Concerned About Climate Change? Assessing and Evaluating Climate Actions Awareness Among Citizens For Accountability of Government and Policy Makers Efforts

Anonymous ACL submission

Abstract

Climate change is reflected in extreme and uncertain weather events, the melting of glaciers, the spreading of diseases, and crop failure leading to threats to food security. Climate change poses serious challenges for humanity itself. Citizens, Corporations, Governments, Local bodies and Policymakers need to come up with innovative solutions to address the climate change problems from several dimensions, one of the dimensions is to make people aware amount climate change and its impact. But without citizen's behavioural changes, climate change actions are not possible. There is a need for innovative quantification and objective methods to assess, monitor and evaluate the citizens' engagement, discussion and direction of information flow regarding Climate actions so that the government's and policymakers' efforts can have course corrections if needed. This research work proposes an innovative approach and methodology to assess climate action discourses through social media public discussion, and engagement using the integration of advanced NLP, sentiment analysis, and machine learning models in spatial and temporal domains. The experiment is designed to evaluate the climate action feedback of Indian citizens over social media space from 2015 to 2020. The study unravels noteworthy insights with year 2020 stands out with the highest engagement score of 1.6672, suggesting a significant increase in overall engagement. In 2021, the engagement score remains high at 1.6666, almost similar to the previous year. However, the Momentum Score of 0.7107 suggests a substantial positive momentum, signifying a notable recovery or increase in engagement compared to the previous year. The proposed research provides insights, directions and new ways to explore climate action research for policymakers and government officials for future courses of action.

1 Introduction

Climate change, a threat to the existence of humanity, is primarily attributed to global warming and the burning of fossil fuels(Wuebbles and Jain, 2001). Climate change impact is felt globally in increasing frequency and intensity of extreme weather events, increasing risks of new virus outbreaks and pandemics, rising sea levels etc(McMichael and Lindgren, 2011) resulting in threats to food security, livelihood and socio-economic systems across the globe specifically in coastal communities(Hernández-Delgado, 2015). To address these challenges and control climate change impact and consequences, The global governance forums and community have asked countries to achieve nationally determined commitments (NDC). NDCs are reported by countries internationally to show their progress and commitment to addressing climate change(Hsu et al., 2021). Primarily, climate change efforts are aligned with a major target of bringing global temperatures below 1.5 degrees from the pre-industrialised period as per IPCC recommendations(Smith et al., 2009). This requires to adoption of policies, programmes and future direction of growth and awareness to achieve NetZero. Each country is designing its own industrial and growth policy, especially climate change and action awareness programs for the citizens, companies and institutions to achieve NetZeor.

Without citizens' involvement and their contribution in terms of changes in mindset lifestyle and discourses around them, the success of climate actions is not possible. Governments and other stakeholders are attempting to change the behaviour of citizens' products and services, consumption patterns and lifestyles to promote sustainability to achieve climate change goals(Berquier and Gibassier, 2019). Awareness and behavioural changes depend on the constant information flow

and feedback and accountability of climate actions among citizens and between stakeholders(Newell et al., 2022). Such a scenario requires developing innovative methodologies to assess climate action progress objectively in a quantitative manner and their impact on citizens' space. This requires assessment and gauging of citizens' engagement about climate actions and government efforts to align the climate efforts and course corrections and set the accountability. Present-day digital technologies and social media have penetrated our daily lives and are reflections of our thinking as we express our views, opinions, and suggestions and share them with the masses instantly(Pirhonen et al., 2020). So Social media data is a rich resource to gauge public opinion about any issue nowadays and has been used in many sectors such as elections, marketing, business promotions, etc(Duan et al., 2023). However, there is a lack of research work to gauge public opinions and their understanding and behaviour change patterns about climate actions. The significance of Twitter as a real-time information hub is underscored by its role in disseminating opinions, news, and discussions on pressing issues. The following are contributions of research work.

1. This research work proposes an innovative approach and methodology to assess climate action discourses, public discussions, and engagement over Twitter.

2. Research work analyses social media data for climate action awareness among citizens spatially and temporally.

3. The experiment uses India's social media space for climate action efforts from 2015 to 2020. India as one of the most populated and vulnerable countries has been taken in the experiment.

4. Research work proposes an innovative model using advanced NLP techniques and machine learning approaches together with topic modelling and sentiment analysis by harnessing the wealth of unstructured social media data on Twitter.

5. The proposed research leads us towards the objectives and quantifiable assessment of climate action efforts and accountable insights among citizens for policymakers and government officials for future courses of action.

2 Literature Survey

Existing research and developments highlight the connections between the social identity approach to the psychology of climate change(Mackay et al., 2021). Segerberg et al. used online and social media campaigns specifically for the awareness of climate change efforts and evaluated those campaigns (Segerberg, 2017). This research was only limited to designed campaigns and their assessment. Brink et al. experimented with extensive surveys on citizen engagement in climate adaptation, focusing on the role of values, worldviews, gender and place of the citizens etc(Brink and Wamsler, 2019). Haro-de-Rosario et al, applied social media to enhance citizen engagement with local government for the improvement of governance services. It was not an assessment study but an intervention assessment study(Haro-de Rosario et al., 2018). Piselli et al designed an experiment to apply social media data to evaluate awareness about the energy communities using online news and digital platform data(Piselli et al., 2022). Mia et al research work presented a measure of climate actions using assessment data of ten megacities(Mia et al., 2018). Roxburgh et al studied the characterising of climate change discourse on social media during extreme weather events(Roxburgh et al., 2019). Hamid et al explored social media for environmental sustainability awareness in the higher education domain(Hamid et al., 2017). Shakeela et al research explored understanding tourism leaders' perceptions and their opinion of risks from climate change and presented an assessment of policymaking processes in the Maldives. In this research work, they proposed a social amplification of risk framework (SARF) (Shakeela and Becken, 2015). Walter et al evaluated the impact of attempts to correct health misinformation on social media using a meta-analysis approach (Walter et al., 2021). Criado et al. used collaborative technologies and social media data to engage citizens and governments during the COVID-19 Crisis in Spain (Criado et al., 2020). Few researchers also used social media data in politics for assessing party politics, values the design of social media services and implications of political elites' values and ideologies to mitigate political polarisation through design(Grön and Nelimarkka, 2020). Daga et al experimented with integrating citizen experiences in cultural heritage archives: requirements, state of the art, and challenges (Daga et al., 2022). Hubert, Rocío B

et al analyzed and visualised government-citizen interactions on Twitter to support public policy-making(Hubert et al., 2020). Similar studies have been conducted in several domains and they have significantly helped the knowledge and stakeholders. However, it acknowledges the challenges in capturing the broader societal understanding and support for climate initiatives. Some studies are event-specific and some are region-specific and have limitations in terms of scalability, real-time data collection, and the ability to capture nuanced sentiments. To address this gap, the proposed research aims to leverage social media platforms for assessing citizen engagement in climate action efforts. By employing ML and NLP techniques, the study aims to extract meaningful insights from large volumes of social media data. The research work specifically addresses the following questions what are the key themes and trends in the progression of climate change discourse in India from 2015 to 2020? How has the sentiment surrounding climate change in tweets originating from India evolved over the 6 years, and what factors contribute to these changes? What is the sentiment polarity distribution in tweets related to climate change, and how does it vary across different regions and demographics within India? What is the frequency of tweets discussing climate change in India over the specified time frame, and are there notable peaks or troughs in response to specific events or policy changes? What are the significant components within climate change-related tweets, such as prevalent hashtags, linguistic patterns, and user engagement, and how do these contribute to shaping public discourse on climate change in India?

3 Experimentation and Proposed Model

3.1 Problem Formulation

Suppose, there is N number of social media posts from Twitter represented as set $D = \{d_1, d_2.....d_N\}$. Here d_i represents one particular instance of post/information. Let the social media posts and content be given a set again with several features $F = \{F_1, F_2....F_M\}$ respectively. Here N represents the total number of stories/social media posts etc in the data set and N represents the number of attributes in each post. The calculated values are determined after doing feature engineering and designing a new formula. Mathematically,

$$A = F[D = \{d_1, d_2.....d_N\}] \quad (1)$$

Where F is the awareness score/engagement function using inherent social media post features and hashtags and associated metrics such as likes, retweets, comments etc. Additionally, there are other assessment metrics also which have been used such as polarity and word cloud etc.

3.2 Dataset and Description

A large dataset of tweets related to climate actions is collected using Twitter API and Hashtags such as #ClimateChange, #GlobalWarming, #ClimateAction, #ClimateCrisis, #ClimateJustice, #Sustainability, #ClimatePolicy, #RenewableEnergy, #GreenNewDeal, #CarbonFootprint, #ClimateEmergency, #ClimateScience, #ParisAgreement, #CleanEnergy, #ClimateAdaptation, #EcoFriendly, #ZeroEmissions, #ClimateSolutions, #ClimateResilience, #ActOnClimate. This dataset includes tweets, user information, timestamps, tweet-related text, engagement metrics, likes, comments, quotes, retweets etc.

3.3 Proposed Methods and Approaches

The proposed research model applies advanced computational and quantitative approaches together with NLP techniques. Techniques such as tokenization, lemmatization, and stop word removal are applied to extract and unveil prevalent themes in the Twitter data about climate change discourse in India. The model also analyses the sentiment expressed in tweets related to climate change in India. With advanced computational and quantitative approaches together with NLP techniques, the model also analyses the sentiment expressed in tweets related to climate change in India and the proposed for determination of awareness/engagement score. The proposed model evaluates the Engagement Value(E) by designing a novel formulation for climate actions defined as.

$$E = \frac{\alpha * L + \beta * R + \theta * C + \lambda * CS}{N} \quad (2)$$

In this equation,α, β and θ are weights assigned to the features from the post which include likes(L), retweets(R) and comment(C) to reflect their importance. Similarly, our experiment calculates the momentum of the climate actions among citizens and is calculated as follows.

$$G = \frac{(WeightEngagement) * (EngagementScore) + (Weigh}{} \quad (3)$$

In this formulation, weights are assigned to each component/factor to reflect their importance based on the significance you attribute to engagement, trend analysis, and post-frequency.

Additionally, advance sentiment analysis of climate actions was performed using customised model based on VADER (valence-aware dictionary and sentiment Reasoner) which is a pre-built sentiment analysis model designed for social media text. It utilises a combination of a sentiment lexicon and grammatical rules to assess the sentiment of a piece of text. VADER is particularly adept at handling nuanced expressions, slang, and emoticons commonly found in social media language. It provides a sentiment polarity score for text, indicating the positivity, negativity, or neutrality of the content. In the VADER sentiment analysis model, an initial step involves generating sentiment scores for positive, negative, neutral, and compound sentiments. Following this, tweets are categorised into positive, negative, or neutral classes based on the compound value. If the compound score is less than -0.5, the tweet is labelled as negative; if the score falls between -0.5 and 0.5, it is considered neutral, and if the score exceeds 0.5, the tweet is classified as positive.

4 Result and Discussions

The analysis revealed dynamic shifts in climate change discourse on Twitter in India (2015-2020). Identified topics encompassed environmental policies, natural events, and public awareness campaigns. Figure 1 depicts climate change and actions-related trends from 2015 to 2023. [h] A collective word cloud for each year from 2015 to 2020 was generated to visually represent the predominant themes in citizen discussion around climate actions as depicted in Figure 2, 3, 4, 5, 6 and 7. Notably, terms such as "warm", "climate" and "change " emerged prominently, underscoring the importance of climate change. Strikingly, "environ" for "environment" appeared with the largest font size, indicating its significance within the dataset. Further collective word clouds of individual years are also generated. Furthermore, another word cloud for year (2015-2020) was generated specifically to capture positive responses for climate change. Here

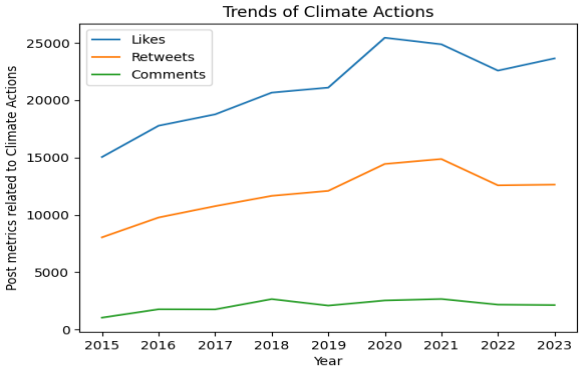

Figure 1: Plot depicting climate change and actions-related trends from 2015 to 2023.

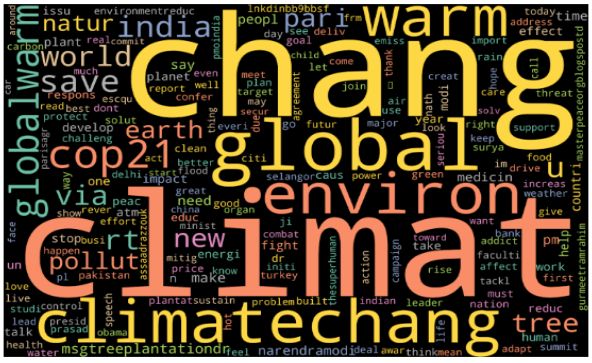

Figure 2: Collective Word Cloud (2015)

Figure 3: Collective Word Cloud (2016)

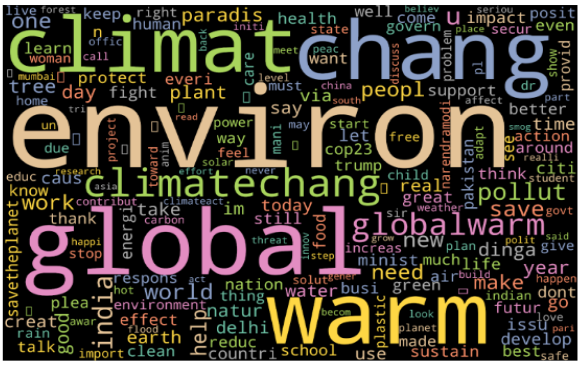

Figure 4: Collective Word Cloud (2017)

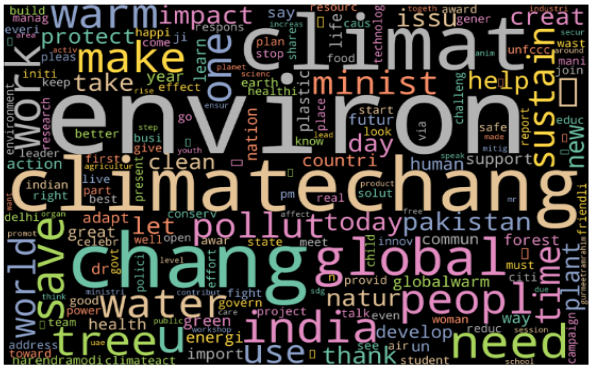

Figure 5: Collective Word Cloud (2018)

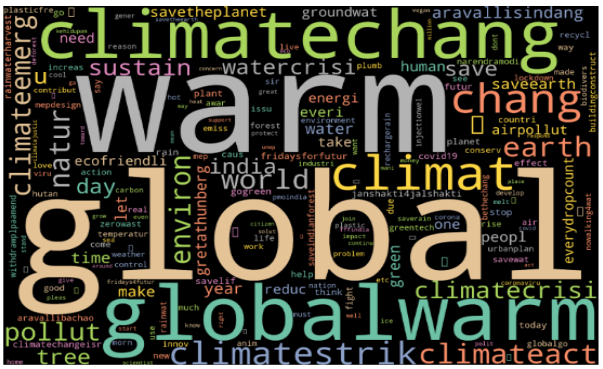

Figure 7: Collective Word Cloud (2020)

Figure 6: Collective Word Cloud (2019)

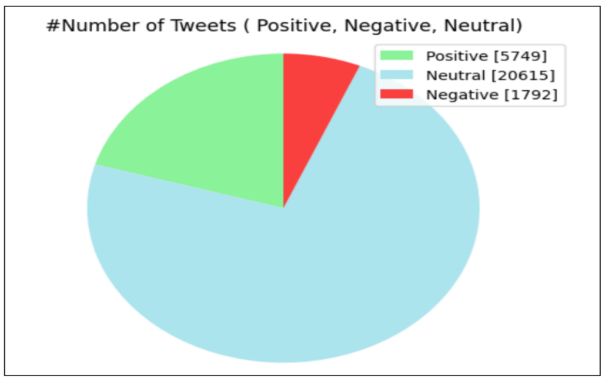

Figure 8: Representation of Citizens in Number of Tweets (Positive, Negative, Neutral) (2015-2020) in climate awareness.

we can see words like "sustain", "save" and "environ" with large font size indicating their importance in the positive discussion related to climate change. Further positive word clouds of individual years are also generated. The word cloud for the year (2015-2020) dedicated to negative sentiments emerged as a little smaller among the positive, neutral, and negative word clouds. The presence of terms such as "global warm," "threat," and "destroy" in this cloud dictates the gravity of adverse reactions and responses within the dataset. Further negative word clouds of individual years are also generated. For instance, 20.42% of the tweets were classified as Positive, 73.22% as Neutral, and 6.36% as Negative, providing an overview of the sentiment dynamics within the analysed dataset related to climate actions awareness(Figure 8). For instance, in 2015, out of 6,407 tweets, 967 (15.09%) were positive, 395 (6.17%) were negative, and 5,045 (78.74%) were neutral, offering insights into the sentiment distribution across the specified years. The average length of tweets for the total period from 2015 to 2020 is 104 characters, and the average word count per tweet is 14. Results in Figures showcases the most positively engaged tweets related to climate change over the span of 2015 to 2020. It provides insight into the content, sentiment, and themes of the top 50 tweets that garnered positive responses during this period, offering a snapshot of impactful and resonant messages within the Twitter climate change discourse. Here Figure 11 illustrates the

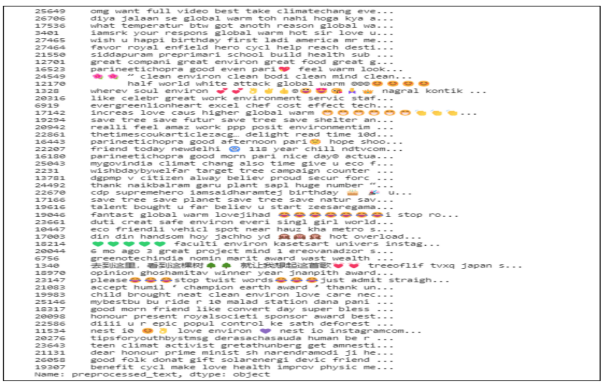

Figure 9: Top 50 Positive Tweets (2015-2020)

distribution of sentiment scores in a dataset. Three KDE plots depict the probability density of "Positive" (green), "Negative" (red), and "Neutral" (yellow) sentiments. The x-axis represents sentiment

Figure 10: Top 50 Negative tweets(2015-2020)

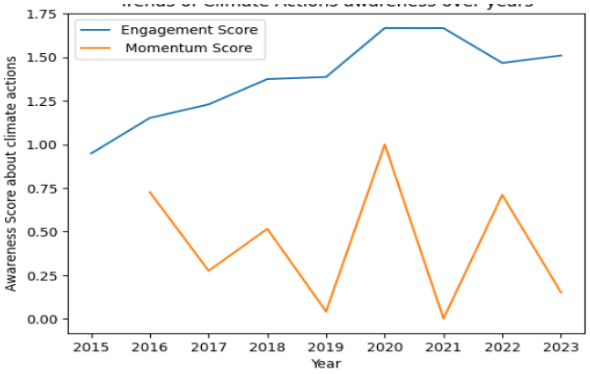

Figure 13: Engagement and momentum score of climate actions over the years

values, and the shaded areas convey the estimated probability density. Clear distinctions emerge between the sentiment categories, providing insights into the dataset's sentiment distribution.

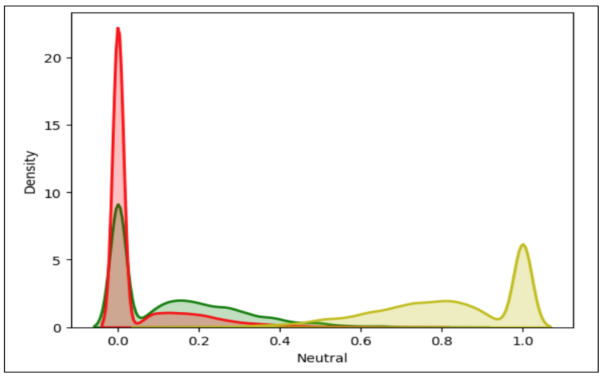

Figure 11: Visualising Sentiment Scores Of Positive, Neutral And Negative Tweets

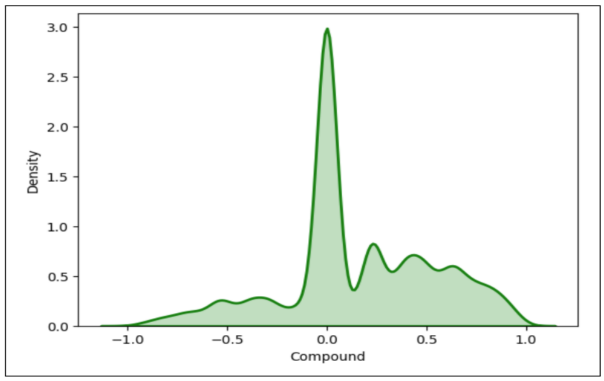

Figure 12: Visualisation of Sentiment Score

The Figure 13 displays a visual representation of sentiment scores across the dataset. The visualization provides a comprehensive overview of the distribution and patterns in sentiment, aiding in the interpretation of sentiment dynamics in the context of climate change discourse. Figure 11 illustrates the distribution of sentiment scores of all combined data sets and their intensity by depicting the probability density of "Positive" (green), "Negative" (red), and "Neutral" (yellow) sentiments. It reflects that negative sentiment is intense. The neutral sentiments are as intense as positive tweets. It shows that negative citizens are highly negative and positive and neutral opinions of citizens are average in terms of polarity of intensity. Figure 13 demonstrates the engagement and momentum score of the climate action from 2015 to 2023. Engagement in climate actions among the citizens is increasing but there is slightly more engagement in 2020 and 2021.

Quantitatively, In 2017, the engagement score 1.2296, indicating a relatively high level of engagement compared to other years. The momentum score of 0.2760 suggests a moderate increase in engagement from the previous year, indicating a positive trend. The engagement score increases to 1.3746 in 2018, indicating a higher overall engagement compared to the previous year. The Momentum Score of 0.5167 suggests a substantial increase in engagement momentum, indicating a notable positive trend. 2020 stands out with the highest engagement score of 1.6672, suggesting a significant increase in overall engagement. The momentum score of 1.0000 indicates a maximum positive momentum, signifying a substantial and impactful change in engagement from the previous year.

5 Conclusion

The study unravels noteworthy insights into the climate change discourse on Twitter in India from 2015 to 2020. The collective word cloud highlighted "environ" for "environment" with the largest font size. Positive sentiment was associ-

ated with words like "sustain," "save," and "environ," while negative sentiment featured terms like "global warm," "threat," and "destroy." The study unravels noteworthy insights into the climate change discourse on Twitter in India from 2015 to 2023. Neutral tweets dominated, followed by positive and negative sentiments tweets. Year 2020 stands out with the highest engagement score of 1.6672, suggesting a significant increase in overall engagement. In 2021, the engagement score remains high at 1.6666, almost similar to the previous year. However, the Momentum Score of 0.7107 suggests a substantial positive momentum, signifying a notable recovery or increase in engagement compared to the previous year. In 2023, the engagement score increases to 1.5098, suggesting a rebound in overall engagement. These scores can provide insights into trends and patterns helping stallholders understand the awareness and state of climate actions. These findings contribute to understanding the multifaceted nature of climate change discussions on social media, offering insights for policymakers and communicators aiming to engage with diverse perspectives and enhance climate change communication strategies. This study can be applied in any country and regional national groups such as G7 and G20 countries, applying the same methodology to unveil comparative trends in climate change discourse. It helps in investigation of regional variations in sentiment, engagement, and key themes to contribute a global perspective.

References

Roger Berquier and Delphine Gibassier. 2019. Governing the "good citizen" and shaping the "model city" to tackle climate change: Materiality, economic discourse and exemplarity. *Sustainability Accounting, Management and Policy Journal*, 10(4):710–744.

Ebba Brink and Christine Wamsler. 2019. Citizen engagement in climate adaptation surveyed: The role of values, worldviews, gender and place. *Journal of cleaner production*, 209:1342–1353.

J Ignacio Criado, Ariana Guevara-Gómez, and Julián Villodre. 2020. Using collaborative technologies and social media to engage citizens and governments during the covid-19 crisis. the case of spain. *Digital Government: Research and Practice*, 1(4):1–7.

Enrico Daga, Luigi Asprino, Rossana Damiano, Marilena Daquino, Belen Diaz Agudo, Aldo Gangemi, Tsvi Kuflik, Antonio Lieto, Mark Maguire, Anna Maria Marras, et al. 2022. Integrating citizen experiences in cultural heritage archives: requirements, state of the art, and challenges. *ACM Journal on Computing and Cultural Heritage (JOCCH)*, 15(1):1–35.

Huijue Kelly Duan, Miklos A Vasarhelyi, Mauricio Codesso, and Zamil Alzamil. 2023. Enhancing the government accounting information systems using social media information: An application of text mining and machine learning. *International Journal of Accounting Information Systems*, 48:100600.

Kirsikka Grön and Matti Nelimarkka. 2020. Party politics, values and the design of social media services: Implications of political elites' values and ideologies to mitigating of political polarisation through design. *Proceedings of the ACM on human-computer interaction*, 4(CSCW2):1–29.

Suraya Hamid, Mohamad Taha Ijab, Hidayah Sulaiman, Rina Md. Anwar, and Azah Anir Norman. 2017. Social media for environmental sustainability awareness in higher education. *International Journal of Sustainability in Higher Education*, 18(4):474–491.

Arturo Haro-de Rosario, Alejandro Sáez-Martín, and María del Carmen Caba-Pérez. 2018. Using social media to enhance citizen engagement with local government: Twitter or facebook? *New media & society*, 20(1):29–49.

Edwin A Hernández-Delgado. 2015. The emerging threats of climate change on tropical coastal ecosystem services, public health, local economies and livelihood sustainability of small islands: Cumulative impacts and synergies. *Marine Pollution Bulletin*, 101(1):5–28.

Angel Hsu, John Brandt, Oscar Widerberg, Sander Chan, and Amy Weinfurter. 2021. Exploring links between national climate strategies and non-state and subnational climate action in nationally determined contributions (ndcs). In *Making Climate Action More Effective*, pages 39–53. Routledge.

Rocío B Hubert, Elsa Estevez, Ana Maguitman, and Tomasz Janowski. 2020. Analyzing and visualizing government-citizen interactions on twitter to support public policy-making. *Digital Government: Research and Practice*, 1(2):1–20.

Caroline ML Mackay, Michael T Schmitt, Annika E Lutz, and Jonathan Mendel. 2021. Recent developments in the social identity approach to the psychology of climate change. *Current Opinion in Psychology*, 42:95–101.

Anthony J McMichael and Elisabet Lindgren. 2011. Climate change: present and future risks to health, and necessary responses. *Journal of internal medicine*, 270(5):401–413.

Parvez Mia, James Hazelton, and James Guthrie. 2018. Measuring for climate actions: a disclosure study of ten megacities. *Meditari Accountancy Research*, 26(4):550–575.

Peter Newell, Freddie Daley, and Michelle Twena. 2022. *Changing our ways: Behaviour change and the climate crisis*. Cambridge University Press.

Jari Pirhonen, Luciana Lolich, Katariina Tuominen, Outi Jolanki, and Virpi Timonen. 2020. "these devices have not been made for older people's needs"–older adults' perceptions of digital technologies in finland and ireland. *Technology in Society*, 62:101287.

C Piselli, A Fronzetti Colladon, L Segneri, and AL Pisello. 2022. Evaluating and improving social awareness of energy communities through semantic network analysis of online news. *Renewable and Sustainable Energy Reviews*, 167:112792.

Nicholas Roxburgh, Dabo Guan, Kong Joo Shin, William Rand, Shunsuke Managi, Robin Lovelace, and Jing Meng. 2019. Characterising climate change discourse on social media during extreme weather events. *Global environmental change*, 54:50–60.

Alexandra Segerberg. 2017. Online and social media campaigns for climate change engagement. In *Oxford Research Encyclopedia of Climate Science*.

Aishath Shakeela and Susanne Becken. 2015. Understanding tourism leaders' perceptions of risks from climate change: An assessment of policy-making processes in the maldives using the social amplification of risk framework (sarf). *Journal of Sustainable Tourism*, 23(1):65–84.

Joel B Smith, Stephen H Schneider, Michael Oppenheimer, Gary W Yohe, William Hare, Michael D Mastrandrea, Anand Patwardhan, Ian Burton, Jan Corfee-Morlot, Chris HD Magadza, et al. 2009. Assessing dangerous climate change through an update of the intergovernmental panel on climate change (ipcc)"reasons for concern". *Proceedings of the national Academy of Sciences*, 106(11):4133–4137.

Nathan Walter, John J Brooks, Camille J Saucier, and Sapna Suresh. 2021. Evaluating the impact of attempts to correct health misinformation on social media: A meta-analysis. *Health communication*, 36(13):1776–1784.

Donald J Wuebbles and Atul K Jain. 2001. Concerns about climate change and the role of fossil fuel use. *Fuel processing technology*, 71(1-3):99–119.