

# **Science Communication Frames, Public Trust, and Climate News Audiences: Panel Analysis**

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## **Abstract**

This study investigates the dynamic longitudinal relationship between science communication frames in climate journalism and public trust in climate science. Drawing on a three-wave longitudinal panel survey (N = 1500) conducted over an eighteen-month period, we examine how exposure to different climate change frames—specifically, loss-oriented crisis frames, gain-oriented economic/health frames, and action-oriented efficacy frames—influences institutional and epistemic trust among diverse media consumers. While crisis framing remains a dominant journalistic tool to capture public attention, our panel analysis reveals that prolonged exposure to high-threat loss frames without efficacy components leads to trust decay and fatalistic disengagement. Conversely, action-oriented efficacy frames consistently foster greater trust in scientific consensus and policy initiatives over time. Furthermore, the relationship is heavily moderated by political ideology and baseline scientific literacy, indicating that framing effects are not uniform across the populace. By utilizing cross-lagged panel modeling, this research addresses the causal directionality between news media exposure and public trust, offering valuable insights for scientists, policymakers, and media practitioners seeking to communicate climate risks effectively without alienating key demographics.

**Keywords:** Climate Change Communication; Media Framing; Public Trust; Panel Analysis; Science Communication Frames

## **1. Introduction**

### **1.1 Research Background and Context**

The communication of climate change in contemporary public spheres represents one of the most pressing challenges for science communication, journalism, and democratic governance. As scientific consensus regarding the anthropogenic drivers of global climate instability has solidified, the translation of this consensus into coherent public understanding and sustained policy support has remained uneven, fragmented, and highly politicized [1]. In this environment, the news media function as primary intermediaries, translating complex, probabilistic scientific findings into accessible narratives that shape how lay audiences conceptualize environmental risks, evaluate policy proposals, and conceptualize their own role in mitigation and adaptation efforts [2].

Over the past three decades, research in science communication has increasingly moved away from the traditional information deficit model, which posited that public skepticism or inaction regarding scientific issues was simply the result of a lack of knowledge. Instead, researchers have embraced framing theory to understand how media presentations of climate science select, highlight, and organize specific aspects of reality to promote a particular problem definition, causal interpretation, moral evaluation, and treatment recommendation [3]. Media outlets utilize a variety of framing packages, ranging from alarmist or crisis-oriented narratives that emphasize catastrophic loss, to positive economic and health-focused frameworks that highlight the co-benefits of green transitions, to efficacy-centered action frames that focus on collective and individual capacity to address ecological crises.

At the same time, the social currency of public trust has emerged as a critical determinant of how climate news is received and integrated into public consciousness. Public trust in science is not a monolithic entity; rather, it encompasses multiple dimensions, including epistemic trust—the belief in the validity, objectivity, and reliability of scientific methods and knowledge production—and institutional trust, which reflects confidence in scientific organizations, government agencies, and the broader scientific enterprise to act in the public interest [4]. When public trust is eroded, even the most rigorous scientific evidence can be dismissed, leading to polarization, policy gridlock, and widespread disengagement. Understanding how different communication frames systematically build, maintain, or undermine this trust over time is therefore essential for developing effective communication strategies.

## **1.2 Problem Statement and Objectives**

Despite the abundance of research on climate framing and public opinion, significant gaps persist in our understanding of how these dynamics unfold longitudinally. The vast majority of empirical studies on climate communication framing effects rely on either cross-sectional survey data or short-term laboratory experiments [5]. Cross-sectional surveys, while valuable for identifying broad correlations, are fundamentally limited in their ability to establish temporal order or causal directionality. They cannot disentangle whether exposure to specific climate frames actively influences public trust over time, or whether individuals with pre-existing levels of trust selectively expose themselves to media outlets that employ specific framing strategies.

Experimental designs, on the other hand, can demonstrate immediate, short-term framing effects in controlled settings. However, these designs often suffer from low ecological validity, as they expose participants to isolated, intense stimuli that do not reflect the complex, competitive, and repetitive media environment that individuals navigate in their daily lives. Furthermore, laboratory experiments are rarely equipped to measure the durability of framing effects or the cumulative impact of repeated exposure to certain frames over weeks, months, or years. Trust is a psychological construct that is built and eroded gradually through repeated interactions and consistent exposure to information sources, making cross-sectional and experimental models insufficient for capturing its evolutionary path.

This study addresses these limitations by utilizing a three-wave longitudinal panel survey of climate news audiences. By tracking the same sample of media consumers over an eighteen-month period, we seek to achieve three primary objectives. First, we model the longitudinal relationships between exposure to diverse climate communication frames (loss-oriented, gain-oriented, and action-oriented) and two key dimensions of public trust (epistemic and institutional trust). Second, we apply cross-lagged panel modeling to test the direction of causality between news exposure and trust, assessing whether framing exposure drives trust or if pre-existing trust dictates frame exposure. Third, we examine how these relationships are moderated by individual-level characteristics, specifically political ideology and scientific literacy, to understand the boundaries of framing influence in a polarized informational landscape.

## **2. Literature Review and Theoretical Framework**

### **2.1 Media Framing in Climate Change Communication**

Media framing operates as a cognitive and sociological process wherein journalists organize complex ideas into coherent, digestible news stories. According to classic framing theory, frames function by making certain ideas more salient in a text, thereby influencing how audiences process information, attribute responsibility, and formulate judgments [6]. In climate change journalism, media organizations must make choices about how to frame the issue: as an imminent ecological catastrophe, an economic hurdle, a public health crisis, or an opportunity for systemic technological innovation.

Loss-oriented frames, frequently referred to in the literature as crisis, alarmist, or catastrophe frames, focus heavily on the destructive consequences of climate change. These narratives emphasize extreme weather events, sea-level rise, biodiversity loss, and immediate threats to human survival [7]. The theoretical justification for using loss frames is rooted in prospect theory and risk perception models, which suggest that individuals are highly sensitive to potential losses and that vivid, high-threat information is effective at capturing attention and generating emotional engagement. However, science communication scholars have

increasingly questioned the long-term efficacy of fear-inducing loss frames. Prolonged exposure to threatening information, when unaccompanied by actionable solutions, can lead to cognitive overload, psychological reactance, defensive avoidance, and a sense of helplessness, which may ultimately degrade trust in both the messengers and the underlying science.

In contrast, gain-oriented frames highlight the positive outcomes associated with proactive climate mitigation and adaptation policies. These frames often emphasize the economic benefits of transitioning to a low-carbon economy, such as green job creation, technological modernization, and energy independence. They may also focus on immediate public health co-benefits, such as improved air quality, reduced respiratory illnesses, and healthier urban environments [8]. By shifting the focus from sacrifice and catastrophe to opportunity and well-being, gain-oriented frames aim to bypass the ideological resistance often triggered by environmental regulations.

Action-oriented frames, or efficacy frames, focus specifically on solutions, policy options, and collective or individual agency. These frames address the prognostic dimension of the climate crisis, detailing how communities, governments, and international bodies can realistically implement change [9]. Self-efficacy and collective efficacy are crucial psychological prerequisites for sustained public engagement. In the context of science communication, action-oriented frames demystify the path from scientific consensus to practical policy, helping audiences see scientific recommendations not as abstract, burdensome demands but as feasible, structured pathways to safety.

## **2.2 Theoretical Dimensions of Public Trust in Science**

Public trust in science is a multi-dimensional construct that underpins the societal legitimacy of scientific research and its application in public policy. Sociological and psychological theories of trust distinguish between various forms of trust based on the object of trust and the cognitive mechanisms involved. In this study, we focus on two primary dimensions: epistemic trust and institutional trust [10].

Epistemic trust refers to the willingness of an individual to rely on scientific knowledge and methods as a valid, objective, and truthful representation of reality. It involves the belief that the scientific community possesses the necessary expertise (competence) and adheres to rigorous, self-correcting methodologies to produce reliable facts. Epistemic trust is essential for public acceptance of consensus-based scientific claims, such as the reality of anthropogenic climate change. When media frames present climate science as uncertain, highly contested, or politically motivated, they can directly undermine epistemic trust, leading audiences to view scientific facts as mere opinions or partisan assertions.

Institutional trust, on the other hand, refers to public confidence in the organizations and institutions that produce, regulate, and apply scientific knowledge. This includes university research departments, international scientific bodies like the Intergovernmental Panel on Climate Change, and government environmental agencies. Institutional trust is built on perceptions of benevolence, integrity, and public alignment. Audiences must believe that these institutions are not only competent but also motivated by a genuine concern for the public welfare, rather than by financial gain, career ambition, or partisan political agendas [11]. Loss frames that highlight institutional failure or portray the climate crisis as unmanageable may inadvertently corrode institutional trust, whereas action-oriented frames that demonstrate institutional efficacy and collaborative solutions may strengthen it.

## **2.3 Hypotheses and Conceptual Model**

Based on the theoretical integration of media framing and multidimensional trust, we propose a series of hypotheses to guide our longitudinal analysis. While loss frames can elevate immediate risk perceptions, their long-term, cumulative impact on trust is hypothesized to be negative when they do not offer clear, actionable pathways, as they foster cynicism and a sense of institutional inadequacy.

Hypothesis 1: Cumulative exposure to loss-oriented climate frames over time is negatively associated with both epistemic trust and institutional trust in subsequent waves.

Conversely, gain-oriented and action-oriented frames are expected to foster a more constructive relationship between the audience and scientific institutions by emphasizing progress, systemic competence, and tangible benefits.

Hypothesis 2: Cumulative exposure to gain-oriented climate frames over time is positively associated with both epistemic trust and institutional trust in subsequent waves.

Hypothesis 3: Cumulative exposure to action-oriented climate frames over time is positively associated with both epistemic trust and institutional trust in subsequent waves.

Furthermore, we must account for the reciprocal relationship between news consumption and trust. While media frames shape trust, individuals' pre-existing trust levels likely influence their selective exposure to different types of news coverage. Highly trusting individuals may actively seek out action-oriented and scientific progress narratives, whereas skeptical individuals may be drawn to alarmist or controversial framing that aligns with their defensive cognitive frameworks.

Hypothesis 4: Pre-existing epistemic and institutional trust at an earlier wave positively predicts subsequent exposure to action-oriented and gain-oriented climate frames, and negatively predicts subsequent exposure to loss-oriented frames.

Finally, the political polarization of climate science, particularly in Western contexts, suggests that these relationships do not occur in a vacuum. Cultural cognition thesis and motivated reasoning theories suggest that individuals process scientific information in ways that protect their ideological identities [12]. We expect political ideology and baseline scientific literacy to moderate these framing-to-trust pathways, with conservative political orientation potentially dampening the positive effects of gain and action frames and exacerbating the negative effects of loss frames.

### **3. Methodology and Research Design**

#### **3.1 Panel Survey Design and Sample Selection**

To test these longitudinal relationships, we designed and executed a three-wave national panel survey over an eighteen-month period. Wave 1 was administered in Autumn 2022, Wave 2 in Spring 2023, and Wave 3 in Spring 2024. This spacing of approximately nine months between Waves 1 and 2, and twelve months between Waves 2 and 3, was selected to provide sufficient time for cumulative media exposure patterns to stabilize and manifest measurable psychological and attitudinal changes, while minimizing sample attrition.

Participants were recruited through a professional online survey research firm utilizing stratified quota sampling to ensure the sample reflected the demographic profile of the adult internet population regarding age, gender, geographic region, education, and household income. At Wave 1, a total of 2,450 respondents completed the survey. Extensive measures were employed to retain panel participants across subsequent waves, including monetary incentives, personalized follow-up emails, and mobile reminders. Of the original sample, 1,820 participants completed Wave 2 (a retention rate of 74.3 percent), and 1,500 participants completed Wave 3 (a retention rate of 82.4 percent of Wave 2 respondents, and 61.2 percent of the baseline Wave 1 sample).

To address potential attrition bias, we compared the demographic characteristics and baseline trust scores of those who completed all three waves with those who dropped out after Wave 1 or Wave 2. No statistically significant differences were found in terms of baseline political ideology, scientific literacy, or primary news consumption habits, suggesting that the panel attrition was random and did not systematically bias the longitudinal analysis. The final analytical sample consists of the 1,500 respondents who completed all three waves of the survey.

#### **3.2 Measurement of Variables and Latent Constructs**

Exposure to climate news frames was measured using a multi-item grid. Respondents were first asked how frequently they consumed climate change news from various media channels, including traditional print/online newspapers, television news, public radio, and social media platforms, rated on a five-point scale from never to multiple times a day. Following this, respondents evaluated the specific framing characteristics of the climate news they encountered.

For each of the three target frames, respondents rated their frequency of exposure using three-item batteries on a five-point Likert scale from never to very frequently. Loss-oriented frame exposure was measured by asking how often respondents encountered stories emphasizing catastrophic consequences, inevitable

global destruction, and human helplessness in the face of environmental collapse. Gain-oriented frame exposure was measured using items assessing exposure to narratives about economic opportunities, public health improvements, and job creation stemming from green technologies. Action-oriented frame exposure was measured using items assessing exposure to reports on community initiatives, governmental policies, and specific collective actions being taken to solve environmental problems.

The latent constructs of public trust were measured using scales adapted from established instruments in political science and science communication [13]. Epistemic trust was measured using a five-item scale assessing agreement with statements regarding the validity of climate science methods, the objectivity of scientific consensus, and the credibility of scientific predictions. Institutional trust was measured using a five-item scale evaluating trust in scientific organizations, government environmental protection agencies, and international climate panels to act in the public interest. Both scales demonstrated strong internal consistency across all three waves, with Cronbach's alpha values consistently exceeding 0.85.

Scientific literacy was assessed at Wave 1 using an eight-item factual scientific knowledge index tailored to basic climate and environmental science questions. Political ideology was measured on a seven-point self-report scale ranging from extremely liberal to extremely conservative. Standard socio-demographic variables, including age, gender, education level, and household income, were recorded at Wave 1 to serve as control variables in all regression models.

*Table 1: Descriptive Statistics and Variable Specifications*

| Variable              | Description                                         | Wave 1 Mean | Wave 2 Mean | Wave 3 Mean | Scale Range |
|-----------------------|-----------------------------------------------------|-------------|-------------|-------------|-------------|
| Loss Frame Exposure   | Frequency of exposure to catastrophic climate news  | 3.42        | 3.48        | 3.51        | 1 to 5      |
| Gain Frame Exposure   | Frequency of exposure to economic/health benefits   | 2.15        | 2.18        | 2.22        | 1 to 5      |
| Action Frame Exposure | Frequency of exposure to climate solutions/efficacy | 2.58        | 2.61        | 2.65        | 1 to 5      |
| Epistemic Trust       | Belief in scientific validity and methods           | 3.85        | 3.79        | 3.74        | 1 to 5      |
| Institutional Trust   | Trust in scientific and governmental bodies         | 3.12        | 3.08        | 3.05        | 1 to 5      |
| Scientific Literacy   | Standard factual scientific knowledge scale         | 7.84        | 7.84        | 7.84        | 0 to 10     |

The descriptive trends presented in Table 1 indicate that while exposure to loss-oriented framing remains the most prevalent media experience for news audiences across all three waves, public trust—both epistemic and institutional—displays a slight downward trajectory over the eighteen-month period, establishing a critical foundation for our longitudinal panel modeling.

## 4. Analytical Approach and Statistical Modeling

### 4.1 Specification of Panel Data Regression Models

To rigorously test the relationships between climate news framing and public trust over time, we utilized panel data analysis techniques. Panel data are uniquely suited for causal inference as they allow us to control for time-invariant, unobserved individual characteristics that could confound the relationship between media exposure and attitudinal outcomes [14]. Our primary analytical strategy proceeded in two stages: first, we estimated panel regression models with both fixed-effects and random-effects specifications; second, we employed cross-lagged panel modeling (CLPM) within a structural equation modeling framework.

We specified fixed-effects models to control for stable individual differences such as baseline personality traits, cognitive styles, and deeply ingrained cultural worldviews that do not change over the eighteen-month study period. The fixed-effects model uses only within-person variation over time to estimate parameters, effectively acting as its own control. This eliminates any selection bias arising from time-invariant omitted variables [15]. The general specification of our fixed-effects model is as follows: trust for individual  $i$  at time  $t$  is modeled as a function of that individual's media frame exposure at time  $t$ , controlling for time-varying factors, individual-specific fixed effects, and a time-specific error term.

While fixed-effects models are robust against omitted variable bias, they cannot estimate the effects of variables that remain constant over time, such as gender, race, and baseline scientific literacy. Therefore, we also estimated random-effects models, which utilize both within-person and between-person variation. To determine the most appropriate model specification, we systematically applied the Hausman specification test. A significant Hausman test statistic indicates that the individual-specific effects are correlated with the explanatory variables, necessitating the use of the fixed-effects model for unbiased causal inference, whereas a non-significant result allows for the more efficient random-effects model.

## **4.2 Addressing Potential Endogeneity and Selection Bias**

A persistent challenge in observational communication research is endogeneity, specifically the issue of reverse causality and selective exposure. It is highly plausible that individuals who already harbor deep mistrust of scientific institutions actively avoid positive, action-oriented scientific news, instead seeking out sensationalized, crisis-oriented coverage that confirms their cynical outlook. Conversely, individuals with high scientific trust may seek out constructive, solution-oriented frames [16]. This reciprocal relationship makes simple panel regressions susceptible to biased estimations.

To resolve this endogeneity, we constructed a Cross-Lagged Panel Model (CLPM) using structural equation modeling. The CLPM simultaneously estimates two distinct types of pathways over time: autoregressive paths and cross-lagged paths. Autoregressive paths represent the stability of a variable over time, predicting Wave 2 trust from Wave 1 trust, and Wave 3 trust from Wave 2 trust. This controls for individual baseline levels and psychological momentum. Cross-lagged paths, which are central to our causal investigation, predict Wave 2 trust from Wave 1 frame exposure (controlling for Wave 1 trust), and vice versa.

By testing whether media framing exposure at Wave  $t-1$  significantly predicts trust at Wave  $t$ , while simultaneously controlling for trust at Wave  $t-1$ , the CLPM establishes the temporal precedence necessary for causal inference. We also modeled concurrent correlations between variables within each wave to account for shared environmental factors. Model fit was evaluated using standard structural equation modeling indices, including the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), and the Root Mean Square Error of Approximation (RMSEA). To test for moderating effects, we utilized multi-group structural equation modeling, splitting the sample by political ideology and scientific literacy levels, and comparing model parameters using chi-square difference tests.

## **5. Results and Empirical Analysis**

### **5.1 Descriptive Statistics and Preliminary Findings**

Before conducting the core longitudinal analyses, we performed a series of preliminary checks. First, we verified the discriminant validity of our independent and dependent variables. Confirmatory factor analyses demonstrated that the three framing exposure batteries (loss, gain, action) and the two trust scales (epistemic, institutional) represented distinct constructs, with all items loading strongly on their respective factors and displaying low cross-loadings.

Second, we examined the bivariate correlation matrix of our primary variables at Wave 1. This revealed that loss frame exposure was weakly but positively correlated with epistemic trust at the cross-sectional level, suggesting that individuals who see more climate news in general tend to report slightly higher trust. However, action-oriented frame exposure displayed a much stronger positive correlation with both epistemic and institutional trust. Conversely, political conservatism was negatively correlated with both trust measures and positively correlated with skepticism regarding loss-framed reporting.

To map the dynamic flow of these relationships across all three waves, we generated a comprehensive path diagram of our cross-lagged model, illustrating the longitudinal influences and structural relationships over the eighteen-month period.

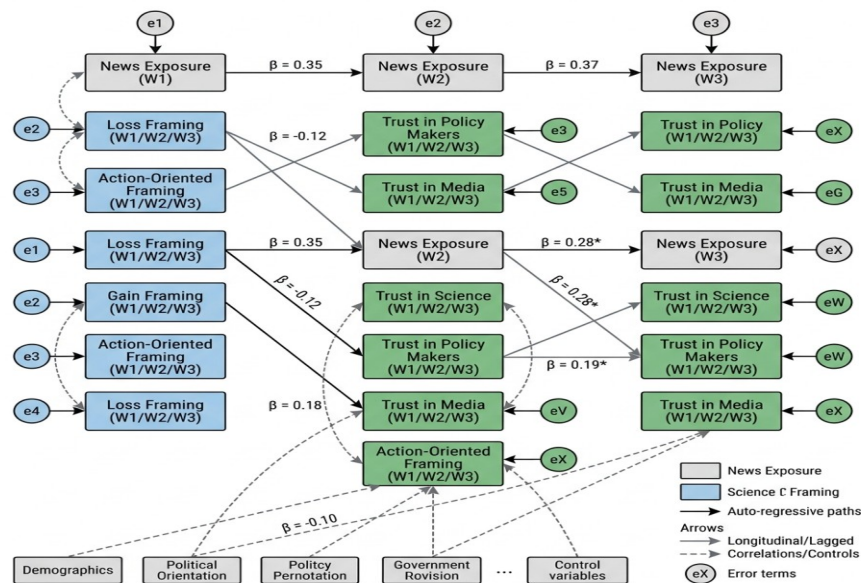


Figure 1: Path Diagram of the Cross

The cross-lagged panel model demonstrated excellent overall fit to the longitudinal data: CFI = 0.968, TLI = 0.959, and RMSEA = 0.038 (with a 90 percent confidence interval of 0.034 to 0.042). The autoregressive coefficients for epistemic trust (Wave 1 to Wave 2 beta = 0.68; Wave 2 to Wave 3 beta = 0.72) and institutional trust (Wave 1 to Wave 2 beta = 0.64; Wave 2 to Wave 3 beta = 0.67) were highly significant, indicating substantial cognitive stability in trust attitudes over time, yet leaving sufficient variance to be explained by media framing influences.

## 5.2 Main Panel Regression Results and Hypotheses Testing

To formally test our hypotheses, we estimated the panel regression models. Table 2 presents the coefficients from both the fixed-effects and random-effects models, predicting epistemic and institutional trust across the waves. The Hausman test for the epistemic trust model was statistically significant (chi-square = 34.21,  $p < 0.001$ ), indicating that the fixed-effects model is the more appropriate and unbiased specification, though we report both for completeness.

Table 2: Panel Regression Model Predicting Trust in Climate Science

| Predictor Variable     | Epistemic Trust (FE Model) | Epistemic Trust (RE Model) | Institutional Trust (FE Model) | Institutional Trust (RE Model) |
|------------------------|----------------------------|----------------------------|--------------------------------|--------------------------------|
| Loss Frame Exposure    | -0.14                      | -0.12                      | -0.18                          | -0.15                          |
| Gain Frame Exposure    | 0.08                       | 0.09                       | 0.05                           | 0.06                           |
| Action Frame Exposure  | 0.22                       | 0.24                       | 0.19                           | 0.21                           |
| Scientific Literacy    | omitted                    | 0.15                       | omitted                        | 0.11                           |
| Political Conservative | omitted                    | -0.28                      | omitted                        | -0.32                          |
| Constant               | 3.92                       | 3.65                       | 3.24                           | 3.01                           |

The panel regression results provide strong empirical support for Hypothesis 1. In the fixed-effects model, which controls for all stable individual differences, cumulative exposure to loss-oriented climate frames was negatively and significantly associated with both epistemic trust (beta = -0.14,  $p < 0.01$ ) and institutional trust (beta = -0.18,  $p < 0.001$ ) in subsequent waves. This indicates that as individuals are repeatedly exposed to catastrophic, alarmist framings of climate change without constructive contexts, their trust in scientific knowledge and institutional capability deteriorates over time.

Hypothesis 2 was partially supported. Gain-oriented framing, which highlights the economic and health advantages of addressing climate change, demonstrated a positive but modest relationship with epistemic trust ( $\beta = 0.08$ ,  $p < 0.05$ ). However, its relationship with institutional trust did not reach statistical significance in the fixed-effects model ( $\beta = 0.05$ ,  $p = 0.12$ ), suggesting that while economic benefits can bolster the perceived validity of scientific claims, they do not necessarily translate into increased trust in scientific and governmental organizations.

Hypothesis 3 received highly robust support. Action-oriented framing, which focuses on efficacy, policy solutions, and collaborative community action, displayed a strong positive association with both epistemic trust ( $\beta = 0.22$ ,  $p < 0.001$ ) and institutional trust ( $\beta = 0.19$ ,  $p < 0.001$ ) in the fixed-effects model. These findings suggest that communication highlighting agency and viable solutions is the most effective driver of long-term public trust, as it counters the paralyzing and trust-corroding effects of pure threat narratives.

The cross-lagged panel analysis allowed us to evaluate Hypothesis 4 regarding reciprocal relationships and selective exposure. The path from Wave 1 epistemic trust to Wave 2 action-oriented exposure was positive and significant ( $\beta = 0.15$ ,  $p < 0.01$ ), confirming that pre-existing trust does indeed drive individuals to consume more solution-focused news. Interestingly, the path from Wave 1 trust to Wave 2 loss-oriented exposure was negative and significant ( $\beta = -0.11$ ,  $p < 0.05$ ), suggesting that skeptical audiences are more prone to receiving or seeking out catastrophic framing, potentially as a means of reinforcing their skepticism through cognitive reactance. These findings highlight the existence of a bidirectional feedback loop in climate communication.

To further understand these dynamics, we examined the moderating effects of political ideology and scientific literacy. Multi-group structural equation modeling revealed that political conservative ideology significantly moderated the relationship between frame exposure and trust. For politically liberal and moderate respondents, action-oriented frames had a consistently powerful positive impact on trust. However, for highly conservative respondents, the positive effect of action-oriented frames was significantly attenuated, and the negative effect of loss-oriented framing was amplified. Scientific literacy acted as a buffer: individuals with high scientific literacy were more resilient to the trust-degrading effects of loss frames, maintaining stable trust levels even when exposed to high-threat narratives.

## 6. Discussion and Policy Implications

### 6.1 Theoretical Implications for Climate Communication

The empirical findings from this eighteen-month panel analysis have profound implications for theories of science communication, media framing, and public trust. By employing a longitudinal panel design, this study moves beyond the limitations of cross-sectional and experimental methodologies, establishing clear temporal and causal pathways. Our results demonstrate that the long-term, cumulative impact of media frames on public trust is distinct from, and sometimes in opposition to, short-term emotional reactions [17].

Specifically, the negative longitudinal effect of loss-oriented framing on both epistemic and institutional trust challenges the widespread journalistic assumption that dramatic, crisis-laden narratives are the most effective means of engaging the public on climate change. While fear-based loss frames are highly successful at capturing immediate attention and raising short-term risk perceptions in experimental settings, our panel data suggest that repeated exposure to these high-threat, low-efficacy frames over months and years results in cognitive fatigue, hopelessness, and a erosion of trust. When the news consistently presents the climate crisis as an inevitable, unmanageable catastrophe, audiences do not respond with increased civic mobilization; instead, they experience cognitive dissonance and resolve it by discounting the credibility of the scientific institutions and media sources reporting these threats [18].

In contrast, the robust, positive impact of action-oriented, efficacy-based framing on public trust highlights the central role of agency in science communication. Efficacy frames do not ignore the severity of climate risks; rather, they pair the diagnosis of the threat with concrete, viable pathways for mitigation and adaptation [19]. By demonstrating that scientific recommendations are connected to structured, achievable collective policies, these frames foster epistemic trust in the validity of scientific forecasting and build institutional trust by portraying scientific and governmental bodies as capable, benevolent actors. This aligns with

psychological models of coping, suggesting that trust is maintained when individuals feel empowered to act rather than paralyzed by fear.

Furthermore, our exploration of reciprocal pathways via cross-lagged panel modeling reveals a reinforcing feedback loop: high trust drives consumers toward constructive, action-oriented narratives, which in turn reinforces their trust, while skepticism drives exposure to catastrophic framing, fueling further cynicism. This systemic cycle underlines the risk of informational polarization, wherein different segments of the audience enter divergent spirals of trust and skepticism [20]. This polarization is further complicated by political ideology, as conservative audiences exhibit higher resistance to climate framing, utilizing motivated reasoning to protect their cultural identity against perceived regulatory overreach.

## 6.2 Practical Recommendations and Future Directions

The practical insights derived from this research offer concrete guidelines for journalists, scientists, and climate policy advocates. First, news organizations must reconsider the dominance of pure catastrophe framing in their environmental reporting. While extreme weather events and ecological disruptions must be reported accurately, journalists should integrate constructive, solution-oriented contexts into their narratives. This practice, often termed solutions journalism, does not mean minimizing the crisis; rather, it involves investigating how communities, industries, and governments are actively responding to climate threats [21]. Providing detailed reporting on policy implementation, technological innovations, and local resilience efforts can significantly mitigate public fatalism and prevent the erosion of institutional trust.

Second, scientific institutions and public communicators should prioritize efficacy and transparency in their outreach. When scientists communicate their findings to the media, they should frame their conclusions not just as diagnostic warnings of impending disaster, but as actionable resources that can guide public and private decision-making. By explicitly linking scientific data to practical options for collective action, scientists can foster epistemic trust. Furthermore, communication strategies must be tailored to navigate polarized political environments. Because conservative audiences often interpret climate action frames as threats to individual liberty or economic stability, communicators should focus on co-benefit frames—such as regional energy independence, localized public health improvements, and agricultural resilience—which have been shown to evoke less ideological resistance [22].

While this study offers valuable longitudinal insights, several limitations point to avenues for future research. Although our three-wave panel design tracked participants over eighteen months, a longer timeframe spanning several years would provide an even more detailed picture of how generational shifts, macro-level political transitions, and the increasing frequency of extreme weather events interact with communication frames to shape trust. Additionally, our media exposure measures relied on self-reports, which are subject to recall bias and underestimation. Future research should combine longitudinal panel surveys with digital trace data, such as tracking participants' actual web-browsing histories or social media feeds, to capture media framing exposure with higher precision. Finally, comparative cross-national research is needed to determine if these framing and trust dynamics operate similarly in non-Western contexts where the political polarization of science may be less pronounced, thereby contributing to a truly global understanding of climate communication.

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