, management, cultural studies, and psychology, have been applied to explain climate change, making the landscape more intricate, necessitating a more systematic and objective approach to identifying, categorizing, and understanding these theories.

Through a systematic theoretical review and thematic analysis of 73 articles and reports, this study makes three significant contributions to climate change literature. First, it systematically identifies, categorizes, and analyzes the primary theories of climate change. Second, it provides a comprehensive interdisciplinary synthesis of theories from other disciplines, including economics, political science, sociology, management, cultural studies, and psychology that have been that have been used to explain climate change. Third, it synthesizes emerging theoretical perspectives in climate change research, offering an integrated theoretical foundation to guide future research in the field.

2 Methodology

This study employed a systematic theoretical review methodology to identify, assess, and synthesize existing scholarly publications on climate change theories and emerging theoretical perspectives. The systematic theoretical review approach was selected because of its rigorous, transparent, and reproducible framework in selecting relevant high-quality and relevant literature, encompassing both peer-reviewed publications and gray literature that address a specific research question (Elasu et al., 2023; Moher et al., 2009; Page et al., 2021; Wassie and Adaramola, 2019). The review process adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines and followed the established protocols for performing systematic reviews developed by Liberati et al. (2009) and Moher et al. (2009).

2.1 Formulating research questions

As mentioned earlier, systematic literature reviews aim to provide answers to well-defined research questions. This review of theoretical literature seeks to address three key questions:

1. What are key theories of climate change, how are they categorized?
2. What theories from other disciplines have been applied to explain climate change?
3. What are the emerging theoretical perspectives in climate change research?

2.2 Search for articles and gray literature

To search for relevant journal articles and gray literature, multiple search engines, databases, and academic journals were utilized. This study sourced the journal articles from well-known databases, including Science Direct, Taylor & Francis, Emerald, and Google Scholar, which offer extensive collections of academic literature. These databases were selected due to their broad coverage of peer-reviewed research across diverse disciplines, such as science, engineering, and social sciences, making them ideal for this study (Elasu et al., 2023; Elsevier, 2024; Emerald, 2013; Taylor and Francis, 2023). Google General was also utilized to supplement the search. Peer-reviewed journals were selected based on their Journal Impact Factor.

2.3 Search strategy

2.3.1 Search terms and strings

To identify appropriate published journal articles and gray literature from databases and journals, the following search terms, strings, and Boolean operators were used: "Theories of climate change," "Theories AND climate change," "Theories of global warming," "Theories AND global warming," "Economics AND theories of climate change," "Sociology AND theories of climate change," "Politics AND theories of climate change." "Management AND theories of climate change," "Cultural studies AND theories of climate change," "Psychology AND theories of climate change," "Social-ecological systems (SES) theory AND climate change," "Planetary boundaries theory AND climate change," "Climate change justice theory, "Anthropocene studies AND climate change," "Complex Adaptive Systems (CAS) Theory AND climate change," "Post-normal science & transdisciplinarity AND climate change," "Climate colonialism & degrowth theory AND climate change," "More-than-human & multispecies theory AND climate change." "Narrative & discourse theories AND climate change," and "Geoengineering governance theories AND climate change."

TABLE 1 Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
Time frame: there was no time restriction	No exclusions
Type of articles: scholarly, peer-reviewed research articles, and review articles	Excluded: encyclopedias, book chapters, discussions, short communications, editorials, book parts, earlycite articles, case studies, expert briefings, executive summaries, graphic analysis, and magazine articles.
Reports from reputable organizations (gray literature) were included in the study.	Conference papers were excluded.
Language: articles in English	Excluded articles in German, French, Polish, Spanish, Norsk, and Portuguese. All articles written in languages that the author is not familiar with were excluded.
Coverage: global focus, including articles from every continent	No exclusions
Accessibility: articles with online full-text availability	Excluded articles with incomplete texts
Relevance: articles with abstracts addressing the research questions	Excluded articles not relevant to the Research Topic

2.3.2 Inclusion and exclusion strategy

As detailed in Table 1, this study imposed no time restriction on the selection of journal articles and gray literature to ensure a comprehensive review of all relevant literature, including foundational studies and authoritative gray literature. While peer-reviewed journal articles were prioritized, supplementary gray literature from reputable organizations was also incorporated. Only reports meeting these credibility standards were included, with all other documents excluded from consideration.

2.4 Material collection

The last search for published journal articles and gray literature was conducted on April 25, 2025. Each search word was entered differently on Science Direct, Taylor & Francis, Emerald, and Google Scholar, and the results were recorded separately, as shown in Table 2. A total of 1,914,656 articles and reports were identified through electronic search, distributed as follows: Science direct (1,003,700), Taylor and Francis (199,356), Emerald (265,356), Google scholar (446,233) and 11 gray literature were hand searched from google general. Following initial title and abstract screening, we excluded 1,914,394 articles. Subsequent eligibility assessment narrowed the selection to 73 articles and reports. These qualifying records (detailed in Figure 1) were subsequently analyzed to address the research questions outlined in Section 2.1.

2.5 Data charting

The data from each reviewed paper was recorded into an Excel file to include the year, author, journal, and information obtained from the questions. Following that, the first stage of analysis (descriptive analysis) was conducted utilizing an Excel spreadsheet.

3 Findings

3.1 Descriptive analysis

This section systematically analyzes the 73 articles and reports included in this study (see Table 3), which provides a summary of Journal Articles and reports and summarizes the findings in tables and figures along multiple dimensions or categories for simple presentation and interpretation.

3.1.1 Articles and reports by publication year

Figure 2 illustrates the yearly distribution of the 73 records (articles and reports). Publication frequency peaked in recent years, with 15 records appearing in 2016–2017 (7 and 8 records, respectively). A significant portion (23 records) were published between 2020 and 2025. The remaining 35 records span 1955–2019, including 5 records from 2008. The increasing scholarly attention on climate change theories reflects the growing recognition of their complexity and interdisciplinary relevance, bridging other disciplines such as economics, political science, sociology, management, cultural studies, and psychology, alongside emerging theoretical perspectives.

3.1.2 Articles and reports by journals and institutions

As detailed in Table 4, the analyzed articles and reports originated from diverse academic journals and reputable organizations. The Intergovernmental Panel on Climate Change (IPCC) and Climate Change emerged as the most frequent sources, contributing four and three publications, respectively. Other notable journals, including Annual Review of Political Science, Climate Dynamics, Climate of the Past, IOP Conference Series: Earth and Environmental Science, and Tellus A: Dynamic Meteorology and Oceanography, each supplied two articles. The remaining sources listed in Table 4 were represented by single publications.

3.2 Synthesis

This section presents the synthesis of the reviewed articles and reports based on the specific questions guiding the review, as follows.

3.2.1 Theories of climate change

The analysis of the reviewed articles and reports reveals that climate change has been explained by nine (9) primary theories. These theories can be thematically organized into

TABLE 2 Data collection.

Search term	Science direct	Taylor and Francis	Emerald	Google scholar	Google general
"Theories of climate change"	228,440	7,386	46,665	19,300	11
"Theories AND climate change"	112,003	1,123	46,624	19,500	
"Theories of global warming"	228,440	3,217	7,462	21,400	
"Theories AND global warming"	46,898	7812	2256	21,100	
"Economics AND theories of climate change"	55,811	102,404	27,635	121,000	
"Sociology AND theories of climate change"	9,764	3,240	11,295	53,600	
"Politics AND theories of climate change"	64,696	2,714	4,510	73,600	
"Management AND theories of climate change"	133,860	22,013	44,337	20,400	
"Cultural studies AND theories of climate change"	57,095	1,856	27,851	18,000	
"Psychology AND theories of climate change"	22,387	9,709	25,652	29,400	
"Social-ecological systems (SES) theory AND climate change"	7,264	1,586	4,534	2,430	
"Planetary boundaries theory AND climate change"	6,968	16,168	498	21,900	
"Climate change justice theory	17,833	3,756	12,044	20,700	
"Anthropocene studies AND climate change"	1,712	3,051	408	10,700	
"Complex Adaptive Systems (CAS) Theory AND climate change"	1,327	9,047	130	19,700'	
"Post-normal science and transdisciplinarity AND climate change"	116	190	130	15	
"Climate colonialism and degrowth theory AND climate change"	67	141	10	370	
"More-than-human and multispecies theory AND climate change"	598	855	12	298	
"Narrative and discourse theories AND climate change"	8,188	2,701	3,451	20,300	
"Geoengineering governance theories AND climate change"	233	387	15	1,620	
Total	**1,003,700**	**199,356**	**265,356**	**446,233**	**11**

four distinct categories: natural climate forcing theories, atmospheric and chemical composition theories, human-centric theories, and complex systems & emerging theories as illustrated in Table 5.

3.2.2 Theories from other disciplines applied to explain climate change

As illustrated in Table 6, various theories from other disciplines, such as economics, political science, sociology, management, cultural studies, and psychology, have been applied to explain climate change. Six thematic categories of these cross-disciplinary theories were identified: economic theories, political science theories, sociological theories, management theories, cultural studies theories, and psychology theories.

3.2.3 Emerging theoretical perspectives in climate change research

Several emerging theoretical perspectives in climate change research have been identified as listed in Table 7. The emerging theoretical perspectives in climate change research are grouped into four thematic clusters: systems-based theories, justice and equity theories, post-humanist and knowledge theories, and governance and technological theories.

4 Discussion

4.1 Theories of climate change

4.1.1 Human-centric theories

Human-centric theories (anthropogenic climate change theory and atmospheric justice: A political theory of climate change) emphasize human agency and structural inequalities as the primary drivers of climate change. Anthropogenic climate change theory is the most widely cited theory, accounting for 37.5% (12 papers) of the reviewed literature. Proposed by Callendar (1938), and popularized by the Intergovernmental Panel on Climate Change (IPCC) (1990), the core idea of the theory is that human activities such as fossil fuels consumption, deforestation, and industry are the primary drivers of recent global climate change [Callendar, 1938; Intergovernmental Panel on Climate Change (IPCC), 2023]. The predominance of this theory reflects the strong scientific consensus among academics, environmentalists, policy makers and international debates in both scientific and political spheres that human-induced greenhouse gas (GHG) emissions are the principal drivers of current climate change (Carmo and Nunes, 2008; Engels, 2016; Hillerbrand and Ghil, 2008; Johns et al., 2003; Matthews et al., 2004; Redlin and Gries, 2021; Stern and Kaufmann, 2014; von Storch and Stehr, 2006). However, climate change skepticism and denialism are increasing, offering significant challenges to

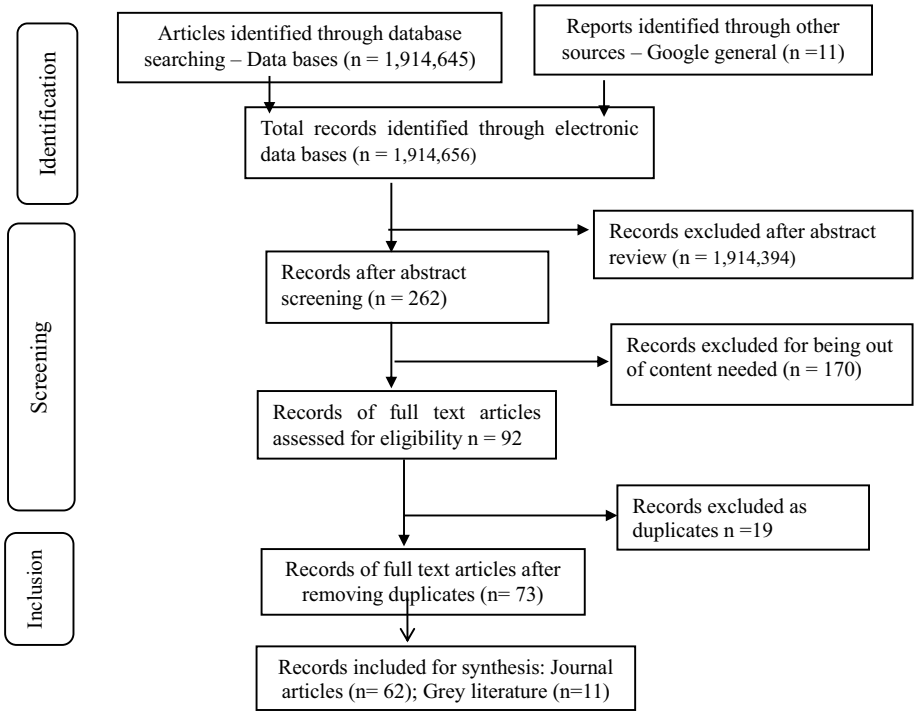

FIGURE 1
PRISMA flow chart.

the global consensus on climate action, impacting both policy-making and public perception (Biddlestone et al., 2022; Bolsen and Druckman, 2018; Tyagi and Carley, 2021; Uscinski et al., 2017). Despite climate experts' unanimous agreement that climate change is real and man-made, over 40% of Americans disagree (Uscinski and Olivella, 2017). Additionally, conspiracy theories about climate change origins and impacts exist, despite significant scientific consensus (Biddlestone et al., 2022).

The atmospheric justice: A political theory of climate change (9.4%, 3 papers) was proposed by Shue (1993), further developed by others (Caney, 2005; Lane, 2016; Vanderheiden, 2008), the core idea of the theory is that climate change is an ethical and political issue; emphasizing that historical emitters bear greater responsibility for mitigation and adaptation (Caney, 2005; Lane and Rosenblum, 2017; Shue, 1993; Vanderheiden, 2008). This theory is particularly influential in debates on climate justice, highlighting disparities between high-emitting industrialized nations and vulnerable developing countries. Its inclusion signals growing interdisciplinary engagement with climate change beyond purely physical sciences (Choi et al., 2024; HadŽić, 2024). Critics argue that it's difficult to implement in international policy due to conflicting national interests (Posner and Sunstein, 2007).

4.1.2 Natural climate forcing theories

Natural climate forcing theories (astronomical and Milankovitch theories of climate change) examine planetary-scale physical mechanisms that drive climate change independent of human influence. The astronomical theory of climate change (6.3%, 2 papers), was proposed by Agassiz (1838) and Adhémar (1842), later refined by Le Verrier (1855), Croll (1875), and Murphy (1876). The theory suggests that variations in Earth's orbit (orbital motion, rotational motion, and insolation) influence solar radiation distribution, leading to ice ages and interglacial periods (Berger, 2009; Croll, 1864; Imbrie and Imbrie, 1980; Smulsky, 2016). Critics argue that the theory lacks explanatory power for rapid modern climate change, as orbital cycles operate over tens of thousands of years (Ruddiman, 2006).

Milankovitch Theory (21.9%, 7 papers) was proposed by Milankovitch (1941), a Serbian engineer and mathematician. The Milankovitch theory states that periodic oscillations in the Earth's orbital cycles produce analogous periodicity in climate variation lasting 19,000 to 1,200,000 years (Berger, 1988, 2021; Pollard et al., 1980; Puetz et al., 2016). Despite a large body of data on the relationship between global ice volume and insolation changes caused by fluctuations in the Earth's orbit the theory remains undefined (Roe, 2006).

4.1.3 Atmospheric composition theories

Atmospheric composition theories (greenhouse and carbon dioxide theories of climate change) elucidate how changes in the Earth's gaseous envelope regulate global climate through radiative and chemical processes. The greenhouse theory of climate change was proposed by Fourier (1824), experimentally validated by Arrhenius (1896). The core idea of the theory is that certain atmospheric gases e.g., carbon dioxide (CO_2), methane (CH_4)

TABLE 3 Summary of the journal articles and reports.

Item type	Author/year	Title
Journal article	Smulsky, 2016	Fundamental principles and results of a new astronomic theory of climate change
Journal article	Berger, 2009	Astronomical theory of climate change
Journal article	Cess and Wronka, 1979	Ice ages and the Milankovitch theory: a study of interactive climate feedback mechanisms
Journal article	Pollard et al., 1980	Response of a zonal climate-ice sheet model to the orbital perturbations during the Quaternary ice ages
Journal article	Berger, 1988	Milankovitch Theory and Climate
Journal article	Berger, 2021	Milankovitch, the father of paleoclimate modeling
Journal article	Ganopolski, 2023	Toward Generalized Milankovitch Theory (GMT)
Journal article	Roe, 2006	In defense of Milankovitch
Journal article	Puetz et al., 2016	Evaluating alternatives to the Milankovitch theory
Journal article	Mudge, 1997	The development of the "greenhouse" theory of global climate change from Victorian times
Journal article	Allmendinger, 2017	The refutation of the climate greenhouse theory and a proposal for a hopeful alternative
Report	Plass, 1956	The carbon dioxide theory of climatic change
Report	Fleming, 2020	The rise and fall of the carbon dioxide theory of climate change
Journal article	von Storch and Stehr, 2006	Anthropogenic climate change: a reason for concern since the 18th century and earlier.
Journal article	Engels, 2016	Anthropogenic climate change: how to understand the weak links between scientific evidence, public perception, and low-carbon practices
Journal article	Redlin and Gries, 2021	Anthropogenic climate change: the impact of the global carbon budget
Journal article	Johns et al., 2003	Anthropogenic climate change for 1860 to 2100 simulated with the HadCM3 model under updated emissions scenarios
Journal article	Hillerbrand and Ghil, 2008	Anthropogenic climate change: scientific uncertainties and moral dilemmas
Journal article	Stern and Kaufmann, 2014	Anthropogenic and natural causes of climate change
Report	Intergovernmental Panel on Climate Change (IPCC), 2021	Climate change 2021: the physical science basis
Report	Intergovernmental Panel on Climate Change (IPCC), 2022	Climate change 2022: mitigation of climate change
Report	Intergovernmental Panel on Climate Change (IPCC), 2023	AR6 synthesis report: climate change 2023
Journal article	(Matthews et al., 2004)	Natural and anthropogenic climate change: incorporating historical land cover change, vegetation dynamics and the global carbon cycle
Journal article	Carmo and Nunes, 2008	Climate change and human activities in Brazil with emphasis on the coastal zone
Report	Intergovernmental Panel on Climate Change (IPCC), 2014	Climate change 2014: mitigation of climate change
Journal article	Dinda, 2004	Environmental Kuznets curve hypothesis: a survey
Journal article	Leal and Marques, 2022	The evolution of the environmental Kuznets curve hypothesis assessment: a literature review under a critical analysis perspective
Journal article	Gill et al., 2017	Is Environmental Kuznets Curve Still Relevant?
Journal article	Maneejuk et al., 2020	Does the environmental Kuznets curve exist? An international study
Journal article	Stern, 2004	The rise and fall of the environmental Kuznets curve
Journal article	Stern, 1998	Progress on the environmental Kuznets curve?
Journal article	Kuznets, 1955	Economic growth and income inequality
Report	Grossman and Krueger, 1994	Economic growth and the environment
Journal article	Lane, 2016	Political theory on climate change
Report	Vanderheiden, 2008	Political theory and global climate change
Report	Vanderheiden, 2008	Atmospheric justice: a political theory of climate change
Report	Saltzman, 2002	Dynamical paleoclimatology generalized theory of global climate change
Journal article	Maasch et al., 2005	Barry Saltzman and the theory of climate
Report	Cohen, 2012	Telemorphosis: theory in the era of climate change
Report	Svensmark and Calder, 2007	The chilling stars: a new theory of climate change
Journal article	Peters et al., 1999	Economic theory and climate change policy
Report	Lane and Rosenblum, 2017	The political theory of climate change: state of the field
Report	Schofield, 2015	Climate change and social choice theory
Journal article	Carmen et al., 2022	Building community resilience in a context of climate change: the role of social capital

(Continued)

TABLE 3 (Continued)

Item type	Author/year	Title
Journal article	Kirchmair, 2023	Enforcing constitutional sustainability. clauses in the age of the climate crisis: insights from social contract theory on how to take account of future generations
Journal article	Nurkasanah and Sarwoprasodjo, 2024	The lens of social learning theory: an imitation behavior to adapting climate change in agriculture
Journal article	Kreft et al., 2023	Farmers' social networks and regional spillover effects in agricultural climate change mitigation
Journal article	Fielding and Hornsey, 2016	A social identity analysis of climate change and environmental attitudes and behaviors: insights and opportunities
Journal article	McAdam, 2017	Social movement theory and the prospects for climate change activism in the United States
Journal article	Blok, 2010	Topologies of climate change: actor-network theory, relational-scalar analytics, and carbon-market overflows
Journal article	Basak, 2017	Agency theory and international climate change financing accountability regimes
Journal article	Furlan Matos Alves et al., 2017	Contingency theory, climate change, and low-carbon operations management
Journal article	Sichach, 2024	Applying diffusion of innovation theory to effectively advocate for sustainable climate change approaches by Northern Kenya pastoralist communities.
Journal article	Broome, 2008	The ethics of climate change
Journal article	Madani, 2011	Hydropower licensing and climate change: insights from cooperative game theory
Journal article	Comyns, 2018	Climate change reporting and multinational companies: insights from institutional theory and international business
Journal article	Arya and Kumar, 2023	An investigation of climate change, eco-anxiety and risk perception in the context of theory of planned behavior
Journal article	Cristina De Stefano et al., 2016	A natural resource-based view of climate change: innovation challenges in the automobile industry
Journal article	Izzania et al., 2024	Carbon emission disclosure in Indonesia: perspective of stakeholder theory
Journal article	Wyss, 2013	Cooperation for climate adaptation in tourism: an agenda for the Alps based on structuration theory
Journal article	McNeeley and Lazrus, 2014	The cultural theory of risk for climate change adaptation
Journal article	Tam and Chan, 2023	Conspiracy theories and climate change: a systematic review
Journal article	Hossain et al., 2024	Social-ecological systems approach for adaptation to climate change
Journal article	Mathias et al., 2017	On our rapidly shrinking capacity to comply with the planetary boundaries on climate change
Journal article	Baxi, 2016	Toward a climate change justice theory?
Journal article	Pétursdóttir, 2017	Climate change? Archaeology and Anthropocene
Journal article	Talukder et al., 2024	Complex adaptive systems-based framework for modeling the health impacts of climate change
Journal article	Lidskog, 2025	Navigating global environmental challenges: disciplinarity, transdisciplinarity, and the emergence of Mega-Expertise
Journal article	Krauss et al., 2012	Introduction: post-normal climate science
Journal article	Tornel, 2019	Climate change and capitalism: a degrowth agenda for climate justice
Journal article	Tschakert et al., 2021	Multispecies justice: climate-just futures with, for and beyond humans
Journal article	Kulaeva, 2025	Narratives of change: how climate change narratives have evolved since the 1970s
Report	Baiman, 2025	Only direct climate cooling (or geoengineering) can reduce near term climate harm - though GHG emissions cuts and removal are essential in the long term, and four other critically important points on climate change

(Continued)

TABLE 3 (Continued)

trap infrared radiation, warming the planet (Fleming, 1999; Mudge, 1997; Pierrehumbert, 2010). Critics argue that early models oversimplified feedback mechanisms; modern critiques focus on underestimating cloud dynamics (Allmendinger, 2017; Sherwood et al., 2020).

The carbon dioxide theory of climate change was proposed by Arrhenius (1896). The theory directly links atmospheric CO_2 concentrations to global temperature changes (Arrhenius, 1896; Plass, 1956). Critics argue that early calculations overestimated climate sensitivity; later research incorporated feedback loops [Fleming, 2020; Intergovernmental Panel on Climate Change (IPCC), 2021]. The limited representation of greenhouse and carbon dioxide theories of climate change in recent literature may indicate that these foundational theories have been absorbed into broader anthropogenic theory of climate change.

4.1.4 Complex systems theories

Complex systems theories (dynamical paleoclimatology, Telemorphosis, and the chilling stars theories of climate change) provide a paradigm shift in climate science by conceptualizing Earth's climate as a dynamic, interconnected system characterized by feedback loops, tipping elements, and emergent properties. The Dynamical Paleoclimatology: Generalized Theory of Global Climate Change (6.3%, 2 papers), was proposed by Saltzman (2002). The theory integrates Milankovitch cycles with non-linear feedbacks e.g., ocean circulation, ice-albedo to explain abrupt climate shifts (Maasch et al., 2005; Saltzman, 1990, 2002). Critics

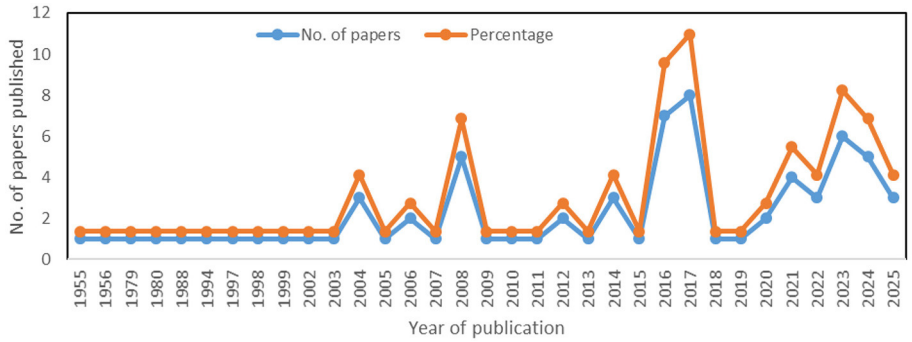

FIGURE 2
Articles and reports by publication year.

argue that the theory is highly complex, making it difficult to apply to contemporary climate predictions (Rial et al., 2004).

The Telemorphosis: Theory in the Era of Climate Change (3.1%, 1 paper) was proposed by Morton (2012). According to theory, climate change disrupts traditional spatial/temporal scales, requiring new philosophical frameworks (Morton et al., 2012). Climate change can be explained by issues such as ecologies of war, post-carbon philosophy, ecotechnics, time, unicity, scale, post-trauma, and health (Cohen, 2012). Critics argue that the theory is abstract and lacking empirical testability (Cohen, 2012).

The Chilling Stars: A New Theory of Climate Change (3.1%, 1 paper) was proposed by Svensmark and Calder (2007). The theory argues that cosmic rays seed cloud formation, modulating Earth's albedo and temperature (Svensmark and Calder, 2007). Critics argue that the theory has limited experimental support; most studies find GHG forcing dominates (Pierce and Adams, 2009). The marginal presence of the dynamical paleoclimatology, Telemorphosis, and the chilling stars theories of climate change suggests either limited empirical support or nascent stages of academic acceptance.

4.2 Theories from other disciplines applied to explain climate change

4.2.1 Economic theories

Economic theories dominate the interdisciplinary landscape, particularly the environmental Kuznets curve (EKC) theory. The theory was proposed by Kuznets (1955), and was later adapted by Grossman and Krueger (1991). Other researchers who contributed to the environmental Kuznets curve (EKC) Theory include Shafik and Bandyopadhyay (1992), Grossman and Krueger (1993), Selden and Song (1994), Panayotou (1993), Holtz-Eakin and Selden (1992), and Cropper and Griffiths (1994). The theory suggests that an inverted U-shaped relationship between economic growth and environmental degradation, positing that pollution increases during early development but decreases after reaching a certain income threshold (Aruga, 2019; Dinda, 2004; Gill et al., 2017; Grossman and Krueger, 1994; Gyamfi et al., 2021; He et al., 2021; Kasioumi and Stengos, 2020; Kuznets, 1955; Maneejuk et al., 2020; Stern, 2004). While this framework has been influential in shaping policy debates about sustainable development pathways, it has faced substantial criticism for its deterministic assumptions about technological progress and its failure to account for ecological thresholds (Stern, 2004). The economic theory (1 paper) typically focuses on market-based solutions to climate change, such as carbon pricing mechanisms, though these approaches often neglect distributional impacts and non-market values (Peters et al., 1999; Spash, 2007).

4.2.2 Political science theories

The political theory of climate change draws on Dryzek's (2013) work to examine how power asymmetries and governance structures shape climate policy outcomes (Dryzek, 2013). This perspective highlights the challenges of multilateral cooperation in addressing transboundary environmental problems, particularly the persistent North-South divide in climate negotiations (Dryzek, 2013; Lane and Rosenblum, 2017; Newell et al., 2015). However, critics note that the theory struggles to explain why certain political systems are more effective than others in implementing climate policies, pointing to the need for more comparative institutional analyses (Harrison, 2010).

4.2.3 Sociological theories

Sociological theories (social choice, social capital, social contract, social learning, social network, social identity, and social movement theories) collectively emphasize the social dimensions of climate change. For example, the social movement theory (McAdam, 2017; Rootes, 2013) examines how grassroots activism influences climate change policy, while social network theory (Kreft et al., 2023) analyzes information diffusion through social systems. Social identity theory (Fielding and Hornsey, 2016; van der Linden, 2015) helps explain polarized climate change beliefs, and social learning theory (Nurkasanah and Sarwoprasodjo, 2024; Pahl-Wostl, 2007) explores how communities adapt to climate impacts. Social choice theory (Dietz, 2003; Schofield, 2015) analyzes how collective decisions on climate change policy are made, considering voting systems, preference aggregation, and public opinion. Social capital theory (Adger, 2003; Carmen et al., 2022) posits that trust, networks, and community cohesion enhance adaptive capacity to

TABLE 4 A review of articles and reports published in different journals and institutions.

No.	Journal	No. of papers	Impact factor
1	Reviews of geophysics	1	25.02
2	Sustainable development	1	15.22
3	Wiley interdisciplinary reviews: climate change	1	11.5
4	Journal of cleaner production	1	11.08
5	Annual review of political science	2	10.73
6	Energy policy	1	10.49
7	World bank research observer	1	10.39
8	American economic review	1	10.33
9	Supply chain management	1	9.72
10	Ecological economics	1	7.1
11	Journal of environmental psychology	1	6.8
12	World development	1	6.49
13	Ambio	1	6.09
14	Journal of climate	1	4.89
15	Climatic change	3	4.58
16	Geophysical research letters	1	4.55
17	Climate dynamics	2	4.5
18	International journal of climate change strategies and management	1	4.48
19	Sustainability	1	4.46
20	Advances in water resources	1	4.26
21	Heliyon	1	4
22	Scientific reports	1	3.88
23	Journal of climate change and health	1	3.85
24	Climate of the past	2	3.81
25	Environment and planning D: society and space	1	3.57
26	Theoretical and applied climatology	1	3.19
27	Climate	1	3.14
28	Physica D: non-linear phenomena	1	3.12
29	Scientific American	1	3.1
30	Accounting forum	1	3
31	Frontiers in psychology	1	2.89
32	Environment and development economics	1	2.3
33	Tellus A: dynamic meteorology and oceanography	2	2
34	Weather, climate, and society	1	1.92
35	International journal of energy economics and policy	1	1.84
36	Environment pollution and climate change	1	1.69
37	Geografiska Annaler, series A: physical geography	1	1.47
38	Journal of human rights and the environment	1	1.46
39	Weather	1	1.37
40	Energy and emission control technologies	1	1.3
41	SAR (Soedirman Accounting Review): journal of accounting and business	1	1.26
42	Advances in astrophysics	1	1.093
43	Journal of statistical planning and inference	1	1.05
44	Archaeological dialogues	1	0.87
45	Nature and culture	1	0.6
46	IOP conference series: earth and environmental science	2	0.55
47	SSRN electronic journal	1	0.3
48	Revue de geographie alpine-journal of alpine research	1	0.2
49	Terrae incognitae	1	0.2
50	Encyclopedia of earth sciences series	1	0.106
51	ICL journal	1	0.67
52	Benedictine university	1	
53	Danish National Space Center (DNSC)	1	
54	Intergovernmental Panel on Climate Change (IPCC)	4	
55	John Hopkins University, Baltimore	1	
56	Massachusetts Institute of Technology (MIT)	1	
57	National Bureau of Economic Research (NBER)	1	
58	Oxford university	1	
59	Princeton university	1	
60	Springer Nature Switzerland	1	
61	University of Michigan	1	
62	Washington university	1	
63	Yale university	1	
	Total	73	

climate change. Social contract theory (Doshi and Garschagen, 2023; Kirchmair, 2023) highlights the importance of collective action and shared responsibility for addressing the global climate change challenge. These theories provide valuable insights into human behavior and collective action on climate change, though they often lack integration with structural political-economic analyses (Shove, 2010).

TABLE 5 Theories of climate change.

No.	Themes	Theories	No. of papers	Percentage
1.	Natural climate forcing theories	Astronomical theory of climate change	2	6.3
		Milankovitch theory of climate change	7	21.9
2.	Atmospheric composition theories	Greenhouse theory of climate change	2	6.3
		Carbon dioxide theory of climate change	2	6.3
3.	Human-centric theories	Anthropogenic climate change theory	12	37.5
		Atmospheric justice: a political theory of climate change	3	9.4
4.	Complex systems theories	Dynamical paleoclimatology generalized theory of global climate change	2	6.3
		Telemorphosis: theory in the era of climate change	1	3.1
		The chilling stars: a new theory of climate change	1	3.1
		Total	**32**	**100.0**

TABLE 6 Theories from other disciplines applied to explain climate change.

No.	Discipline	Themes	Theories	No. of papers
1.	Economics	Economic theories	Environmental Kuznets curve theory	8
			Economic theory	1
2.	Political science	Political science theories	Political theory of climate change	1
3.	Sociology	Sociological theories	Social choice theory	1
			Social capital theory	1
			Social contract theory	1
			Social learning theory	1
3.	Sociology	Sociological theories	Social network theory	1
			Social identity theory	1
			Social movement theory	1
4.	Management	Management theories	Actor-network theory	1
			Agency theory	1
			Contingency theory	1
			Diffusion of innovation theory	1
			Ethical theory	1
			Game theory	1
			Institutional theory	1
			Planned behavior theory	1
			Resource-based view theory	1
			Stakeholder theory	1
			Structuration theory	1
5.	Cultural studies	Cultural studies theories	Culture theory	1
6.	Psychology	Psychology theories	Conspiracy theory	1
	Total			**30**

4.2.4 Management theories

Management theories (actor-network, agency, contingency, diffusion of innovation, ethical, game, institutional, planned behavior, resource-based view (RBV), stakeholder, and structuration theories) contribute numerous theoretical lenses to understand organizational responses to climate change. For example, the stakeholder theory (Freeman, 1999; Izzania et al., 2024) examines corporate climate change strategies, while institutional theory (Comyns, 2018; Dimaggio and Powell, 1983) explains isomorphic pressures in sustainability in climate change

TABLE 7 Emerging theoretical perspectives in climate change research.

No.	Themes	Emerging theories
1.	Systems-based theories	Social-ecological systems (SES) theory
		Planetary boundaries theory
		Complex Adaptive Systems (CAS) theory
2.	Justice and equity theories	Climate change justice theory
		Environmental justice theory
		Climate colonialism and degrowth theory
3.	Post-humanist and knowledge theories	More-than-human and multispecies theory
		Post-normal science and transdisciplinarity theory
4.	Governance and technological theories	Geoengineering governance theories
		Narrative and discourse theories

reporting. The resource-based view (Barney, 1991; Cristina De Stefano et al., 2016) analyzes competitive advantages from green innovations. Actor-network theory (ANT) (Besel, 2011; Blok, 2010) views climate change as a network of human and non-human actors, e.g., scientists, policymakers. Agency theory (Basak, 2017) examines international climate change financing accountability regimes. Contingency theory (Furlan Matos Alves et al., 2017) posits that organizational effectiveness depends on fitting structure to low-carbon operations management. Diffusion of innovation theory (Sichach, 2024) explains how new ideas, e.g., renewable technology, are spread through social systems via communication channels over time. Ethical theory (Broome, 2008) explores the moral implications of climate change, focusing on issues like responsibility for emissions and the obligation to act for future generations. The game theory (Buck et al., 2022; Madani, 2011) develops a conceptual framework with which to analyze climate change as a strategic or dynamic game. The theory of planned behavior (TPB) (Arya and Kumar, 2023) can be applied to understand and predict individual behavior related to climate change. Structuration theory (Bastien et al., 1995; Wyss, 2013) provides a framework for understanding the relationship between human agency and social structures, useful in analyzing climate change. While these theories offer micro-level insights into firm behavior, they help shape the dominant perception of climate change as a strategic issue in organizational and management studies, not as a societal or ethical issue (Daddi et al., 2018).

4.2.5 Cultural and psychological theories

The cultural theory (McNeeley and Lazrus, 2014; Verweij et al., 2022) examines how worldviews shape climate change risk perceptions, while conspiracy theory (Lewandowsky et al., 2013; Tam and Chan, 2023) explores psychological barriers to climate change action. These approaches highlight the importance of subjective interpretations in climate change debates, though they sometimes underemphasize material interests and institutional power (Hulme, 2009).

4.3 Emerging theoretical perspectives in climate change research

4.3.1 Systems-based theories

Systems-based theories (social-ecological systems (SES), planetary boundaries, and complex adaptive systems (CAS) theories) have transformed climate science by emphasizing interconnectedness, feedback loops, and non-linear dynamics. For example, social-ecological systems (SES) theory (Folke et al., 2016) recognizes the intertwined nature of social and ecological systems and how they mutually influence each other. This theory is particularly relevant to understanding and addressing the impacts of climate change, as climate change is a complex multifaceted issue that affects both natural ecosystems and human societies [Hossain et al., 2024; Intergovernmental Panel on Climate Change (IPCC), 2021]. The Planetary Boundaries theory (Rockström et al., 2009) identifies nine critical Earth System processes, including climate change, that must be kept within safe operating space to maintain a stable and resilient Earth (see Figure 3). Climate change, specifically, is one of the boundaries that has already been crossed, with human activities increasing greenhouse gas concentrations and altering the planet's energy balance (Mathias et al., 2017). While influential in policy circles e.g., the 1.5°C target in the Paris Agreement, debates persist about the rigidity of these thresholds and their equity implications, particularly regarding historical responsibility (Biermann et al., 2022).

Complex Adaptive Systems (CAS) theory provides a framework for understanding climate change by recognizing that the climate system and related human-environment interactions are complex and dynamic, with emergent behaviors and tipping points, such as Amazon dieback or Atlantic circulation collapse that are difficult to predict (Levin et al., 2013; Talukder et al., 2024).

4.3.2 Justice and equity theories

Justice-oriented theories (climate change justice, environmental justice, and climate colonialism and degrowth theories) have reshaped climate discourse by centering historical responsibility, power imbalances, and systemic inequalities. Climate change justice theory argues that climate change impacts are not evenly distributed, and that historically marginalized and vulnerable populations, particularly those in the Global South, are disproportionately affected by the climate crisis despite contributing the least to greenhouse gas emissions (Baxi, 2016; Choi et al., 2024; HadŽić, 2024). Environmental justice theory argues that all people, regardless of race, income, or other characteristics, have the right to a healthy and safe environment (Ali, 2006; Scott, 2014). Climate colonialism and degrowth theory (Hickel, 2020) expose how "green" transitions often reproduce colonial extraction patterns, particularly through carbon offsetting and renewable energy supply chains. Climate colonialism refers to the disproportionate burden and vulnerability of marginalized communities, particularly in the Global South, to climate change impacts, often exacerbated by historical and ongoing colonial structures (Bhambra and Newell, 2022; Sultana, 2022). Degrowth theory proposes that economic growth is incompatible with a sustainable future and the need to address climate change, arguing

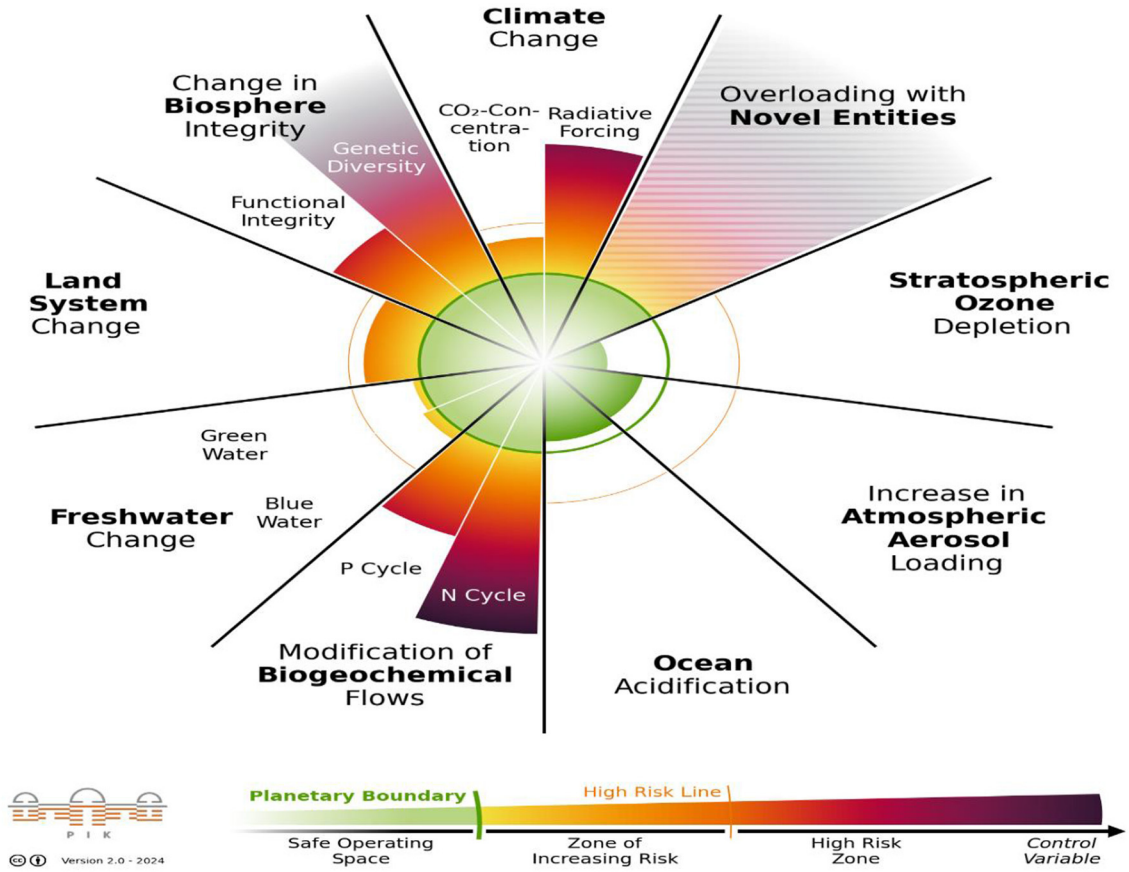

FIGURE 3
The planetary boundaries framework. Adopted from Caesar et al. (2024) planetary health check 2024.

for a deliberate scaling down of production and consumption to prioritize ecological balance and social wellbeing (Smith et al., 2021; Tornel, 2019; Warlenius, 2023). These theories advocate for consumption reduction and debt cancellation for climate-vulnerable nations but face significant political resistance in growth-oriented economies (Choi et al., 2024; HadŽić, 2024).

4.3.3 Post-humanist and knowledge theories

Post-humanist and knowledge theories (more-than-human and multispecies, post-normal science and transdisciplinarity theories) challenge anthropocentrism by recognizing non-human agency in climate change systems. The "more-than-human" and "multispecies" theory on climate change expands the traditional human-centric focus, emphasizing the interconnectedness of all life forms and the environment. This approach encourages a relational understanding of the climate change crisis, acknowledging the responsibilities and impacts on other species and ecosystems, and promoting more just and sustainable futures (Pétursdóttir, 2017; Price and Chao, 2023; Tschakert et al., 2021). Post-normal science and transdisciplinarity theory advocates for knowledge co-production, integrating scientific, indigenous, and local knowledge through participatory methods to address climate change (Krauss et al., 2012; Lidskog, 2025; Norström et al., 2020).

4.3.4 Governance and technological theories

Governance and technological theories (geoengineering governance and narrative and discourse theories) examine how institutions, policies, and technological innovations shape climate change action. Geoengineering governance theory addresses the ethical, political, and regulatory dilemmas surrounding large-scale climate interventions e.g., solar radiation management (SRM) and carbon removal (Baiman, 2025; Reynolds and Horton, 2020). The narrative and discourse theory examines how stories, narratives, language, media, storytelling, youth-led counter-narratives, and political actors shape perceptions of climate change and policy responses (Kulaeva, 2025; Moezzi et al., 2017). These theories are vital because climate change is not just a scientific or technical problem—it's a socio-political challenge requiring coordinated institutions and cutting-edge solutions (Hulme, 2015).

5 Conclusion

This systematic theoretical review examined existing theories of climate change, as well as interdisciplinary theories from economics, political science, sociology, management, cultural studies, and psychology that have been used to explain climate change, while also identifying emerging theoretical perspectives.

The findings highlight the multidimensional nature of climate change theories, encompassing four primary climate change theories, interdisciplinary theories, and emerging theoretical perspectives. This variation suggests that no single theory can fully explain the complexity of climate change, necessitating an integrated approach. These findings are in line with Weyant et al. (1995) and Parson and Fisher-Vanden (2003) who emphasize integrated assessment modeling of global climate change. The review revealed that anthropogenic climate change theory dominates the literature, representing 37.5% (12 papers) of the reviewed literature, reinforcing the strong scientific consensus among academics, environmentalists, and policymakers that human-induced greenhouse gas emissions are the primary drivers of current climate change. This finding is in line with Lynas et al. (2021) and Abraham et al. (2014) who concluded that the scientific consensus on human-caused contemporary climate change—expressed as a proportion of the total publications—exceeds 99% in the peer reviewed scientific literature. However, while anthropogenic theory remains central, its integration with other theories has created a more comprehensive understanding of the climate change crisis. The distribution of these theories in the literature also research indicates prevailing trends, with a strong focus on human-induced factors alongside traditional Earth-system-based explanations. Ultimately, the study affirms that addressing climate change requires a synthesis of scientific, socio-political, and systemic perspectives to develop effective mitigation and adaptation strategies. This finding is in line with Casado-Asensio and Steurer (2014) and Goklany (2007) who emphasize integrated strategies on sustainable development, climate change mitigation and adaptation.

5.1 Areas for future research and policy implications

The diverse theoretical perspectives explored in this study lay the foundation for more innovative and holistic approaches to tackling the climate change crisis. While the multidimensional nature of climate change theories is well-established, significant research gaps persist, necessitating further investigation. Future studies should focus on four key areas: First, constructing a unified theoretical framework that bridges the primary climate change theories, interdisciplinary theories, and emerging theoretical perspectives; Second, translating interdisciplinary and emerging theories into actionable and measurable policy solutions; Third, validating emerging theoretical perspectives across different geographical and socio-political contexts; and Fourth, fostering translational research that links the theoretical insights with real-world applications in various sectors. Addressing these gaps will enhance both scholarly understanding and practical climate change action.

The diverse theoretical perspectives on climate change discussed in this study offer critical insights for policymakers, industry stakeholders, and educators in developing effective mitigation and adaptation strategies.

5.1.1 For policymakers

The dominance of anthropogenic climate change theory underscores the urgent need for policies that reduce greenhouse gas emissions through stringent regulations, carbon pricing, and incentives for renewable energy adoption. However, the Milankovitch and astronomical theories remind policymakers to consider long-term climatic cycles in infrastructure and agricultural planning. Atmospheric justice and political science theories highlight the necessity of equitable climate policies that address historical disparities in emissions and vulnerability, ensuring that marginalized communities are not disproportionately burdened. Economic theories suggest market-based solutions e.g., carbon trading and green investments, while governance and technological theories emphasize adaptive policymaking that integrates emerging innovations like carbon capture and AI-driven climate modeling. Justice and equity theories further call for inclusive decision-making processes, ensuring that climate policies are co-designed with affected populations.

5.1.2 For industry stakeholders

The anthropogenic and greenhouse gas theories reinforce corporate responsibility in decarbonizing operations through cleaner technologies and circular economy practices. Management and economic theories advocate sustainable business models that align profitability with climate resilience. Systems-based theories encourage industries to adopt holistic approaches, recognizing interconnected risks in supply chains and ecosystems. Cultural and psychological theories suggest that corporate climate action should also address consumer behavior, leveraging social norms and values to drive sustainable consumption. Meanwhile, governance and technological theories push industries to invest in research and development (R&D) for low-carbon innovations while engaging in multi-stakeholder climate partnerships.

5.1.3 For educators

The interdisciplinary nature of climate change calls for curricula that integrate the primary climate change theories, e.g., Milankovitch cycles, dynamical paleoclimatology, with social science theories, e.g., atmospheric justice, sociological theories, to foster a comprehensive understanding among students. Post-humanist and knowledge theories encourage critical engagement with indigenous and local ecological knowledge, broadening the discourse beyond Western scientific paradigms. Justice and equity theories should inform climate education to emphasize ethical responsibility, while system-based approaches can help students analyze climate change as a complex, interconnected challenge. Educators must also leverage psychological and cultural theories to design engagement strategies that motivate pro-environmental behavior rather than inducing climate anxiety.

Collectively, these theoretical insights demand a multi-dimensional, justice-centered, and adaptive approach to climate action—one that bridges scientific rigor, socio-political equity, and practical innovation across all sectors.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

JM: Investigation, Writing – original draft, Writing – review & editing. JN: Conceptualization, Writing – original draft, Writing – review & editing. MA: Supervision, Writing – review & editing. FB: Methodology, Writing – original draft, Writing – review & editing. RA: Investigation, Writing – original draft, Writing – review & editing. SE: Investigation, Writing – original draft, Writing – review & editing.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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