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How do students and pre-service teachers perceive the climate crisis and global warming through the IPCC Lens?

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Conceptual clarity in climate-related terminology is essential for enabling individuals to accurately interpret environmental phenomena and develop well-grounded attitudes. Despite growing scholarly attention to climate perceptions, comparative studies examining how secondary school students and pre-service teachers simultaneously conceptualise both the climate crisis and global warming remain limited. This study addresses that gap by investigating these perceptions through the globally recognised framework of the Intergovernmental Panel on Climate Change (IPCC), which encompasses not only physical and scientific dimensions but also social, psychological, governance, and ecological ones. Employing a phenomenological research design, this study comparatively examined how 18 secondary school students from a public secondary school and 24 pre-service teachers from a public university in Türkiye conceptualised the climate crisis and global warming through metaphors during the 2024–2025 academic year. Data were collected via a semi-structured, open-ended Metaphor Perception Form and subjected to descriptive analysis grounded in an IPCC-derived thematic framework comprising six categories: Physical Threat and Scientific Findings; Social Vulnerability and Justice; Psychological Perception and Uncertainty; Adaptation and Mitigation Strategies; Science, Policy, and Decision-Making; and Ecosystem and Natural The study identified 12 distinct metaphors for the climate crisis and 14 for global warming among students, and 21 for the climate crisis and 22 for global warming among pre-service teachers. In both groups, metaphors most frequently corresponded to the Physical Threat and Scientific Findings category. Students produced no metaphors aligned with Social Vulnerability and Justice, Adaptation and Mitigation Strategies, or Science, Policy, and Decision-Making for either phenomenon. Pre-service teachers similarly produced no metaphors within Social Vulnerability and Justice for the climate crisis, nor within Social Vulnerability and Justice or Adaptation and Mitigation Strategies for global warming. The predominance of threat-centred metaphors across both groups suggests that climate-related learning remains anchored in physical and disaster-oriented frames, with justice, governance, and mitigation dimensions largely absent from participants' conceptual repertoires. These findings highlight the need for pedagogical approaches that move beyond disaster imagery toward climate justice, democratic agency, and active participation in solution processes within both secondary and teacher education contexts.

KEYWORDS
Intergovernmental Panel on Climate Change, climate crisis, global warming, pre-service teachers, secondary school students, perceptions

1 Introduction

Conceptual clarity in climate-related terminology appears critical not only for the consistency of scientific debate, but also for enabling individuals to accurately interpret climate phenomena, evaluate public discussions in an informed manner, and develop well-grounded attitudes. Although "climate change" and "global warming" are frequently used interchangeably in public discourse (Benjamin et al., 2017), these terms are not synonymous and emphasise distinct aspects of the phenomenon. According to the Working Group I (WGI) glossary of the IPCC Sixth Assessment Report (AR6), *climate change* refers to a change in the state of the climate that can be identified by changes in the mean and/or variability of its properties, persisting for an extended period, typically decades or longer (Intergovernmental Panel on Climate Change, 2021). *Global warming*, by contrast, refers more specifically to the long-term increase in observed global surface temperature relative to a baseline reference period (Intergovernmental Panel on Climate Change, 2021). Global warming therefore denotes a directional temperature trend, whereas climate change encompasses a broader set of climatic shifts—including changes in precipitation patterns, sea level, ice coverage, and the frequency of extreme weather events—and their consequences.

Alongside the formal scientific terms climate change and global warming, labels such as *climate crisis* and *climate emergency* have increasingly gained currency in public and media discourse, foregrounding urgency, seriousness, and moral responsibility. These expressions should not be treated as technical synonyms for climate change or global warming. Within the IPCC framework, the concepts of global warming and climate change are predominantly employed in WGI, which focuses on the physical science basis, whereas the terms climate crisis and climate emergency are more prominent in the social, policy, and action-oriented contexts of WGII (Impacts, Adaptation and Vulnerability) and WGIII (Mitigation of Climate Change) (Intergovernmental Panel on Climate Change, 2022a, 2022b). In 2019, *The Guardian* newspaper began using these terms to heighten public concern and draw attention to urgency (Schäfer et al., 2023). Defining the situation as a "crisis" is regarded as a critical step toward organised action (Maipas and Kavantzas, 2024). At the same time, recent empirical studies indicate that changes in terminology alone do not automatically strengthen willingness to act: a national U.S. terminology experiment found that "climate change" and "global warming" were generally the most familiar terms, whereas "climate crisis" and "climate emergency" were less familiar and did not elicit greater perceived urgency or policy support (de Bruine Bruin et al., 2024). Similarly, large-scale experiments testing multiple labels across diverse populations reported null effects of terminology on stated willingness to engage in climate action (Goldwert et al., 2024). Complementing this experimental evidence, corpus-based analyses of recent UK newspaper discourse show that the term "climate crisis" has been rising and tends to co-occur with urgency-related language, while "climate change" remains dominant in policy contexts (Lam and Lam, 2025).

Effectively addressing climate change requires a response that is simultaneously scientific, political, social, and educational. The IPCC AR6 Synthesis Report underscores that climate-related change must be understood not only through rising temperatures and physical degradation, but also through unequal vulnerability, social justice, governance, decision-making, and collective responsibility, and that prioritising equity and meaningful participation can strengthen both adaptation and mitigation (Intergovernmental Panel on Climate Change, 2023). In this context, mitigation—aimed at limiting further environmental damage—and adaptation—aimed at adjusting to already changing conditions—stand out as the core strategies for addressing climate change (Bevins, 2020). However, for these strategies to find resonance at the societal level, citizens must be environmentally conscious, sufficiently well-informed, and capable of contributing to decision-making processes with their own considered views (Ekborg and Areskoug, 2006; Fortner, 2001). Equipping individuals with the knowledge and competencies needed to make sound decisions is therefore indispensable for a sustainable future and for the safety and preservation of our planet (Kola-Olusanya, 2017). Moreover, today's children are growing up in a world already burdened with serious problems such as pollution, poverty, and biodiversity loss—a reality that makes raising children to be more environmentally conscious, sensitive, and well-educated than ever before all the more important (Hedefalk et al., 2015).

Any comprehensive approach to addressing climate change must include both formal and non-formal education, since it can be argued that individuals must understand this phenomenon and the factors contributing to it in order to make informed lifestyle choices that can influence climate outcomes (Yencken et al., 2000). Education is a key component of the response to the climate crisis; it helps individuals and societies understand the causes, effects, and solutions of global warming, facilitates informed decision-making through awareness, strengthens young people's climate consciousness, and plays a critical role in developing both adaptation and mitigation capacities. Education therefore lies at the heart of societal transformation toward addressing climate change (UNESCO, 2021; UNESCO and MECCE, 2024). Yet unlike other socio-scientific issues such as air pollution, the specificity of climate change lies in addressing a danger that is not yet fully visible, and thus people's understanding of it can be complicated by misinformation that denies the threat (Dupigny-Giroux, 2010; Ekborg and Areskoug, 2006; Schreiner et al., 2005). At this point, educational institutions—and universities in particular—play a critical role in coping with the adverse effects of climate change by generating knowledge, disseminating it, and integrating climate change issues into teaching and research programmes (Ahmed et al., 2021).

It is believed that faculties of education, along with the pre-service teachers they educate, should possess comprehensive knowledge about climate change, the climate crisis, and global warming; shape their pedagogical skills within the framework of climate consciousness; and recognise that by guiding their future students, they can help generate a powerful domino effect against the climate crisis and global warming. Having a strong knowledge base about climate change helps teachers fulfil this role effectively (McNeal et al., 2017; Sadler et al., 2006), and it is known that teachers' beliefs about the causes of climate change influence their students (Stevenson et al., 2014). As Dawson (2015) emphasised, given its political and controversial nature, climate change is one of the most important socio-scientific issues that teachers at all levels of education can address (Bråten et al., 2011). Systematic climate change education provided by teachers in schools is significant in shaping young people's knowledge and beliefs in this area (Dupigny-Giroux, 2010; Ekborg and Areskoug, 2006; Schreiner et al., 2005). For teachers and teacher candidates who will raise the eco-citizens of the future, equipping themselves with knowledge, skills, and values related to climate action and educating their students to become agents capable of combating the climate crisis monster may be as critical as ending greenhouse gas consumption. Determining what topics young people are concerned about, what they already know, and what they need to learn is essential for designing teaching processes and ensuring that they align with and support the transition to sustainability (de Rivas et al., 2024).

On the other hand, young people's voices on climate change have perhaps never been as significant and visible as they are today. The first signs of young people's growing unrest about climate action emerged when students began skipping school to join "climate strikes." In August 2018, 15-year-old Swedish climate activist Greta Thunberg started a

protest called "Skolstrejk för klimatet" ("School Strike for Climate"). Thunberg soon attracted international media attention, and the campaign — referred to by various names such as "Fridays for Future," "Youth for Climate," and "Youth Strike 4 Climate"—grew rapidly after COP24 in December 2018. On 15 March 2019, thousands of young people from more than 100 countries left school to demand that their governments take concrete action to prevent climate change. These demands were particularly linked to the fact that their generation would be more severely affected by the consequences of climate change (Warren, 2019). The actions and demands of young people also received support from many scientists and academics (Hagedorn et al., 2019). As Thunberg (2019) emphasised, there is one thing young people are aware of: our house is on fire, and our choices will have effects lasting hundreds or even thousands of years (Intergovernmental Panel on Climate Change, 2023).

Within the scope of the research, the literature on perceptions of climate change/climate crisis and global warming clusters around three lines: students at different educational levels (Tse, 2013; Doğru and Saraç, 2013; Lee et al., 2020; Oliver and Adkins, 2020; Mahanoğlu, 2019; Gülen and Dönmez, 2020; Kılıçoğlu and Yılmaz, 2021; Avcı and Kana, 2022; Sánchez-Almodóvar et al., 2022; de Rivas et al., 2024; Gencer et al., 2024; İyci, 2024; İnan and Polat, 2024; Yaşar, 2024), pre-service teachers (Papadimitriou, 2004; Sever, 2013; Kaya, 2013; Ambusaidi and Al Washahi, 2016; Boon, 2016; Arslan and Zengin, 2016; Yel and Karakuş, 2019; Oran, 2023; Hariyono et al., 2024; Semenderoğlu et al., 2024; Morote et al., 2025), and comparative designs including both groups (Boon, 2010; Bevins, 2020). Based on the literature, it is observed that studies comparatively examining the perceptions of secondary school students and pre-service teachers regarding the climate crisis and global warming are limited.

This study is considered original not only because it comparatively examines the meaning worlds of the relevant groups regarding the climate crisis and global warming, but also because it interprets these perceptions through the globally recognised scientific framework of the IPCC. It is considered that the political, social, and adaptive dimensions of the IPCC framework may enable individuals to approach the climate crisis and global warming not merely as environmental phenomena, but as multidimensional issues intertwined with decision-making, justice, equity, and social responsibility. These dimensions can offer reflections on the values, belief systems, and power relations through which individuals make sense of the climate crisis. Metaphor analysis, which can contribute to understanding how individuals concretise abstract and complex environmental processes through mental imagery, may be accepted as a functional tool for making visible the reflections of these multidimensional IPCC themes in perceptions. In this regard, the study can provide insights into how cognitive representations of the climate crisis may be shaped not only at the informational level, but also across political, social, and ethical awareness dimensions. Furthermore, this approach is associated with the potential to observe the extent to which the perceptions of secondary school students and pre-service teachers regarding these two phenomena converge or diverge within their mental frameworks, thereby making it possible to gain a holistic perspective that captures both phenomena in an integrated manner. In addition, it is thought that the study may be beneficial and thus contribute to the literature by enabling an understanding of the needs of eco-citizen secondary school students in developing conscious climate-action attitudes and behaviours, by identifying how the future teachers who will raise these citizens can play a guiding and inspiring role in these processes, and by determining their own needs in this context. The aim of the research is to determine and comparatively examine the perceptions of secondary school students and pre-service teachers regarding the climate crisis and global warming through metaphors. Accordingly, this study addresses the following research questions in a comparative manner between secondary school students and pre-service teachers:

- What metaphors do secondary school students and pre-service teachers use to conceptualise (a) the climate crisis and (b) global warming?
- How are these metaphors thematically categorised within the IPCC-based framework, and how do the thematic distributions differ between secondary school students and pre-service teachers?

2 Method

2.1 Research design

This study was conducted within the framework of the phenomenological design, one of the research designs of the qualitative research method. Phenomenology is the most suitable qualitative research design for researchers who aim to examine how individuals interpret their experiences and lives, reveal the relationships between events and how individuals perceive them, explore how they experience the essence of a phenomenon, and investigate the commonalities among individuals (Tekindal, 2021; Swanborn, 2010). In this study, phenomenology was used also as an analytic stance to foreground participants' lived meaning-making of the climate crisis and global warming. Accordingly, although the analysis involves themes, these are treated as phenomenological meaning structures rather than topic-based themes in conventional thematic analysis (Moustakas, 1994; van Manen, 2016; Braun and Clarke, 2006).

2.2 Study group

The study group consisted of 18 secondary school students studying at a public secondary school (Grades [5–8]; typically aged [11–14]) and 24 pre-service teachers enrolled in a faculty of education at a public university (Year [1–4]/undergraduate level). Of the 24 pre-service teachers, 17 were female and 7 were male; of the 18 secondary school students, 8 were female and 10 were male. Both groups attended the "Climate Crisis is Real" exhibition held on March 12, 2024, at the faculty where the pre-service teachers were enrolled. Completion of the Metaphor Perception Form served as a condition of entry to the exhibition; functioning, in effect, as an admission ticket and data were collected from all participants who attended on that day. This design ensured that metaphor responses were gathered before participants entered the exhibition space, thereby controlling for potential exposure effects and ensuring that the metaphors produced reflected participants' pre-existing conceptual frameworks rather than impressions shaped by the exhibition content. In selecting the sample, the convenience sampling method, one of the purposeful sampling techniques, was preferred. This method relies on participants who are readily accessible to the researcher (Patton, 2015). Facilitating criteria such as the researcher's accessibility to participants and the participants' willingness to provide data were taken into consideration. Because convenience sampling was used within one public secondary school and one public university in Türkiye, the findings are not intended to be statistically generalisable beyond comparable settings. The institutional and socio-cultural characteristics of these contexts (e.g., curriculum emphases, local exposure to climate-related events, and family/media discourse) may

have shaped the metaphors elicited; therefore, the results should be interpreted as context-sensitive and analytically transferable.

2.3 Data collection tools

The data of the study were collected using a semi-structured, open-ended "Climate Crisis and Global Warming Perception Metaphor Form". In the form, secondary school students and pre-service teachers were asked to develop metaphors by completing the sentences: "Climate crisis is like … because …" and "Global warming is like … because …". Metaphors enable individuals to transfer appearances, concepts, and terminology related to a particular situation to a domain that they know little or nothing about (Ertem, 2017). The word "like" is generally used to better explain the relationship between the subject and the source of the mental image, while the word "because" is used to provide a logical basis for the generated metaphors (Saban, 2009). The sentence stems; "Climate crisis is like …" and "Global warming is like …" elicited participants' metaphorical conceptualisations of each phenomenon, while the "because …" clause captured the explanatory reasoning that grounded these conceptualisations and allowed us to trace causal, systemic, and where articulated more abstract meanings in the justification texts. Prior to data collection, all participants were provided with a brief explanation of the concept of metaphor and were given an illustrative example (e.g., "Time is like money because it runs out if wasted"). This step was particularly important for secondary school students to ensure that responses reflected genuine metaphorical reasoning rather than literal descriptions. Accordingly, the data source of the study consisted of the metaphors produced by secondary school students and pre-service teachers regarding the climate crisis and global warming, together with their written justifications.

2.4 Data collection and analysis

In the study, secondary school students and pre-service teachers were asked, within the context of the relevant interview form, to generate metaphors separately for the phenomena of the climate crisis and global warming and to explain the basis of the metaphors they produced. The metaphors developed and their justifications were subjected to descriptive analysis. Descriptive analysis involves summarizing data in line with themes or categories predetermined by the researcher, presenting them faithfully to the participants' expressions, and including quotations to reflect their views (Creswell and Poth, 2018). Descriptive analysis was carried out through the following stages: Target theme identification and coding stage: At this stage, the researchers first determined the target themes based on the literature and expert opinions, drawing from IPCC reports, which, since 1990, have presented the current state of the climate, demonstrated the impacts of climate change on nature and society, and addressed measures aimed at limiting global warming, adapting to, and mitigating the effects of climate change. Then, regarding the data provided by secondary school students and pre-service teachers in the interview forms, coding was carried out as follows: for secondary school students (SS) and the order of participation in the metaphor-generation study (e.g., since a secondary school student completed the form as the fourth participant, coded as SS4), and for pre-service teachers (PT) and the order of participation (e.g., since a pre-service teacher completed the form as the fifth participant, coded as PT5). Compilation of metaphors stage: At this stage, the metaphors produced were listed alphabetically within themselves, and representative metaphors with a high level of thematic representational power were selected to form a "reference metaphor list." This list was prepared for two main purposes: to serve as a reference source and to ensure the verification of the data analysis and interpretations of the study. Matching with identified themes stage: This stage involved examining the metaphors produced in terms of the characteristics of the climate crisis and global warming and aligning them with the target themes. At this point, the relationship between the feature and the source of each metaphor produced by secondary school students and pre-service teachers was analyzed. Following phenomenological analytic moves, analysis began with repeated holistic reading of all metaphor statements and horizonalization (treating each statement as a potential meaning-bearing unit) (Moustakas, 1994). Significant statements were then condensed into meaning units and iteratively clustered into composite meaning structures for each phenomenon and participant group (Giorgi, 2009; van Manen, 2016). After this inductive meaning-clustering, the IPCC-derived categories were used as an evidence-based organizing matrix to locate these meaning structures within internationally recognized dimensions of climate impacts and responses and to support systematic comparison (Gale et al., 2013). The resulting metaphors were independently matched by two subject-matter experts to the IPCC-based themes, and any discrepancies were resolved through discussion until consensus was reached. The resulting images were then matched by the researchers with the themes developed based on the Intergovernmental Panel on Climate Change (2023) report and expert opinions: physical threat and scientific findings, social vulnerability and justice, psychological perception and uncertainty, adaptation and mitigation strategies, science, policy, and decision-making, ecosystem and natural balance.

IPCC-derived themes were selected as a deductive analytic lens because they offer a widely recognized, evidence-based synthesis of the core dimensions through which climate impacts and responses are discussed. Using this framework allowed us to systematically map participants' metaphors onto comparable thematic domains and to identify which dimensions were represented/underrepresented in their meaning-making. The epistemological rationale for this mapping rests on conceptual metaphor theory (Lakoff and Johnson, 1980): metaphors systematically structure abstract domains through concrete source domains, rendering participants' mental framing structures visible and comparable across IPCC categories (Flusberg et al., 2017). Nonetheless, translating subjective metaphors into pre-specified categories requires interpretive judgment; overlapping cases were resolved through inter-expert consensus. The tension between the phenomenological design and the deductive use of IPCC categories is acknowledged: themes were applied only after an initial inductive meaning-clustering stage, yet the schematic framework may have oriented interpretive judgment.

Physical threat and scientific findings theme relates to participants perceiving the climate crisis and global warming as direct physical threats, disasters, or scientific phenomena, considering narratives such as temperature increase, sea-level rise, extreme weather events, and wildfires. Social vulnerability and justice theme concerns the perception of the climate crisis and global warming as phenomena that may exacerbate social inequalities, considering narratives such as vulnerable groups, climate justice, post-disaster inequality, migration, and food security. Psychological perception and uncertainty theme focuses on the psychological impacts of the climate crisis and climate change, considering narratives such as eco-anxiety, uncertainty, denial, and feelings of inadequacy. Adaptation and mitigation strategies theme relates to human strategies for taking preventive (adaptation) and mitigating (emission-reducing) actions against the climate crisis and global warming, considering narratives such as adaptation strategies, sustainable energy, greenhouse gas reduction, and green infrastructure. Decision-making, science, and policy

relationship theme addresses the perspective that the climate crisis and global warming are not only scientific but also political and economic issues, considering narratives such as policy measures, economic strategies, and governance. Ecosystem and natural balance theme focuses on aspects of the climate crisis and global warming related to natural cycles, ecosystem destruction, and biodiversity loss, considering narratives such as ecological damage and species migration or decline.

2.5 Validity and reliability

In this research, four fundamental criteria proposed by Ravitch and Carl (2019) were adopted to ensure the validity and reliability of the qualitative data: credibility, transferability, confirmability, and consistency. To ensure credibility, three different experts worked in coordination during the preparation, implementation, coding, and analysis processes of the data collection tools. These experts included a specialist in social studies education working on environmental and climate issues, a specialist in science education focusing on environment and climate, and an expert in measurement and evaluation. At every stage of the research, final decisions were made by considering the evaluations and suggestions of the relevant field experts.

After the analysis process was completed, the findings were presented to field experts for review, and efforts were made to achieve consensus. In cases of disagreement, a discussion environment was created to develop a common framework, and credibility was further strengthened by having different coders check the data. To enhance transferability, all documents used during the data collection and analysis phases were preserved in their original form without any modification. The data collection process, coding methods, and analytical approaches were explained in detail, and participants' statements were presented as direct quotations without interpretation, allowing readers to make their own assessments. The interviews were conducted directly by the researchers, and each stage was carried out under the guidance of the relevant experts.

Within the consistency criterion, the same data collection tool was administered to both secondary school students and pre-service teachers, data were collected under similar conditions, and equal time was provided to participants, thereby ensuring standardization. To strengthen the scientific consistency of the research, an extensive literature review was conducted, and the findings were compared with previous studies. To ensure confirmability, the data collection tools, raw data, codings derived from these data, and analysis processes were systematically archived. In this way, the research process was rendered verifiable by an independent researcher.

3 Findings

The IPCC category distribution across all groups and phenomena can be examined through the heatmap presented in Figure 1. Detailed frequency distributions of individual Climate Crisis metaphors are provided in Appendix Figure 1, and individual Global Warming metaphors in Appendix Figure 2; a grouped comparison of IPCC category frequencies across both groups and phenomena is presented in Appendix Figure 3.

3.1 Findings regarding the metaphors developed by secondary school students and pre-service teachers toward the climate crisis and global warming

As detailed in Appendix Figure 1, secondary school students produced a total of 18 metaphors related to the climate crisis, 12 of which were distinct from one another. Among the metaphors they developed, the most frequent one was "End of life" (3), followed by "Disaster" (2), "People" (2), "Snake" (2), and "Apocalypse" (2) as other prominent metaphors. All remaining metaphors were used only once. Concerning pre-service teachers, they produced a total of 23 metaphors related to the climate crisis (23 valid metaphors obtained from 24 participants, one form was excluded from the analysis as it lacked semantic coherence), 21 of which were distinct from one another. The most frequently developed metaphors were Smoking/Smoke (2) and Apocalypse (2) while all other metaphors appeared only once.

As detailed in Appendix Figure 2, secondary school students developed a total of 18 metaphors related to global warming, 14 of which were distinct from one another. Among these metaphors, "End of the world" (3) was the most frequently used, while "Warming of the air" (2) and "LGS" (2) were identified as other prominent metaphors. All other metaphors were used only once. Concerning pre-service teachers, they developed a total of 24 metaphors related to global warming, 22 of which were distinct from one another. The most frequently observed metaphors were Burning stove (2) and End (2) while all other metaphors appeared only once.

3.2 Findings regarding the categories in which the metaphors developed by secondary school students and pre-service teachers about the climate crisis and global warming are grouped

As detailed in Figure 1 and Appendix Figure 3 and the metaphors produced by secondary school students for the climate crisis mapped onto the IPCC categories 19 times. The most prominent category was Physical Threat and Scientific Findings ($n = 13$), followed by Psychological Perception and Uncertainty ($n = 3$) and Ecosystem and Natural Balance ($n = 3$). No student metaphors aligned with Social Vulnerability and Justice, Adaptation and Mitigation Strategies, or Science, Policy, and Decision-Making. For pre-service teachers, climate-crisis metaphors corresponded to the IPCC categories 32 times. Physical Threat and Scientific Findings remained the most represented ($n = 11$), while Science, Policy, and Decision-Making and Ecosystem and Natural Balance followed ($n = 7$ each). In contrast, Social Vulnerability and Justice was not represented.

A similar pattern emerged for global warming. Secondary school students' metaphors yielded 27 IPCC-category matches, most frequently in Physical Threat and Scientific Findings ($n = 16$) and Ecosystem and Natural Balance ($n = 9$), with no metaphors corresponding to Social Vulnerability and Justice, Adaptation and Mitigation Strategies, or Science, Policy, and Decision-Making. Pre-service teachers' global-warming metaphors produced 29 matches, again concentrated in Physical Threat and Scientific Findings ($n = 11$) and Psychological Perception and Uncertainty ($n = 8$); Social Vulnerability and Justice and Adaptation and Mitigation Strategies were not represented.

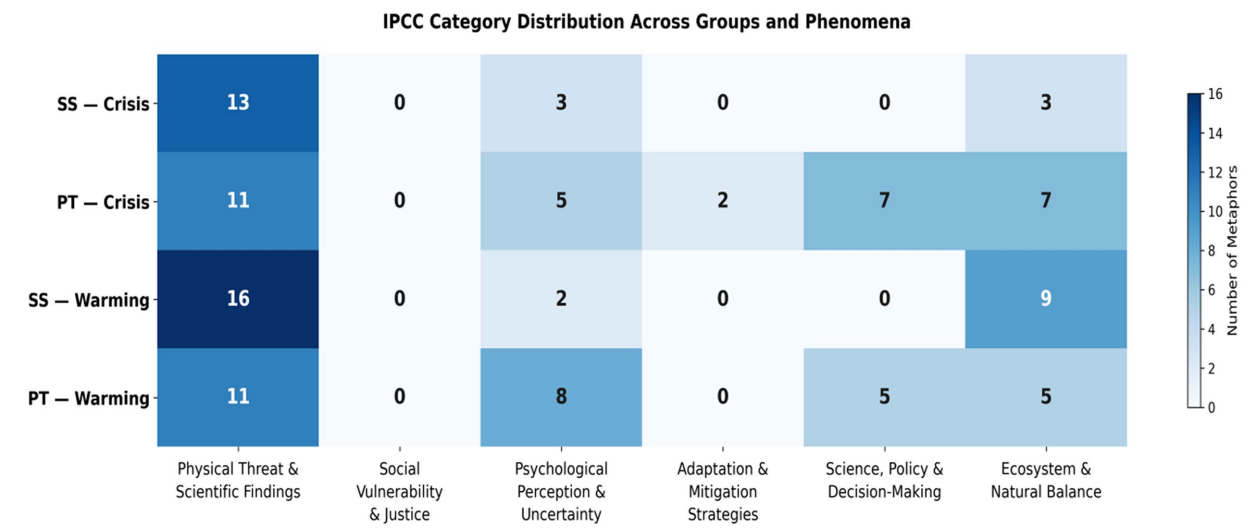

FIGURE 1
IPCC category distribution across groups and phenomena.

Direct quotations selected from the Climate Crisis and Global Warming Perception Metaphor Form are presented below, organized under their respective IPCC-based thematic categories. Each quotation is followed by a brief analytical note explaining the conceptual mapping between the metaphor and its assigned category.

3.2.1 Physical threat and scientific findings

SS16: *"The climate crisis is like a crocodile because just as a crocodile kills people, the climate crisis can also bring an end to humanity." [the metaphor frames the climate crisis as a lethal, predatory force causing direct physical harm to humanity].*

SS18: *"The climate crisis is like the apocalypse because it can bring the end of humankind." [apocalyptic framing reflects perception of catastrophic, civilizational-scale physical destruction].*
PT1: *"The climate crisis is like regret because regret is a feeling that disturbs a person every day, just like the climate crisis." [persistent, inescapable disturbance maps onto the continuous and accumulating nature of climate impacts].*
PT2: *"The climate crisis is like drowning because it puts an end to existence." [drowning as existential physical termination directly mirrors catastrophic climate threat to life].*
SS10: *"Global warming is like a saw because it can destroy us from the root." [irreversible structural destruction from the root reflects escalating, systemic physical damage].*
SS16: *"Global warming is like a shark because, like it, dangerous weather events may occur." [shark as apex predator maps onto the unpredictable and dangerous nature of extreme weather events].*
PT23: *"Global warming is like a drowning man because it ends life." [direct physical death framing signals perception of global warming as an existential threat to biological survival].*
PT15: *"Global warming is like fire because it is ready to destroy everything. What we think is something small might actually be the spark of this fire." [fire as destructive force with escalating, uncontrollable spread reflects scientific understanding of tipping points and cascading impacts].*

3.2.2 Psychological perception and uncertainty

PT10: *"The climate crisis is like school because it is very frightening." [fear and anxiety as dominant emotional response reflects eco-anxiety framing of climate crisis].*
SS17: *"The climate crisis is like mathematics because it doesn't kill, but it makes you suffer." [chronic, non-lethal suffering maps onto sustained psychological burden and climate-related distress].*
PT15: *"The climate crisis is like a vegetative state because you say you're alive, but it has no meaning." [loss of meaning and agency reflects feelings of helplessness and existential uncertainty associated with climate crisis].*
PT24: *"The climate crisis is like a distant mountain because it seems far away, but it is much closer than it looks."*
[psychological distance and underestimation of proximity reflects cognitive bias in climate risk perception].
SS8: *"Global warming is like a meteor because it keeps getting closer."*
[approaching but not-yet-arrived threat maps onto temporal uncertainty and sense of impending but unresolved danger].
SS18: *"Global warming is like the LGS exam because it causes extreme panic."*
[exam-induced panic reflects eco-anxiety and the psychological pressure of looming, high-stakes environmental consequences].
PT11: *"Global warming is like a dark room because we cannot see the future."*
[darkness as metaphor for uncertainty directly maps onto unpredictability and lack of clarity regarding climate futures].
PT18: *"Global warming is like an ex-lover because we are exposed to it even if we don't want to be." [unwanted but inescapable exposure reflects feelings of powerlessness and involuntary vulnerability to climate impacts].*

3.2.3 Adaptation and mitigation strategies

> PT16: *"The climate crisis is like an exam because it is a problem that needs to be solved." [framing the crisis as a solvable problem implies active human agency and solution-oriented response, consistent with mitigation thinking].*
> PT17: *"The climate crisis is like the rotten side of an apple because if we don't cut it off, it will spread to the whole apple." [surgical removal of rot as preventive action directly maps onto early mitigation intervention to prevent irreversible systemic spread].*

3.2.4 Science, policy, and decision-making

> PT9: *"The climate crisis is like smoking because you knowingly poison yourself." [conscious self-harm despite knowledge reflects the gap between scientific evidence and policy/individual decision-making, central to climate governance debates].*
> PT18: *"The climate crisis is like a child because we nurture and raise it with our own hands." [human agency in creating and escalating the crisis implies political and institutional responsibility for decisions that have produced current conditions].*
> PT1: *"Global warming is like a supernova because they either turn into neutron stars or black holes. If we take good care of the Earth, we can continue to live with little energy like neutron stars; but if we don't, we may be trapped in darkness like a black hole, not knowing what our end will be." [bifurcated outcome contingent on human choices maps directly onto IPCC scenarios linking policy decisions to divergent climate futures].*
> PT10: *"Global warming is like a stove because the more we affect it, the more it heats up." [feedback loop between human action and intensifying warming reflects scientific understanding of anthropogenic forcing and the policy imperative to reduce emissions].*

3.2.5 Ecosystem and natural balance

> SS13: *"The climate crisis is like evil because it prevents people from growing fruits and vegetables." [disruption of food production systems reflects impact on agricultural ecosystems and biodiversity-dependent natural processes].*
> SS7: *"The climate crisis is like people because it pollutes everywhere." [widespread pollution across all environments maps onto systemic ecosystem contamination and loss of natural balance].*
> PT21: *"The climate crisis is like the apocalypse because it destroys the sources of life for living beings." [destruction of life sources frames climate crisis as collapse of ecological foundations supporting all living systems].*
> PT11: *"The climate crisis is like an insidious disease because it slowly destroys our world." [slow, cumulative destruction mirrors gradual degradation of ecosystems and natural cycles under sustained climate pressure].*
> SS13: *"Global warming is like the Earth's core because the climate stabilizes and our country becomes fertile." [Earth's core as regulator of natural thermal balance reflects understanding of climate as a natural system whose equilibrium sustains ecological productivity].*
> SS15: *"Global warming is like a desert because it deprives people of water and exposes them to heat." [desertification as consequence of warming directly maps onto IPCC projections of water scarcity and ecosystem degradation in arid regions].*
> PT24: *"Global warming is like a football player with torn ligaments because it will never be the same again and will struggle to heal in pain." [irreversible structural injury maps onto permanent loss of ecosystem integrity and the limited recovery capacity of natural systems under prolonged warming].*
> PT8: *"Global warming is like being unable to experience seasons because it affects all of them." [disruption of seasonal cycles reflects climate-driven alteration of phenological patterns and natural temporal rhythms in ecosystems].*

4 Results, discussion, and recommendations

Before beginning the discussion, we would like to remind that, since the study group in this research was formed in accordance with the nature of qualitative research focusing on in-depth meaning construction and based on a small, non-probability sample, it is important that the results be evaluated as limited solely to the meaning worlds of this participant group. In addition, the metaphor patterns observed in this study are likely shaped by contextual factors related to participants' developmental stage and lived environment. Age and school level may influence the degree to which phenomenon is conceptualized through concrete, experience-near frames versus more abstract socio-political frames (e.g., justice, governance). Likewise, recent local experiences-such as floods, heatwaves, storms, wildfires, drought, or pollution episodes-can heighten the salience of certain risks and thereby make specific metaphors more "available" in participants' narratives. Family conversations and the visibility of climate-related content in news and social media may further amplify emotionally vivid threat-based images, while socio-economic conditions may shape whether climate change is imagined primarily as an environmental hazard or also as an issue of unequal vulnerability and distributive justice. Furthermore, prompt design may have favored concrete, threat-based responses over abstract framings such as justice or governance (Saban, 2009); absent metaphors should therefore reflect not only awareness gaps but also developmental abstraction limits as well. For these reasons, the findings should be interpreted as context-sensitive and analytically transferable rather than statistically generalizable.

The first result obtained within the scope of the research revealed that the 18 secondary school students participating in the study developed 12 different metaphors for the climate crisis and 14 different metaphors for global warming, and the 24 pre-service teachers developed 21 different metaphors for the climate crisis and 22 different metaphors for global warming. Regarding the climate crisis, secondary school students most frequently produced the metaphor end of life (3), and, as other prominent metaphors, disaster (2), people (2), snake (2), apocalypse (2); regarding global warming, they most frequently produced the metaphor end of the world (3), and, as other prominent metaphors, heating of the air (2), LGS (2). Regarding the climate crisis, pre-service teachers most frequently produced the metaphors smoking (2) and apocalypse (2), and, regarding global warming, they most frequently produced burning stove (2) and the end (2). From this, it can be said that participants exhibited a certain level of diversity in how they made sense of the phenomena of the climate crisis and global warming. It is believed that this can be read not only as a numerical density, but also as an indicator that participants may have

rich ways of constructing meaning regarding these phenomena. The studies of Kaya (2013), Arslan and Zengin (2016), Gülen and Dönmez (2020), and Avcı and Kana (2022) also appear to point to the diversity of metaphors directed at global warming due to its nature as a multi-layered phenomenon and concept.

The metaphors end of life, apocalypse, disaster, snake, people, end of the world, heating of the air, and LGS, which were more frequently developed by secondary school students, may indicate that the climate crisis and global warming were perceived more along the axes of end, destruction, danger, fear, and anxiety; that they were conceptualized as phenomena associated with fate, mostly beyond control but also created by human hands to that extent, bearing elements of threat, being a scientific reality, and being a strong source of concern and that students may have evaluated these phenomena mostly as an irreversible rupture. The studies in the literature (Doğru and Saraç, 2013; Gülen and Dönmez, 2020; Avcı and Kana, 2022) are also believed to overlap with this perspective. Doğru and Saraç (2013) examined primary school students' perceptions of global warming through metaphors, and the metaphors such as sun, volcano, and monster in this study were understood to indicate that global warming was explained sometimes as a high accumulation of heat and sometimes as a destructive and uncontrollable force. Gülen and Dönmez (2020) examined middle school students' perceptions of global warming through metaphors, and the metaphors such as fire, hell, and heating-burning in the study appear to draw attention to the continuity and burning nature of warming and to describe the crisis as a factor threatening the planet's habitability. Avcı and Kana (2022) similarly investigated middle school students' perceptions of global warming through metaphors, and the prominent metaphors such as war, disaster, and element that disrupts the natural balance in the study were interpreted to indicate that the relevant phenomena were perceived as a mutual conflict between humans and nature. From the metaphors people and snake, which were among the other prominent metaphors in this research, the impression was obtained that students may have positioned the human, in the role within the climate crisis and global warming, not as an ineffective element but as an agent who affects and is affected. Again, in the study of Gülen and Dönmez (2020), contexts such as disruptor and melter may be directed toward human intervention, and in Avcı and Kana (2022), the categories element that disrupts the natural balance and element of threat are believed to have addressed this relationship. However, the prominent metaphor LGS developed by students in this study may show that the climate crisis and global warming can be perceived not only as ecological phenomena but also as psychological and anxiety-inducing phenomena that resemble the processes of pressure, competition, and uncertainty in the individual's daily life. While in the study of Doğru and Saraç (2013) some of the students appear to highlight global warming as a phenomenon that should be prevented, in Gülen and Dönmez (2020), the themes of balance and precaution drew attention, and in Avcı and Kana (2022), this context appears to have been conceptualized as struggle and a situation requiring measures. While it is considered that in the aforementioned studies the students may have implied that they thought of the climate crisis and global warming as an exam to be overcome, in this research the perspective of focusing more on the experienced anxiety and thus leaning toward the solution point appears weaker, and in this respect the research was considered to differ from other studies.

The metaphors smoking/smoke, burning stove, apocalypse, and the end, which were more frequently developed by pre-service teachers, suggest that the climate crisis and global warming were perceived not only as external destruction but also as human-induced, continuous, and irreversible processes. This perspective is thought to carry a similar orientation to the study by Arslan and Zengin (2016), which examined pre-service science teachers' perceptions of global warming through metaphors, where pre-service teachers saw global warming as the deterioration of natural balance, the consequence of what we have done, and the end. Likewise, the frequently repeated metaphors stove, apocalypse, and human can be thought to represent a deterioration based on human intervention, similarly to the metaphors burning stove and smoking in the present research. In the study by Kaya (2013), which examined pre-service social studies teachers' perceptions of global warming through metaphors, it was also observed that pre-service teachers most frequently concentrated in the categories of increase in temperature and increase in effect over time. This orientation was considered to potentially overlap with the perception of the physical process based on heating/heatedness represented by the burning stove metaphor in the present research. The metaphors apocalypse and the end also stood out in both studies. These similarities may indicate that pre-service teachers evaluated the climate crisis and global warming as an irreversible breaking point at which human impacts on nature have reached their limit. When the first result obtained by the present research is evaluated together with the literature, it is assumed that the perceptions of secondary school students regarding the climate crisis and global warming may be shaped more from a context encompassing threats that are external, uncontrollable, or created by human hands, together with their own experiences; whereas it was considered that pre-service teachers made sense of global warming both in the context of the physical cause-effect chain and similarly in the context of the human role and responsibility.

The second result obtained in the research, in a context overlapping with the first result, determined that the metaphors developed by both secondary school students and pre-service teachers regarding the climate crisis and global warming most frequently corresponded to the category "Physical Threat and Scientific Findings." It is considered that the result also overlaps in places with other studies in the literature. In the study by Sánchez-Almodóvar et al. (2022), which addressed Spanish secondary students' perceptions of climate change and extreme weather events, the vast majority of students saw climate change as a threat to life, and again a large proportion associated the origin of climate change with human activities. This finding is considered to potentially reflect a similar tendency to the present research, in which secondary school students developed threat-centered metaphors and perceived these phenomena at times as human-induced degradation. Similarly, in the study by Mahanoğlu (2019), which examined middle school students' perceptions of global warming, students defined global warming as a process that emerges as a result of human activities and threatens living life. In the study by Kılıçoğlu and Yılmaz (2021), which also addressed middle school students' perceptions of global warming, the fact that students saw factory smoke, exhaust gases, and deodorant use as the most important causes, and explained the consequences of global warming with physical threat and scientific findings such as melting glaciers, desertification, and rising water levels, appears to overlap with the perception in the present research. The findings of Yaşar (2024), focusing on middle school students' perceptions of global warming, were similarly interpreted to indicate that students expressed climate change as

shifts in seasons, disruption of temperature balance, and threat to living life. In the study by De Rivas et al. (2024), which addressed Spanish secondary students' perceptions of climate change, it was understood that anxiety levels toward this phenomenon were high and that a large proportion of students saw climate change as a physical threat. In the research conducted by Tse (2013) on primary and secondary school students' perceptions of climate change in Hong Kong, students also perceived climate change as a serious environmental threat. From an environmental psychology perspective, the dominance of disaster- and bodily-harm metaphors can be read as an affect-laden form of climate risk representation. For many children and young people, climate change is encountered through vivid, emotionally charged cues (e.g., extreme weather imagery and crisis-focused narratives), which can make "physical threat" meanings more cognitively available and easier to express metaphorically than abstract, systemic mechanisms. Recent systematic evidence indicates that eco-anxiety among children and young people is shaped not only by direct exposure to environmental hazards but also by media exposure and perceived institutional/government inaction, factors that can intensify feelings of threat, helplessness, and urgency (Niedzwiedz et al., 2025). Consistent with this, qualitative syntheses show that youth eco-emotions frequently include worry and anxiety but also anger, frustration, and powerlessness, emotions that readily map onto catastrophic and health-related metaphorical frames (Wu et al., 2025). Among pre-service teacher research, Sever (2013) found that pre-service science teachers frequently focused on physical processes such as temperature increase and air pollution, while Yel and Karakuş (2019) noted that candidates emphasized physical indicators such as glacier melt, species extinction, and drought. Morote et al. (2025) similarly reported that a large proportion of pre-service primary teachers explained climate change as human-induced. Taken together, the concentration of both groups in the "Physical Threat and Scientific Findings" category reflects a shared tendency to engage with the climate crisis through observable environmental effects and scientifically verifiable physical changes.

This pattern holds across both groups: among student studies, Mahanoğlu (2019), Kılıçoğlu and Yılmaz (2021), İnan and Polat (2024), and Yaşar (2024) all indicate that climate-related thinking tends to remain at the level of individual environmental awareness without extending to justice, governance, or systemic mitigation. Among pre-service teacher studies, Yel and Karakuş (2019) found that the "measures to be taken" dimension was weak and action-oriented thinking underdeveloped, while Oran (2023) reported that policy, governance, and social inequality received limited attention. The exception noted by Hariyono et al. (2024)—where pre-service teachers did emphasize mitigation and adaptation—underscores that such orientations require explicit pedagogical scaffolding. The relative absence of metaphors mapped to "Social Vulnerability and Justice" can be interpreted through an ecopedagogical and citizenship-education lens. When climate-related learning is framed predominantly as a biophysical or disaster-centered problem, students may develop impact-oriented metaphors without spontaneously generating justice-oriented or participatory metaphors that foreground inequality, intergenerational ethics, governance, and collective agency. Importantly, evidence also suggests that psychological distance is often overestimated as a barrier, many people already perceive climate change as occurring "here and now" so merely emphasizing local impacts may not reliably produce justice thinking or civic agency (van Valkengoed et al., 2023). In educational terms, moving from affective threat to democratic agency typically requires explicit pedagogical work (e.g., deliberation on climate justice, analysis of differential vulnerability, and participatory experiences that connect concern to collective action). Such an approach aligns with syntheses showing that climate-related anxiety can coexist with, and even motivate, pro-environmental engagement when it is channeled into meaningful action rather than helpless passivity (Kühner et al., 2025).

As a result, this research offers certain insights for policymakers and teacher education programs to develop students' awareness of the climate crisis not only through disaster imagery, but also through the perspectives of just transition, democracy, human rights, and global citizenship, and it indicates that "it is necessary not only to introduce students and pre-service teachers to these experienced phenomena as if showing a documentary about a crisis that another planet is experiencing, but to teach ways of active participation in solution processes." The climate crisis and global warming are a concrete test of global citizenship. It is one thing for students to fail this test; it is another, which will leave us all failing, for teachers to fail this test as well.

Based on the findings, several actionable implications can be considered for climate change education in social studies and teacher education: (1) Integrate an explicit climate justice strand (inequality, differential vulnerability, intergenerational ethics, and just transition) through structured classroom deliberations and case-based learning; (2) Design participatory, action-oriented projects that connect climate emotions to collective agency (e.g., school–community climate action portfolios, student-led "mini climate assemblies," or local adaptation plans); (3) Strengthen media and information literacy by analyzing how extreme-weather imagery and crisis framing shape risk perceptions and metaphors; (4) Embed locally grounded investigations (risk mapping, interviews with local stakeholders, and neighborhood observations) to connect scientific content with lived experience while avoiding a purely disaster-centered narrative. Future research could extend this line of inquiry by linking metaphor repertoires to climate-action pathways.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Education Research and Publication Ethics Committee (Egitim Arastirmalari ve Yayin Etik Kurulu), Sakarya University Rectorate, Sakarya University, Sakarya, Türkiye. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. Written informed consent was obtained from the individual(s), and minor(s)' legal guardian/next of kin, for the publication of any potentially identifiable images or data included in this article.

Author contributions

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APPENDIX FIGURE 1
Frequency Distribution of All Climate Crisis Metaphors by Participant Group. Panel (a) displays the frequency distribution for Secondary School Students (total: 18 metaphors, 12 distinct); Panel (b) displays the frequency distribution for Pre-Service Teachers (total: 23 metaphors, 21 distinct). Bars highlighted in red indicate metaphors with frequency > 1.

APPENDIX FIGURE 2
Frequency Distribution of All Global Warming Metaphors by Participant Group. Panel (a) displays the frequency distribution for Secondary School Students (total: 18 metaphors, 14 distinct); Panel (b) displays the frequency distribution for Pre-Service Teachers (total: 24 metaphors, 22 distinct). Bars highlighted in red indicate metaphors with frequency > 1.

APPENDIX FIGURE 3
Distribution of Metaphors Across IPCC Categories by Participant Group and Phenomenon. Panel (a) presents the Climate Crisis distribution; Panel (b) presents the Global Warming distribution. Blue bars represent Secondary School Students; red bars represent Pre-Service Teachers.

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