

# **Analysis of the potential of NLP techniques to identify climate change themes in Canadian social media textual content**

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## Abstract

Social media discussions about climate change offer valuable insights into how the public views climate issues and their willingness to engage in personal climate actions. Understanding individual climate actions is crucial because households are responsible for more than 70% of global carbon emissions, and lifestyle changes alone can reduce carbon emissions by approximately 15%. This research examines 17926 textual entries from two Canadian subreddits (r/ClimateCrisisCanada, r/AskACanadian) from January 2023 to December 2024 to identify individual activities and behaviours associated with greenhouse gas (GHG) emissions discussed in Canadian climate discourse, addressing this gap in understanding authentic climate behavior priorities. We employed BERTopic (Bidirectional Encoder Representations from Transformers for topic modelling) in three configurations: baseline class-based Term Frequency-Inverse Document Frequency (c-TF-IDF), Maximal Marginal Relevance (MMR) diversity optimization, and KeyBERT semantic enhancement. This multi-configuration approach was essential because individual climate behaviors are discussed using diverse terminology and overlapping contexts, requiring different analytical lenses to capture the full spectrum of behavioral discussions without missing nuanced distinctions. Thematic analysis revealed that Canadians predominantly discuss four key behavioural domains in climate discourse: energy management (representing the largest category with 3-6 topics depending on model configuration), transportation choices (consistently 2 topics across all models), dietary decisions (2-3 topics), and consumption patterns (1 topic focused primarily on waste management and recycling). Energy discussions proved most diverse, encompassing residential heating solutions, renewable energy adoption, and nuclear power preferences, whilst transportation maintained remarkable consistency across models with distinct themes of sustainable mobility options and vehicle technology transitions. The comparative modelling approach demonstrated that different BERTopic configurations capture complementary aspects of climate behaviour discourse, with KeyBERT's semantic enhancement providing the most detailed categorization of technical solutions. These findings provide empirical evidence for understanding Canadian individual climate action priorities, offering essential insights for targeted climate policy and communication strategies.

**Keywords:** climate behavior, social media analysis, topic modeling, BERTopic, individual climate action, Canadian climate discourse.

## 1. Introduction

Climate change has become one of the most pressing challenges of the 21st century, driven by environmental disruption that affects ecosystems around the world [1]. With global population growth and the continued expansion of industrial activities, greenhouse gas (GHG) emissions have now reached levels that pose serious threats to ecosystems, economic stability, and human welfare across the globe. Given the severity of this crisis, most countries have now committed to the Sustainable Development Goals (SDGs) and are actively pursuing a range of mitigation strategies to address climate change impacts [1]. Effectively addressing this complex crisis necessitates coordinated action across multiple levels, encompassing not only governmental and industrial initiatives but also individual behavioural changes in everyday life. Research indicates that households are responsible for more than 70% of global carbon emissions, with each person generating roughly 6 tons of carbon dioxide (CO<sub>2</sub>) equivalent annually [2]. This significant household contribution highlights the critical importance of individual lifestyle choices in combating climate change [3]. Research demonstrates that lifestyle changes can lead to reductions of approximately 15% in CO<sub>2</sub> emissions [4], with daily choices related to transportation, energy use, food consumption, and waste management directly influencing individual carbon footprints [3].

Canada represents a particularly compelling case study for individual climate behaviour research due to its unique position in global climate discourse. The country maintains one of the highest per-capita emissions rates worldwide whilst experiencing rapid climate impacts, including Arctic warming and extreme weather events such as wildfires and flood [5]. Simultaneously, Canada ranks among the world's top five fossil fuel producers while maintaining international climate commitments [6]. Lloyd and Rhodes note that this creates inherent tensions that influence public discussions about climate responsibility, with organized communication efforts shaping how Canadians think about individual versus collective climate action [6]. For instance, Canada is responsible for 1.5% of global emissions, with approximately 18.8% of emissions in 2017 resulting from residential energy use [7]. This context makes understanding Canadian climate discourse particularly important for identifying how citizens navigate the tension between personal responsibility and systemic change.

However, there remains a critical knowledge gap regarding what individual climate actions Canadians prioritize in their everyday discussions. People's reactions to climate change vary significantly across countries, influenced by personal experiences, cultural backgrounds, and direct exposure to both climate impacts and social pressures [8]. This makes it essential to examine authentic online conversations, as these reveal the practical behaviours people consider most important for addressing climate change rather than what policies suggest they should prioritize.

While previous research has examined climate change discussions across different social media platforms [9, 10], complementary insights have emerged from large-scale survey research employing open-ended questions to understand public climate preferences. Notably, Tvinnereim et al. [11] conducted extensive cross-national surveys revealing how citizens articulate climate policy priorities when given opportunities for open responses. Similarly, Savin et al. [12] demonstrate through analysis of open survey responses across 13 EU countries that public preferences on climate policies often differ from what structured surveys suggest, revealing more nuanced understandings of individual versus collective climate action [12]. These survey-based findings complement social media analysis by providing broader demographic representation, whilst our Reddit-focused approach captures the authentic, unfiltered discussions that emerge in naturalistic online environments. This study addresses a specific gap by focusing on individual climate actions within Canadian social media conversations, providing insights essential for targeted climate communication and policy strategies. While surveys tell us what climate actions people prioritize when directly asked, social media analysis reveals how these actions are naturally discussed, contextualized, and debated in everyday conversations. Social media platforms have become important resources for examining climate-related behaviours and public responses [13], offering access to spontaneous discussions where individuals voice concerns, share personal experiences, and debate potential climate solutions [14, 15]. Reddit emerges as particularly valuable for capturing Canadian climate discourse for several reasons [9]. First, Reddit's subreddit structure enables the analysis of geographically specific conversations (r/AskACanadian, r/ClimateCrisisCanada) that explicitly focus on Canadian perspectives and experiences. Second, Reddit's discussion format encourages more detailed, substantive conversations compared to character-limited platforms like Twitter, allowing for richer exploration of individual climate behaviours and their contextual factors.

Individual climate action encompasses diverse behaviours across multiple domains, each influenced by distinct psychological, social, and structural factors. Hampton and Whitmarsh [3], identified six key domains of individual choice for climate action: food, energy, transport, shopping, influence, and citizenship, emphasizing that effective climate policy requires understanding how individual, social, physical, and political factors combine to shape low-carbon choices in domain-specific ways. Building on this comprehensive framework, the present study examines Canadian climate discussions through topic modelling of individual activities and behaviours spanning these domains. This study addresses the research question: "How do Canadians discuss individual climate actions in authentic online discourse, and what does this reveal about citizen-driven climate behavior priorities?". Our analysis organizes the individual climate behavior topics found through topic modeling into five main areas: transportation, energy, diet, consumption, and lifestyle choices. These five areas are based on established research about individual climate actions, especially Hampton and Whitmarsh's framework [3]. We created specific keyword lists for each area to categorize the topics systematically.

Climate change discussions happen across diverse contexts, from private conversations and social media to scientific journals, news articles, and political debates, demonstrating the issue's pervasive relevance [9]. Text analysis plays a crucial role in helping researchers extract key insights and identify trends from these complex, multi-layered climate conversations [16]. However, analyzing large volumes of textual content can be efficiently addressed using artificial intelligence (AI) methods in a more timely and cost-effective approach [17]. Topic modelling is an unsupervised machine learning technique that helps researchers uncover word patterns without requiring predefined labels [18, 19, 20]. However, traditional topic modelling approaches, such as Latent Dirichlet Allocation (LDA), treat documents as bag-of-words and fail to capture the contextual relationships between terms [21]. To address this limitation, we employ Bidirectional Encoder Representations from Transformers for topic modelling (BERTopic), an advanced approach that utilizes contextual embeddings to identify meaningful topics [22, 23]. BERTopic has demonstrated strong performance in revealing hidden themes within unstructured text, especially in fields like climate change, public health and environmental communication where context matters [9, 21, 22]. The method uses pre-trained transformer models to understand how words relate to their surrounding context, making it particularly suitable for social media analysis, where language tends to be informal and highly variable [9]. We utilized topic modelling to uncover latent themes within the large amount of unstructured textual data sourced from social media [18, 19].

Individual climate behaviours in social media discourse demonstrate multifaceted characteristics that require different analytical perspectives for comprehensive understanding. Each BERTopic configuration captures distinct aspects of how climate behaviours emerge in discourse, necessitating a comparative approach to ensure comprehensive analysis. We employed three BERTopic configurations to compare how different analytical approaches capture individual climate behaviors, as each method reveals distinct aspects that would be missed by a single approach. First, the baseline class-based Term Frequency-Inverse Document Frequency (c-TF-IDF) configuration captures foundational topic structures by identifying the most distinctive terms within each topic cluster. This approach reveals the core vocabulary and primary themes that characterize different behavioural domains, providing essential baseline understanding of how Canadians articulate individual climate actions [24]. Second, the Maximal Marginal Relevance (MMR) configuration optimizes topic diversity and reduces redundancy by ensuring topics remain distinct whilst maintaining comprehensive coverage. This is particularly crucial for climate behaviour analysis, as individual actions often overlap across domains (e.g., energy efficiency affecting both heating and transportation choices). MMR helps identify nuanced behavioural distinctions that might otherwise be conflated [25]. Third, the KeyBERT semantic enhancement configuration improves topic coherence and semantic meaningfulness by leveraging advanced contextual embeddings [25].

By applying computational text analysis to identify how individual climate actions emerge in Canadian discourse, this research has two key objectives. First, to provide empirical evidence of which individual behavioral domains Canadians discuss in authentic online climate conversations. Second, to compare how different topic modeling approaches capture individual climate behaviors, testing three separate BERTopic configurations to determine which method most effectively identifies behavioral discussions within social media climate discourse.

The remainder of this article is structured as follows: Section 2 presents the data description, preprocessing steps, and methodology. Section 3 illustrates the outcomes of experiments conducted to assess topic quality and addresses the research question. Section 4 discusses the final conclusions and future work directions.

## 2. Materials and methods

This section describes three BERTopic configurations designed to identify individual climate behaviours in social media discourse. Individual climate behaviours are often discussed using varied terminology and overlapping contexts that can be missed by a single analytical approach, requiring comparative testing to ensure comprehensive behaviour identification.

### 2.1. Data description

Reddit is a standalone social media platform and discussion website, containing over 100000 user-created communities called subreddits where users can post content and engage in discussions through comments and are identified by the "r/" prefix, with posts limited to 40000 characters each [26]. We collected data using the Python Reddit API Wrapper (PRAW) from January 2023 to December 2024. Our initial dataset comprised both Reddit posts and comments from two publicly available climate-focused subreddits: "r/ClimateCrisisCanada" and "r/AskACanadian". To ensure our dataset captured genuine climate-related discussions from AskCanadian, we applied keyword filtering using climate-related terms: "climate", "emissions", "global warming", "temperature", "footprint", "fuel", "CO<sub>2</sub>", and "GHG". Each document included metadata: Reddit Post\_ID, SubReddit, Created\_utc, Post\_title, Score, Num\_comments, Created\_date, Created\_year, and textual content. Reddit users may not be representative of the broader Canadian population, as social media platforms typically attract specific demographic segments. However, Reddit provides valuable access to organic, unfiltered climate discussions within these online communities. We split longer documents into individual sentences to prevent information loss and improve topic assignment accuracy. After removing duplicates and filtering sentences shorter than 10 words, our final dataset contained 17926 sentences for topic modelling analysis. Due to privacy considerations, this study focuses on textual content rather than user demographic information.

### 2.2. Data preprocessing



Given BERTopic's reliance on contextual embeddings from transformer models, our preprocessing approach was designed to preserve the semantic and syntactic information essential for accurate contextual understanding whilst addressing the specific noise characteristics of Reddit content. Unlike traditional topic modelling approaches that benefit from extensive text normalization, transformer-based models like BERT require minimal preprocessing to maintain their contextual reasoning capabilities [9]. Our preprocessing pipeline focused on essential cleaning steps whilst preserving linguistic context. We used Python's Natural Language Toolkit (NLTK) to remove technical artifacts common in social media content, including URLs, email addresses, and excessive whitespace that could interfere with embedding generation. Emojis were retained where they contributed semantic meaning to climate discussions. Critically, we preserved stop words, punctuation patterns, and grammatical structures that provide contextual cues for BERT's attention mechanisms. Text was converted to lowercase for consistency, but lemmatization and aggressive tokenization were avoided to maintain the natural language structure that transformer models leverage for semantic understanding. This minimal preprocessing approach ensures that contextual relationships between words remain intact, allowing BERTopic to capitalize on BERT's ability to understand nuanced meanings, negations, and conditional statements that are particularly important in climate discourse analysis.

## 2.3. BERTopic methodology

### 2.3.1. BERTopic implementation

We applied BERTopic [23] in two experimental configurations to examine how different approaches affect topic extraction from climate behaviour discussions. BERTopic combines contextual embeddings with clustering techniques to identify meaningful topics while preserving semantic relationships between terms [22, 23]. Table 1 presents the detailed configuration for each experiment, ensuring reproducibility and fair comparison across methods.

Experiment 1 (Baseline): We implemented the standard five-step BERTopic process using class-based Term Frequency-Inverse Document Frequency (c-TF-IDF) without additional representation of refinement. This approach uses "BAAI/bge-small-en-v1.5" for text embedding since it demonstrates strong performance on information retrieval tasks and handles social media text effectively, making it well-suited for analyzing climate discussions from Reddit [27], UMAP for dimensionality reduction, HDBSCAN for clustering, CountVectorizer for tokenization, and c-TF-IDF for topic extraction [9].

Experiment 2 (Enhanced Representations): We added a sixth step using two representation techniques: MMR for diversity optimization and KeyBERT for semantic enhancement. MMR selects diverse keywords to reduce redundancy [25], while KeyBERT leverages BERT embeddings to extract semantically meaningful terms [9].

Table 1. Experimental configuration summary for BERTopic model variations

| Experiment                    | Embedding Model        | UMAP Parameters                                                     | HDBSCAN Parameters                                                                            | Vectorizer                                                                               | Representation Model                        | nr_topics |
|-------------------------------|------------------------|---------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|---------------------------------------------|-----------|
| <b>Experiment 1(Baseline)</b> | BAAI/bge-small-en-v1.5 | n_neighbors=15<br>n_components=5<br>min_dist=0.0<br>metric='cosine' | min_cluster_size=50<br>min_samples=10<br>metric='euclidean'<br>cluster_selection_method='eom' | CountVectorizer<br>(min_df=2,<br>max_df=0.7,<br>ngram_range=(1,2),<br>max_features=5000) | None (c-TF-IDF only)                        | 120       |
| <b>Experiment 2(MMR)</b>      | BAAI/bge-small-en-v1.5 | n_neighbors=15<br>n_components=5<br>min_dist=0.0<br>metric='cosine' | min_cluster_size=50<br>min_samples=10<br>metric='euclidean'<br>cluster_selection_method='eom' | CountVectorizer<br>(min_df=2,<br>max_df=0.7,<br>ngram_range=(1,2),<br>max_features=5000) | MaximalMarginalRelevance<br>(diversity=0.3) | 120       |
| <b>Experiment 3(KeyBERT)</b>  | BAAI/bge-small-en-v1.5 | n_neighbors=15<br>n_components=5<br>min_dist=0.0<br>metric='cosine' | min_cluster_size=50<br>min_samples=10<br>metric='euclidean'<br>cluster_selection_method='eom' | CountVectorizer<br>(min_df=2,<br>max_df=0.7,<br>ngram_range=(1,2),<br>max_features=5000) | KeyBERTInspired                             | 120       |

243

244 The UMAP parameters control dimensionality reduction: n\_neighbors=15 determines the local  
245 neighborhood size for preserving data structure, n\_components=5 reduces the high-dimensional  
246 embeddings to 5 dimensions for efficient clustering, min\_dist=0.0 allows tight clustering by  
247 minimizing distance between similar points, and cosine metric measures similarity based on  
248 document orientation rather than magnitude. The HDBSCAN clustering parameters ensure robust  
249 topic formation: min\_cluster\_size=50 requires at least 50 documents to form a valid topic, filtering  
250 out noise and ensuring meaningful clusters, min\_samples=10 sets the minimum neighborhood  
251 density for core points, euclidean metric measures distance in the reduced dimensional space, and  
252 eom (excess of mass) selection method identifies the most stable clusters. The CountVectorizer  
253 parameters optimize text representation: min\_df=2 excludes terms appearing in fewer than 2  
254 documents to remove rare words, max\_df=0.7 excludes terms appearing in more than 70% of  
255 documents to filter common words, ngram\_range=(1,2) captures both single words and two-word  
256 phrases, and max\_features=5000 limits vocabulary size to the most informative terms. The  
257 complete list of 50 topics identified in each experiment is presented in S1 Table for detailed  
258 examination.

### 259 2.3.2 Traditional metrics and LLM-based evaluation

260 We employed a dual evaluation strategy combining automated metrics with large language model  
261 assessment. Traditional coherence metrics included Normalized Pointwise Mutual Information  
262 (NPMI) and C\_V coherence measures, calculated using the OCTIS framework [28]. NPMI scores  
263 range from -1 to +1, with positive values indicating meaningful semantic relationships. C\_V scores  
264 range from 0 to 1, with higher values signifying superior topic interpretability [29, 30]. Topic  
265 diversity scores measure distinctiveness across the entire topic set [30].



For LLM-based evaluation as a scalable alternative to human expert assessment, we used GPT-4o to assess topic quality using structured prompts adapted from Stambach et al. [31]. Topics were classified into three categories: high-quality (score = 1) showing strong thematic unity, medium-quality (score = 2) demonstrating moderate coherence, and low-quality (score = 3) lacking coherent thematic structure. This dual evaluation approach addresses limitations of purely statistical measures by incorporating semantic understanding that aligns with human interpretation of topic coherence [31]. Below is the structure of the prompt used:

*Evaluate the following topic modeling results. For each topic, classify it as high-quality (score = 1), medium-quality (score = 2), or low-quality (score = 3) based on thematic coherence and interpretability.*

- HIGH (score = 1): Topics showing strong thematic unity with clearly related terms.*
- MODERATE (score = 2): Topics demonstrating moderate coherence with some thematic connection but less precision.*
- LOW (score = 3): Topics lacking coherent thematic structure, with disparate or overly general terms.*

*Format your response as "GPT Quality Score: X (QUALITY\_LEVEL)".*

To improve the model's understanding and reduce ambiguity, example classifications were included:

- Topic: "public, transport, transit, bike, cycling, walk, car, driving, sustainable, mobility" → GPT Quality Score: 1 (HIGH)*
- Topic: "heating, heat, pump, energy, efficient, home, cost, gas, electric, system" → GPT Quality Score: 2 (MODERATE)*
- Topic: "tax, change, rounding, climate, fight, impact, china, stack, changing, skiing" → GPT Quality Score: 3 (LOW)*

## 3. Results and discussion

### 3.1. Model performance comparison

Three BERTopic model configurations were evaluated to identify the optimal approach for extracting individual GHG-related behaviours from Canadian climate change discourse. The baseline model, MMR, and KeyBERT representation models each generated 50 topics and were assessed using both automated metrics and GPT-based quality evaluation. The KeyBERT model demonstrated superior performance across most key metrics. It achieved the highest coherence scores with C\_V coherence of 0.6244 and NPMI coherence of 0.1373, indicating more semantically coherent topic clusters. The KeyBERT model also produced the most reliable topics,

with 3 high-quality topics and no low-quality topics according to GPT evaluation. The MMR model showed competitive performance with a similar average GPT score of 2.04 and produced 3 high-quality topics. However, it exhibited weaker coherence performance (C\_V: 0.5570, NPMI: 0.0580) whilst maintaining reasonable topic diversity at 0.5900. The presence of 1 low-quality topic suggests some inconsistency in topic formation. The baseline model achieved the highest topic diversity at 0.6440, indicating greater distinctiveness between topics, and showed moderate coherence (C\_V: 0.5704, NPMI: 0.0924). However, it produced the most variable quality results with both 2 high-quality and 2 low-quality topics. Based on these results, the KeyBERT model provided the optimal combination of topic coherence, interpretability, and consistency, with no low-quality topics compromising the analysis of specific individual activities and behaviours. Table 2 presents the hyperparameter configurations used across three experiments.

Table 2. BERTopic model performance comparison

|                             | MMR    | KeyBERT | Baseline |
|-----------------------------|--------|---------|----------|
| <b>Topic Diversity</b>      | 0.5900 | 0.4760  | 0.6440   |
| <b>NPMI Coherence</b>       | 0.0580 | 0.1373  | 0.0924   |
| <b>C_V Coherence</b>        | 0.5570 | 0.6244  | 0.5704   |
| <b>High Quality Topics</b>  | 3      | 3       | 2        |
| <b>Medium Quality Topic</b> | 46     | 47      | 46       |
| <b>Low Quality Topics</b>   | 1      | 0       | 2        |

### 3.2. Discourse analysis through word cloud extraction

The word cloud visualization reveals distinct characteristics in how each BERTopic model captures climate discourse patterns (Fig 1). The Baseline model demonstrates a strong institutional focus, with dominant terms like "pbo" (Parliamentary Budget Office), "carney", "rebate", and "inflation" reflecting policy-oriented discussions around Canada's carbon pricing system. In contrast, the MMR and KeyBERT models show enhanced semantic precision and behavioral nuance. The MMR model successfully diversifies topic coverage by balancing environmental urgency terms ("wildfire", "forest fire", "methane") with economic critique vocabulary ("capitalism", "wealth"), while introducing more household-level concepts like "recycled", "plastic", and regional identifiers. KeyBERT produces the most semantically coherent output, clustering around precise climate terminology ("carbon tax", "global warming", "renewable energy") and notably capturing individual-level behavioral language such as "transit", "carbon footprint", "believe climate", and "denying climate."

Fig 1. Word cloud across BERTopic model configurations

### 3.3. Topics directly related to individual activities and behaviours

#### 3.3.1. Baseline BERTopic model performance

The baseline BERTopic model successfully identified 8 topics directly related to individual activities and behaviours from the 50 generated topics. This extraction rate demonstrates that whilst individual-level discussions represent a minority of Canadian climate discourse on Reddit, they constitute a substantial and measurable portion of the conversation. The baseline BERTopic model identified 50 topics in total; however, only 49 are displayed in the grid as Topic -1, representing outlier documents that could not be categorized into coherent topics, was excluded from visualization (Fig 2).

Fig 2. Topic overview grid for Baseline model (c-TF-IDF), displaying 49 topics in a 7×7 layout. Red-highlighted topics represent individual physical activities, while blue topics represent other thematic clusters. Each cell shows the topic ID, document count, and top 10 representative words.

### • **Transport-related activities**

The model captured two distinct transportation themes. Topic 17 focused on sustainable mobility options, highlighting public transportation systems, cycling, and walking as alternatives to private vehicle use. Topic 18 concentrated specifically on vehicle technology transitions, particularly the shift from internal combustion engines to electric and hybrid vehicles. This distinction reveals that Canadian Reddit users discuss both behavioural changes and technological adoption related transport strategies.

### • **Energy-related behaviours**

Energy discussions emerged across three distinct contexts. Topic 14 addressed residential heating and home efficiency measures, reflecting Canada's significant heating demands and the potential for individual energy conservation. Topic 19 focused on heating fuel costs and billing, suggesting that economic considerations drive much of the individual energy discourse. Topic 29 captured discussions about renewable energy technologies, indicating interest in personal adoption of clean energy solutions.

### • **Dietary choices**

Food-related behaviours appeared in multiple contexts, with Topic 3 addressing fundamental dietary choices including plant-based diets and agricultural impacts. Topic 13 specifically examined food economics, linking grocery costs and food pricing to climate considerations. Interestingly, Topic 14 overlapped between diet and energy categories, suggesting interconnected discussions about household resource management.

### • **Consumption patterns**

Topic 1 focused exclusively on waste management and recycling behaviours, particularly around single-use plastics and packaging materials. This singular focus suggests that consumption discussions in Canadian climate discourse concentrate heavily on waste reduction rather than broader purchasing decisions. The category distribution reveals that energy and diet topics each generated three distinct discussion themes, whilst transport produced two focused topics and consumption yielded only one. This pattern suggests that Canadians engage most diversely with energy and food-related climate actions, possibly reflecting the direct household relevance of these behaviours.

## **3.3.2 Enhanced representation models**

The MMR model identified 9 topics related to individual activities, a notably higher extraction rate than the baseline model. This improved coverage suggests that MMR's diversity mechanism successfully reduced topic redundancy whilst preserving distinct individual behaviour discussions. The MMR-enhanced model identified 50 topics in total; however, only 49 are displayed in the grid as Topic -1, representing outlier documents that could not be categorized into coherent topics, and were excluded from visualization (Fig 3).

Fig 3. Topic overview grid MMR-enhanced model, displaying 49 topics in a 7×7 layout. Red-highlighted topics represent individual physical activities, while blue topics represent other thematic clusters. Each cell shows the topic ID, document count, and top 10 representative words.

- **Enhanced energy focus**

The MMR model's most striking feature was its granular breakdown of energy-related behaviours into five distinct topics. Topic 14 maintained focus on residential heating efficiency and cost management, similar to the baseline model. However, MMR uniquely separated broader energy transition discussions (Topic 22) from specific technology adoption conversations. Topic 28 concentrated exclusively on solar panel installation and energy storage systems, whilst Topic 29 addressed renewable energy infrastructure and grid considerations. This detailed segmentation reveals that Canadian energy discussions encompass multiple scales from individual technology choices to systemic energy transitions.

- **Transport categories**

Transport discussions remained split between sustainable mobility (Topic 17) and vehicle technology (Topic 18), mirroring the baseline model's structure. However, MMR's Topic 18 introduced more nuanced language around "driving less" and "efficient vehicle" choices, suggesting the model captured both technological and behavioural dimensions of transport decisions more effectively than the baseline.

- **Streamlined dietary discussions**

MMR consolidated dietary conversations into two primary themes. Topic 3 focused on plant-based diets and agricultural systems, whilst Topic 19 overlapped with energy concerns around heating and fuel costs. Interestingly, the MMR model eliminated the separate food pricing topic present in the baseline, instead of integrating economic considerations into the broader energy-diet overlap topic.

- **Consistent consumption focus**

Like the baseline model, MMR produced a single consumption-focused topic centered on recycling and plastic waste management, though with more detailed terminology around "environmentally friendly" practices and "plastic waste" specifically. The MMR model's strength lies in its detailed energy categorization, potentially reflecting the complexity and diversity of individual energy choices available to Canadians. However, this granularity came at the cost of some dietary discussion of nuance.

The KeyBERT model identified 9 topics related to individual activities. Whilst capturing a similar number of topics to MMR, KeyBERT demonstrated superior semantic coherence and produced the most detailed energy-related categorization of all three models. The KeyBERT-enhanced model identified 50 topics in total; however, only 49 are displayed in the grid as Topic -1, representing outlier documents that could not be categorized into coherent topics, was excluded from visualization (Fig 4).

Fig 4. Topic overview grid KeyBERT-enhanced model, displaying 49 topics in a 7×7 layout. Red-highlighted topics represent individual physical activities, while blue topics represent other thematic clusters. Each cell shows the topic ID, document count, and top 10 representative words. (Continued)

- **Comprehensive energy analysis**

KeyBERT's most distinctive feature was its granular breakdown of energy discussions into six distinct categories, surpassing both baseline and MMR models. The model separated residential heating systems into two focused topics: Topic 14 addressed traditional heating costs and fuel concerns, whilst Topic 15 specifically examined heat pump technology and climate-appropriate heating solutions. This distinction reflects the growing Canadian discourse around heat pump adoption as a climate solution. KeyBERT also uniquely isolated nuclear energy discussions (Topic 30), recognizing the distinct nature of nuclear power conversations in Canadian climate discourse. Topics 22, 28, and 29 systematically separated renewable energy policy discussions, energy storage technology, and wind/solar infrastructure respectively. This comprehensive categorization suggests that KeyBERT's representation approach effectively captured the technical complexity and diversity of individual energy choices available to Canadians.

- **Transport focus**

Transport discussions maintained the familiar split between sustainable mobility options (Topic 17) and vehicle technology transitions (Topic 18). KeyBERT's Topic 17 demonstrated clearer language around "mode transportation" and specific public transport options, whilst Topic 18 focused precisely on vehicle efficiency and electric adoption without the behavioural elements ("driving less") captured by MMR.

- **Consumption and diet categories**

Like the other models, KeyBERT produced a single consumption topic focused on recycling and plastic waste management. The dietary discussions were consolidated into the two heating-related topics (14 and 15), suggesting that KeyBERT recognized the interconnected nature of household resource management rather than treating food and energy as entirely separate domains. KeyBERT's strength lies in its ability to distinguish between different scales and types of energy decisions from individual technological adoption (heat pumps, solar panels) to broader energy system preferences (nuclear, renewables). This nuanced approach provides the most comprehensive view of how Canadians discuss individual energy choices within climate discourse.

### 3.4. Limitations

This study has several limitations that should be acknowledged. First, Reddit's user demographics may not be representative of the broader Canadian population, as the platform tends to attract younger, more tech-savvy users who may hold different views on climate change than the public. This demographic skew potentially limits the generalizability of findings to the wider Canadian population, particularly regarding older age groups or those with limited digital engagement. Second, our analysis focused on a specific period, which may not capture seasonal variations in climate discussions or evolving public discourse over time. Third, the topic modeling approach, whilst effective at identifying discussion themes, relies on word co-occurrence patterns that may miss nuanced contextual meanings or sarcastic comments common in Reddit discourse.

## 4. Conclusion and future studies

This study analyzed 17,926 textual entries from two Canadian subreddits (r/ClimateCrisisCanada, r/AskACanadian) gathered over a three-year period to address a critical research gap: understanding how Canadians articulate and discuss individual GHG-emitting behaviours in online discourse. Using BERTopic topic modelling with three different representation approaches, baseline c-TF-IDF, MMR diversity optimization, and KeyBERT semantic enhancement, we systematically extracted and analyzed behavioural domains to answer: What individual activities and behaviors related to GHG emissions are discussed in Canadian climate change discourse on Reddit?. The comparative modelling approach proved essential, as each configuration revealed different dimensions of climate behaviour discourse. The KeyBERT model demonstrated superior performance with the highest coherence scores (C\_V: 0.6244, NPMI: 0.1373) and produced the most reliable topics with no low-quality classifications.

The analysis revealed that Canadians predominantly discuss four key behavioural domains: energy management (representing the largest category with 3-6 topics depending on model), transportation choices (consistently 2 topics across models), dietary decisions (2-3 topics), and consumption patterns (1 topic focused primarily on waste management and recycling). Transportation discussions consistently emerged across two distinct themes: sustainable mobility options emphasizing public transit, cycling, and walking; and vehicle technology transitions focusing on electric and hybrid adoption. Unlike other behavioural domains that showed variation across models, transportation maintained remarkable consistency in both topic count and thematic structure, suggesting it represents a particularly salient and well-defined area of climate concern for Canadians. Energy discussions proved most diverse, ranging from residential heating solutions and cost considerations to renewable energy adoption and nuclear power preferences. Dietary conversations linked food choices to both environmental and economic concerns, whilst consumption discussions concentrated narrowly on plastic waste and recycling behaviours. The study demonstrated that different BERTopic configurations capture complementary aspects of climate behaviour discourse. KeyBERT's semantic enhancement provided the most detailed categorization of technical energy solutions, whilst baseline and MMR models captured broader contextual factors and practical implementation challenges respectively. Future research should investigate regional variations in climate behaviour discourse, as initial evidence suggests that provincial contexts significantly impact individual climate discussions. Finally, expanding the



analysis to include other Canadian online platforms could provide broader demographic representation beyond Reddit's user.

## Abbreviations

GHG: Greenhouse Gas  
 BERTopic: Bidirectional Encoder Representations from Transformers for topic modeling  
 c-TF-IDF: class-based Term Frequency-Inverse Document Frequency  
 MMR: Maximal Marginal Relevance  
 NPMI: Normalized Pointwise Mutual Information  
 LLM: large language models  
 GPT-4o: Generative Pre-trained Transformer version 4 omni  
 SDGs: Sustainable Development Goals  
 CO<sub>2</sub>: carbon dioxide  
 AI: artificial intelligence  
 NLP: Natural language processing  
 LDA: Latent Dirichlet Allocation  
 PRAW: Python Reddit API Wrapper  
 NLTK: Natural Language Toolkit  
 NMF: Non-Negative Matrix Factorization  
 UMAP: Uniform Manifold Approximation and Projection  
 PCA: Principal Component Analysis  
 HDBSCAN: Hierarchical Density-Based Spatial Clustering of Applications with Noise  
 OCTIS: Optimizing and Comparing Topic models Is Simple

## Data availability statement

The dataset analyzed in this study was collected from Reddit (<https://www.reddit.com/>). The data consists of publicly posted textual content related to climate change. Due to the terms of service of these platforms and ethical considerations regarding user privacy, the dataset supporting the conclusions of this article is included as supplementary material.

## CRedit authorship contribution statement

**Negar Shabanpour:** Conceptualization, Methodology, Software, Formal analysis, Investigation, Data Curation, Writing - Original Draft, Visualization. **Stéphane Roche:** Conceptualization, Methodology, Writing - Review & Editing, Supervision, Project administration, Funding acquisition. **Sehl Mellouli:** Methodology, Writing - Review & Editing, Supervision.

## References

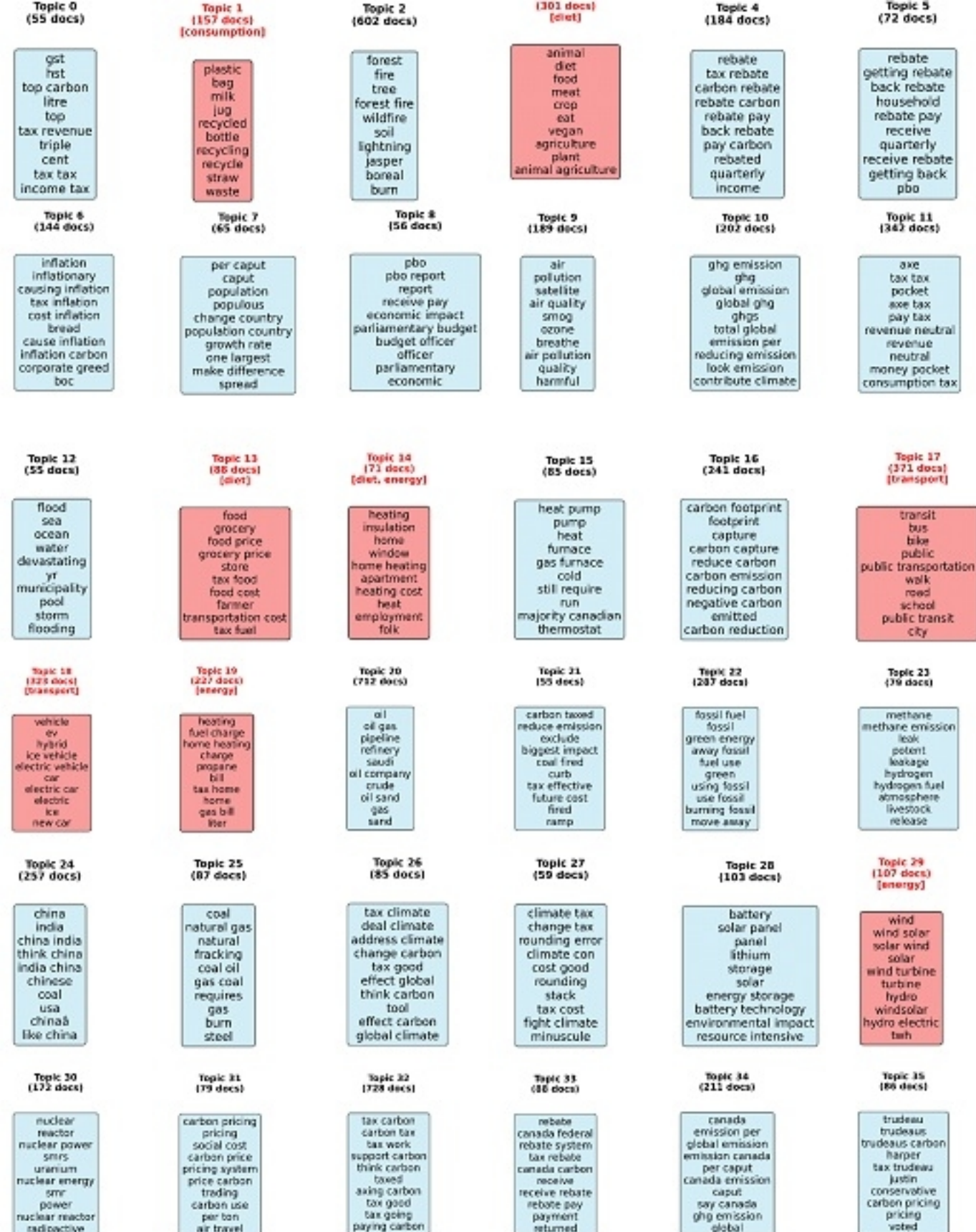
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- S1 Table. Complete list of topics identified in experiments. Detailed breakdown by experiment type and frequency of occurrence.

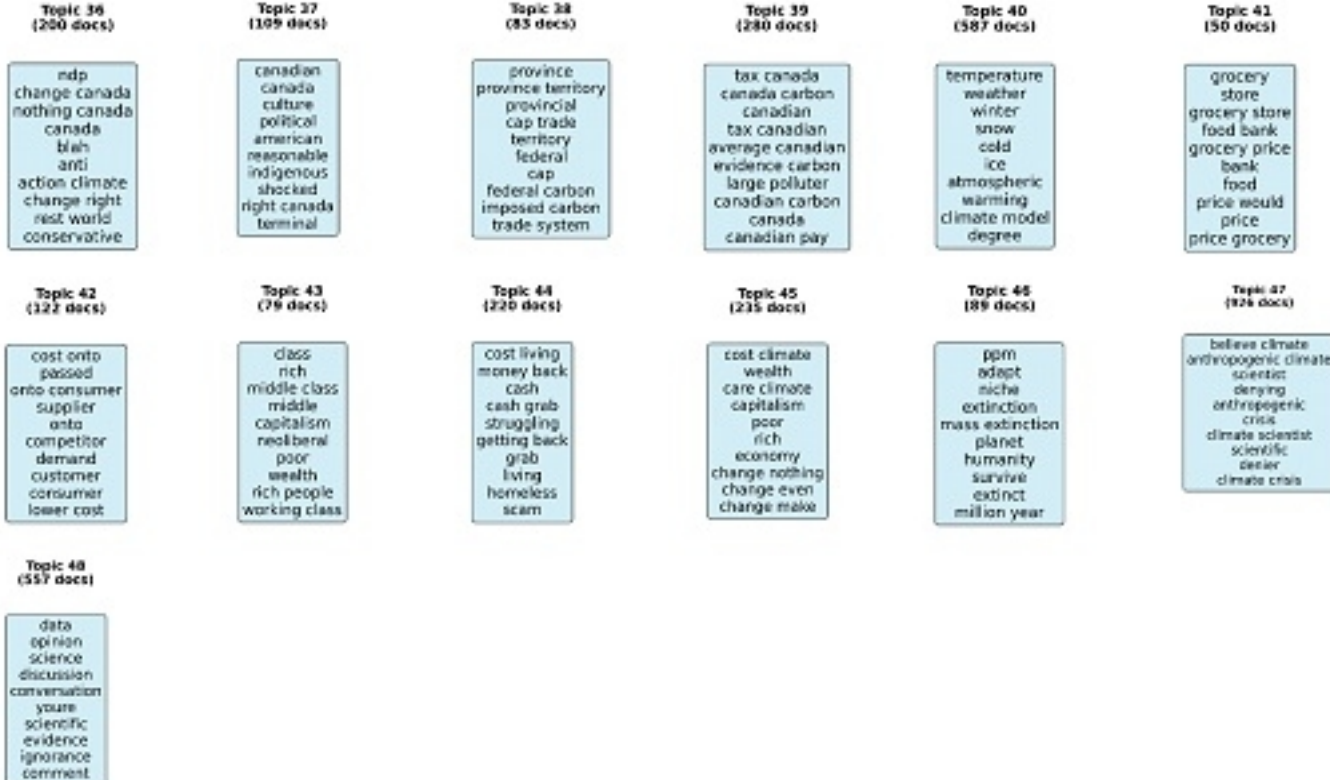




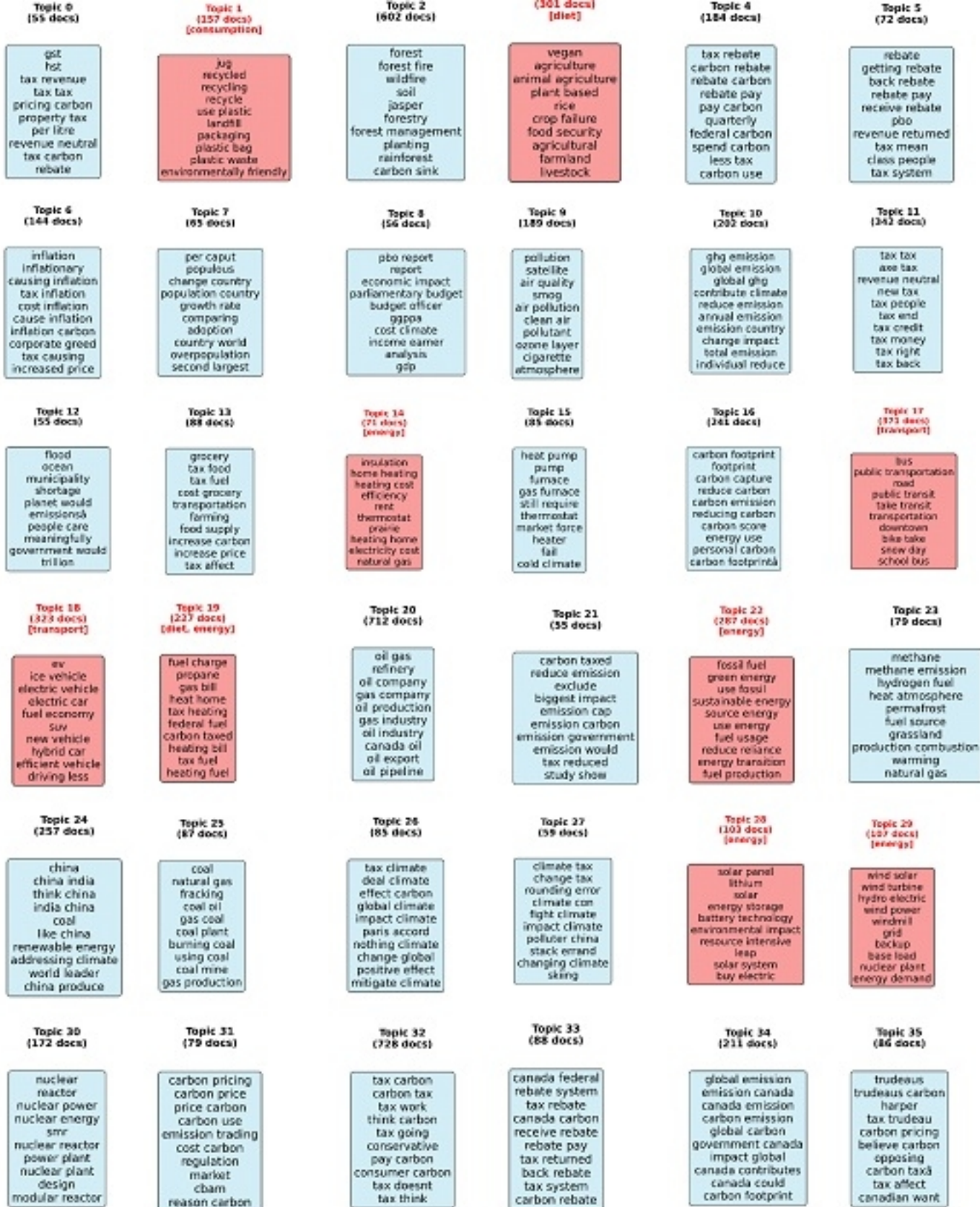


Figure

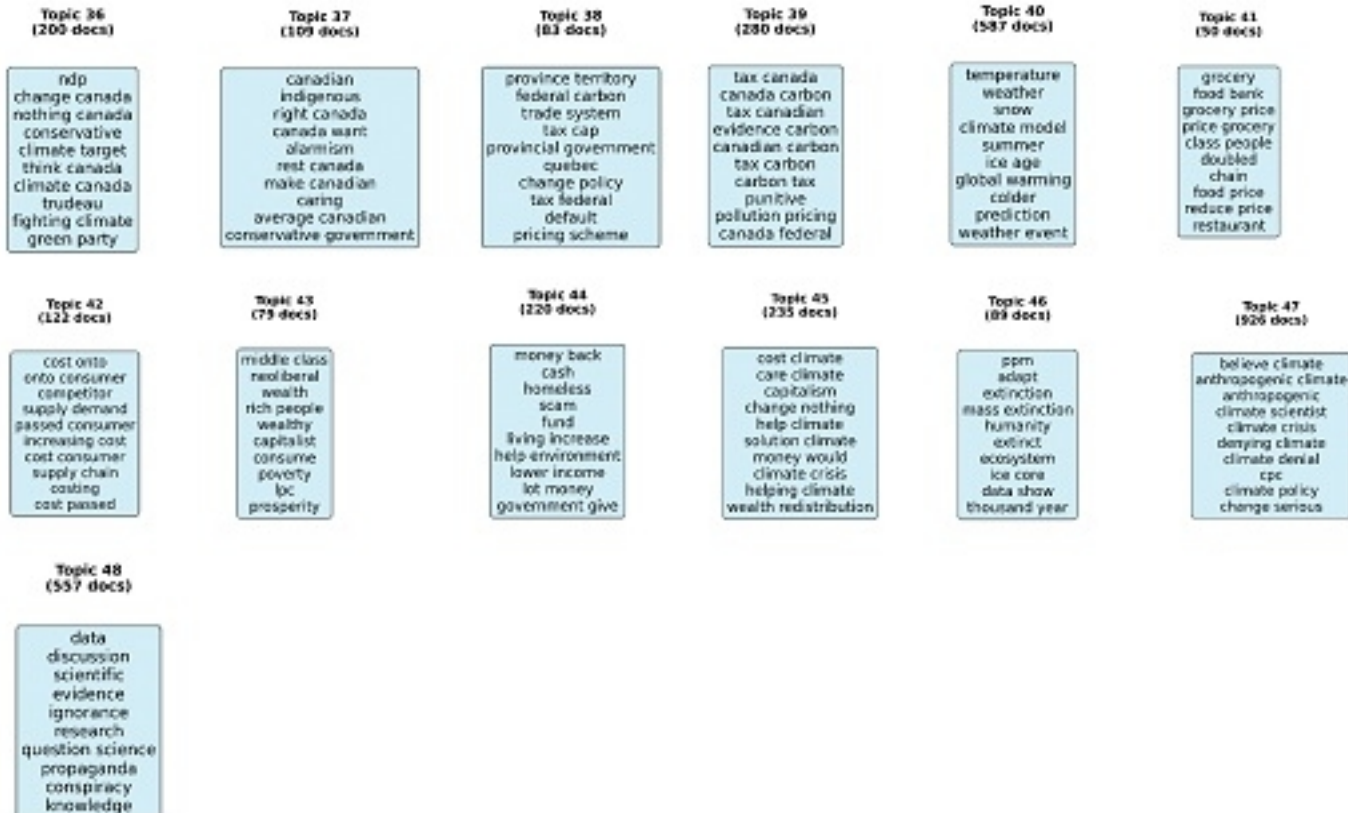




Figure

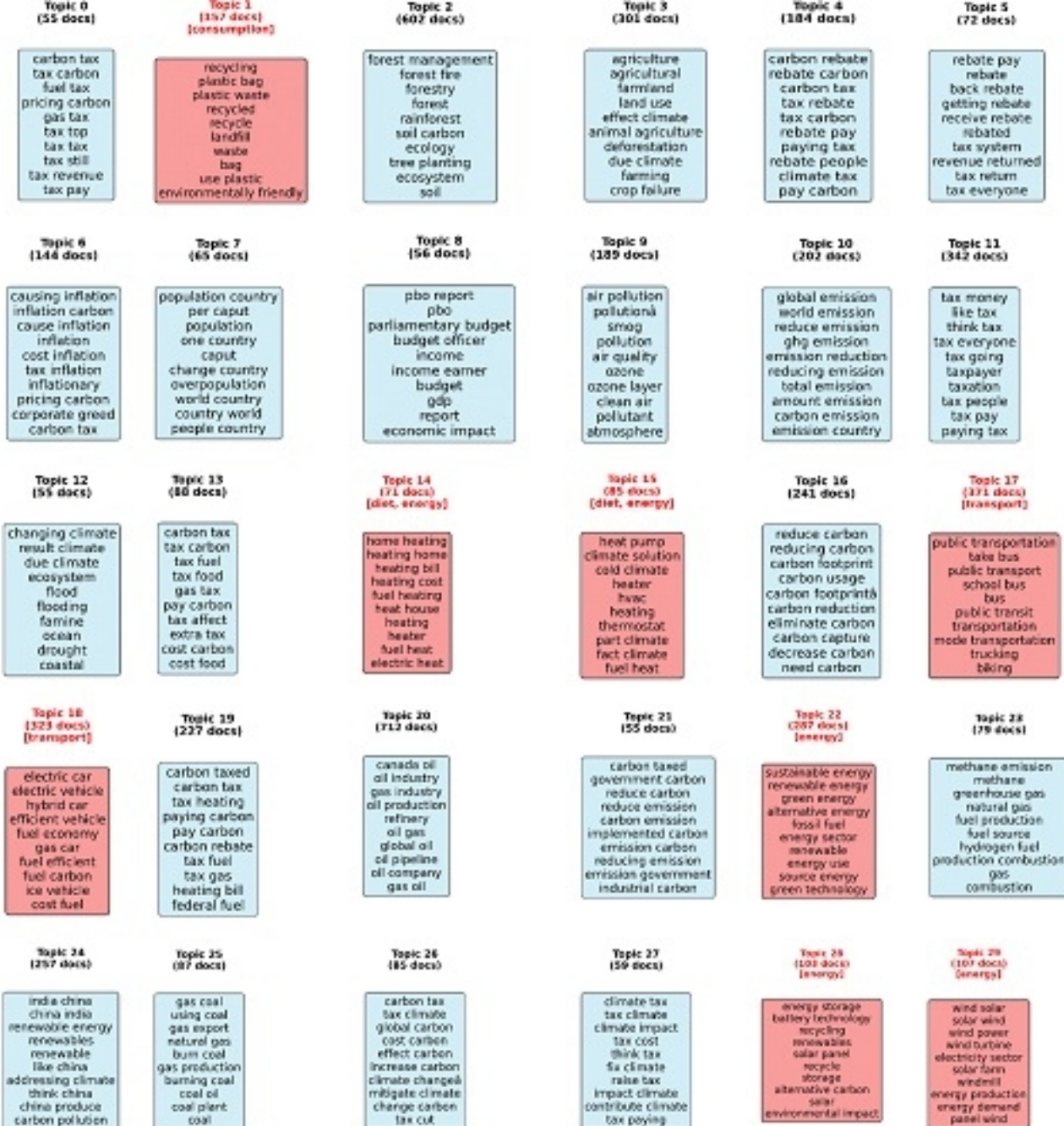


Figure



Figure





Figure

**Topic 30  
(172 docs)  
(energy)**

nuclear reactor  
nuclear power  
nuclear energy  
nuclear plant  
modular reactor  
nuclear  
reactor  
power plant  
power generation  
electricity sector

**Topic 31  
(79 docs)**

carbon pricing  
carbon price  
emission trading  
price carbon  
cost carbon  
expensive carbon  
industrial carbon  
carbon use  
carbon credit  
pricing system

**Topic 32  
(720 docs)**

carbon tax  
tax carbon  
paying carbon  
pay carbon  
tax think  
consumer carbon  
tax implemented  
money carbon  
expensive carbon  
tax good

**Topic 33  
(88 docs)**

carbon rebate  
tax rebate  
tax canada  
rebate pay  
rebate system  
canada carbon  
getting rebate  
receive rebate  
tax returned  
rebate

**Topic 34  
(211 docs)**

canadian carbon  
canada emission  
emission canada  
global carbon  
canada contributes  
global emission  
world emission  
carbon footprint  
canada world  
carbon pollution

**Topic 35  
(86 docs)**

trudeau carbon  
tax trudeau  
carbon tax  
carbon pricing  
pricing carbon  
trudeau  
trudeau  
harper  
carbon tax  
expensive carbon

**Topic 36  
(290 docs)**

climate canada  
denying climate  
climate changed  
agree climate  
climate policy  
climate crisis  
change canada  
changing climate  
acknowledge climate  
fighting climate

**Topic 37  
(109 docs)**

canada want  
canada contributes  
canada world  
canada need  
make canadian  
average canadian  
canada could  
canadian  
rest canada  
indigenous

**Topic 38  
(183 docs)**

carbon tax  
provincial government  
province territory  
federal carbon  
provincial  
government carbon  
province  
quebec  
ontario  
tax cap

**Topic 39  
(280 docs)**

carbon tax  
canada carbon  
tax carbon  
canadian carbon  
tax canada  
tax canadian  
emission tax  
paying carbon  
pollution pricing  
taxing canadian

**Topic 40  
(587 docs)**

global warming  
climate model  
climate science  
current climate  
warming  
ice age  
canada climate  
global temperature  
arctic  
weather pattern

**Topic 41  
(160 docs)**

price grocery  
cost grocery  
grocery price  
price food  
food price  
grocery store  
food cost  
reduce price  
shopping

**Topic 42  
(122 docs)**

cost consumer  
passed consumer  
costing  
cost passed  
consumer  
supply demand  
increasing cost  
demand  
operating cost  
cost people

**Topic 43  
(79 docs)**

middle class  
rich poor  
poverty  
wealthy  
lower class  
poorer  
prosperity  
poor people  
wealth  
rich people

**Topic 44  
(220 docs)**

government give  
spending  
give money  
cost living  
use money  
funding  
income people  
lower income  
income  
higher cost

**Topic 45  
(235 docs)**

helping climate  
climate crisis  
help climate  
stop climate  
climate impact  
climate action  
change climate  
effect climate  
solution climate  
cost climate

**Topic 46  
(89 docs)**

niche  
ecosystem  
ecological  
extinction  
nature  
mass extinction  
survival  
life  
change climate  
extinct

**Topic 47  
(926 docs)**

climate science  
anthropogenic climate  
climate denial  
climate scientist  
science climate  
believe climate  
denying climate  
think climate  
climate policy  
global warming

**Topic 48  
(557 docs)**

question science  
scientific  
scientific community  
science  
scientist  
research  
human race  
data  
evidence  
debate