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Psychological distance and efficacy: analyzing the framing of climate change on US agricultural news websites using LLM-assisted content analysis

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Agriculture has significantly contributed to overall greenhouse gas emissions. Farmers' perceptions of climate change play a critical role in shaping their attitudes toward adopting sustainable agricultural practices. News media play a crucial role in shaping public awareness and perceptions of climate change, which in turn may influence people's behavior. Agricultural media serve as an important source of information for agricultural practices. However, there is limited research focusing on agricultural media and its potential relation to farmer practices. This study aims to address these gaps by applying a Large Language Model-assisted Content Analysis method to analyze climate change-related articles published between 2014 and 2023, across three US agricultural news websites. The findings indicate that agricultural media frequently use efficacy-related frames to discuss climate change. Rather than engaging in political or scientific debates, these outlets focus on information that is directly applicable and relevant to farming practices. Additionally, agricultural media may mitigate psychological distance in the reader (the farmer) by emphasizing immediate climate change risks, and addressing local concerns.

KEYWORDS

agricultural media, climate change, efficacy, framing, LLM-assisted content analysis, psychological distance

Introduction

As a significant source of greenhouse gases (GHGs), agriculture contributed 10.5% to overall US emissions in 2022 (USDA Economic Research Service, 2025). Consequently, the sector has been identified as having considerable potential to reduce climate impact. At the same time, agriculture is not only a major emitter but also highly sensitive to climate variability, such as changes in water availability, crop yields, and agricultural competitiveness (Fei et al., 2023; Fraysse et al., 2025; U.S. Environmental Protection Agency, 2025; Zhu et al., 2023). Addressing these dual challenges therefore requires both mitigation and adaptation efforts (Arbuckle et al., 2015). Agriculture can mitigate emissions through practices that reduce or sequester GHGs, while also adapting to climate change impacts by improving productivity and resilience. In the US, a series of Climate-Smart Agriculture programs, for example, the *Partnerships for Climate-Smart Commodities* initiative (restructured into the *Advancing Markets for Producers* initiative in April 2025) was initiated to encourage the adoption of sustainable agricultural practices (USDA, 2025).

However, barriers to the adoption of novel on-farm practices exist. Although over 80% farmers acknowledge that climate change is occurring, most attribute climate variability to

natural cycles, with only 18% primarily attributing it to human activity (Arbuckle, 2021a). Among the U.S. general public, political affiliation has been shown to be a strong and consistent predictor of climate change beliefs and concern, with liberals and Democrats being more likely than conservatives and Republicans to accept the reality, anthropogenic causes, and risks of climate change (McCright et al., 2016). This partisan divide is evident in national survey data. A recent Pew Research report found that only 20% of Republicans say human activity contributes a great deal to climate change, compared to 70% of Democrats (Pew Research Center, 2024). Similarly, findings from the latest *Climate Change in the American Mind* survey indicated that large majorities of liberal Democrats (91%) and moderate/conservative Democrats (76%) consider global warming a high or very high priority for the president and Congress, compared with only 22% of liberal or moderate Republicans and just 12% of conservative Republicans (Leiserowitz et al., 2025a). Although this relationship has been well documented in the general population, given that approximately 61% of U.S. farmers identify as Republican (Agri-Pulse, 2024), similar patterns of skepticism toward human-caused climate change may also be present within this population.

At the same time, farmers occupy a unique position in relation to climate because of their direct and ongoing exposure to weather variability and extremes that affect planting, cultivation, and harvesting (Arbuckle, 2021b). This experiential proximity means that farmers are often highly aware of climate variability and, in many cases, motivated to take action to protect their productivity and economic viability. In such a context, access to relevant and credible climate information is critical for enabling effective adaptation and mitigation strategies (IPCC, 2007).

How this information is communicated also matters. Media framing can shape audience perceptions in powerful ways (e.g., Jones et al., 2017). Media coverage that frames climate change as a matter of scientific uncertainty or elite disagreement can distort public understandings of the extent of scientific consensus. By presenting anthropogenic climate change and policy responses as unresolved or contested issues, such framing contributes to diminished perceptions of urgency and can delay public support for action (Boykoff and Boykoff, 2004). Empirical research further demonstrates that message framing has measurable effects on audience perceptions and responses. Manipulating outcome frames (gain vs. loss) and distance frames (local vs. distant) leads to systematic differences in perceived severity of climate impacts and attitudes toward mitigation (Spence and Pidgeon, 2010). Efficacy-focused frames shape audiences' efficacy beliefs, which in turn are associated with greater intentions to engage in climate-related political participation (Hart and Feldman, 2016).

Agricultural media are an important source that farmers use to access agricultural information. Due to a tradition of utilitarian thinking, farmers tend to prioritize information that is directly relevant to their agricultural activities (Meze-Hausken, 2004). Consequently, agricultural media may serve as crucial knowledge brokers, translating mitigation and adaptation measures into concepts within a local context that can align with farmers' daily practices. Therefore, it is essential to examine how climate change–related information is portrayed in agricultural media. However, the majority of prior content analysis studies have been concentrated on legacy media, such as national newspapers and TV (e.g., Schäfer and Schlichting, 2018). Compared to these sources, agricultural media have been relatively understudied. Existing studies on agricultural media coverage often span short periods and narrow thematic scopes, typically focusing on newspapers and magazines (Asplund et al., 2013; Rust et al., 2021).

In today's digital age, the Internet has become a vital tool for farmers, with 80% frequently using it for agricultural decision-making (Arbuckle, 2020). Traditional farm publications have evolved by establishing online platforms to meet the evolving needs of their readership. Thus, exploring framing strategies employed on agricultural news websites and how they have evolved over the past decade is important for understanding how climate change is presented to farmers' communities and for assessing the potential impact on their perceptions of climate change and sustainable agricultural practices.

In this study, we examined framing strategies of climate change in agricultural news from two dimensions. The first is fear and efficacy. According to the Extended Parallel Process Model, fear appeals can be most persuasive when accompanied by strong efficacy information that provides audiences with concrete, actionable solutions (Witte, 1992). This is particularly relevant for agricultural contexts: farmers, who are highly attentive to costs, risks, and returns, could be more responsive to messages that link climate risks to potential economic losses (fear) or emphasize how adaptation measures can stabilize yields (efficacy) (Läpple, 2025). Yet, little is known about how agricultural media frame climate change through this lens.

The second one is psychological distance—whether climate change is presented as a near or distant threat, as local or non-local, as affecting "people like us" or distant others, and as certain or uncertain (Liberman et al., 2007; Trope and Liberman, 2010). Research has shown that psychological distance strongly shapes risk perception and willingness to act on climate change (Schattman et al., 2021). Among farmers, prior work suggests that communication is more effective when it emphasizes locally experienced extreme weather rather than distant or abstract scenarios (Easton and Faulkner, 2016). However, relatively little attention has been paid to how media discourse itself constructs psychological distance.

Recently, "large language models" (LLMs) have proven to be novel and powerful tools to enhance effectiveness in qualitative coding of content (e.g., Demszky et al., 2023; Liang et al., 2022). Utilizing LLMs can significantly reduce the time and effort required when handling large datasets. However, their application in the field of communication research remains limited so far. This study seeks to contribute to this growing area by applying LLM-assisted content analysis methods (Chew et al., 2023) to climate change coverage in three U.S. agricultural news websites, with a focus on how these media frame climate change through the perspective of efficacy and psychological distance.

Literature review

Agricultural media and climate change

People are dependent on news media for information, especially when society is undergoing social change and conflict (Loges, 1994). News media use may lead to specific kinds of cognitive, affective, and behavioral change in individuals based on people's dependence on information resources (e.g., Vrselja et al., 2024). Apart from traditional mainstream media, information specifically directed to farmers is predominantly available in specialized agricultural-sector media

(Asplund et al., 2013). Agricultural media encompass a variety of platforms dedicated to disseminating agricultural information, including magazines, farm papers, newsletters, radio and television stations, networks, websites, and other electronic platforms (Evans and Heiberger, 2016). In the classic study exploring the adoption of hybrid corn in two Iowa communities, Ryan and Gross (1943) found that farm journals and radio were among the top four channels through which farmers initially acquired knowledge about hybrid corn. Currently, agricultural magazines or newspapers (used by 63% of farmers) are still the leading sources for farmers to first learn about new agricultural products, equipment, services, or suppliers (Thomas, 2022). What's more, farmers' trust in agricultural media is relatively high. Iowa Farm and Rural Life Poll (Arbuckle, 2021a) showed that 39% of farmers somewhat trust or strongly trust the farm press, while only 9% have trust in mainstream news media, and 40% strongly distrust them.

Agricultural media play an important role in communicating climate change-related information to farming communities. Although relatively few content analyses focus specifically on agricultural outlets, existing studies in Europe and North America have examined how farming outlets frame climate-related issues.

Rust et al. (2021) analyzed coverage of sustainable agricultural practices in two leading UK farming magazines (*Farmers Weekly* and *Farmers Guardian*) between 1998 and 2020. They found that attention to sustainability increased over time, but that reporting was primarily framed in economic and agronomic terms, with relatively little emphasis on environmental benefits. O'Morain and Robbins (2024) analyzed how Irish specialist farming media frame climate action using 6 weeks of coverage of the Irish Government's 2021 Climate Action Plan from three outlets: the *Irish Farmers Journal*, the *Farming Independent*, and *Agriland*. They found that Irish farming outlets framed climate action primarily as a political and policy issue. Economic implications for farmers were frequently raised but played a secondary role relative to policy and conflict-oriented framings. Asplund et al. (2013) examined climate change coverage in Swedish farming magazines (*Land* and ATL) from 2000 to 2009 and observed a sharp rise in attention after 2006. Four dominant frames—conflict, scientific certainty, economic burden (of policy), and action—structured this coverage. In contrast to mainstream news media, farming magazines rarely employed catastrophic "doomsday" narratives, instead emphasizing local relevance, practical impacts, and actionable responses. Wall and Smit's study (2006) examined how Canadian farm and nonfarm media portray climate change adaptation through a content analysis of news coverages from 2002 to 2004. The analysis showed that adaptation was frequently discussed implicitly through practical risk-management strategies. Farm media were more likely to link climate and weather impacts with concrete adaptive responses, while non-farm media emphasized impacts alone and government programs.

Fewer studies exist in the United States. Orton et al. (2024) analyzed 271 climate change-related articles published between 2000 and 2020 in three U.S. agricultural magazines (*Beef*, *Farm Journal*, and *Farm Industry News*). Their findings showed that the dominant frame was scientific certainty, but only 34% of articles explicitly attributed climate change to human activity. Church et al. (2017) focused on the coverage of the 2012 Midwest drought in U.S. farm trade media, analyzing 1,000 articles from 10 major agricultural trade publications. Their study showed that coverage overwhelmingly emphasized immediate drought impacts, while offering mainly short-term recovery strategies. Explicit mentions of climate change were rare (only 2.2% of articles), and even when referenced, climate change was treated as a factual backdrop rather than directly linked to the drought. Transformative adaptation strategies (e.g., soil health, diversification, systemic resilience) were nearly absent from coverage. Instead of highlighting long-term climate risks, these outlets largely attenuated them by framing the drought as a short-term crisis solvable within existing farming systems.

Taken together, agricultural media engage with climate change in ways that differ from mainstream news outlets. However, systematic examinations of the framing strategies used by agricultural media remain limited, particularly in the U.S. context. This gap highlights the need for further investigation.

Media framing, efficacy, and psychological distance

The concept of framing was first introduced by Goffman (1974). Entman (1993) further developed the idea, defining framing as a process "to select some aspects of a perceived reality and make them more salient in a communication text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation for the item described" (p. 52). An increasing amount of experimental research suggests that the framing of climate change communication can influence audiences' information processing, attitudes, and behavior (e.g., Bertolotti and Catellani, 2014).

Threat and efficacy are central framing elements in climate change coverage (Bolsen and Shapiro, 2018; Feldman et al., 2015; Nabi et al., 2018). Negative emotions, like fear, have been widely considered as a potent driver of climate change risk perceptions and policy support, underlining the significant role they play in shaping responses to climate change (Chaiken and Trope, 1999; Evans, 2008). However, while fear appeal messages may capture people's attention, their effectiveness may be contingent on some specific conditions (Bolls et al., 2001). A substantial body of research has shown that fear-based communication may backfire, leading to avoidance, defensive processing, or message rejection (e.g., Poonamallee, 2025). For example, O'neill and Nicholson-Cole (2009) found that fear-inducing climate messages often evoke feelings of helplessness and overwhelm, leading to disengagement rather than sustained engagement. Similarly, Bilfinger et al. (2024) found that fear appeals did not increase public support for climate mitigation or willingness to engage in discussion about climate change.

The Extended Parallel Process Model (EPPM) offers a theoretical explanation for these mixed effects. According to the EPPM, individuals' responses to fear appeals depend on their evaluations of both perceived *threat* and *efficacy* (Maloney et al., 2011; Witte, 1992). When individuals perceive a high level of threat but low efficacy, they are more likely to engage in fear control processes—such as ignoring or rejecting the message—rather than adopting the recommended behavior (Ruiter et al., 2014; Witte and Allen, 2000).

Consistent with this theoretical logic, a growing body of empirical research highlight the critical interplay between threat and efficacy in persuasive climate messages. Overemphasizing catastrophic "doomist" narratives may discourage action (Feldman and Hart, 2021), whereas

efficacy-enhancing themes, such as concrete recommendations and assurances of capability, are more effective in motivating audiences (Hulme, 2009; Witte, 1992). This applies to farmers as well. Sorvali et al. (2022) found that Finnish farmers' willingness to adopt mitigation practices was driven primarily by perceived efficacy: believing they could implement mitigation measures was the strongest predictor of actual behavior, while risk perception and climate change beliefs had comparatively weaker effects.

Some studies have examined how news media frame climate change by conveying information about threats and efficacy. Feldman et al.'s study (2015) indicated that impacts and actions related to climate change have often been discussed separately in national media. This means that readers may receive information about the impacts of climate change without learning how to mitigate them, or they may be informed about actions to address climate change without understanding why those actions are necessary. Hart and Feldman (2014) observed that U.S. network television news frequently emphasized the threat of climate change, but often lacked efficacy messages. However, little is known about whether agricultural media frame climate change in this way, even though farming audiences represent a crucial group for both adaptation and mitigation.

Psychological "distance" refers to how people perceive the conceptual distance between an object and themselves (Liberman et al., 2007). Construal Level Theory (CLT; Liberman and Trope, 2008) describes the relation between psychological distance and the extent to which people's thinking is abstract or concrete (Trope and Liberman, 2010); it is an account of how such psychological distance influences individuals' thoughts and behavior (Trope et al., 2007). CLT assumes that psychologically distant events are processed as abstract high-level construals comprising general decontextualized features, whereas psychologically "close" events are seen as concrete low-level construals comprising specific contextual details. According to CLT, psychological distance encompasses four dimensions: *Hypothetical distance* refers to the perceived likelihood of an event, with less probable events experienced as more distant; *Temporal distance* refers to when an event happens, with events in the distant past or future perceived as more distant than those occurring in the present; *Social distance* refers to who is affected by an event, with impacts on socially dissimilar or unfamiliar others perceived as more distant; *Spatial distance* refers to the physical location of an event, with events occurring in geographically distant places perceived as more distant (Liberman and Trope, 2008; Trope and Liberman, 2010).

Previous research shows that minimizing psychological distance can strengthen public engagement with climate change. Studies using experimental surveys illustrate this effect. For instance, Huang and Guo (2024) found that pairing fear appeals with short-term frames increased problem and involvement recognition. Similarly, Jones et al. (2017) showed that framing climate change as temporally, spatially, or socially close significantly heightened risk perception and concern.

Among farmers, psychological distance also influences decisions. Research with Egyptian farmers found that greater perceived distance reduced recognition of water scarcity's environmental, social, and economic consequences (Riaz et al., 2025). In Iran, Azadi et al. (2019) reported that farmers who perceived climate change as more distant were less likely to adopt adaptive practices. In New York, Partridge (2016) found that lower social and hypothetical distance predicted farmers' willingness to pay for mitigation, while concern for climate impacts was tied to temporal, social, and hypothetical distance. However, not all contexts follow this pattern. For example, in Puerto Rico, where farmers are already highly aware of climate change due to Hurricane Maria, Rodríguez-Cruz and Niles (2021) argued that psychological distance may no longer be a useful explanatory framework. Instead, structural and institutional barriers, such as limited resources, disaster aid, governance challenges, and land tenure, better explain why farmers fail to adopt adaptive practices despite high awareness.

Studies suggest that mainstream journalism often frames climate change as distant. For example, Guenther and Brüggemann (2023) analyzed climate futures reporting in Germany, India, South Africa, and the U.S., concluding that journalism typically portrayed futures as distant ("not here, not now, not me"), particularly when tied to ecosystem science. Similarly, Feldman et al. (2015) assessed "threat" through the dimensions of temporal and spatial proximity. They found that only 30% of U.S. newspaper stories mentioned present-day impacts and just 14.6% referenced U.S.-based impacts, instead emphasizing distant futures or impacts in polar and developing regions. These findings suggest that mainstream outlets often depict climate change as temporally and spatially remote. However, no content analysis to date has explicitly examined agricultural media through the framework of CLT.

Our study

Given farmers' unique position as both climate-sensitive producers and key actors in mitigation and adaptation, understanding how agricultural media communicate climate change threats, efficacy, and psychological distance is critical. Building on prior research, this study examines how U.S. agricultural news websites frame climate change over time.

First, we focus on how agricultural media balance climate change threats and efficacy messages.

> *RQ1:* How often have U.S. agricultural news websites discussed (a) climate change threats and (b) efficacy, and (c) how often are threats and efficacy discussed together?

Farmers are practical decision-makers who seek information that connects climate change to concrete actions such as adaptation practices (Arbuckle et al., 2015). Wall and Smit (2006) found that non-farm outlets emphasized impacts only (68%), while farm media more frequently highlighted adaptation strategies (69%). Because adaptation-oriented coverage inherently foregrounds actionable responses, this suggests that agricultural outlets may be more inclined to frame climate change in terms of actionable efficacy responses rather than overwhelming threats. Thus, we hypothesize that:

> *H1:* U.S. agricultural news websites are more likely to emphasize efficacy than threat.

Beyond the relative emphasis on threat versus efficacy, prior research also suggests that agricultural media may differ from mainstream outlets in the specific types of frames they employ.

> *RQ2:* How have U.S. agricultural news websites framed the type of (a) climate change threats and (b) efficacy messages?

Research shows that agricultural producers tend to be more responsive to information emphasizing tangible benefits such as improved yields or economic savings (Arbuckle et al., 2015). Studies of European agricultural media show that climate change coverage is often framed in economic and agronomic terms, with an emphasis on optimistic and solution-oriented narratives (Rust et al., 2021). Similarly, U.S. research indicates that agricultural publications frequently adopt frames highlighting scientific certainty and the productive role of agriculture in mitigation efforts (Orton et al., 2024). These findings suggest that agricultural media may favor efficacy frames that emphasize achievable and beneficial actions over frames that stress obstacles or limitations. Accordingly, we hypothesize that:

> *H2:* U.S. agricultural news websites are more likely to emphasize positive efficacy than negative efficacy.

Second, we investigate how agricultural media frame climate change across the four dimensions of psychological distance.

> *RQ3:* How have U.S. agricultural news websites discussed the temporal, spatial, social, and hypothetical distance of climate change?

Agricultural media have historically been regarded as among the most rapid and effective channels for raising awareness, stimulating interest, and providing knowledge about innovations, risks, and safety issues. In this sense, agricultural media may function as a large informal continuing education system for farmers in the U.S. (Evans and Heiberger, 2016). Importantly, farmers directly experience climate variability (e.g., droughts, floods, pest pressures, planting windows), making climate change a present and tangible concern rather than a distant or hypothetical one (Arbuckle et al., 2015; USDA, 2024). In line with this immediacy, agricultural media tend to emphasize scientific certainty regarding the reality and consequences of climate change, particularly as it relates to agricultural productivity and adaptation needs, while downplaying scientific uncertainty or debate (Morrison et al., 2017; Orton, 2021). Building on prior climate change communication research, hypothetical distance is conceptualized as perceived certainty regarding the reality and scientific credibility of climate change, including beliefs about whether climate change is occurring, the extent of scientific consensus, and causal attribution (Maiella et al., 2020; McDonald et al., 2015; Spence et al., 2012). Thus, we hypothesize that:

> *H3:* U.S. agricultural news websites emphasize scientific certainty more than uncertainty.

Moreover, because agricultural livelihoods are closely tied to local weather patterns and regional conditions, messages that are geographically relevant and action-oriented are particularly salient for farmers. Asplund et al. (2013) found that farming magazines made climate change more concrete by emphasizing local impacts and individual farmers' responses to climate change. Likewise, each of the three agricultural outlets analyzed has a clearly defined geographic scope (see Table 1). Thus, we propose that agricultural media are more likely to highlight present-day climate impacts and localized content.

> *H4:* U.S. agricultural news websites emphasize current impacts of climate change more than past or future impacts.
>
> *H5:* U.S. agricultural news websites are more likely to frame climate change in local-related terms than non-local terms.

TABLE 1 Agricultural news websites.

Title	Periodicity	Website	Circulation	Range	Articles (N)	Description
AGweek	Weekly	https://www.agweek.com/	Readership: 40,405 Printed and mailed: 8,210 Digital replica readership: 23,985[1]	Minnesota, Montana, North Dakota, South Dakota	755	AGweek was created on Aug. 5, 1985. It is a weekly agricultural and food science research magazine reporting on the latest developments in agriculture and food production
AgUpdate	Weekly	https://agupdate.com	Daily e-News Circulation: 33,000[2]	Illinois, Iowa, Missouri, Wisconsin, North Dakota, South Dakota, Minnesota, Nebraska, Wyoming, Colorado, Montana, Kansas, Idaho	1,458	AgUpdate is a comprehensive platform for the latest agriculturally related news and events from across America's heartland created by Lee Agri-Media. It includes 14 publications[3] (e.g., *Illinois Farmer Today*, *Iowa Farmer Today, Missouri Farmer Today*)
AgriNews	Weekly	https://www.agrinews-pubs.com	Illinois AgriNews: 21,062[4] Indiana AgriNews: 10,170[5]	Illinois, Indiana	449	AgriNews was created in 1977 and joined Shaw Media in 2019. It was first published as Ag-News and was circulating in Illinois (*Illinois AgriNews*). Then *Indiana AgriNews* was started in 1982. AgriNews covers topics that affect local farm families and their businesses[6].

[1]Data retrieved from the Forum Communications website (https://advertising.forumcomm.com/niche/agweek-print/) on 2024-02-15.
[2,4,5]Data retrieved from the J.L Farmakis Inc. website on 2024-02-15.
[3]Data retrieved from the AgUpdate website (https://agupdate.com/site/publications/publications.html) on 2024-02-15.
[6]Data retrieved from the AgriNews "About Us" page (https://www.agrinews-pubs.com/about/) on 2024-02-15.

Finally, we assess how these framing patterns have evolved over time.

> *RQ4:* What trends can be observed in the use of threat-, efficacy-, and psychological distance-related frames over the ten-year period?

Method

LLM-assisted content analysis

Previously, content analysis has often been conducted through manual human coding (e.g., McComas and Shanahan, 1999). Traditionally, this involves training coders to classify text based on a codebook developed from theoretical frameworks and prior studies. While human coding allows for detailed, theory-driven interpretation, it is also repetitive, time-consuming, and resource-intensive, making it impractical for larger datasets (Kroon et al., 2024). As a result, researchers often rely on small samples, which can significantly limit the statistical power of their analyses and reduce the reliability of findings (Geiß, 2021). To address these challenges, researchers have increasingly adopted computational tools for content analysis. Recent advances in AI have introduced Large Language Model-assisted content analysis, offering scalability and improved semantic understanding compared with manual or rule-based approaches (e.g., Chew et al., 2023).

Studies have demonstrated high levels of agreement with human coders and superior performance on complex, context-rich texts. For example, Chew et al. (2023) utilized GPT-3.5 to analyze four publicly available datasets and reported strong human–model agreement (*Gwet's AC1* > 0.76) for most of the codes. Fan et al. (2024) coded 1,000 comments for the latent construct of "deliberativeness" using GPT-4o and a fine-tuned GPT-3.5. The results show Krippendorff's α was 0.88 for human–human, 0.77 for human–GPT-4o, and 0.77 for fine-tuned GPT-3.5. Internal consistency was 0.99 for fine-tuned GPT-3.5 and 0.92 for GPT-4o. Bijker et al. (2024) used GPT-3.5-turbo to analyze 537 forum posts on sugar reduction and found solid intercoder agreement across inductive and deductive analyses. Precision of mechanism detection ranged from 66 to 88%. Intercoder agreement (Fleiss' κ) ranged from 0.72 to 0.82 for inductive coding and 0.58–0.73 for deductive approaches. Hohenwalde et al. (2025) tested various prompting strategies and model versions (gpt-3.5-turbo, gpt-4-turbo, gpt-4o) to categorize societal actors in 2883 German news articles. Using a Named Entity Recognition and Classification pipeline, they evaluated model performance through F1-scores (a balanced metric that represents the harmonic mean of precision and recall) compared to human coding. The results showed GPT-4-turbo performs best (*F1* = 0.82), outperforming GPT-3.5-turbo (0.79) and GPT-4o (0.70). Dunivin (2025) used GPT-4 and GPT-3.5 to apply nine socio-historical codes to 232 New York Times passages mentioning "W.E.B. Du Bois." and GPT-4 achieved strong agreement with human coders. The average Cohen's κ for GPT-4 was 0.68 compared to human–human agreement of 0.78. GPT-4 matched or exceeded $\kappa = 0.75$ for three codes.

Some studies have compared LLM-based coding with human coding and traditional computational methods, highlighting LLMs' advantages in handling large datasets, capturing semantic nuance, and adapting to context. Farjam et al. (2025) used LLaMA 3.1–70b to replicate Feldman et al. (2015), which manually coded 642 U.S. news articles on climate change. They applied the LLM to the full U.S. corpus (3,274 articles) and achieved high inter-rater reliability. Agreement between the LLM and Feldman et al.'s original coding has high agreement, ranging from 0.63 to 0.81. Kousa (2024) compared a rule-based NLP tool (Etuma) with GPT-4 in Finnish discourse on electric vehicle subsidies, finding GPT-4 delivered higher precision but lower recall, while Etuma achieved higher recall but lower precision. Both approaches yielded comparable F1 scores, indicating an overall equilibrium between accuracy and completeness in model performance. Ghatora et al. (2024) contrasted traditional machine learning models (Random Forest, Naive Bayes, SVM) with GPT-4 for sentiment analysis on a Flipkart dataset of over 205,000 labeled product reviews. Results showed that SVM achieved the highest performance on short reviews (*Accuracy* = 0.68, *F1* = 0.67), while GPT-4 outperformed all models on longer summaries (*Accuracy* = 0.82, *F1* = 0.81).

Although LLM-assisted content analysis has demonstrated human-level performance across various reasoning tasks, its application in communication research remains limited. This study aims to contribute to the field by providing a practical example of the method's potential.

Variables and measurements

The current study includes three sets of variables (see Table 2 and Supplementary Table 1 in the Supplementary Tables document for the definitions and examples of the variables).

1. Threat: Threat refers to how the message emphasizes the negative consequences of climate change. It typically highlights risks, damages, or losses across different domains of society. In this study, we code threat as the presence of negative impacts in four domains: *economy, environment, public health*, and *agriculture* (Bolsen and Shapiro, 2018; Feldman et al., 2015).
2. Efficacy refers to how messages convey the perceived ability to respond effectively to climate change. We examine who can act, whether the proposed response works, and what concrete actions are available.
   (a) Internal and external efficacy. Following the EPPM, we code three dimensions of efficacy—*self-efficacy, response efficacy*, and *external efficacy* (Bolsen and Shapiro, 2018; Feldman et al., 2015; Witte and Allen, 2000). Each dimension is coded as positive (signals that action is feasible/effective or that institutions will respond) or negative (signals that action is infeasible/ineffective or that institutions will not respond).
   (b) Action/policy impact. As a complement to response efficacy, we also code the consequences of implementing action/policy—such as their concrete benefits or costs across *economy, environment, public health*, and *agriculture* (Bolsen and Shapiro, 2018; Feldman et al., 2015; Hart and Feldman, 2014). Each consequence is coded as positive (benefits/opportunities) or negative (costs/risks).
   (c) Action type. We identify the type of action discussed to show that specific strategies exist and are implementable, including *mitigation* and *adaptation* strategies.

TABLE 2 Codebook.

Category	Code	Definition	Explanation
Threat	Economy	The negative impacts of climate change on economy	Does the text explicitly reference the negative impacts of climate change on the economy? Code Yes if it mentions negative impacts such as reduced agricultural yield. Code Yes if it mentions harms such as warm winters, increased extreme weather events, droughts, or floods that affect the economy. Code this strictly, such as the negative economic impact of climate change should be directly mentioned.
	Environment	The negative impacts of climate change on environment	Does this text explicitly reference the negative impacts of climate change on the environment? Code Yes if it mentions changing climate patterns caused by climate change. Code this strictly, such as the negative environmental impact should be directly mentioned.
	Public health	The negative impacts of climate change on public health	Does this text explicitly reference the negative impacts of climate change on human health?
	Agriculture	The negative impacts of climate change on agriculture	Does the text explicitly reference the negative impact of climate change on agriculture? Code Yes if it mentions harms such as warm winters, increased extreme weather events, droughts, or floods affecting farming.
Internal/external efficacy	Self efficacy_Positive	An individual's ability to successfully perform actions or make behavioral changes to address climate change	Does this text explicitly reference that an individual can adopt a specific technique, policy, or action to address climate change in a way that is financially or technologically feasible/easy? Code this strictly, such as the ease of taking certain action for individuals should be directly mentioned.
	Self efficacy_Negative	An individual's inability or lack of capacity to successfully perform actions or make behavioral changes to address climate change	Does this text explicitly reference that individual action to address climate change is impossible, difficult, or expensive?
	Response efficacy_Positive	The effectiveness or potential for success of policies or actions in addressing climate change	Does this text explicitly reference the potential or actual success of policies, techniques, or actions in addressing climate change or related issues, such as increased extreme weather events, droughts, or floods?
	Response efficacy_Negative	The ineffectiveness or lack of potential for success of policies or actions in addressing climate change	Does this text explicitly reference the lack of potential or actual success of policies, techniques, or actions in addressing climate change or related issues, such as increased extreme weather events, droughts, or floods?
	External efficacy_Positive	The responsiveness or willingness of politicians, industry leaders, or other elites to take action on climate change	Does this text explicitly reference how political leaders/government officials/corporate executives/scientists are responsive to demands in addressing climate change or related issues, such as increased extreme weather events, droughts, or floods? Investing in new research or innovative technology should be code as yes.
	External efficacy_Negative	The unresponsiveness or unwillingness of politicians, industry leaders, or other elites to take action on climate change	Does this text explicitly reference how political leaders/government officials/corporate executives/scientists are not responsiveness to demands in addressing climate change or related issues, such as increased extreme weather events, droughts, or floods?
Policy/action impact	Economy_Positive	The positive impacts of climate policies/actions on economy	Does this text explicitly reference the positive impacts of climate-related policies, techniques, or actions on economy? Code Yes if it mentions positive economic effects such as increased agricultural productivity or higher yields. Code this strictly, such as the positive economic impact should be directly mentioned.
	Economy_Negative	The negative impacts of climate policies/actions on economy	Does this text explicitly reference the negative impacts of climate-related policies, techniques, or actions on economy? Code this strictly, such as the negative economic impact should be directly mentioned.
	Environment_Positive	The positive impacts of climate policies/actions on environment	Does this text explicitly reference the positive impacts of climate-related policies, techniques, or actions on environment? Code this strictly, such as the positive environmental impact should be directly mentioned.
	Environment_Negative	The negative impacts of climate policies/actions on environment	Does this text explicitly reference the negative impacts of climate-related policies, techniques, or actions on environment?
	Public health_Positive	The positive impacts of climate policies/actions on human health	Does this text explicitly reference the positive impacts of climate-related policies, techniques, or actions on human health? Code this strictly, such as the positive impact should be directly mentioned.
	Public health_Negative	The negative impacts of climate policies/actions on human health	Does this text explicitly reference the negative impacts of climate-related policies, techniques, or actions on human health?
	Agriculture_Positive	The positive impacts of climate policies/actions on agriculture	Does this text explicitly reference the positive impacts of climate-related policies, techniques, or actions on agriculture?
	Agriculture_Negative	The negative impacts of climate policies/actions on agriculture	Does the text explicitly mention any negative impacts of climate-related policies, techniques, or actions on agriculture?

(Continued)

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TABLE 2 (Continued)

Category	Code		Definition	Explanation
Action	Mitigation		Strategies aimed at reducing the causes of climate change	Mitigation refers to strategies aiming to reduce the concentration of GHGs in the atmosphere. Does this text explicitly reference any mitigation strategies?
	Adaptation		Strategies aimed at adjusting to the impacts of climate change	Adaptation refers to strategies aimed at adjusting to or reducing the risks and impacts of climate change. Does this text explicitly reference any adaptation strategies, including techniques that improve agricultural productivity?
Social distance	Farmer sources		Climate change is presented through socially close, farmer-oriented sources	Does the text explicitly reference farmers' voices? This includes direct quotes, indirect attributions, anecdotes, or narratives in which farmers share their firsthand experiences, opinions, or perspectives related to agriculture and farming practices.
	Non-farmer sources	Scientists	Climate change is presented through socially distant non-farmer sources (e.g., scientists, government, industry, and nonprofits)	Does the text include direct quotes or indirect attributions of statements from scientists/researchers? This includes researchers employed by government agencies.
		Government		Does the text include direct quotes or indirect attributions of statements from government actors or government agencies at the federal, state, local, or international level? Scientists or researchers employed by government agencies should not be counted here.
		Industry		Does the text include direct quotes or indirect attributions of statements from corporations, private companies, trade associations, or other business/industry groups?
		Nonprofit		Does the text include direct quotes or indirect attributions of statements from a nonprofit or non-governmental organization (NGO/NPO)? Trade and industry associations do not count as NGO/NPO.
Spatial distance	Local		Climate change is presented through local versus non-local perspective	Does the text mention any of the following: (1) the name of these states —Montana, Idaho, Wisconsin, Wyoming, Colorado, North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa, Missouri, Illinois, or Indiana; (2) the names of counties or cities within these states; or (3) organizations located in these states?
Hypothetical distance	Scientific certainty		Climate change is presented as a scientifically established fact	Does this text explicitly reference scientific certainty on the existence or anthropogenic nature of climate change? Code Yes if climate change is presented as a scientifically established fact.
	Scientific certainty_anthropogenic		Climate change is presented as being primarily caused by human activities	Does this text explicitly reference scientific certainty on the anthropogenic nature of climate change? Code this strictly, such as a specific statement related to the anthropogenic nature of climate change should be directly mentioned.
	Scientific uncertainty		Climate change is presented as uncertain or scientifically questionable	Does this text explicitly reference a statement that questions the existence, anthropogenic nature, or seriousness of climate change?
Temporal distance	Past		Climate change impacts are presented as having occurred in the past	Does this text explicitly reference negative impacts of climate change or related issues (e.g., warm winters, increased extreme weather events, droughts, floods, sand storms) that occurred in the far past, typically more than several decades ago?
	Present		Climate change impacts are presented as currently occurring	Does this text explicitly reference negative impacts of climate change or related issues (e.g., warm winters, increased extreme weather events, droughts, floods, sand storms) that are occurring now or expected within the near future, typically within the next 20 years?
	Future		Climate change impacts are presented as expected to occur in the future	Does the text explicitly reference negative impacts of climate change or related issues (e.g., warm winters, increased extreme weather events, droughts, floods, sand storms) that will occur in the far future or will primarily affect future generations?

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3 Psychological distance captures how messages position climate change along four dimensions (Feldman et al., 2015; McDonald et al., 2015; Orton et al., 2024; Spence et al., 2012):

- o Temporal distance: Whether impacts of climate change are framed as *past, present*, versus *future* (urgency/immediacy).
- o Spatial distance: Whether climate change is presented as *local* versus *non-local*.
- o Social distance: whether climate change is presented through socially close, farmer-oriented sources versus socially distant non-farmer sources (e.g., *scientists, government, industry, nonprofits*).
- o Hypothetical distance: The degree of *certainty* vs. *uncertainty* regarding the reality and scientific credibility of climate change. Because prior research shows that agricultural media may emphasize climate change certainty while avoiding explicit discussion of human causation (Orton et al., 2024), we code *anthropogenic cause of climate change* as a separate variable. This allows us to capture this distinctive framing pattern without conflating causal attribution with the broader construct of hypothetical distance.

Data collection

Three agricultural news websites, *AGweek*, *AgUpdate*, and *AgriNews*, were selected for this study (Table 1). These outlets were chosen based on several criteria. First, all three are long-established, professionally oriented agricultural news organizations, rather than lifestyle or promotional content. Second, they primarily serve farmers in the U.S. Midwest and Upper Midwest, regions that are both central to U.S. agricultural production and highly vulnerable to climate variability, making climate-related coverage particularly salient for their audiences. Third, each outlet maintains a consistently updated digital platform, enabling systematic content collection and longitudinal analysis across outlets. Compared to print publications, news websites offer greater flexibility and immediacy, enabling the publication of a broader range of stories, real-time updates, and multimedia content. This online environment allows for more dynamic and expansive coverage, providing a more comprehensive representation of each outlet's climate-related reporting.

The unit of analysis of this study is the news article text. We focus exclusively on the written textual content of news articles and do not analyze accompanying imagery, videos, or other visual elements. We conducted searches on the selected three websites, using the keyword "climate change" in the search boxes provided on the websites, sampling from January 1st, 2014, to December 31st, 2023. This keyword was used by most previous research on climate change news coverage, allowing for easier comparisons with prior work (e.g., Boykoff, 2007). Although some scholarship employs additional terms, such as *global warming* or *climate crisis*, we restricted our search to "climate change" for two reasons: (1) "climate change" is a more scientifically recognized term and is commonly used in the media. (2) Our search for "global warming" on these websites got limited results—311 in *AGweek*, 216 in *AgUpdate*, and 17 in *AgriNews*. For "climate crisis," we found even fewer results. 17 in *AGweek*, 57 in *AgUpdate*, and 79 in *AgriNews* and the majority of them also mentioned "climate change." The 10-year study period was selected based on both data availability considerations and theoretical relevance. Prior to 2014, substantial inconsistencies existed across outlets in the searchability, completeness, and volume of climate change–related articles. For example, the earliest searchable content from *AGweek* begins in 2006, while *AgriNews* data are only available starting in 2008. Moreover, both *AGweek* and *AgriNews* experienced sharp declines in article volume during earlier years, with annual counts often dropping to around 10 articles, creating pronounced cross-outlet imbalances and potential bias in longitudinal comparisons. At the same time, this decade represents a theoretically meaningful window for examining longitudinal trends in climate change framing. It spans the latter half of the Obama administration, when climate change became increasingly institutionalized in U.S. policy discourse; the Trump administration, marked by heightened politicization and the U.S. withdrawal from the Paris Agreement; and the Biden administration, during which climate action was re-prioritized through major legislation such as the 2022 Inflation Reduction Act. Together, these phases provide sufficient temporal variation to examine changes in media framing over time while maintaining consistency in platform format and editorial practices across outlets.

Then, on the search results page, we employed web scraping techniques to gather all the information present on that page and any subsequent pages. The data, including the title, author, date, and text, were extracted and saved as a CSV file for subsequent analysis. The total sample size is 2,959 articles. Before the start of the analysis, a screening process was employed. Fifteen article links were found to be without content, 240 articles were duplicates. All of these articles were removed. At the time of analysis, the LLM used in this study had a maximum context window of 4,097 tokens. Articles exceeding this limit could not be reliably analyzed without truncation, which could compromise coding accuracy and consistency. To ensure that all texts were processed under identical technical constraints, 50 articles that exceeded this limit were excluded from the analysis. The remaining dataset includes 2,662 analyzable articles, with 755 from *AGweek*, 1,458 from *AgUpdate*, and 449 from *AgriNews*. We did not distinguish between news and opinion pieces, as labeling practices were different across outlets. For example, *AgriNews* provides no labels, *AgUpdate* uses categories such as "top story" or "featured" but not opinion. Also, 1,082 of 1,458 articles in *AgUpdate* lacked labels. In *AGweek*, only 29 of 755 articles were marked as opinion.

Data analysis

We utilized GPT-5 to perform the analysis in this study. Unlike traditional computational methods (such as NLP packages) that emphasize algorithmic optimization but often lack the interpretive depth of qualitative coding, LLM-assisted coding combines human expertise with model reasoning in an iterative process of codebook and prompt design, testing, and refinement (Dunivin, 2025) (Figure 1).

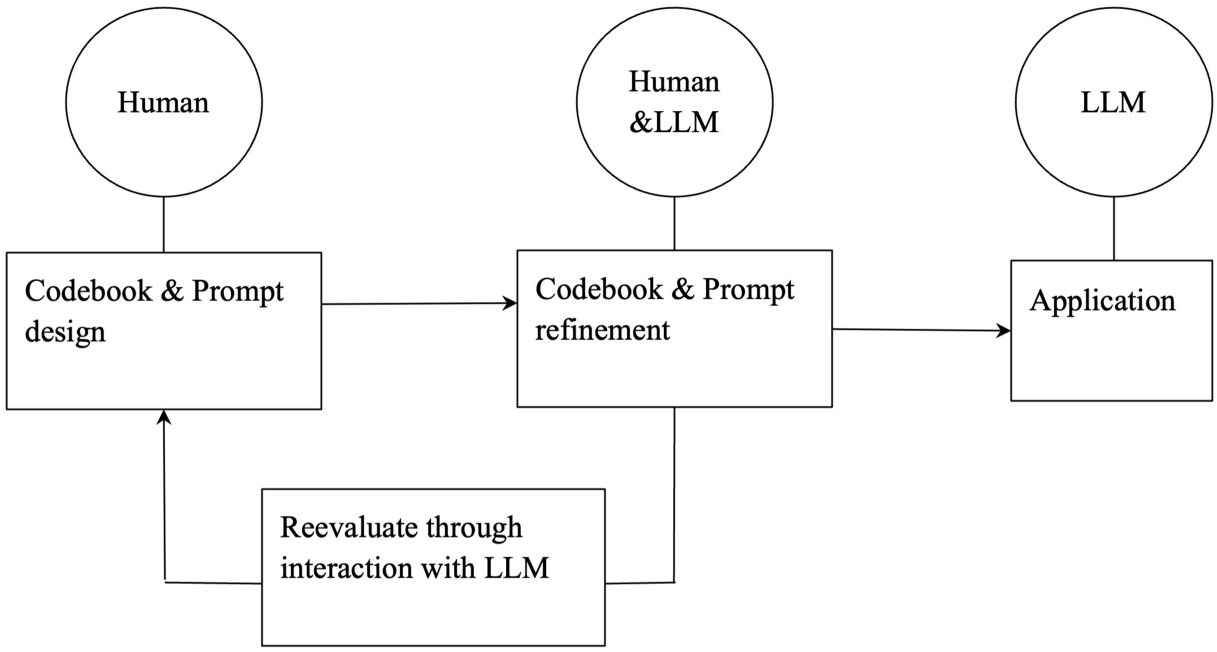

FIGURE 1
Workflow for LLM-assisted content analysis (conceptually adapted from Dunivin, 2025).

1 **Codebook and prompt design**. Initially, we developed a codebook based on prior research, including a comprehensive list of code names ("code") and code descriptions ("explanation"). We then developed a zero-shot coding prompt (Table 3), meaning that no labeled examples were provided for any category. To enhance validity and transparency, we used role prompting and chain-of-thought prompting, requiring the model to generate a brief "coding reason" for each classification (Chew et al., 2023). This stage was researcher-driven, ensuring clear coding instructions before model application.
2 **Conduct manual coding and LLM coding**. To assess both the accuracy and reliability of automated classification, we employed a two-stage coding procedure that combined human and LLM coding. A random sample of 100 articles was drawn from the full dataset to serve as the validation subset. These articles were independently coded by two trained human coders and by the LLM, following the same primary codebook developed in the initial code design phase.

TABLE 3 Prompt.

```
prompt = f"""
You are a qualitative coder who is annotating news articles from agricultural news websites.
To code this article, do the following:
- First, read the codebook and the text.
- Next, decide which code is most applicable and explain your reasoning for the coding decision.
- Finally, print the most applicable code as "Yes" or "No" and your reason for the coding decision using the format: "Reason: ".
{content}
{question}
"""
```

3 **Tests of reliability and Codebook revision**. Following this, reliability was assessed by comparing LLM outputs with human gold-standard manual codes, using unweighted Cohen's Kappa as a measure of reliability.

The coding process was non–mutually exclusive, meaning that each article could receive multiple codes if it contained overlapping frames. For instance, an article could be coded simultaneously as "*Economy Threat*," and "*Self Efficacy*" if the text addressed all these perspectives.

For the LLM coding, a structured prompting procedure was used. The model iterated through the full list of codes one by one, evaluating each article independently for the presence or absence of that code. The coding scheme was designed to capture the presence of thematic elements within an article. Thus, in each iteration, the LLM produced a binary decision ("yes" if the code applies; "no" if not), regardless of whether the coded element constituted the main focus or a marginal mention in the text.

The codebook was refined through close examination of discrepancies between human and LLM coding decisions. Each disagreement was reviewed to determine whether it stemmed from ambiguous wording, inconsistent inclusion criteria, or the model's over- or under-interpretation of textual meaning. Specifically, Supplementary Table 2 in the Supplementary Tables document illustrates how code definitions were revised to clarify causal logic and strengthen boundary conditions. For example, the initial definition of the *Economy (Threat)* code required explicit mention of "economic impacts," but many LLM errors arose when the model failed to recognize that statements about *crop losses or yield decline* implied direct economic harm. The final version therefore added explicit instructions that reductions in

TABLE 4 Human-model agreement.

Category	Frame	Cohen's Kappa	
		Human-LLM coeff_val	Human-human coeff_val
Threat	Economy	0.911	0.887
	Environment	0.957	0.889
	Public Health	1.0	0.904
	Agriculture	1.0	0.929
Internal/external efficacy	Self Efficacy-Positive	0.823	0.863
	Self Efficacy-Negative	0.753	0.784
	Response Efficacy-Positive	0.757	0.903
	Response Efficacy-Negative	0.809	0.891
	External Efficacy-Positive	0.899	0.926
	External Efficacy-Negative	0.658	0.79
Policy/action impact	Economy-Positive	0.918	0.918
	Economy-Negative	0.885	0.926
	Environment-Positive	0.92	0.898
	Environment-Negative	1.0	0.884
	Public Health-Positive	0.884	1.0
	Public Health-Negative	0.795	1.0
	Agriculture-Positive	0.92	0.9
	Agriculture-Negative	0.951	0.947
Action	Mitigation	0.899	0.959
	Adaptation	0.88	0.9
Social distance	Farmer Sources	1.0	0.974
	Scientific Sources	0.959	0.959
	Government Sources	0.94	0.94
	Industry Sources	0.938	0.958
	Nonprofit Sources	0.896	0.932
Hypothetical distance	Scientific Certainty	0.898	0.878
	Scientific Certainty_anthropogenic	0.846	0.846
	Scientific Uncertainty	1.0	1.0
Spatial distance	Local	0.976	0.976
Temporal distance	Past	0.884	0.74
	Present	0.858	0.96
	Future	0.808	0.846

agricultural yield should also count as economic impacts. The refinement also addressed LLM tendency patterns noted in the pilot phase: the model was "too strict" in excluding implied causal links (e.g., when impacts were clearly economic but not explicitly labeled) and "too loose" when over-inferring meaning not directly expressed in the text. To mitigate these issues, the final codebook added stricter wording such as *"Code Yes only if the negative impact is directly mentioned"* and provided illustrative examples from the agricultural corpus to standardize interpretation across codes (see Supplementary Table 2 for examples of codebook revision). This "human-in-the-loop" approach enabled scalable coding while preserving interpretive depth (see Table 2 for the final codebook).

In total, 31 codes achieved high reliability ($\kappa > 0.70$) after refinement, with one code rated as fair ($\kappa > 0.60$) (Table 4). When comparing human-LLM coding with human-human coding, the LLM achieved performance comparable to that of human coders. This iterative revision not only increased consistency between human and model judgments but also enhanced the interpretive transparency of the codebook. Detailed pilot samples and corresponding code for the reliability test are provided in Supplementary Data Sheets 4–8 (Data Sheet 4: Pilot dataset. Data Sheet 5: LLM pilot coding results. Data Sheet 6: Human pilot coding results 1. Data Sheet 7: Human pilot coding results 2. Data Sheet 8: Gold-standard human pilot coding results.)

4 **LLM coding on the final dataset**. We then applied LLM-assisted content analysis to the entire dataset to identify dominant frames and examine their evolution over time.

TABLE 5 Distribution of threat- and efficacy-related frames in agricultural news.

Category	Frame		Threat		Efficacy		All
			Total articles (*N*)	% of all threat related articles (*N* = 1,232)	Total articles (*N*)	% of all efficacy related articles (*N* = 2,283)	% of all articles (*N* = 2,662)
Threat	Economy		525	42.61			19.72
	Environment		972	78.90			36.51
	Public Health		134	10.88			5.03
	Agriculture		863	70.05			32.42
Threat-only			127	10.31			4.77
Threat-related			1,232	100.00			46.28
Internal/external efficacy	Self Efficacy	Positive			159	6.96	5.97
		Negative			111	4.86	4.17
	Response Efficacy	Positive			1,673	73.28	62.85
		Negative			503	22.03	18.90
	External Efficacy	Positive			1,707	74.77	64.12
		Negative			112	4.91	4.21
Policy/action impact	Economy	Positive			749	32.81	28.14
		Negative			276	12.09	10.37
	Environment	Positive			1,156	50.64	43.43
		Negative			123	5.39	4.62
	Public Health	Positive			97	4.25	3.64
		Negative			30	1.31	1.13
	Agriculture	Positive			985	43.14	37.00
		Negative			222	9.72	8.34
Positive_efficacy					2,092	91.63	78.59
Negative_efficacy					795	34.82	29.86
Action	Mitigation				1,100	48.18	41.32
	Adaptation				1,304	57.12	48.99
Efficacy-only					1,178	51.60	44.25
Efficacy-related					2,283	100.00	85.76
Both threat & efficacy					1,105	48.40	41.51
Neither threat & efficacy					252	11.04	9.47

Results

Threat and efficacy

We examined how the agricultural news websites framed climate change in terms of threat and efficacy. Initially, we assessed the overall frequency of articles categorized under threat and efficacy-related frames. Articles highlighting the *negative* effects of climate change were categorized as threat-related, while those emphasizing *internal/external efficacy*, *policy/action impact*, and *actions* were classified as efficacy-related see Supplementary Table 1 in the Supplementary Tables document for examples.

We addressed RQ1 by calculating the frequencies of articles that focus on threat, efficacy, and those that incorporate both elements. We observed a higher frequency of efficacy-related articles compared to threat-related articles. A significant majority of articles (2,283, 85.76%) used efficacy-related frames, while 46.28% (1,232) used threat-related frames. In addition, articles exclusively using efficacy frames without threat were more common (1,178, 44.25%) than those using both efficacy and threat-related frames (1,105, 41.51%), while articles focusing solely on threat were the least common (127, 4.77%) (Table 5). Thus, H1 was supported.

To address RQ2, we examined the distribution of different types of threats and efficacy-related frames (Table 5). Across the dataset, positive efficacy frames were dominant, appearing in 2,092 articles (78.59%), whereas negative efficacy frames were far less common (795, 29.86%). Among efficacy-related frames, *positive external efficacy* (1,707, 74.77%) and *response efficacy* (1,673, 73.28%) were most prominent. Coverage also frequently highlighted the positive impact

TABLE 6 Distribution of psychological distance-related frames in agricultural news.[1]

Category	Frame		Threat		Efficacy		All	
			Total articles (*N*)	% of all threat related articles (*N* = 1,232)	Total articles (*N*)	% of all efficacy related articles (*N* = 2,283)	Total articles (*N*)	% of all articles (*N* = 2,662)
Temporal	Past		81	6.57	88	3.85	109	4.09
	Present		1,121	90.99	1,141	49.98	1,298	48.76
	Future		296	24.03	296	12.97	323	12.13
Spatial	Local		756	61.36	1,466	64.21	1,740	65.36
	Non-local		476	38.64	817	35.79	1,192	34.64
Social	Farmer sources		247	20.05	459	20.11	527	19.80
	Non-farmer sources	Scientific	859	69.72	1,251	54.80	1,394	52.37
		Government	607	49.27	1,102	48.27	1,278	48.01
		Industry	323	26.23	840	36.79	956	35.91
		Nonprofit	350	28.41	635	27.81	709	26.63
Hypothetical	Scientific certainty_ anthropogenic		108	8.77	127	5.56	149	5.60
	Scientific certainty		781	63.39	942	41.26	1,035	38.88
	Scientific uncertainty		100	8.12	181	7.93	221	8.30

Only "local" and "non-local"" are mutually exclusive categories.

of climate policies/actions on the environment (1,156, 50.64%) and agriculture (985, 43.14%). By contrast, negative efficacy was rarely mentioned. Most of them were fewer than 10%. Thus, H2 was supported.

For threat-related frames, more than 70% of articles emphasized the negative impacts of climate change on the environment (78.90%) and agriculture (70.05%), while 42.61% addressed economic consequences. Public health was the least emphasized (10.88%). Among efficacy-related frames, more than half of the articles referred to environmental efficacy (positive: 1,156, 50.64%; negative: 123, 5.39%), followed by agricultural efficacy (positive: 985, 43.14%; negative: 30, 1.31%). Economic efficacy was less frequent (positive: 749, 32.80%; negative: 276, 12.08%). Public health efficacy was still rarely discussed (≈5%). While agriculture is salient, environmental consequences and efficacy dominate agricultural media coverage of climate change.

Psychological distance

We examined psychological distance across temporal, spatial, social, and hypothetical dimensions in the full dataset as well as within the threat- and efficacy-related categories, with particular attention to whether climate change was framed as psychologically close or distant (Table 6).

For hypothetical distance, coverage largely framed climate change as psychologically close by emphasizing scientific certainty rather than uncertainty. *Scientific certainty* appeared in 1,035 articles (38.88%), far exceeding *scientific uncertainty* (221, 8.30%), supporting H3. However, this sense of proximity was only partially realized, as relatively few articles (149, 5.60%) explicitly emphasized the anthropogenic nature of climate change. The same pattern was observed in the threat/efficacy subset.

For temporal distance, coverage overwhelmingly framed climate change as psychologically proximate by emphasizing *present* threat (1,298, 48.76%), with fewer articles focusing on *past* (109, 4.09%) or *future* (323, 12.13%) impacts. Still, this pattern was the same in the threat/efficacy subset, supporting H4.

For spatial distance, coverage similarly favored psychological proximity. *Local* frames dominated (1,740, 65.36%) compared to non-local frames (919, 34.64%), indicating that climate change was most often portrayed as affecting geographically close contexts. The same distribution appeared in the threat/efficacy subset, supporting H5.

This pattern did not extend to social distance. *Scientific* (1,394, 52.37%) and *government* sources (1,278, 48.01%) were most frequently cited, while *farmer* sources appeared in only 527 articles (19.80%). In threat-related articles, *scientific* sources were cited more frequently (859, 69.72%) than in efficacy-related articles (1,251, 54.80%), whereas *industry* sources were less common (323, 26.22% vs. 840, 36.79%).

Taken together, these findings indicate that agricultural media tend to frame climate change as temporally, spatially, and hypothetically close, while maintaining greater social distance in climate change narratives by relying less on farmers as information sources and social actors.

Trends

We examined the trends of threat/efficacy and psychological distance-related articles using linear regression, based on monthly percentages (Table 7 and Figure 2).

TABLE 7 Monthly trends of frames in agricultural news.

Category	Frame		Slope_per_month	SE	p_value	R_squared
	Economy		**−0.0006**	**0.0002**	**<0.01**	**0.0531**
	Environment		**−0.0010**	**0.0003**	**<0.001**	**0.0856**
	Public health		0.0002	0.0002	0.137	0.0204
Threat	Agriculture		−0.0002	0.0003	0.535	0.0024
Total threat related			**−0.0013**	**0.0003**	**<0.001**	**0.1198**
Threat only			−0.0001	0.0001	0.6120	0.0011
	Self efficacy_Positive		**0.0005**	**0.0001**	**<0.001**	**0.1222**
	Self efficacy_Negative		**0.0004**	**0.0001**	**<0.001**	**0.0926**
	Response efficacy_Positive		**0.0014**	**0.0004**	**<0.001**	**0.1094**
	Response efficacy_Negative		0.0001	0.0003	0.684	0.0013
Internal/external	**External efficacy_Positive**		**0.0009**	**0.0003**	**<0.05**	**0.0423**
efficacy	**External efficacy_Negative**		**−0.0003**	**0.0001**	**<0.05**	**0.0288**
	Economy_Positive		**0.0010**	**0.0003**	**<0.001**	**0.0839**
	Economy_Negative		**0.0004**	**0.0001**	**<0.01**	**0.0363**
	Environment_Positive		**0.0019**	**0.0003**	**<0.001**	**0.2038**
	Environment_Negative		0.0002	0.0001	0.0698	0.0210
	Public health_Positive		−0.0001	0.0001	0.4439	0.0040
	Public health_Negative		0.0001	0.0001	0.1075	0.0154
	Agriculture_Positive		**0.0018**	**0.0004**	**<0.001**	**0.1719**
Policy/action impact	**Agriculture_Negative**		**0.0009**	**0.0002**	**<0.001**	**0.1580**
	Mitigation		**0.0022**	**0.0003**	**<0.001**	**0.2660**
Action	Adaptation		0.0006	0.0003	0.076	0.0227
Total efficacy related			**0.0006**	**0.0002**	**<0.05**	**0.0309**
Efficacy only			**0.0018**	**0.0003**	**<0.001**	**0.2230**
Both threat & efficacy			**−0.0012**	**0.0003**	**<0.001**	**0.1035**
Neither threat & efficacy			**−0.0005**	**0.0002**	**<0.05**	**0.0337**
	Farmer sources		**0.0013**	**0.0002**	**<0.001**	**0.1915**
		Industry	**0.0015**	**0.0003**	**<0.001**	**0.1567**
		Nonprofit	**−0.0008**	**0.0003**	**<0.01**	**0.0621**
		Government	**−0.0008**	**0.0003**	**<0.05**	**0.0420**
Social distance	Non-farmer sources	**Scientific**	**−0.0007**	**0.0003**	**<0.05**	**0.0353**
Spatial distance	Local		**0.0017**	**0.0004**	**<0.001**	**0.1574**
	Scientific certainty		0.0000	0.0003	0.9171	0.0001
	Scientific certainty_anthropogenic		**−0.0004**	**0.0001**	**<0.01**	**0.0541**
Hypothetical distance	**Scientific uncertainty**		**−0.0007**	**0.0002**	**<0.001**	**0.1137**
	Past		−0.0000	0.0002	0.8913	0.0002
	Present		**−0.0011**	**0.0003**	**<0.001**	**0.0832**
Temporal distance	**Future**		**−0.0008**	**0.0002**	**<0.001**	**0.0891**

Frames with significant trends are highlighted in bold.

We found that *threat*-related coverage declined significantly over time. In particular, articles discussing the negative impacts of climate change on the *economy* and the *environment* showed significant decreases. By contrast, *efficacy*-related coverage increased. All *positive* internal and external efficacy frames rose over time. The discussions of both positive and negative policy impacts on the *economy* and *agriculture*, as well as the positive impacts on the *environment* also increase. Similarly, coverage of *mitigation* strategies grew significantly.

For psychological distance frames, the use of *farmer* sources—although relatively limited—increased over time, while reliance on *nonprofit*, *government*, and *scientific* sources declined. *Local* frames

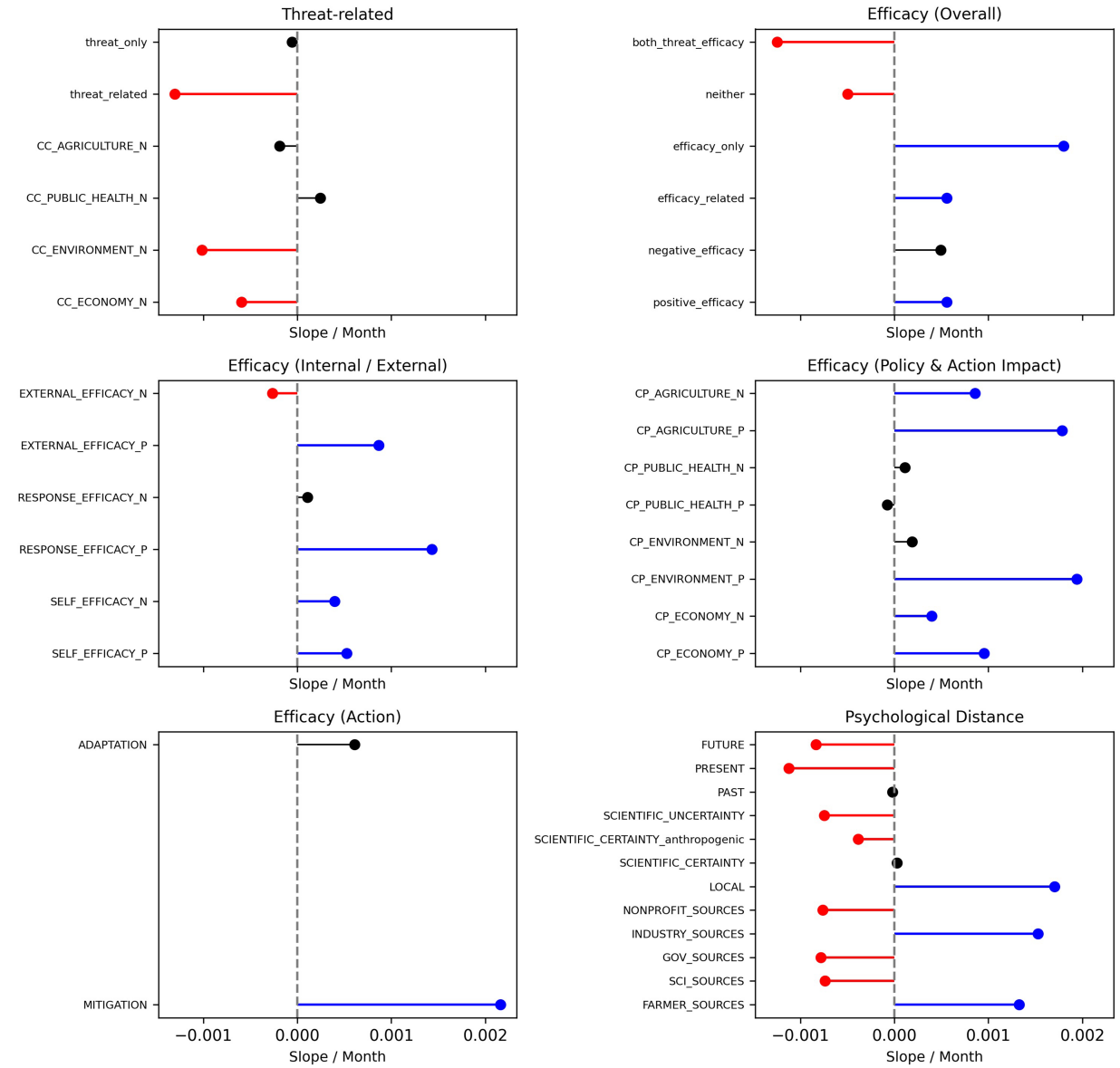

FIGURE 2
Temporal trends in agricultural news. Each dot represents the ordinary least squares (OLS) slope per month for a specific frame over time. Red dots indicate statistically significant negative slopes ($p < 0.05$), blue dots indicate statistically significant positive slopes ($p < 0.05$), and black dots indicate non-significant results ($p \geq 0.05$).

continued to rise steadily. At the same time, both scientific uncertainty and *scientific* certainty (*anthropogenic*) decreased. Finally, coverage of *present* and *future* climate change impacts declined.

We also analyzed trends in climate change-related news stories on each website by calculating the monthly average number of articles. We found that over the 10-year period, *AgriNews* exhibited a statistically significant increasing trend for the number of articles (*slope* = 9.28, $p < 0.01$), while *AgUpdate* and *AGweek* did not show statistically significant trends in frequency (Table 8). As shown in Figure 3, coverage across all sources experienced two prominent peaks—one in 2015 and another in 2021- alongside a notable low point in 2018.

We checked the development history of these three websites to investigate whether internal publishing factors contributed to the observed peaks. *AgriNews*, established in 1977, became part of Shaw Media in 2019. Following that, the number of climate change-related articles increased in 2020, peaking in 2021. We did not identify similar ownership or operational changes for *AGweek* or *AgUpdate* that might explain fluctuations. External factors may also account for these patterns. First, the peaks align with Democratic administrations—2015 under Obama and 2021 under Biden—while a decline occurred during the Trump administration (2017–2021). Second, some coverage trends appear to correspond with major climate policy milestones. For example, the signing of the Paris Agreement in 2015 and the U.S. reentry in 2021 align with peaks in coverage, while the U.S. withdrawal in 2017 corresponds with the lowest point. Third, certain spikes may reflect extreme weather events, such as the 2014 Nebraska Tornado Outbreak and the 2021 multi-state tornadoes (Figure 3).

TABLE 8 Annual trends of climate change-related articles across three agricultural news websites (count).

Year	AgriNews	AgUpdate	AGweek	All
2014	6	190	32	228
2015	14	135	212	361
2016	14	120	193	327
2017	34	101	48	183
2018	28	84	21	133
2019	27	169	33	229
2020	76	134	27	237
2021	115	228	93	436
2022	81	180	37	298
2023	54	117	59	230
Slope	9.28**	2.32	−9.29	2.30
p-value	0.007	0.67	0.25	0.83

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Discussion

This study examines how U.S. agricultural news websites have framed climate change over the past decade, focusing on the interplay between threat and efficacy frames, and the construction of psychological distance. Several important insights emerge from the findings.

First, agricultural news websites predominantly use efficacy-related frames, with many fewer articles focusing on threat-related frames. Many articles exclusively contain only efficacy elements, such as references to new techniques for adapting to or mitigating climate change. The majority of threat-related articles also incorporate efficacy elements. The tendency of agricultural media to place greater emphasis on efficacy may contrast with trends in mainstream media. For example, a content analysis by Stecula and Merkley (2019) found that major U.S. mainstream media have increased their focus on risks and dangers. Feldman et al.'s study (2015) showed that external efficacy framing was largely missing in mainstream U.S. newspapers.

In addition, agricultural media emphasize positive efficacy over negative efficacy. Specifically, positive *external* efficacy is predominant, accounting for 64.12% of all sampled articles, followed by *response* efficacy at 62.85%. The majority of agricultural news articles discuss the responsiveness of external sources, such as political leaders, government officials, corporate executives, and scientists, in addressing climate change. Articles also frequently emphasize the benefits of policies and techniques on agriculture, demonstrating that agricultural media pay considerable attention to the effectiveness of climate actions and advocate for such measures.

Meanwhile, approximately half of the articles cover mitigation or adaptation strategies, with adaptation receiving more attention than mitigation. By contrast, adaptation coverage in mainstream newspapers remains more limited, and most stories simply acknowledge the need to adapt rather than documenting concrete actions (Ford and King, 2015).

One explanation lies in the nature of agricultural media. Farmers rely on these outlets for information relevant to their daily activities, making them perhaps the nation's largest nonformal program of continuing education for farmers, ranchers, and their families (Evans and Heiberger, 2016). Agricultural media's editorial decisions are shaped by a mix of reader needs, advertiser pressures, and public perceptions, highlighting their distinct position in the broader communication landscape. Abrams and Meyers' (2010) interviews with agricultural editors revealed that they view farm safety as a core risk issue but define their role as offering practical, solution-oriented reporting distinct from mainstream outlets. Their coverage is deliberately action-oriented, designed to provide advice and steps for mitigating risks. Rather than amplifying risks, agricultural editors aim to attenuate risk perceptions by prioritizing solutions over alarm.

Importantly, this approach may build a sense of efficacy and hopefulness among individual farmers. Previous literature, such as Markowitz and Guckian (2018), suggests that highlighting solutions can encourage individual engagement and increase motivation to take action. Swim et al. (2018) also indicate that the "technological solutions" frame is more persuasive to conservative audiences than the "harmful impacts" frame.

However, we also noticed that in agricultural media, *self-efficacy* is rarely discussed, which is the same as broader patterns of efficacy framing in climate coverage in mainstream media (Feldman et al., 2015; Hart and Feldman, 2014). This scarcity may reflect both the structural features of climate change as a collective action problem—where solutions are framed primarily at the governmental or policy level—and journalistic norms that privilege drama, conflict, and reliance on elite sources (Hart and Feldman, 2014). Reporters often avoid offering "mobilizing information," as doing so may be perceived as advocacy rather than objective reporting (Bennett, 2020; Feldman et al., 2015; Lemert, 1984). As a result, news outlets emphasize external and response efficacy far more frequently than self-efficacy.

Framing climate change through narratives that highlight members of the same group or community (e.g., "people like me," such as other farmers) may reduce perceived social distance and make climate risks feel more personally relevant. Such reduced social distance has been shown to strengthen risk perceptions and engagement, whereas imagining impacts on socially distant others tends to lower perceived risk (Schattman et al., 2021). However, in our study, only around 20% of the articles use farmer sources. The predominant information sources are scientific experts, followed by government agencies, reflecting agricultural media's reliance on institutional expertise over farmer perspectives (Orton, 2021). This aligns with findings from other contexts. For instance, O'Morain and Robbins (2024) analyzed the *Irish Farmers Journal*'s coverage of Ireland's 2021 Climate Action Plan and found that individual farmers were quoted in just 2.2% of articles, compared to 38% that quoted government officials. Similar patterns appear in the U.S. context. Whitaker and Dyer (2000) reported that American agricultural magazines relied most heavily on educational institutions (62.2%) and government agencies (60.8%) when covering environmental and food safety issues. More recently, Orton et al. (2024) found that university scientists and extension experts were the most common sources in U.S. agricultural magazines, while farmers were cited in only about 10% of articles.

This pattern reflects a broader tendency to link sustainability actions in agriculture to scientific evidence and government authority rather than to farmers' lived experience. In our sample, scientific

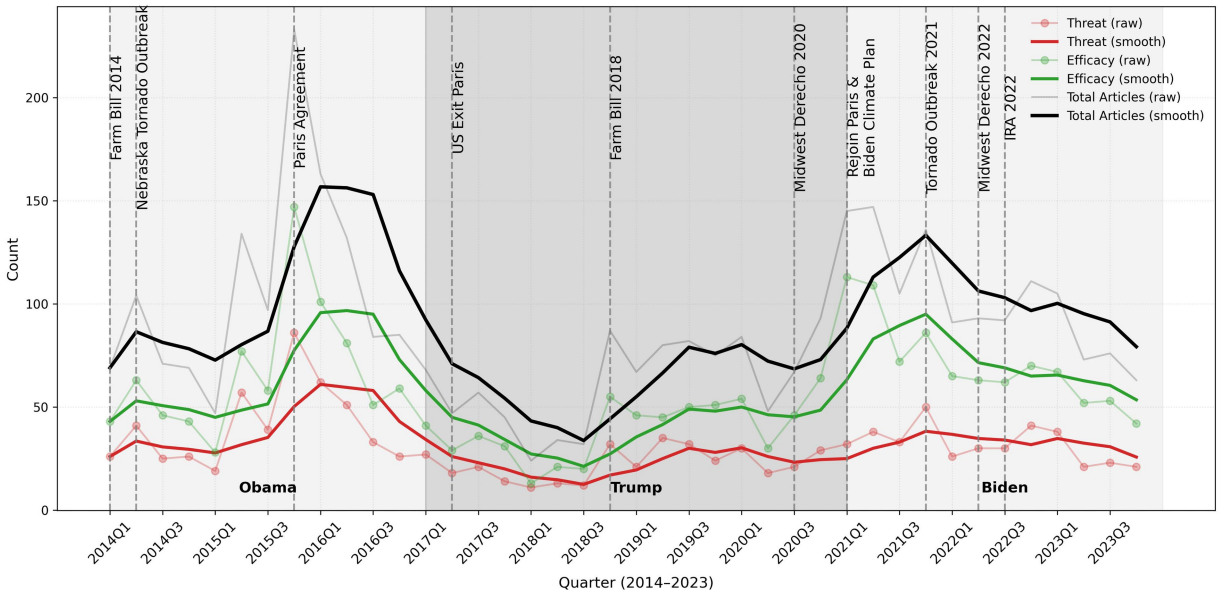

FIGURE 3
Quarterly trends of agricultural news (count). 1. Q1–Q4 denotes calendar quarters (e.g., Q1 represents the first quarter of the year); 2. Shaded background areas indicate U.S. presidential administrations, with darker shading corresponding to the Trump administration and lighter shading corresponding to the Obama and Biden administrations; 3. Vertical dashed lines mark major climate policy and extreme weather events; 4. The analysis was conducted using monthly average data, but this figure is plotted on a quarterly basis for clearer visualization.

sources appear more frequently in threat-related coverage, suggesting that scientific evidence is often mobilized to highlight the negative impacts of climate change. This reflects a commitment to present climate change as a matter of established consensus and empirical certainty. Journalists may also favor these sources because farmers and general audiences place high levels of trust in scientists or extension agents when evaluating climate change-related information (Arbuckle et al., 2015; Borrelli et al., 2018).

However, the relative underrepresentation of farmers as sources has important implications for social distance in climate change communication. While scientific and governmental sources may enhance credibility and risk salience (Kasperson et al., 1988), farmers tend to place particularly high trust in other farmers and agribusiness peers when making production-related decisions, and peer experience plays a critical role in shaping perceptions of feasibility and appropriate practice (Borrelli et al., 2018). Consistent with this, Kuhfuss et al. (2016) found that farmers are more willing to enroll in an agri-environmental scheme when they believe that their peers will also participate. By foregrounding scientific experts and governmental sources while underrepresenting farmers' own experiential knowledge, agricultural media may frame climate change as an issue primarily governed by external authority rather than embedded in farmers' everyday decision-making contexts. In this sense, the observed sourcing pattern reflects an elite-driven narrative structure, which may limit farmers' identification with climate change discourse and sustain social distance between the issue and those most directly involved in agricultural decision-making (Ranjan et al., 2019).

We found that agriculture is one of the most prominent impact domains discussed in climate change coverage. In threat-related articles, the negative impact of climate change on agriculture was the second most frequently discussed. Similarly, in efficacy-related coverage, the positive effects of climate policy on agriculture appeared more often than those concerning the economy or public health. However, environmental impacts were referenced even more frequently than agricultural ones in articles with both threat and efficacy frames. It contrasts with some studies suggesting that agricultural media typically pay less attention to environmental dimensions (Rust et al., 2021). One possible explanation lies in the coding scheme. The categories were non–mutually exclusive, and the coding process did not distinguish between a main topic and a secondary or marginal mention. Thus, some environmental mentions may not represent the article's main emphasis.

From the perspective of psychological distance, almost half agricultural news articles on climate change threats highlight present impacts, a pattern that differs somewhat from mainstream media. In U.S. newspapers, although present-day impacts are the most frequently mentioned, they appear in only about 30% of articles. Some outlets, such as *USA Today*, place relatively greater emphasis on future impacts (Feldman et al., 2015). Network television news also highlights both the present and future (Hart and Feldman, 2014). In addition, agricultural coverage is strongly localized, with more than 60% of articles discussing climate change in terms of local impacts or ways to address the issue within local communities. It is a much greater emphasis than that found in mainstream media's coverage of U.S. issues (Feldman et al., 2015; Hart and Feldman, 2014).

Generally, agricultural media mention scientific certainty more than uncertainty. Among articles related to threats, more than 60% mention scientific certainty, and with scientific sources being the most frequently cited. These articles often combine discussions of the negative impacts of climate change with scientific evidence to provide a stronger assertion about the occurrence of climate change. It aligns with the broader communicative context in the United States, in which public acceptance of climate change and scientific consensus has increased over time. Data from the *Climate Change in the*

American Mind surveys show that a majority of Americans believe climate change is happening and that it is primarily human-caused (Leiserowitz et al., 2022, 2023, 2024, 2025b).

However, although climate change is mostly presented as a scientifically established fact, only 5% of articles mentioned human-caused climate change, a pattern consistent with Orton (2021). This suggests that agricultural media adopt a practical approach to discussing climate change. The reluctance to delve into politically charged topics or debates about the anthropogenic nature of climate change can also be seen as strategic, given the divisive nature of climate change discussions in the U.S. political landscape (Pew Research Center, 2024).

Climate change has become a "litmus test" in the US, with Republicans more likely to align with climate-skeptic viewpoints to differentiate themselves from Democrats, particularly with respect to debates over the causes of climate change about 61% of farmers are identified as Republican (Agri-Pulse, 2024). In this case, directly engaging in political debate topics could threaten individuals' identities and risk a backfire effect among Republican farmers (Markowitz and Guckian, 2018). Agricultural media's focus on non-contentious, practical aspects of climate change can be seen as a method to maintain engagement with their audience without pushing anyone away. This strategy likely serves to keep the discourse constructive and directly relevant to the immediate concerns of farmers, ensuring that discussions on climate policy and scientific findings are framed in terms of direct relevance to agriculture and practical applicability.

From the longitudinal analysis, we observed several clear, though modest, trends in the distribution of framing patterns. The proportion of coverage emphasizing climate change threats has steadily declined, whereas efficacy framing and localized contextualization have increased. At the same time, reliance on government and scientific sources has reduced, while use of farmer voices has grown, although from a low baseline. This suggests a gradual shift of agricultural media toward farmer-centered, practice-oriented communication.

Limitation

While the analysis offers important insights, several limitations should be noted.

First, the dataset does not differentiate between news and opinion content, which may affect interpretations of tone and intent.

Second, some coding strategies may lack precision. For instance, our coding strategy focused on whether a given theme was present in an article, regardless of whether it constituted a primary or a secondary focus. In other words, we did not assess the relative dominance or salience of frames within the overall narrative. This presence-based coding strategy allows for comprehensive detection of co-occurring themes in large-scale text data, but also introduces a limitation when interpreting the relative prominence of specific domains. Also, in identifying local coverage, we relied on the occurrence of place names within each outlet's geographic circulation area. This method may misclassify articles that merely mention a location without actually focusing on local issues. Future studies could develop more refined coding strategies to improve the accuracy of frame identification.

Thirdly, this study demonstrates the utility of LLM–assisted content analysis for handling large-scale, text-rich datasets. By combining researcher expertise with large language models, it becomes possible to achieve both scalability and interpretive nuance, generating results comparable in reliability to human coders while also expanding the feasibility of long-term, multi-dimensional framing analyses. However, despite efforts to increase accuracy, the LLM still sometimes makes errors, such as applying the codebook too rigidly or too loosely (see Supplementary Table 3 in the Supplementary Tables document for examples). Nevertheless, rapid progress in the performance of AI models and the emergence of models that are tuned to specific domains of language mean that media content analysis will experience further leaps in terms of efficiency and accuracy. Future studies should continue exploring methods to enhance the use of this type of content analysis.

Conclusion

Taken together, our findings suggest that agricultural media construct a distinctive climate communication environment—one that differs in important ways from mainstream news coverage and reflects the pragmatic orientation of farming audiences. Rather than centering climate change discourse on alarm or political conflict, agricultural news websites consistently emphasize efficacy-oriented narratives and psychologically proximate framings. In this sense, they function more as applied knowledge brokers, translating climate risks into information that is relevant to farm management, policy participation, and adaptation planning. Theoretically, these findings have important implications for understanding how media framing may shape farmers' perceptions of relevance, responsibility, and capacity for action in the context of climate change. Methodologically, this study demonstrates the value of LLM-assisted approaches for large-scale, theory-driven content analysis. By combining human validation with automated coding, LLMs enable researchers to systematically examine complex framing patterns across large datasets while maintaining transparency and analytical rigor. As communication research continues to expand in both scale and scope, LLM-assisted methods offer a promising pathway for advancing both empirical insight and methodological innovation.

Data availability statement

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

Author contributions

WL: Writing – review & editing, Formal analysis, Writing – original draft, Methodology, Visualization, Conceptualization, Data curation. JS:

Methodology, Writing – review & editing, Supervision, Conceptualization. YL: Data curation, Methodology, Writing – review & editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that Generative AI was used in the creation of this manuscript. GPT-5 was used as an analytic tool to assist with automated content coding based on a researcher-developed codebook. Specifications of the prompt design and coding procedures are included in the Methods section.

Any alternative text (alt text) provided alongside figures in this article has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcomm.2026.1759296/full#supplementary-material

DATA SHEET 1
AgriNews sample and code.

DATA SHEET 2
AgriWeek sample and code.

DATA SHEET 3
AgUpdate sample and code.

DATA SHEET 4
Pilot dataset.

DATA SHEET 5
LLM pilot coding results.

DATA SHEET 6
Human pilot coding results 1.

DATA SHEET 7
Human pilot coding results 2

DATA SHEET 8
Gold-standard human pilot coding results.

TABLE 1
Supplementary Tables.

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