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Climate Strikes in the Digital Age: Public Engagement in the Fridays for Future Twitter Discourse

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Abstract
This study examines how the *Fridays for Future (FFF)* movement mobilized public engagement on Twitter during major climate strike events in 2019. Using a mixed methods approach, we analyze over 40,000 tweets from multiple global regions to assess both the intensity and duration of digital participation. Findings reveal sharp spikes in engagement around strike dates, followed by rapid declines, reflecting the episodic nature of online activism. Yet, certain frames such as institutional responsibility (*government*), moral urgency (*actnow*), and youth leadership (*gretathunberg*), consistently anchor high-engagement tweets. While effective in the short term, these frames operate within a polarized digital landscape shaped by backlash and misinformation, limiting long-term impact. By linking message framing to engagement trends, this study offers a more granular, data-driven perspective on the dynamics of digital climate discourse. It contributes to broader debates about the promises and pitfalls of climate activism in the age of social media, underscoring the need for strategies that sustain engagement beyond symbolic moments.
Keywords: Climate change, Social media activism, Fridays for Future, Framing analysis, Twitter

1. Introduction

Climate change is one of the most pressing global challenges of our time, with wide-ranging consequences that extend beyond environmental degradation to encompass significant social and economic impacts. Scientific evidence has conclusively shown that human activities have caused unprecedented warming of the Earth's atmosphere, triggering a climate crisis that is already manifesting in rising temperatures, extreme weather events, and biodiversity loss (Fletcher et al., 2024). Moreover, climate change deepens existing social and economic inequalities. Research indicates that its adverse effects disproportionately impact disadvantaged groups, exacerbating social disparities (Blanz, 2023). This creates a vicious cycle where initial inequalities lead to greater vulnerability to climate impacts, which in turn amplifies these inequalities. Furthermore, climate-related agricultural productivity losses can lead to rising food prices, which disproportionately affect the poorest populations, increasing wealth inequality (Blanz, 2023). As the social and economic consequences of climate change intensify, the need for grassroots activism has become more pressing than ever. In this context, youth-led movements have emerged as powerful forces in demanding urgent action and holding policymakers accountable.

A landmark response to this crisis has been the Fridays for Future (FFF) movement, initiated by Greta Thunberg in 2018. What started as a solitary protest outside the Swedish Parliament rapidly evolved into a global youth-led movement spanning over 150 countries (Thunberg, 2021). FFF has reshaped climate advocacy by connecting local and global narratives, holding

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governments accountable to climate commitments, and influencing public discourse (Spaiser et al., 2022; Thunberg, 2021; Wahlström et al., 2020).

The movement's success has been amplified by social media, enabling real-time coordination, mass mobilization, and public engagement beyond traditional activism (Boulianne et al., 2020). Unlike conventional media, where access is restricted by gatekeeping, platforms like Twitter provide a participatory space for climate discourse and policy advocacy (Tufekci, 2019). Through "connective action", digital technologies have transformed activism, allowing decentralized coordination while reducing dependence on hierarchical structures (Bennett & Segerberg, 2011b). Despite FFF's massive mobilization, concerns remain about the sustainability of digital activism. While its strikes attract millions, engagement often follows episodic bursts, with participation declining post-event (Fernández-Zubieta et al., 2023). This raises questions about whether FFF's online activism translates into sustained discourse and long-term commitment.

This study examines FFF's influence on digital engagement and public discourse on Twitter, addressing critical gaps in understanding how youth-led digital movements mobilize support, sustain engagement, and shape climate narratives (De Moor et al., 2020; Fisher & Nasrin, 2020). By employing semantic network analysis, this study asseses how FFF's framing strategies align with broader climate justice, policy, and scientific advocacy while analyzing patterns of engagement retention over time.

2. Literature Review

2.1 Shifts in Climate Change Discourse Over Time

Recognizing the adverse effects of climate change is vital for mobilizing broad-based support for climate action. Over the last 25 years, public understanding and awareness of climate change have evolved significantly, though not uniformly across regions. Capstick et al. (2014) synthesize global evidence to show that concern has risen in areas like sub-Saharan Africa and South America, while skepticism has increased in Europe, the UK, and Australia. This divergence suggests that climate discourse is shaped by more than scientific knowledge; it reflects cultural, political, and media influences that vary by country.

The U.S. stands out as an outlier among industrialized nations, where public opinion on climate change remains fragmented (Ciocirlan & Pettersson, 2011). This skepticism is rooted in longstanding climate denial campaigns, particularly by conservative political actors, that have systematically undermined public trust in climate science (McCright & Dunlap, 2011). Media coverage has played a key role in amplifying this skepticism (Ciocirlan & Pettersson, 2011). These regional variations set the stage for examining how digital platforms and transnational movements like FFF attempt to reshape the discourse through alternative channels like social media.

While existing research has mapped the trajectory of global climate awareness and media representation, less is known about the *temporal dynamics* of public engagement: namely, whether discourse triggered by climate movements persists over time or fades after moments of visibility. This study addresses that gap by examining FFF's impact on digital climate discourse, particularly whether Twitter engagement during strike events translates into sustained conversations or short-lived surges.

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2.2 Digital Activism and Movement Sustainability

A central challenge for contemporary social movements is sustaining engagement over time, especially in digital spaces where attention is fragmented and fleeting. Classical theories of movement durability emphasize the role of resource mobilization (McCarthy & Zald, 1977) and network cohesion (McAdam, 2003). Yet, digital movements also depend on how well they adapt to evolving platforms and media ecosystems (Benkler et al., 2018). Fridays for Future exemplifies this challenge. While it succeeds in mobilizing massive attention during strike events, it remains unclear whether this engagement persists beyond episodic moments. This study evaluates FFF's sustainability by tracking user engagement across multiple strikes using survival analysis. By identifying user retention patterns, the study offers insight into whether digital participation translates into sustained activist commitment.

2.3 Public Attitudes, Political Polarization, and Media Framing

Public and political responses to climate activism significantly influence how societies engage with climate policy. On one end, youth-led movements like FFF have demonstrably affected political behavior. For instance, Fabel et al. (2022) find that the movement increased support for Green parties in Germany, partially due to reverse intergenerational influence, where children's activism shaped their parents' political views. Such outcomes underscore the potential of grassroots mobilizations to reshape policy preferences.

However, FFF's reception is far from universally supportive. Political responses often mirror deeper ideological divisions. While progressive policymakers in Europe have engaged with the movement's demands, conservative leaders have criticized or trivialized it (Pollex & Berker, 2024). These divergent reactions are indicative of a broader polarization in climate discourse. In nations like the U.S. and Australia, where political and media landscapes are more adversarial, climate activism is often portrayed through a lens of skepticism or hostility (Capstick et al., 2014). This polarization is exacerbated by media environments that either ignore or delegitimize activist voices, contributing to fragmented public discourse.

Capstick et al. (2014) highlight these regional disparities in climate concern, attributing them not only to scientific understanding but also to ideological resistance, media framing, and cultural attitudes. This study builds on these insights by exploring how FFF's digital discourse interacts with these polarized contexts. It asks whether framing strategies used by FFF on platforms like Twitter succeed in bridging ideological divides or remain confined to echo chambers.

2.4 Framing of Environmental Movements

Framing is a critical tool for environmental movements seeking to mobilize support and shape public discourse. Movements construct meaning through the strategic use of language, symbols, and narratives, thereby influencing how the public understands and prioritizes environmental issues. McAdam et al. (1996) emphasize that a movement's success is influenced by how effectively it leverages political opportunities, mobilizing structures, and collective framing.

Comparative studies show that framing strategies differ across movements. Buzogány et al. (2022) contrast FFF's inclusive, youth-driven approach with the more confrontational style of Extinction Rebellion (XR). While FFF focuses on education and participatory messaging, XR emphasizes systemic disruption and direct action. These differences reflect varying beliefs about how best to engage publics and influence change. This research extends such work by analyzing

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how FFF's framing on Twitter constructs different issue agendas, connects climate to political or moral urgency, and appeals to global versus local audiences.
Understanding framing in a digital context is particularly important, as social media allows for message amplification and rapid dissemination. This study contributes to the framing literature by mapping the patterns of keywords in FFF-related tweets and analyzing how these networks reflect associations that structure public understanding of climate discourse.

2.5 Hate Speech, Misinformation, and Polarization in Climate Discourse

Digital spaces offer unprecedented opportunities for activism but also pose risks of polarization, misinformation, and hate speech. Benkler et al. (2018) discuss how online media ecosystems in the U.S. have become fragmented, enabling misinformation and radicalization. This is especially pertinent in climate politics, where digital platforms often serve as battlegrounds between activist messaging and ideological counter-narratives.
Falkenberg et al. (2022) show that social media platforms often amplify existing ideological divides, reinforcing echo chambers that limit meaningful engagement. Similarly, Reyes-Menendez et al. (2018) demonstrate how public sentiment on platforms like Twitter can be tracked through hashtags like #WorldEnvironmentDay, revealing the emotional contours of climate discourse. Misinformation is not merely a by-product of user behavior but often stems from influential figures. Allen and McAleer (2018) analyze how political elites spread misleading statements about climate change, shaping public opinion through misinformation. These patterns create confusion and undermine science-based messaging.
Targeted attacks on activists also affect the quality of digital engagement. Arce-García et al. (2023) examine the online abuse faced by Greta Thunberg during COP25, showing how hate speech can derail public dialogue and deter participation. This study builds on that work by analyzing how FFF discourse adapts to such challenges whether through shifts in framing, or engagement strategies that respond to polarized environments.
To address the gaps identified in the literature, this study investigates the scope, durability, and framing of Fridays for Future's (FFF) influence on Twitter. It evaluates whether climate strike events significantly amplify public engagement with climate-related content, how long such engagement is sustained beyond the events, and how the movement's discourse evolves in online spaces. These objectives are guided by the following research questions (RQs) below:
RQ 1: Does the FFF strikes significantly impact Twitter users' engagement with climate change content and drive noticeable shifts in public perception online?
RQ 2: To what extent do FFF strikes drive both immediate and sustained engagement with climate-related issues on social media?
RQ3: Which keywords in climate protest-related Twitter discourse generate significantly higher public engagement, and what types of frames do they represent?

3. Data Collection and Methodology

Drawing on tweets sourced from diverse regions, including North America, Europe, Australia, and Asia, the dataset was refined through multiple preprocessing steps. This involved eliminating duplicates, removing non-standard characters and unreadable scripts (Bird et al., 2009), ultimately narrowing the corpus to 42,908 tweets directly related to Fridays for Future (FFF) mobilizations. To isolate relevant content, we employed a curated set of high-impact climate hashtags such as *#FridaysForFuture*, *#climatechange*, *#climatecrisis*, *#climateStrike*,

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#GreenNewDeal, and *#climateAction* (Fisher, 2019), ensuring topical consistency across the dataset. These filters were deployed across a wide geographical scope, encompassing tweets from the United States, Europe, Australia, and Asia. However, it's important to note that hashtag-based extraction inevitably missed certain relevant conversations where such tags were omitted.

Following extraction, preprocessing steps were implemented to increase data clarity and quality. These included eliminating special symbols, unidentified scripts, duplicated entries, and retweets that lacked original commentary. Constraints introduced by Twitter's evolving API model, such as monetization and tweet removal policies, necessitated additional steps to maintain dataset consistency and integrity.

To establish temporal alignment with major protest waves, four global strike dates were isolated: March 15, September 20, September 27, and December 6, 2019. Peaks in tweet activity corresponding to these dates were verified using hashtag frequency patterns (Fernández-Zubieta et al., 2023). Additionally, non-relevant or off-topic tweets were removed through manual filtering and contextual keyword checks.

Using a mixed methods approach combining statistical methods with qualitative keyword analysis, the study aimed to capture both the intensity and framing of engagement across these protest events. For statistical validation, engagement during strike versus non-strike periods was compared using a paired t-test, revealing significant spikes in user interaction. To capture overall engagement patterns over time, an ARIMA(5,1,0) model was employed (Abaddi, 2024), enabling trend-based analysis of user attention throughout the protest cycle. To evaluate audience retention across phases of protest participation, Kaplan-Meier survival analysis was used (Firouzjaei, 2022; Chesterton, 2024). This method allowed for visualizing how user engagement decayed over time and offered insights into long-term versus episodic participation patterns.

The tweets underwent a multi-step text normalization process including tokenization, stopword elimination, and lemmatization (Bird et al., 2009). This formed the foundation for semantic analysis. To deepen our understanding of what drives public interaction in digital protest discourse, a keyword-based engagement test was conducted. From the cleaned tweet corpus, the top 300 most frequently occurring keywords were identified, using tokens stripped of stopwords and lemmatized for consistency. For each keyword, the subset of tweets containing that term was isolated, and the average *TotalEngagement* score, defined as the sum of likes, replies, and retweets, was calculated. To determine whether specific keywords generated significantly higher engagement than expected, we computed the z-score of each keyword's average engagement relative to the overall distribution. Ethical precautions were taken to anonymize user data and fully comply with Twitter's platform guidelines and API policies (Blazhevski, 2022).

4. Findings

4.1 Event Detection: FFF's Impact on Digital Engagement

To determine whether observed spikes in Twitter engagement were directly linked to FFF strikes, an event detection analysis was conducted. The objective was to confirm that engagement increases on March 15, September 20, September 27, and December 6, 2019, were driven by FFF-related activity rather than unrelated events. This analysis reveals that engagement metrics

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significantly increased during strike dates, with FFF-related hashtags (#FridaysForFuture, #ClimateStrike, #ClimateAction) outperforming unrelated tweets.[1] This study:

1. Filtered FFF-Related Tweets – Removed tweets containing FFF-specific hashtags to test whether engagement persisted.
2. Reanalyzed Engagement Patterns – After removing FFF-related tweets, the engagement spike disappeared, confirming FFF's role in driving digital discourse.

Figure 1 illustrates this effect, showing engagement spikes on unfiltered data and their disappearance when FFF tweets were excluded.

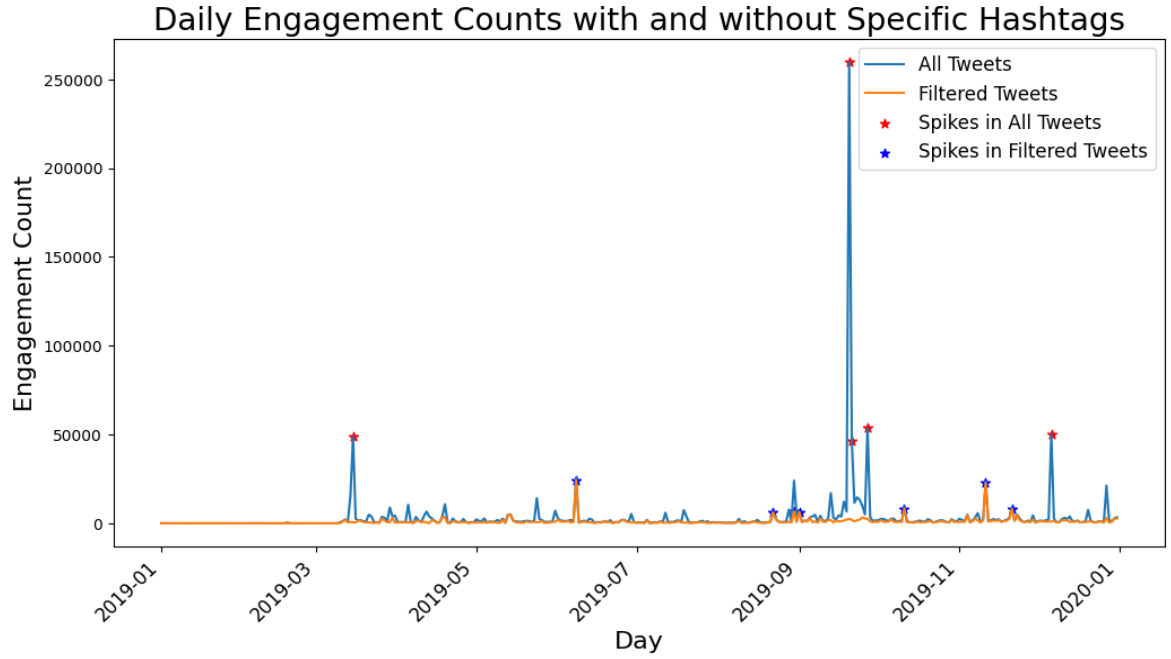

Figure 1: The engagement spike for both the filtered and unfiltered datasets

Statistical Validation

To assess whether these spikes were statistically significant, a **paired t-test** was conducted comparing engagement on strike dates vs. non-strike periods.

- Null Hypothesis (H_0)**:** No significant difference in engagement between strike and non-strike dates.
- Alternate Hypothesis (H_1): **:** Engagement levels on strike dates are significantly different.

The t-test yielded a *t-statistic* of 3.55 (*p-value* = 0.0237), confirming that FFF strike events led to significantly higher engagement. These findings provide robust evidence that FFF strike events were associated with significant increases in public engagement with Climate Change related topics on Twitter.

4.2 Short-Run vs. Long-Run Impact of FFF Strikes on Climate Engagement

To evaluate the influence of FFF strikes on public perception, as reflected through the usage of climate movement-related hashtags, this analysis employed an ARIMA(5,1,0) model was

[1] Engagement metrics were measured using the total number of *retweets* and *favorites*, which serve as indicators of public interaction and amplification on Twitter. The engagement spike was analyzed for its alignment with FFF strike events by examining the frequency and nature of hashtags used during the event dates.

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employed using the *statsmodels* library to examine the temporal patterns of hashtag engagement. This was done in order to quantify the influence of FFF strikes and better understand the oscillatory behavior and memory effects associated with online engagement during these events. The above model analyzed the temporal dynamics of hashtag usage during FFF strikes. The analysis of hashtag usage surrounding the FFF strikes on March 15, September 20, and December 6, 2019, using the ARIMA(5,1,0) model provides a statistically rigorous understanding of the temporal dynamics of online engagement during these events. The model's parameters and diagnostic results are summarized in Table 1-3.

Table 1: ARIMA(5,1,0) Model Summary

Statistic	**Value**
Dependent Variable	Climate Movement Hashtags
Number of Observations	42,908
Model	ARIMA(5,1,0)
Log Likelihood	-47,790.902
AIC	95,593.804
BIC	95,645.805
HQIC	95,610.210
Covariance Type	OPG

Table 2: ARIMA(5,1,0) Coefficients

Parameter	**Coefficient**	**Standard Error**	**z-Value**	**p-Value**	**95% CI (Lower)**	**95% CI (Upper)**
AR(1)	-0.6833	0.0030	-208.94	<0.001	-0.690	-0.677
AR(2)	-0.5499	0.0042	-130.91	<0.001	-0.558	-0.542
AR(3)	-0.4004	0.0047	-85.26	<0.001	-0.410	-0.391
AR(4)	-0.2755	0.0046	-60.05	<0.001	-0.284	-0.266
AR(5)	-0.1472	0.0041	-35.98	<0.001	-0.155	-0.139
$Sigma^2$	0.5432	0.0021	254.38	<0.001	0.539	0.547

Table 3: Model Diagnostics and Residual Tests

Test	**Value**	**p-Value**	**Interpretation**
Ljung-Box (Q)	15.11	0.0001	Autocorrelation detected
Jarque-Bera (JB)	40,723.71	<0.001	Residuals are non-normal
Skewness	1.27	-	Moderate skew
Kurtosis	4.04	-	Heavy-tailed distribution
Heteroskedasticity (H)	1,961.33	<0.001	Variance is not constant

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Autoregressive Influence & Mean Reversion

The significant first-order (AR(1)) and second-order (AR(2)) autoregressive terms indicate that past levels of engagement strongly influence future engagement. This suggests that if a hashtag gains traction, it is likely to continue receiving attention in the short term. However, the negative coefficients on these terms imply mean reversion. This aligns with observed trends in climate activism discussions, where engagement peaks during significant strike event days and then gradually normalizes over time.

Residual Variance & External Shocks

The significant error variance ($\sigma^2 = 0.543$) suggests that while the ARIMA model captures much of the temporal structure, there is substantial unexplained variability. This indicates that external shocks, such as major climate protests, media coverage, or policy announcements, introduce unpredictable spikes in hashtag engagement. These findings reinforce the role of FFF strikes as exogenous drivers of online climate discussions, where engagement levels experience abrupt, event-driven increases beyond what historical trends would predict.

Autocorrelation in Residuals (Ljung-Box Test)

The presence of significant autocorrelation in residuals suggests that hashtag engagement exhibits temporal dependence, meaning that momentum effects exist: engagement spikes tend to persist for a short period before gradually fading. This cyclical behavior indicates that hashtag engagement may follow engagement waves, where public discourse temporarily intensifies before cooling down, only to be reactivated by new events or campaigns.

Non-Normal Residuals (Jarque-Bera Test)

The distribution of residuals shows a moderate skew (1.27), indicating that engagement is prone to extreme spikes, likely driven by FFF protests and related activism. The kurtosis (4.04) suggests the presence of heavy tails, meaning that engagement surges are more extreme and frequent than expected under a normal distribution. This suggests that while daily engagement fluctuates within a stable range, significant events can create highly disproportionate bursts of activity.

Heteroskedasticity (ARCH Test)

The ARCH test confirms that variance in hashtag engagement is not constant over time, meaning that some periods exhibit significantly higher volatility than others. This aligns with the idea that major events can lead to sudden and intense engagement spikes, whereas normal periods see relatively stable and predictable engagement levels.

4.3 Retention Trends and Movement Sustenance

The Kaplan-Meier survival analysis was employed to estimate the retention probability of participants across phases of the FFF movement, providing insights into how many users remained engaged over time. Retention is crucial for understanding the sustained commitment of participants, as well as the overall continuity within the movement. To analyze retention trends in FFF participation, the study segments the movement's timeline into four distinct phases, based on key global climate strike dates: March 15, September 20, and December 6, 2019. These dates represent major moments of mobilization and allow us to assess how engagement evolves before, during, and after these high-visibility events. In order to quantify how many participants remained active across consecutive phases of the FFF movement, the number of retained users was calculated using the following equation:

$$R_i = T_{i-1} \cap T_i$$

Where:

- R_i : The number of retained users transitioning from Phase $i-1$ to Phase i.

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- T_{i-1} : The set of users active in Phase $i-1$.
- T_i: The set of users active in Phase i

The above calculation identifies the participants who consistently contributed to the movement's discourse by tweeting during consecutive phases. For example, for the transition from Phase 1 to Phase 2:

$$R_2 = T_1 \cap T_2$$

Here:

- T_1 : Represents all participants active during Phase 1 (beginning to March 15, 2019).
- T_2 : Represents all participants active during Phase 2 (March 16, 2019, to September 20, 2019).
- R_2: Represents the participants who were active in both Phase 1 and Phase 2.

The equation finds the overlap between T_1 and T_2, giving the number of participants who remained active during the transition. In addition to this, retention rates were calculated by comparing the number of users retained between two phases to the total number of users in the current phase, as follows:

$$Retention\ Rate = \frac{R_i}{|T_i|}$$

Where:

- R_i : Number of retained users between Phase $i-1$ to Phase i.
- $|T_i|$: Total number of participants in Phase i

Retention Rates Across Phases:

The analysis of retention rates highlights a critical dynamic between the emergence of new participants and the retention of existing users.

Table 4: Retention Rates Across Different FFF Strike Phases

Phase Transition	**Retained Users** (R_i)	**Total Users in Phase** ($\|T_i\|$)	**Retention Rate (%)**
Phase 1 to Phase 2	**227**	**652**	**34.8%**
Phase 2 to Phase 3	**1535**	**8920**	**17.2%**
Phase 3 to Phase 4	**608**	**6415**	**9.47%**

The movement demonstrated a significant capacity to attract new participants across different phases, with Phase 3 witnessing the highest influx of 8,920 new users, reflecting the movement's expanding reach and influence. However, this surge in new participants was coupled with a steady decline in the retention of older participants. Retention rates dropped notably from 34.8% between Phase 1 and Phase 2 to 17.2% between Phase 2 and Phase 3, and further to just 9.47% between Phase 3 and Phase 4. Interestingly, the sharp decline to 17.2% between Phase 2 and Phase 3 occurred despite Phase 3 overlapping with the Global September Strikes (Wahlström et al., 2020), one of the most significant climate mobilization events. This decline highlights the persistent challenge of sustaining participant engagement even during periods of heightened global climate activism.

The distribution of common tweeters across phases further reinforces the declining engagement trend observed in the survival analysis. Out of 13,101 total participants, the majority (11,011; 84%) engaged in only one phase, while 1,731 (13.2%) participated in two, and 359 (2.7%) remained active across three phases. Notably, only 34 users (0.26%) consistently tweeted

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throughout all four phases, highlighting the high dropout rates and the difficulty of sustaining long-term engagement within the FFF movement.

The Kaplan-Meier survival analysis further illustrates the likelihood of participants continuing their engagement with the FFF movement across the four phases. Each phase corresponds to a key strike date or period of activity, and survival is defined as participants (measured via tweets) who remained active in the movement over time.

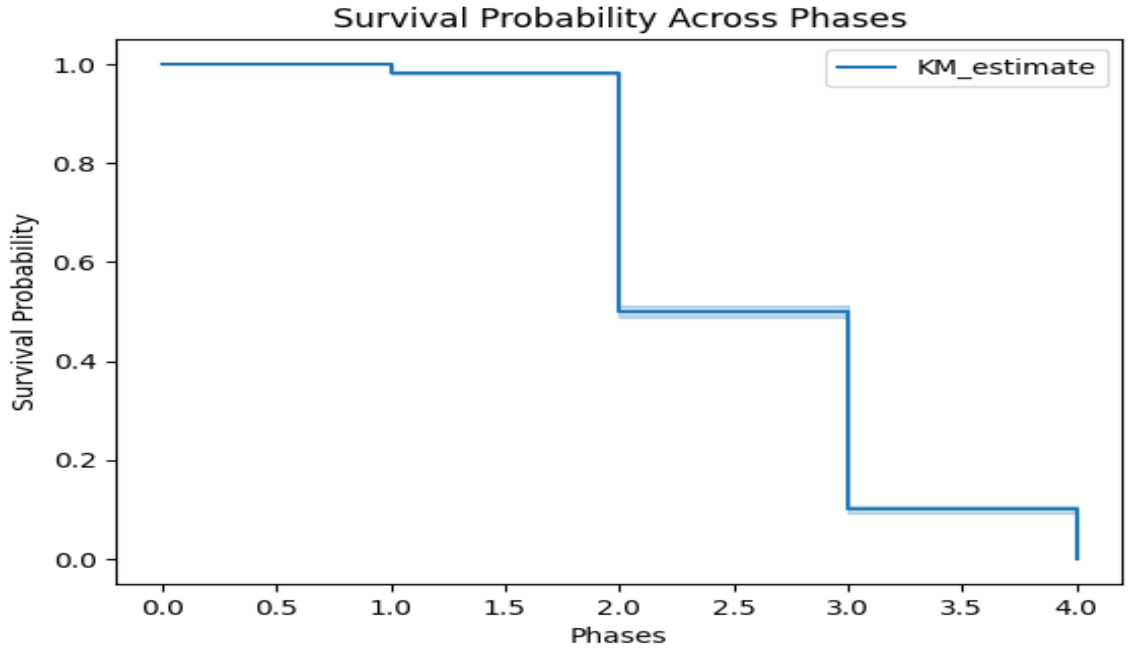

Figure 2: Survival Probabilities for Different FFF Strike Phases

The survival curve starts at 100% in Phase 1, capturing all initial participants, but engagement declines sharply over time. The most significant drop occurs between Phase 2 and Phase 3, following the September 20 strike, with an even steeper decline from Phase 3 to Phase 4, where survival probabilities approach near zero. Retention rates further highlight this trend: 34.8% of Phase 1 participants remained in Phase 2, but retention dropped to 17.2% between Phases 2 and 3, despite one of the largest global strikes in September 2019. The decline continued from Phase 3 to Phase 4, falling to just 9.47%, illustrating the transient nature of engagement and the challenge of sustaining long-term participation within the FFF movement.

4.4 Keyword Engagement Analysis

The final layer of analysis examined keyword-level engagement to understand what thematic elements drew the most public attention. It analyzed public engagement with climate protest-related content on Twitter by examining how frequently used keywords correlated with total engagement (likes, retweets, replies). From a dataset of the top 300 keywords used, we calculated the average engagement per keyword and standardized these scores using z-scores. A z-score above 1.96 indicates that the keyword's engagement level is statistically significant at a 95% confidence level ($p < 0.05$), meaning it is not due to random variation. The analysis revealed 13 keywords that were significantly more engaging than others. These included *demand*, *chicago*, *young*, *boston*, *berniesanders*, *actnow*, *unga*, *nation*, *must*, *government*, *gretathunberg*, *narendramodi*, and *delhi*.

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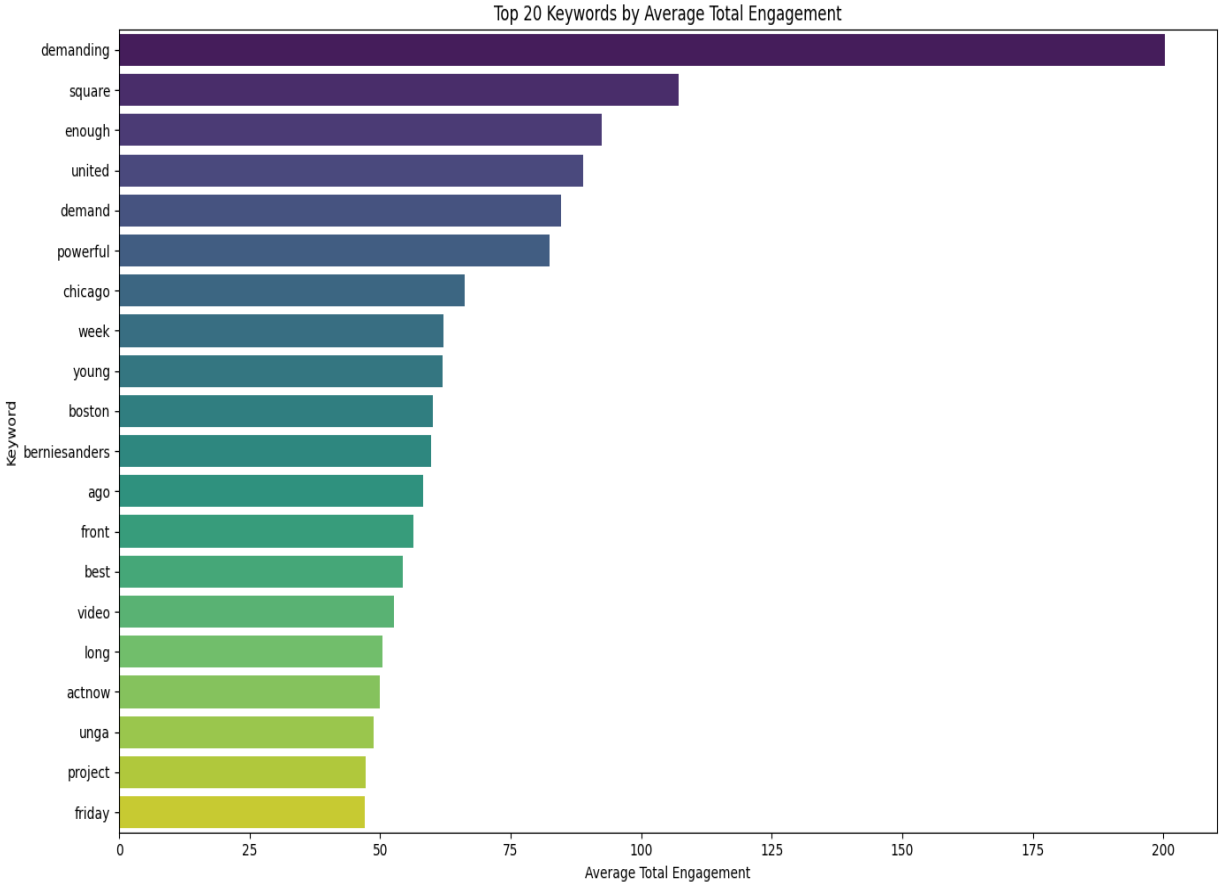

Figure 3: Top 20 keywords by Average Total Engagement

These keywords indicate a mix of high-frequency protest terms, geographically anchored references, and personalized political identifiers. For instance, *demand* (z = 5.6) was the most engaging, highlighting the power of moral urgency and protest-centric language. Local references like *chicago*, *boston*, and *delhi* point to the role of localized identities in boosting digital visibility. The presence of *young* reflects the centrality of youth framing in the Fridays for Future (FFF) movement. The names of public figures like *berniesanders*, *gretathunberg*, and *narendramodi* suggest that associating content with influential leaders can enhance its digital traction. Similarly, institutional terms like *government* and *nation* emphasize that tweets holding institutions accountable tend to receive higher public engagement

5. Discussion

This study offers compelling empirical evidence that Fridays for Future (FFF) strikes serve as critical flashpoints for digital engagement around climate issues. Patterns of heightened retweets, likes, and mentions were observed in direct alignment with global strike days. Crucially, when tweets containing FFF-specific hashtags such as *#FridaysForFuture*, *#ClimateStrike*, and *#ClimateAction* were removed, the observed spikes in engagement disappeared, demonstrating that the surges were not coincidental but directly tied to FFF's mobilization efforts. A statistical comparison between strike and non-strike days confirmed this, revealing significantly higher engagement during protest events. These findings support prior research that positions FFF as a

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key driver of online mobilization and climate discourse (Haßler et al., 2021; Fernández-Zubieta et al., 2023).

However, the data also expose the temporal limitations of this engagement. Despite impressive mobilization during strike periods, digital activity quickly tapered off, returning to baseline levels within days. This reinforces a common pattern in digital activism, its episodic nature. While FFF successfully captures public attention during protest events, maintaining sustained online discourse remains a challenge. The short-lived spikes suggest that visibility is momentarily high but often fails to carry forward into ongoing awareness or advocacy.

To explore whether any persistence exists beyond these spikes, we applied time-series analysis using an ARIMA(5,1,0) model. This revealed that engagement dynamics are not entirely isolated incidents; rather, each strike has some residual influence on subsequent events. For instance, elevated engagement on September 20 may have contributed to the momentum observed on September 27. This temporal dependency, confirmed by significant autoregressive (AR) terms and the Ljung-Box test, suggests that tightly spaced strike events can help sustain engagement over brief intervals. Thus, digital campaigns might benefit from clustering mobilizations to build on residual attention.

Still, the volatility of digital attention remains a constraint. The presence of heteroskedasticity in the data indicates unstable variance in engagement, likely driven by external amplifiers like media coverage, influencer endorsements, or parallel news cycles. Notably, the December 6 strike, which followed previous high-engagement actions, saw markedly lower activity. This suggests that repeated calls to action may lead to diminishing returns or what could be termed *engagement fatigue*. The implication is clear: digital movements must innovate in their strategies if they are to break out of this boom-and-bust cycle.

Beyond participation surges, another crucial question is whether these digitally engaged users remain involved over time. Kaplan-Meier survival analysis provides insight into retention patterns across strike phases. The results are stark: while each phase attracted new participants, only a small fraction remained active across multiple events. From an initial retention of 34.8% between Phase 1 and 2, participation dropped to just 17.2% in the next phase, and by Phase 4, only 9.47% of users continued. In fact, 84% of users participated in only one phase, and a mere 0.26% stayed engaged throughout all four phases. This trajectory illustrates the transient nature of digital activism, where high visibility does not equate to enduring commitment.

These trends reflect broader dynamics of digital participation. Social media provides a low-cost avenue for expressing solidarity, tweeting, sharing hashtags, or liking climate content, yet this form of engagement often lacks depth. As previous studies have shown, the ease of online participation can lead to *moral gratification* or *symbolic action* (Bennett & Segerberg, 2011b; Howard, 2011). While users may feel they've contributed meaningfully by participating in highly visible ways, such actions frequently do not translate into sustained activism or deeper involvement. This study reinforces those findings: despite strong surges of support, FFF struggles to convert episodic digital engagement into a cohesive activist base. The movement appears to rely heavily on attracting new participants for each mobilization, which brings vitality but hinders continuity (Fisher & Nasrin, 2020).

Yet, this transience should not be dismissed as superficial. Instead, such participation may serve as an *entry point* into the climate movement, an initial touchpoint through which individuals become aware of climate issues. Recognizing this potential can help shape strategies that

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transition symbolic involvement into sustained activism. Understanding how to bridge this gap remains a crucial challenge for youth-led climate movements like FFF.

An important contribution of this study is its exploration of how language shapes engagement. Keyword-level analysis revealed that certain terms attracted significantly higher interaction. Statistically significant keywords: such as *demand*, *actnow*, *must*, *government*, *unga*, *gretathunberg*, and *narendramodi*, offer more than surface-level insights. They align closely with established framing strategies from communication theory. For instance, *demand* and *must* invoke moral urgency, while *government* and *nation* reflect institutional critique. Names like *gretathunberg* personalize the movement, while place-names like *delhi* localize abstract global concerns. These patterns underscore that public engagement is not random. It validates the role of intentional framing and vocabulary choices in digital activism. When FFF and its supporters deploy such terms, they are not just rallying slogans. They are constructing the architecture of public discourse consciously.

From a strategic standpoint, these findings have actionable implications. Movements can amplify their digital visibility by aligning their language with terms that consistently attract attention. The fact that keywords reflect a blend of moral, institutional, individual, and geographic frames illustrates FFF's capacity to adapt its message to different audiences. The use of both *berniesanders* and *narendramodi* demonstrates this ideological and national flexibility. This adaptability likely contributes to the movement's global reach, helping it resonate across political contexts.

In summary, this study confirms that FFF has effectively leveraged digital platforms to mobilize global attention, particularly during key protest events. Yet, its influence is characterized more by intense, short-lived spikes than sustained digital engagement. The episodic nature of this participation raises important questions about how digital climate movements can evolve toward long-term mobilization. As the climate crisis intensifies, understanding the mechanisms that drive not just awareness but enduring commitment will be crucial for transforming fleeting engagement into lasting systemic change.

6. Conclusion and Contributions

This study demonstrates that the FFF movement effectively catalyzes short-term spikes in climate-related discourse on Twitter, particularly around globally synchronized strike events. These surges in engagement underscore the movement's capacity to mobilize digital publics; however, the patterns are predominantly episodic. As user activity clusters around specific strike dates and dissipates shortly afterward, it reflects broader concerns about the transience of online activism and the limits of symbolic participation. These issues have been long noted in the literature on hashtag and digital protest movements (Benkler et al., 2018; McCright & Dunlap, 2011).

Despite this limitation, FFF's framing strategies appear to be both deliberate and impactful. Keywords such as *actnow*, *government*, and *gretathunberg* were associated with high engagement, signaling a framing approach that blends moral urgency and institutional accountability. This finding aligns with earlier work by McAdam et al. (1996) and Capstick et al. (2014), which emphasize the role of effective narrative framing in movement success. The moral-institutional framing adopted by FFF likely contributes to its visibility, especially among younger demographics who resonate with personalized calls to action (Fabel et al., 2022).

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However, this engagement does not take place in a neutral space. The online climate discourse remains deeply polarized. As previous studies have shown, digital platforms are rife with ideological backlash, hate speech, and misinformation barriers. Such barriers can weaken public trust in climate science and activists alike (Falkenberg et al., 2022; Arce-García et al., 2023). FFF, like many modern climate movements, must navigate these fragmented digital ecosystems while striving to sustain moral legitimacy and long-term mobilization.

Methodologically, this study contributes to the field by combining semantic network analysis with engagement metrics and user retention tracking. Rather than stopping at surface-level hashtag analytics, it dives deeper into how framing and keyword choice relate to public engagement and how these relationships persist/fail over time. This integrated approach offers empirical backing for theoretical perspectives on digital activism, framing, and movement sustainability (McAdam, 2003; Buzogány et al., 2022).

In essence, this research adds to ongoing debates about the strengths and fragilities of digital climate activism. FFF has demonstrated that emotionally resonant, youth-led communication can ignite global conversations. But as attention spans shorten and digital noise increases, sustaining engagement will require more than moral clarity, it will demand strategic framing, cross-ideological outreach, and new hybrid models of organizing that link online surges with offline, grounded mobilization (McCarthy & Zald, 1977; Reyes-Menendez et al., 2018).

7. Future Work and Limitations

This study opens several threads for further exploration, some of which, admittedly, became evident only as the analysis unfolded. One of the key questions that still lingers is: how can we sustain engagement beyond short-lived peaks during climate strikes? While the data clearly capture moments of collective digital energy, the challenge lies in converting those bursts into ongoing participation. There's also scope to understand how engagement varies across geographies. Though this study takes a global perspective, it doesn't fully unpack the regional contexts that might shape digital climate discourse differently in, say, developed versus developing nations. Political climates, media ecosystems, and cultural values all subtly influence how environmental messages land. So, examining these variations, perhaps using comparative network analysis or localized content clustering. Such analysis could offer richer insight into what makes climate messaging resonate in different places. Another area that could be pushed further is the role of message framing and event sequencing. The way a message is phrased may affect whether people stick around or drop off after a protest wave. Studying how different styles of communication influence retention could provide valuable lessons for climate movements trying to balance awareness-raising with long-term momentum.

That said, the study is not without its limitations. A significant one, to be honest, is that it doesn't distinguish between tweets by core activists and those by the broader public. While this allows for a wide lens, it blurs the lines between deliberate strategy and organic conversations by public in general. Future work might address this by incorporating metadata, verified user tags, or activist-curated account lists to better trace where messaging originates and how it diffuses.

References

1. Abaddi, S. (2024). Forecasting social media engagement: an ARIMA-based approach. *International Journal of Agile Systems and Management*, *1*(1). https://doi.org/10.1504/ijasm.2024.10067382

Citation: Pant, L. (2025). Climate Strikes in the Digital Age: Public Engagement in the Fridays for Future Twitter Discourse. *International Insurance Law Review*, 33 (S5), 213-229.

2. Allen, D. E., & McAleer, M. (2018). Fake news and indifference to scientific fact: President Trump's confused tweets on global warming, climate change and weather. *Scientometrics*, *117*(1), 625–629. https://doi.org/10.1007/s11192-018-2847-y
3. Arce-García, S., Díaz-Campo, J., & Cambronero-Saiz, B. (2023). Online hate speech and emotions on Twitter: a case study of Greta Thunberg at the UN Climate Change Conference COP25 in 2019. *Social Network Analysis and Mining*, *13*(1). https://doi.org/10.1007/s13278-023-01052-5
4. Benkler, Y., Faris, R. and Roberts, H. (2018) *Network propaganda*, *Oxford University Press eBooks*. https://doi.org/10.1093/oso/9780190923624.001.0001.
5. Bennett, W. L., & Segerberg, A. (2011). DIGITAL MEDIA AND THE PERSONALIZATION OF COLLECTIVE ACTION. *Information Communication & Society*, *14*(6), 770–799. https://doi.org/10.1080 /136 9118x.2011.579141
6. Bird, S., Klein, E. and Loper, E. (2009) *Natural Language Processing with Python*. O'Reilly Media.
7. Blanz, A. (2023). Climate-related Agricultural Productivity Losses through a Poverty Lens. *arXiv (Cornell University)*. https://doi.org/10.48550/arxiv.2310.16490
8. Blazhevski, I. (2022). ETHICAL CONSIDERTIONS IN USAGE OF TWITTER DATA. *SCIENCE International Journal*, *1*(1), 27–32. https://doi.org/10.35120/sciencej010127i
9. Boulianne, S., Lalancette, M., & Ilkiw, D. (2020). "School Strike 4 Climate": Social media and the international youth protest on climate change. *Media and Communication*, *8*(2), 208–218. https://doi.org/10.17645/mac.v8i2.2768
10. Buzogány, A., & Scherhaufer, P. (2022). Framing different energy futures? Comparing Fridays for Future and Extinction Rebellion in Germany. *Futures*, *137*, 102904. https://doi.org/10.1016 /j.futures .2022.102904
11. Capstick, S., Whitmarsh, L., Poortinga, W., Pidgeon, N., & Upham, P. (2014). International trends in public perceptions of climate change over the past quarter century. *Wiley Interdisciplinary Reviews Climate Change*, *6*(1), 35–61. https://doi.org/10.1002/wcc.321
12. Chesterton, H. (2024). Crackdowns and coalitions: The relationship between repression, factionalism, and movement survival. *Global Change Peace & Security*, 1–26. https://doi.org/10.1080/147811 58.2024.2405144
13. Ciocirlan, C., & Pettersson, C. (2011). Does Workforce Diversity Matter in the Fight against Climate Change? An Analysis of Fortune 500 Companies. *Corporate Social Responsibility and Environmental Management*, *19*(1), 47–62. https://doi.org/10.1002/csr.279
14. De Moor, J., De Vydt, M., Uba, K., & Wahlström, M. (2020). New kids on the block: taking stock of the recent cycle of climate activism. *Social Movement Studies*, *20*(5), 619–625. https://doi.org/10.1080 /14742837.2020.1836617
15. Fabel, M., Flückiger, M., Ludwig, M., Waldinger, M., Wichert, S., & Rainer, H. (2022). The Power of Youth: Political impacts of the "Fridays for Future" movement. *SSRN Electronic Journal*. https://doi.org/10.2139 /ssrn.4106055
16. Falkenberg, M., Galeazzi, A., Torricelli, M., Di Marco, N., Larosa, F., Sas, M., Mekacher, A., Pearce, W., Zollo, F., Quattrociocchi, W., & Baronchelli, A. (2022). Growing polarization around climate change on social media. *Nature Climate Change*, *12*(12), 1114–1121. https://doi.org/10.1038/s41558-022-01527-x
17. Fernández-Zubieta, A., Guevara, J. A., Roldan, R. C., & Robles, J. M. (2023). Digital Activism Masked—The Fridays for Future Movement and the "Global Day of Climate Action": testing

Citation: Pant, L. (2025). Climate Strikes in the Digital Age: Public Engagement in the Fridays for Future Twitter Discourse. *International Insurance Law Review*, 33 (S5), 213-229.

social function and framing typologies of claims on Twitter. *Social Sciences*, *12*(12), 676. https://doi.org/10.3390/socsci12120676

18. Firouzjaei, H. A. (2022). Survival analysis for user disengagement prediction: question-and-answering communities' case. *Social Network Analysis and Mining*, *12*(1). https://doi.org/10.1007/s13278-022-00914-8
19. Fisher, D. R. (2019). The broader importance of #FridaysForFuture. *Nature Climate Change*, *9*(6), 430–431. https://doi.org/10.1038/s41558-019-0484-y
20. Fisher, D. R., & Nasrin, S. (2020). Climate activism and its effects. *Wiley Interdisciplinary Reviews Climate Change*, *12*(1). https://doi.org/10.1002/wcc.683
21. Fletcher, C., Ripple, W. J., Newsome, T., Barnard, P., Beamer, K., Behl, A., Bowen, J., Cooney, M., Crist, E., Field, C., Hiser, K., Karl, D. M., King, D. A., Mann, M. E., McGregor, D. P., Mora, C., Oreskes, N., & Wilson, M. (2024). Earth at risk: An urgent call to end the age of destruction and forge a just and sustainable future. *PNAS Nexus*, *3*(4). https://doi.org/10.1093/pnasnexus/pgae106
22. Haßler, J., Wurst, A., Jungblut, M., & Schlosser, K. (2021). Influence of the pandemic lockdown on Fridays for Future's hashtag activism. *New Media & Society*, *25*(8), 1991–2013. https://doi.org/10.1177/ 14614448211026575
23. Howard, P. N. (2011). The Net Delusion: The Dark Side of Internet Freedom. by Evgeny Morozov. New York: PublicAffairs, 2011. 432p. $27.95. *Perspectives on Politics*, *9*(4), 895–897. https://doi.org/10.1017 /s1537592711004014
24. McAdam, D. *et al.* (1996) *Comparative perspectives on social movements*, *Cambridge University Press eBooks*. https://doi.org/10.1017/cbo9780511803987.
25. McAdam E. by M.D. and D. (2003) *Social movements and networks : relational approaches to collective action*. http://ci.nii.ac.jp/ncid/BA61767893.
26. McCarthy, J. D., & Zald, M. N. (1977). Resource Mobilization and Social Movements: A Partial theory. *American Journal of Sociology*, *82*(6), 1212–1241. https://doi.org/10.1086/226464
27. McCright, A. M., & Dunlap, R. E. (2011). The Politicization of climate change and polarization in the American public's views of global warming, 2001–2010. *Sociological Quarterly*, *52*(2), 155–194. https://doi.org/10.1111/j.1533-8525.2011.01198.x
28. Pollex, J., & Berker, L. E. (2024). The European Parliament and Fridays for Future: analysing reactions to a new environmental movement by Europe's climate policy champion. *Journal of European Integration*, 1–18. https://doi.org/10.1080/07036337.2024.2334079
29. Reyes-Menendez, A., Saura, J. R., & Alvarez-Alonso, C. (2018). Understanding #WorldEnvironmentDay user opinions in Twitter: A Topic-Based Sentiment Analysis approach. *International Journal of Environmental Research and Public Health*, *15*(11), 2537. https://doi.org/10.3390/ijerph15112537
30. Spaiser, V., Nisbett, N., & Stefan, C. G. (2022). "How dare you?"—The normative challenge posed by Fridays for Future. *PLOS Climate*, *1*(10), e0000053. https://doi.org/10.1371/journal.pclm.0000053
31. Thunberg, G. (2021) *No one is too small to make a difference*. National Geographic Books.
32. Tufekci, Z. (2019). A response to Johanne Kübler's A Review of Zeynep Tufekci – Twitter and Tear Gas: The Power and Fragility of Networked Protest (2017, New Haven: Yale University Press). *International Journal of Politics Culture and Society*, *32*(3), 365–369. https://doi.org/10.1007/s10767-019-9317-2

Citation: Pant, L. (2025). Climate Strikes in the Digital Age: Public Engagement in the Fridays for Future Twitter Discourse. *International Insurance Law Review*, 33 (S5), 213-229.

33. Wahlström, M., de Moor, J., Uba, K., Wennerhag, M., De Vydt, M., Emilsson, K., Johansson, H., Zamponi, L., & et al. (2020). *Protest for a future II: Composition, mobilization and motives of the participants in Fridays For Future climate protests on 20-27 September, 2019, in 19 cities around the world.* Centre for Open Science. https://doi.org/10.17605/OSF.IO/ASRUW

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