**Induced seismicity or political ploy?: Using a novel mix of methods to identify multiple publics and track responses over time to shale gas policy change**

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**Highlights**

- Public responses to policy change involve awareness, interpretations and opinions.
- High public awareness and support exists towards the 2019 shale gas moratorium.
- Sceptical interpretations arose from the timing, source and extent of policy change.
- Social media analysis enables insight into public responses over hours and days.
- Mixed methods enables insights into diverse publics and drivers of ideology, scale and demographics.

**Abstract**

To date, little research has investigated how public perceptions of policies to ban or restrict fossil-fuel extraction change over time; yet this topic is of crucial importance as countries worldwide seek to transition towards 'net zero' economies. This study addresses this gap by focusing on public responses to the 2019 moratorium on shale gas extraction in England, using an analytical framework comprising awareness, interpretations and opinions, and a mixed-method approach combining national survey, social media and local case interviews. Findings show high levels of awareness and support for the moratorium, yet differences between coalitions of interest based on ideology, scale and demographics. Social media analyses reveal a peak in public response across several days during a general election campaign in which different parties took divergent positions on shale gas. Public support for the moratorium – and induced seismicity as the primary reason for its introduction - was evidenced by the national survey, yet coincided with scepticism about its timing, extent and motivation, as indicated by social media activity and local case interviews. For some publics, the moratorium was a ploy to ensure electoral support, embedded in public distrust. This study indicates the merits of a mixed-method approach to understand the psychological and institutional context of public responses to policy change as it unfolds over time, and discusses the longer term implications of politicised attitudes for energy transitions.

**Keywords**

Shale gas, fracking, public responses, awareness, interpretations, opinions, energy transitions, social media, mixed methods.

## 1. Introduction

For over a decade, a booming shale gas industry has transformed the world's energy landscapes. Much of its economic success has been in the United States (1), while elsewhere hopes for a successful shale gas industry have not yet been realised. In the United Kingdom, one of the key risks cited by opponents is that hydraulic fracturing causes induced seismicity (earth tremors). In 2011, seismicity associated with an early exploration well prompted a moratorium by the UK Government. Although the moratorium was lifted in 2012, subsequent exploratory development advanced slowly until August 2019 when another set of induced seismic events (max. 2.9 magnitude) caused by hydraulic fracturing took place. In November 2019, shortly before a general election, the UK's Conservative Government placed an indefinite moratorium on shale gas extraction (hereafter 'SGE') in England via high-volume hydraulic fracturing for the stated reason of scientific uncertainty over the ability to limit induced seismicity (2). Until this point, the Conservative Party had strongly supported shale gas as key to achieving energy security and economic growth (3).

Governance and regulation of shale gas development has varied globally, but included the implementation of moratoria and bans by local governments (4), state or regional governments (e.g. 5), and national governments (6–8). Advances toward shale gas have been made in countries like Argentina, Poland and China, while the practice has been banned or placed on a temporary hold in several other nations in Latin America and Europe, as well as in Australia. There have also been divisions within nations where fracking has moved forward, as a handful of states in the U.S. and four of 10 Canadian provinces have introduced moratoria or bans against fracking. The same has been true in the United Kingdom, where in 2015 Northern Ireland put a presumption against fracking into planning regulations. Wales introduced a moratorium in 2015 and Scotland followed suit in 2017, while in England plans for exploration continued to move forward prior to the 2019 moratorium. Previous research on fracking bans and moratoria has focused on the factors that have led to them (9–11) or their impact on property values (5). While considerable research on public perceptions of shale gas has been conducted both in and beyond the UK (see 12,13,22,14–21) , little research has focused on perceptions of implemented moratoria or bans either on shale gas or other fossil fuels. Mayer and

Malin (2019) used a survey to investigate public support for a temporary state-wide ban on shale gas extraction in Colorado (23). They found that a majority of participants opposed a potential ban, with perceived local economic benefits (i.e. job growth and tax revenue), as well as right wing political ideology identified as important predictors of public objections to a ban. However, to date, no state-wide temporary ban has actually been implemented in Colorado. Further, existing research which incorporates existing moratoria include them peripherally to highlight differences in public perceptions of fracking more generally, not support or opposition to moratoria or bans as specific policies (13,24). As such, no academic research has investigated public perceptions of any existing moratorium or ban on shale gas or any other fossil fuel resource. Nor has research been conducted in ways that might reveal the temporal dynamics of public responses to such a policy change as it unfolds over time immediately following public announcement. These issues are likely to grow increasingly important, and potentially controversial, as states put in place policies to achieve net zero emissions targets that avoid fossil-fuel extraction. This includes cancelling new licenses for oil and gas exploration, as has already been signalled by Denmark, New Zealand and Ireland, yet overlooked in the UK (25) and avoiding new coal extraction, as signalled by UK controversy over planning consent for a Cumbrian coal mine (26).

There has been no commercial production of shale gas by high-volume hydraulic fracturing in the UK to date; only a handful of exploration wells have been drilled. Despite this, 'fracking' has become a major political topic, featuring prominently in political speeches and party manifestos over the last decade, both by supporters and objectors (27). Research on shale gas discourse in the UK highlights the politicised arguments taken up in support of and opposition to fracking, much like in the US context. Those who support shale gas point to opportunities for employment, economic growth, and energy security. Detractors suggest there are considerable environmental risks associated with fracking, and they also express concerns about trusting decision-makers and fairness and justice in shale gas contexts (3). Interestingly, some overlap occurs between pro- and anti-shale gas discourses in focusing on the need to reduce $CO_2$ emissions, though the degree to which relying on shale gas as a bridging fuel to more renewable energy sources and its impact on emissions is contested (28,29).

As noted above, governance approaches vary across the countries of the UK (7). With moratoria on high volume hydraulic fracturing already imposed in Scotland, Wales and Northern Ireland between 2015-2018, England – where plans and regulations are decided upon by the UK Parliament in London – remained the only UK country to allow 'fracking' since 2012. The 2019 moratorium, therefore, represents a milestone in the evolution of energy policy that may have significantly impacted public perceptions of, and support for, shale gas. In light of evidence of a downward trend in public support (14,30), multiple competing discourses around shale gas (3), and the pervasive psychological tendency to interpret events or new information in light of prior beliefs and values (31), it is important to investigate whether the 2019 moratorium was interpreted in diverse ways and even served to further polarise public opinion (22).

Here, we explore ways that people responded over time to this abrupt change in energy policy, with a primary focus on the days immediately following its first announcement in the media on 31st October 2019. Our primary aim is to shed light on the dynamics of awareness and interpretation that led to public opinions of support or objection to the new policy. A secondary aim is to evaluate the value of a mixed-methods approach that integrates national survey data, social media analysis and local case qualitative data, making a methodological contribution to research on public perceptions of energy policy more broadly.

### *1.1 Previous research on shale gas discourse and public opinions in the UK*

Surveys suggest that about twice as many UK citizens as Americans indicate basic recognition of 'fracking'. For example, data collected in the UK and US in 2014 showed that 72% of UK survey participants correctly identified 'fracking' in comparison to 33% of US participants (32). Despite widespread awareness of the topic, research suggests that public support in the UK might be declining over time (14,30,33,34). Nevertheless, no survey of UK residents to date has revealed a majority supporting *or* opposing extraction; instead, 27-55 percent of respondents are non-committal (selecting options such as 'don't know', 'no opinion', or 'neither support nor oppose'). Across the literature,

similar factors emerge repeatedly as being associated with support and opposition for shale gas: for support – being male, voting Conservative, and associating SGE with clean energy, cheap energy, and energy security; for opposition – being female, having strong environmental values, and associating SGE with water contamination, earthquakes, and increased greenhouse gas emissions (13,35).

Qualitative research highlights how opposition to SGE in the UK cannot be explained by a lack of technical understanding or limited awareness of the impacts of extraction (13,20,36–39). Instead, procedural concerns about the role afforded to publics in decision-making (20,36,38,40) and distributive concerns about unequal exposure to risk across populations (13,37,39) motivate opposition and activism. A lack of trust in industry, government, and publicly available scientific information, alongside a questioning of the purported benefits of SGE has also contributed to public scepticism of the necessity for SGE in the UK (13,20,38,39,41,42).

Discursive research has examined ways that SGE has featured in societal discourse. Both the content communicated and the way in which information is shared has been researched using qualitative methods to analyse media articles, policy documents and website text. Markedly divergent findings have arisen in this field. A fundamental difference across articles is in claims of which 'side' is winning the debate over SGE. Whilst some authors contend that the anti-SGE groups' framing of SGE was most effective and winning the debate in the UK (43–48), others forward the exact opposite – that pro-SGE actors' rhetoric and characterisation of SGE has been the dominant framing (49–52). In most cases, 'winning the debate' equated to frames that have resonance with publics; however little research has examined public perceptions of these frames (but see Cotton (53) for an exception). Articles contending that anti-SGE rhetoric is winning in discourse on this issue are more recent than articles contending that the pro-SGE side is winning. This, alongside the contention in some of the articles themselves that the debate has evolved over time (43,44) suggests that UK public discourse might be shifting towards opposition to SGE.

Bomberg (43,44) and Stephan (48) draw attention to the incorporation of broadly-focused concerns into anti-SGE rhetoric as one factor supporting its success. Pro-SGE discourse focuses rather narrowly on a few specific economic benefits (and sometimes the questionable environmental benefit of reduced greenhouse gas emissions [see 27 on this topic]). Anti-SGE rhetoric and framing picks up environmental risks alongside concerns about trust in pro-SGE actors, procedural and distributive justice, and local issues (including a lack of democratic opportunity for local decision making on SGE). Rattle *et al.* (42 p. 238) point to substantial local resistance, but still note 'given the imbalance of power and resources between local and national players, it is likely the will of the national government will prevail'. Furthermore, Williams and Sovacool (3) point to a continued lack of consensus on how to characterise SGE, highlighting nine competing pro and anti-shale frames.

All authors writing on SGE discourse in the UK acknowledge a dominant environment versus economics frame. Many authors cite a local focus in anti-SGE discourse, encompassing social impacts of SGE (e.g., traffic, road quality, housing prices and availability, crime, community character, industrialisation) as well as justice issues – for example, are residents near extraction being asked to shoulder too many risks with too few benefits, and do locals have enough opportunity to effect decision-making (38,43–46,49).

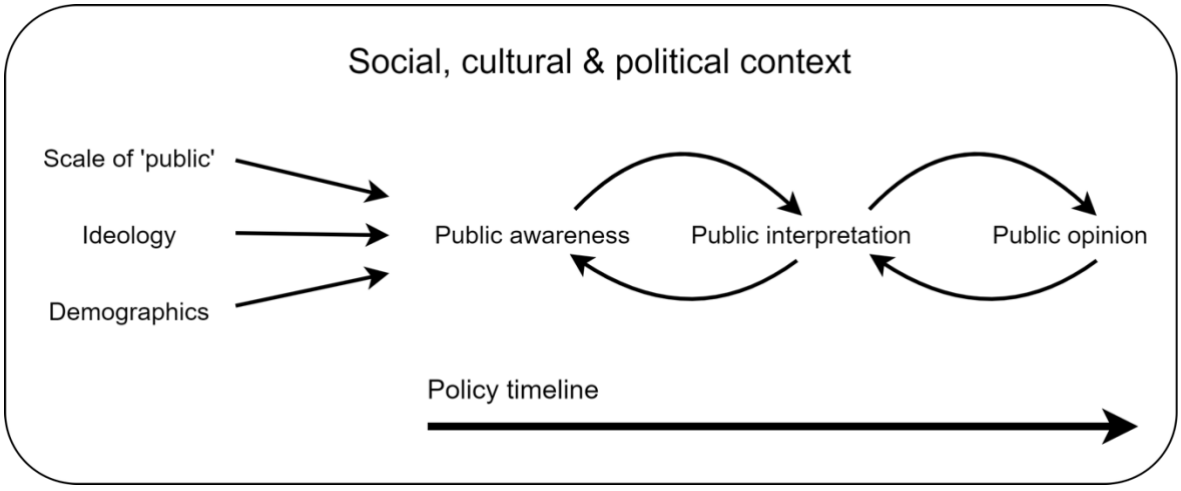
Information sources for these discourses include formal and informal channels. The mass media in the UK are replete with coverage of political developments and social movements on this issue (49,52,55). Social media is increasingly used to share information, to shape public discourse, as well as to support community engagement and activism on SGE. Rattle et al. (54) researched online information use in England across the period 2011-2018, arguing that direct activism against shale gas in the UK has arisen, in part, from improved information access and a sense of disempowerment associated with reduced influence upon policy. Whilst private online communication channels are used for more sustained activism, social media platforms (e.g. Twitter) offer more responsive and flexible modes of engagement. Hopke (56) analysed Tweets around the GlobalFrackdown day of action (19th October 2013), finding that participants used Twitter to foster a sense of solidarity and

bridge local and global concerns when addressing the common goal of a fracking ban. She argued that Twitter offered a means to reach external audiences, as well as a space for collective identity-building and affirmation for a global network of anti-fracking supporters.

Across different information sources, shale gas is interpreted through the lens of existing beliefs, such that those who already support SGE will tend to agree with pro-SGE information while opponents will agree with anti-SGE messages, in line with the psychological tendency for confirmation bias and motivated reasoning (31,57). In other words, SGE information (including policy announcements) is likely to be interpreted differently by different publics. Specifically, given support for SGE is strongly associated with political ideology (13), we expect there to be an ideological filter for public responses to the moratorium.

To date, we are unaware of any study that has investigated how public responses to a controversial energy policy change (in this case, a shale gas moratorium in England) unfold over time across the hours and days immediately following public announcement. Our conception of public response is an over-arching concept that relates public awareness, public interpretations (including discourse about what the moratorium represents, why it was introduced and how people feel about this) and public opinions (including support and objections) (see Figure 1). Although our focus is upon public responses to the 2019 shale gas moratorium in England, we propose a generic framework that can be applied to investigate the temporal dynamics of public responses to any policy change.

Figure 1: Analytical framework describing the dynamics of public responses to policy change over time




To do this, we use a mixed-method approach that integrates national survey, social media and qualitative case study methods, since particular research methods conducted in isolation produce, at best, a partial description of what 'the public' thinks. Moreover, singular methods are unlikely to be able to reveal how individuals interpret policy change over time in response to specific events. Survey research is notably unresponsive to how attitudes or discourse might unfold over relatively short, yet intense time periods (i.e. hours and days) when shale gas features prominently in societal media and discourse. Social media analysis can reveal the role of information sharing in raising public awareness and shaping public interpretations and opinions. Our approach can, therefore, shed light on how the 2019 moratorium was constructed by publics both initially and over time, embedded in institutional relationships (specifically trust in Government), as well as the prevalence and determinants of these understandings amongst the population, attending to spatial and socio-psychological variation across national and local scales.

### *1.2 Aims*

The overall aim of this study was to investigate how public responses to the moratorium evolved over time. Specific objectives included:

1. To explore public awareness and interpretations of the moratorium across time and scale; in particular the role played by social media in information sharing about the scope of policy change, the reasons for the moratorium and how people felt about the policy change;
2. To assess public opinion of the moratorium, including exploring the spatial, demographic and ideological drivers of support and opposition; and
3. To assess the value of a mixed-methods approach to provide insights on public responses to policy change on shale gas fracking.

## 2 Methods

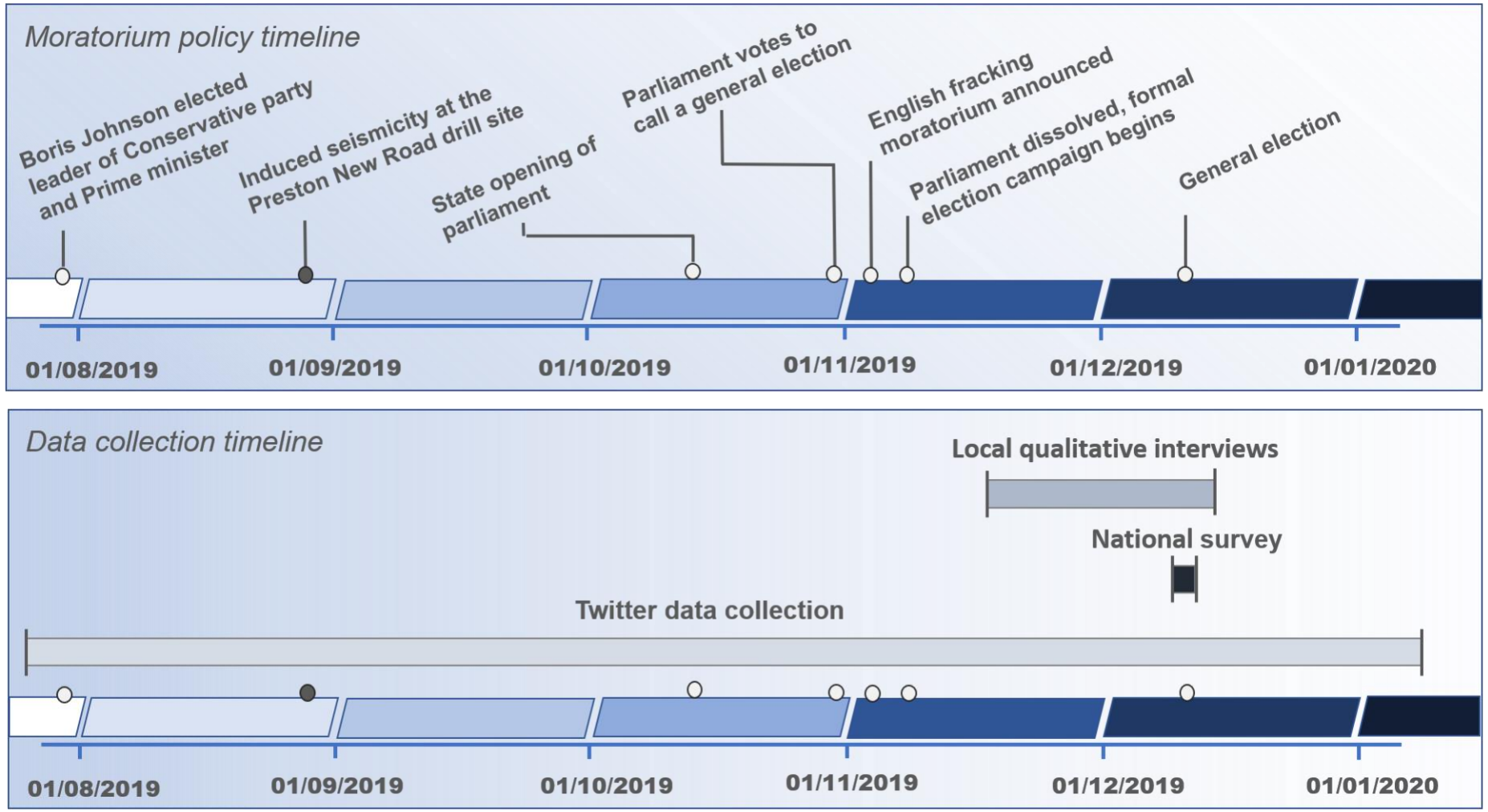
### *2.1 Research design*

Research on public opinion of controversial technologies has found it more likely to be fragmented than a unitary whole; therefore, multiple methods, including representative surveys, are usefully employed (58). Moreover, 'there is much to be gained by mixing qualitative and quantitative methods, to avoid the weaknesses and capitalize on the strengths of each' (48:21). Combining these insights, we employed three methods of data collection to provide a comprehensive, mixed-methods analysis of public responses to the shale gas moratorium at national and local scales. We employed local case study research to collect qualitative data using semi-structured interviews with residents living close to and directly impacted by shale gas drilling proposals. We complemented this with data from two methods at the national scale: analysis of Twitter data to access those who are actively engaged with shale gas on social media; and analysis of survey data from a nationally representative sample of UK adults living across all parts of the UK (see Appendix for details).

Data was collected across the period from August 15$^{th}$ to December 31$^{st}$ 2019. A timeline (see Figure 2) indicates when data was collected as well as key shale gas-related events that occurred across this period, including earth tremors that took place at a drill site operated by Cuadrilla Ltd on August 26$^{th}$ 2019 in Preston New Road, Lancashire; Boris Johnson's election as leader of the Conservative Party and Prime Minister on July 24th; the parliamentary vote in favour of calling a general election on

October 29th; the announcement by the UK government of the moratorium on shale gas exploration in England on 2nd November; and the general election that took place on 12th December 2019.

Figure 2: Timeline of data collection and shale gas related events in the UK (July – December 2019)



### *2.2 National survey*

To investigate awareness, interpretations and opinions of the moratorium, a survey was conducted of a representative sample of the UK public (n=1,674). The sample was drawn from an online panel, and constrained to represent the population based on distribution across: age, gender, UK census region, social grade (socio-economic status), education, vote in the 2017 UK general election, vote in the 2016 EU (Brexit) referendum, and level of attention paid to politics. The survey was administered on 8-9th December 2019, prior to the election held on 12th December 2019. In addition to standard demographic variables such as age, gender, location of residence and social class, questions focused on awareness of the moratorium (yes/no), beliefs about the reasons for its introduction, and levels of support or opposition (4-point scale from 'strongly support' to 'strongly oppose') (see Appendix for further details of procedure, wording and response options).

### *2.3 Social media*

Social media data was accessed using Twitter, specifically geolocated tweets, which are tweets that have a location attribute. They make up only a small fraction of all tweets and therefore appear not to be filtered by Twitter, meaning we are likely to collect all of the geotweets from the UK during the study period. On average this resulted in 200,000 tweets being captured per day covering a wide range of subjects, of which only a small fraction related to fracking. To isolate relevant tweets, keywords were used to filter each message content within the database. This was not restricted to hashtags but where the tweet message contained any of the following: 'frack', 'shale gas' and 'hydraulic frac' as well as one of the key terms 'moratorium', 'ban', 'stop', 'pause' or 'on hold'. To focus on the time period around the moratorium, tweets were constrained between 15th August 2019 and 31st December 2019, producing the final subset of data. The dataset was aggregated by calculating the total number of tweets by day and by area (inside or outside England), which was then turned into a tweet rate by dividing by the total number of tweets on that day (see Appendix for further details of extraction and analytic processes).

*Qualitative analysis of tweets:*

All of the filtered fracking moratorium tweets collected between 25th October and 19th December 2019 were coded qualitatively and thematically analysed (n=58) using Nvivo software. The tweets provide coverage from one week before the moratorium was announced until one week after the general election. The same Codebook used for local case study qualitative research data was initially used to code tweets, but it was modified as appropriate to accommodate this specific dataset (i.e. added a code for 'hashtags' and 'duplicate tweets'). Further information about social media analysis, including the comparative approach to achieving inter-coder agreement (61,62), is provided in the Appendix.

### *2.4 Local case study qualitative research*

Fieldwork was conducted in the vicinity of the village of Great Altcar, Lancashire (see Figure 3) across the period of September 2019 to December 2019. This followed submission of a planning application by Aurora Energy Resources Ltd in September 2019 to conduct exploratory drilling for shale gas. Great Altcar was a suitable case study to investigate local perceptions of the moratorium for four reasons: first, residents were directly impacted by local proposals to drill for shale gas; second, the proposal falls under the same mineral development authority as the site at Preston New Road, but was being developed by a different operator and was at the time at a much earlier development stage; third, while Preston New Road was the site of seismic activity, that community has arguably been overstudied by academic research in contrast to Great Altcar; finally, this case allows us to better understand the degree to which events at Preston New Road might impact perceptions of fracking in nearby communities which also face potential shale gas exploration.

In conducting this fieldwork, we used a combination of methods to triangulate data. This included semi-structured and walking interviews, photo elicitation, participant observation and document analysis. We relied on a combination of purposive and network (snowball) sampling (63,64) to identify a variety of local residents and decisionmakers interested in participating. This involved recruiting via email, telephone, and introductions via initial participants. In total, twenty seven semi-interviews were conducted. Of those twelve participants were available for a follow-up in-person or

phone interview on the specific issue of the moratorium between November 16th and December 11th, 2019. In these follow-up interviews, questions focused on their awareness of the moratorium; their perspectives on the reasons for the moratorium; how, if at all, they believed the moratorium might impact the local drilling proposal, as well as their support or opposition to it (for further details of the participants and qualitative analysis, see Appendix). All interviews were digitally recorded, transcribed verbatim and analysed using Nvivo software.

Figure 3: Map of case study location in Great Altcar, Lancashire, England

### *2.5 Synthesis of data*

Consistent with models of 'triangulation' in mixed-methods research (65), we undertook the different elements of data collection in parallel and then sought to integrate insights. In this case, under each of our three major themes - public awareness, public interpretations and public opinions on the moratorium – we sought to integrate insights from qualitative and quantitative data at national and local scales. Moreover, within each theme, we attended to the temporality of public responses and how different forms of data could illuminate changes over time. The process of integration sought both commonality and divergence across methods, since both can be illuminating, providing a stronger evidence base for interpretation, while also indicating methodological limitations and areas for further research.

## 3. Results

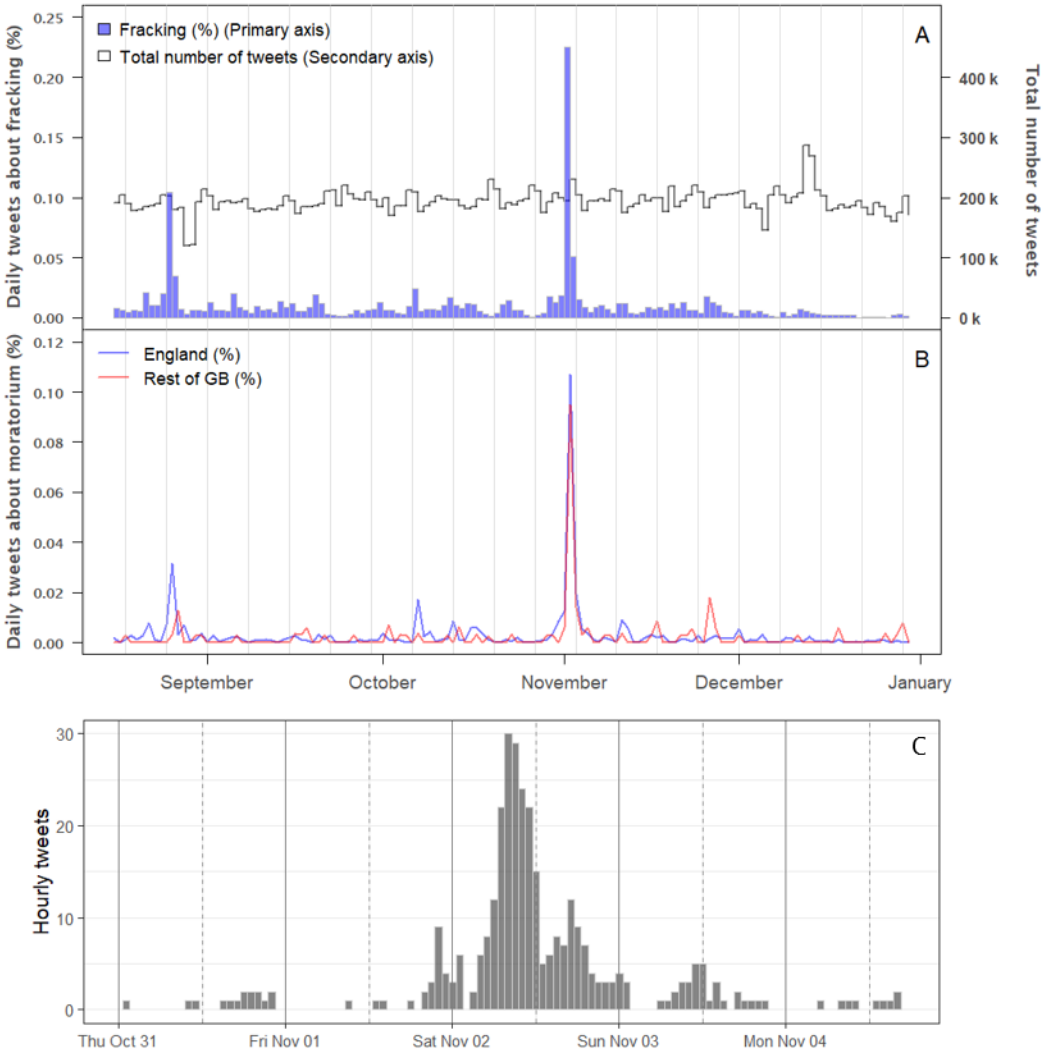
Findings are structured in three sections corresponding to the research aims. The first section focuses on public awareness of the moratorium, investigating when people first learnt about the moratorium, from whom and what it was initially considered to be about. The second section focuses on public interpretations of the moratorium, in particular whether publics at national and local scales agreed with the government narrative about the reasons for its introduction. The final section focuses upon public opinions of the moratorium, specifically levels of public support and the factors that explain these. In line with ethical guidance (66) to preserve anonymity and to adhere to Twitter's terms of use, social media data is not quoted verbatim; instead, composite quotes are provided from multiple tweets.

### *3.1 Public awareness of the moratorium*

Data from the national survey, social media and local interviews indicate that the moratorium announcement was a significant societal event across the UK. When the national survey was collected on December 8-9$^{th}$ 2019, over 76% of respondents reported being aware of the moratorium. High

levels of awareness are unsurprising when social media is taken into account. Total daily tweet activity across the period from 15th August to 31st December 2019 is shown in Figure 4. Part A (black line) shows that Twitter activity is relatively constant over time (i.e. approx. 200k tweets per day), with the exception of a slight increase around the general election in mid-December.

Figure 4. A) The total number of daily tweets recorded (black; secondary axis) alongside the percentage of those tweets with key terms 'frack', 'shale gas' or 'hydraulic frac' (blue; primary axis); B) Percentage of 'moratorium' related tweets within England (blue) and the rest of the UK (red). All data is presented between 15th August 2019 and 31st December 2019; C) Hourly tweets across the weekend of Saturday and Sunday November 2nd-3rd 2019.



However, there were several time points when fracking-related tweets (see Figure 4 A blue bars and Figure B) increased in response to specific events. First, around 28th August 2019, a small peak was related to induced seismicity at the Cuadrilla-owned Preston New Road drill site in Lancashire. A second peak occurred on 26th November 2019 related to an event in Scotland (hence visible in the Rest of the UK data, and not observed for England) where an MP won a legal action against a Scottish political party concerning an alleged receipt of funds from 'a fracking company' (cf. 53). The largest peak corresponds to the days between Friday November 1st (when news media began to report the moratorium) and Monday November 4th, when a press release was issued by the government, with an increase in tweet activity relating to fracking and the moratorium across both England and the rest of the UK (Figure 4 B*)*.

Figure 4 C reveals this sudden increase and decrease in social media activity in a more granular timeframe. After a smaller peak on the Friday evening (likely coinciding with the release of next day's newspaper headlines), social media activity rapidly increased across the morning of Saturday November 2nd, before declining in the early afternoon, followed by a secondary peak in the early evening, likely coinciding with TV news programmes broadcast at 6-7pm, before declining to pre-existing levels by Monday November 4th. This peak at the time of the moratorium announcement was due to an increase in the number of distinct users tweeting about fracking related matters. Prior to the peak, there were less than 30 distinct users sending fracking related tweets each day. In the November peak, this rose to over 400 distinct users.

Further insight into the ways that public responses evolved over the days after the moratorium became publicly known is provided by qualitative analysis of Twitter data. This indicates three key points: first, there is an interplay between social and conventional media in raising public awareness of the moratorium, with Twitter being used to share information first announced online by newspapers; second, public responses were influenced by erroneous initial reporting of a fracking ban; third, there

is a distinctive profile of affective discourse that runs alongside public interpretations of the scope and motives for the new policy.

The first tweet that referred to the moratorium occurred just before noon on Thursday October 31st, linked to a Daily Mail article (published Wednesday October 30th at 11pm) entitled: "Tories 'are set to announce ban on new fracking': Moratorium to be unveiled amid concerns anger at the drilling could hit election hopes." However, it was not until around 9pm on the evening of Friday November 1st that our dataset shows several tweets discussing the moratorium, suggesting that people were accessing early release front pages of newspapers for Saturday November 2nd, as well as other online sources. Analysis of headline sharing on Twitter suggests the importance of The Guardian in comparison to other conventional media sources (see Table 1) as awareness spread via user-to-user sharing of tweets and re-tweets. The Guardian published their first article about the new policy online at 00:01 GMT[1] on Saturday 2nd November and this was the most commonly cited news source (print and online combined) on the topic in our Twitter sample, shared a total of 62 times. Although other broadsheet and compact newspapers (The Times, i, i Weekend) and tabloids (Daily Mail, Daily Mirror) also ran stories on the moratorium that were shared by Twitter users, the number of times these articles were shared was significantly lower than those of The Guardian, with most articles being shared from centrist and centre-left oriented newspapers (see Table 1). The importance of The Guardian newspaper in shaping public interpretations of the moratorium is supported by national survey analysis. While readership of most newspapers correlated significantly with public awareness of the moratorium, only readership of The Guardian and i newspapers correlated significantly and positively with public support ($r=.13$, $p<0.001$ in both cases).

Public responses to the news of the moratorium had a particular affective profile. At the stage of initial awareness, tweets on Friday November 1st were largely positive and celebratory (e.g. "*Government has now banned #fracking effective immediately! Campaigners, we did it!*"), yet by

[1] GMT: Greenwich Mean Time

midnight that day and early on the morning 2nd of November, affective responses had changed to a mix/overlap of scepticism and celebration, as the limited scope of the policy change became more clear. By mid-morning on the 2nd, celebratory tweets tended to drop off, so we see an overall progression from distrust to celebratory to scepticism back to distrust (and a perception of political nature of the decision, e.g. "*Turns out #Tory #fracking ban is really just an #electionploy"*)(see Table 1, final column).

Table 1. Summary of social media and conventional media in public interpretations of the 2019 shale gas moratorium

| **Newspaper Source** | **Publication Date & Time** | **Date & Time of Earliest Tweet** | **Times shared** | **Headline** | **Subheadline(s)** | **Key terms** | **Example Composite Tweets** | **Primary Emotion/Sentiment** |
|---|---|---|---|---|---|---|---|---|
| Daily Mail | 30/10/2019, 22:54 (modified 31/10/2019) | 31/10/2019, 11:43 | 1 | Tories 'are set to announce ban on new fracking': Moratorium to be unveiled amid concerns anger at the drilling could hit election hopes | • Prime Minister Boris Johnson is poised to announce a moratorium on fracking<br>• Comes amid concerns the technology could dent election hopes in December<br>• Fracking for shale gas encouraged by successive Conservative prime ministers | Ban, moratorium, election hopes | *A moratorium is NOT a ban! This temporary stop is to boost election votes in communities impacted by #fracking #Borislies* | Doubt, distrust, perceived as political |
| Guardian (print) | 1/11/2019, 21:47 (image of | 1/11/2019, 22:05 | 3* | Fracking banned in UK after | N/A | Banned, U-turn | *Congratulations to @friends_earth @GreenpeaceUK and* | Pleased, celebratory |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | cover print for 2/11/2019 shared on Twitter by Guardian) | | | government U-turn | | | *campaigners for this win. Fracking banned in UK as government makes major U-turn https://t.co/2ZRrnDPJ9s* | |
| iWeekend | 1/11/2019, before 22:16 (image of cover print for 2/11/2019 shared on Twitter by Guardian) | 1/11/2019, 22:16 | 1 | Fracking to be banned after U-turn by Tories | • Huge victory for eco campaigners and residents who complained about tremors caused by drilling<br>• Government had extolled shale gas industry but now 'cannot rule out future unacceptable impacts'<br>• Green groups welcome decision to shut down fossil fuel industry | Banned, earthquake, victory for eco campaigners, | *It is one minute past midnight on the 2nd of November 2019. It is now official\| the government has withdrawn support for the fracking industry\| an effective ban is in place immediately.*<br>*Government has now banned #fracking effective immediately! Campaigners, we did it!* | Pleased, celebratory |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| The Times | 2/11/2019, 00:01 | 1/11/2019, 22:49 (image of cover print for 2/11/2019 shared on Twitter) | 1 | Johnson to ban fracking: Tories ditch key energy policy to boost green credentials and head off Labor | • N/A | Ban, green credentials | *With #fracking UK energy supply could be cheap, reliable, domestic. Boris #ban decision is just sad attempt at enhancing green credentials* | Skepticism |
| Guardian (online, modified) | 2/11/2019, 00:01 (modified 4/11/2019) | 2/11/2019, 00:24 | 59* | Fracking halted in England in major government U-turn | • Victory for green groups follows damning scientific study and criticism from spending watchdog | Halted, u-turn, victory for green groups | *Government announcing u-turn on #fracking. Thanks campaigners for your hard work. Fracking halted, now #BanFracking* | Celebratory, cautiously hopeful |
| BBC News | 2/11/2019, 00:04 | 2/11/2019, 7:27 | 2 | Fracking halted after government pulls support | The government has called a halt to shale gas extraction - or fracking - in England amid fears about earthquakes. | Halted, earthquakes | *#Earthquakes finally mean #fracking has been halted, but how long will this #temporary measure be in place? #notaban* | Skepticism, cautious |
| MSN/Sky News | 2/11/2019, before 5:15 (earliest Tweet | 2/11/2019, 5:15 | 2 | Fracking banned in England after | N/A | Banned, earthquake | *Fracking banned in England, was it driven by #earthquake or #election fear?* | Skepticism, perceived as political |

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|---|---|---|---|---|---|---|---|---|
| | linked to article) | | | earthquake fears | | | | |
| The Daily Mail | 2/11/2019, 10:01 | 2/11/2019, 19:22 | 1 | Business Secretary Andrea Leadsom calls the UK fracking ban 'disappointing' and insists it is only TEMPORARY until new technology reduces earthquakes risk | • The PM yesterday announced Tory's long-standing policy would be abandoned<br>• But Andrea Leadsom was forced to defend the Government's fracking U-turn<br>• As critics say ban will only last long enough to get votes election on December 12 | Ban, temporary, earthquake, U-turn, election, election | *Supposed #uturn #frackingban is actually TEMPORARY, a #Tory headline grab just in time for the #election. Now's the time to #banfracking FOR GOOD* | Skepticism, frustration, disgust, distrust, perceived as political |
| Sky News (modified from above) | 2/11/2019, 11:45 | 1/11/2019, 23:28 | 4 | Fracking halted ahead of election over earthquake fears | The moratorium will remain in place until new evidence shows the shale gas extraction process | Halted, election, earthquake | *Fracking banned in England after earthquake fears, and conveniently just before #generalelection* | Skepticism, distrust, perceived as political |

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| | | | | | is safe, the government says | | *#electioneering at its finest* ] | |
| The Mirror | 2/11/2019, 14:35 | 2/11/2019, 19:48 | 4 | Tories accused of 'election ploy' after admitting fracking 'ban' is temporary | The UK's Business Secretary Andrea Leadsom said the suspension would only remain in place "until the science changes" | Election ploy, ban, temporary | *Turns out #Tory #fracking ban is really just an #electionploy. Suspension nothing more than a #politicalstunt and likely to end if #Tories win #GE #VoteLabour* | Frustration, distrust, perceived as political |
| The i | 11/11/2019, 16:36 | 11/11/2019, 17:45 | 10 | Boris Johnson accused of fracking U-turn as firms 'could be allowed to drill for shale gas' just days after Tories announced ban | Exclusive: The Government has slipped out a document which reveals ministers may allow more fracking in future | U-turn, ban | *Another #Boris #Uturn on #fracking. Not a ban and #loophole means #fracking far from over in UK* | Distrust |

* it is impossible to determine if Twitter users shared The Guardian article before or after the wording of the headline was modified, except in cases where images of the front page were included.

In local case study research, many interviewees spontaneously brought up the topic of the moratorium at the beginning of the interview before a question could be asked about it. A variety of information sources including social media, TV, radio and local government were used. As one person put it, "*it was all over the news*." All but one interviewee understood the moratorium to be temporary and they used a variety of terms to describe its transitory nature, including: 'suspending', 'temporary ban' and 'on hold.' Several participants admitted that they did not initially realize the temporary nature of the moratorium, and as such were very encouraged by the news and headlines when the moratorium was announced. However, hope of a ban diminished as details emerged. As one interviewee noted:

*"At first, when the announcement was first made about this moratorium, we all thought wow, brilliant. But then when you start looking past what the announcement is and looking to see what the actual effect on the ground is, and you think right, okay, I can see what the fracking companies will do." – Interviewee 6*

Similar to the social media data, following the moratorium announcement, a marked drop off in local people hearing, reading, or talking about fracking was noted by interviewees. They believed that the announcement had removed the topic of fracking from political discourse during the general election campaign at both local and national scales. For example:

*"I think if anything, it's actually decreased with regards to being a conversation topic, since the ruling was carried out, people have kind of moved onto other more immediate issues, that's been put on a back-burner in my experience." – Interviewee 16*

Therefore, the moratorium was constructed by some interviewees as a deliberate political ploy to remove a potentially difficult topic for the Conservative Party from public discourse during the election campaign.

### *3.2 Public interpretations of the moratorium in the context of wider shale gas discourses*

### *3.2.1 What was at stake: ban or moratorium?*

Initial media reports referred to a 'ban' on shale gas. Only the first article in the Daily Mail used the term 'moratorium' in its headline, although confusingly it also referred to a 'ban on new fracking'. The Guardian article announced that fracking was 'banned' but later revised the headline to read that fracking was 'halted'. The language used in the tweets reflects this misrepresentation and subsequent correction. The term 'ban' (and stemmed words: bans, banned, banning) appeared nearly 10 times more frequently (n=348) in the Twitter data than the term 'moratorium' (n=38). Despite many media outlets changing use of the term 'ban' to 'halt' over the following days, the language associated with the moratorium on Twitter continued to suggest permanency such as 'stop', and 'end', although 'temporary' and 'pause' started to emerge when headlines changed and the meaning of moratorium became more widespread (see example Tweet below):

*Headlines are inaccurate reported #fracking ban is a nothing more than a temporary #moratorium.*

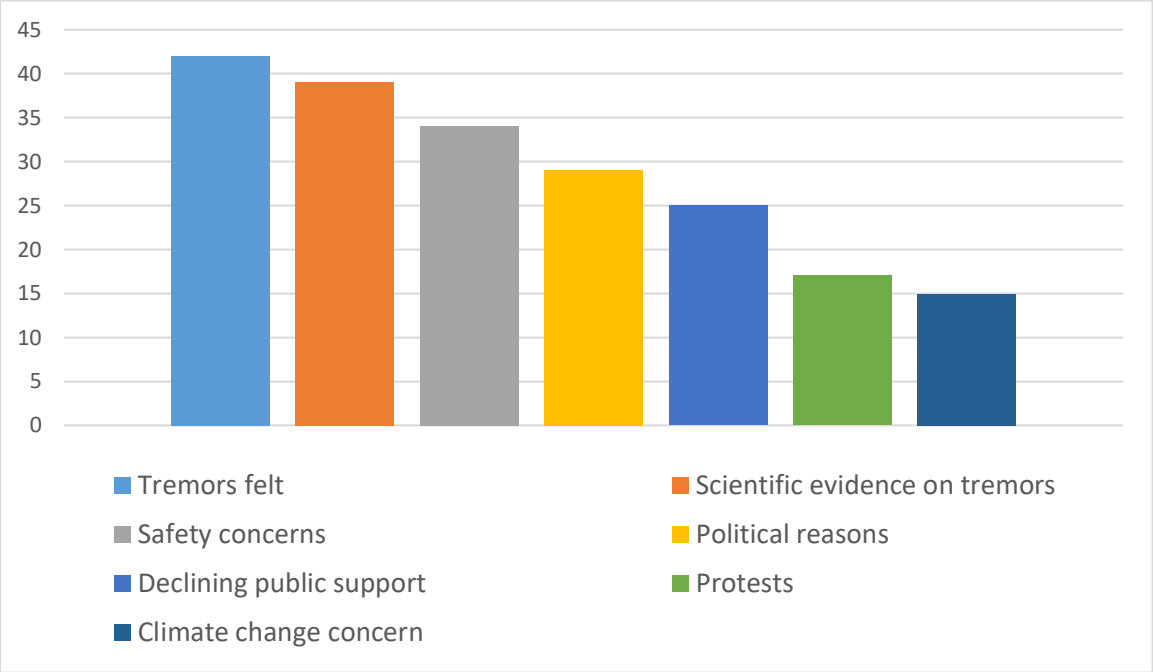
### *3.2.2 Why was it introduced?*

The government's explanation for the moratorium emphasised a lack of scientific understanding of, and ability to predict, induced seismicity from fracking. The tremors that took place on August 26th 2019 in Lancashire were cited in the national policy announcement as challenging the 'safe and sustainable' extraction of shale gas. It was also linked to a lack of available scientific evidence on when seismicity may occur and adoption of a precautionary approach to minimise hazard to local residents living near drill sites. Here, we focus on public interpretations of the reasons for the moratorium, drawing on our three sources of data.

National survey data indicate agreement with the reasons cited by the UK government for the moratorium (see Figure 5). The most highly agreed with reasons were induced seismicity (i.e. 'tremors felt at a shale gas fracking site, 42%) and 'scientific evidence about tremors arising from shale gas extraction' (39%). Concerns for safety at/near the shale gas sites (34%), political reasons

(29%), and declining public support (25%) all fell in the middle. The reasons least frequently agreed to explain why the moratorium was announced were: direct action by protestors (17%) and concern about climate change (15%). Furthermore, in all cases, the percentages for each rationale were higher in the sub-sample of those who reported being aware of the moratorium before taking the survey.

Figure 5. Perceived reasons for the UK Government implementing the moratorium (percentage of survey respondents selecting each reason)




In contrast to the national survey, social media and case study data reveal a stronger emphasis upon the political rationale for announcing the moratorium, linked to the timing of the announcement and its impacts on public discourse. As already mentioned, initial tweets represented the moratorium as a ban, and attributed this as a victory for campaigner groups, particularly those around drill sites in Lancashire and South Yorkshire. Twitter users overwhelmingly cited electoral motivations as the key driver for the moratorium (96 tweets) in comparison to seismic activity (19 tweets) and campaigner pressures (29 tweets). Furthermore, any tweets mentioning seismic activity tended to be ones that expressed mistrust over the use of seismic activity as a driver of the moratorium, or were simply sharing news articles that tied the moratorium to seismic activity. Twitter users suggested the claims

about seismic activity were a cover for political motivations, and that the moratorium was temporary and would be lifted immediately following the election, depending on the outcome:

*Earthquake behind the #moratorium? Or is this simply an #electionploy? #Fracking has NOT been banned. Expect it to begin again with a #Tory win.*

Over the days after it was revealed in the media, as more detailed information about the moratorium became publicly available, realisation that the government had not put a permanent ban on fracking meant that beliefs about the moratorium as being politically motivated and inauthentic increased over time (see section below for more detail).

Local case study data provide an additional perspective with an emphasis on the importance of seismic activity (similar to the national survey) and the political dimensions and timing of the moratorium (similar to the Twitter data). Due to its proximity in the same county (Lancashire), reporting in local media and the presence of regional campaign groups (e.g. Frack Free Lancashire), the salience of events at Preston New Road was already apparent in the case study data prior to the moratorium. Here, support for the moratorium rested on questions of whether or not the fracking could be done safely and without impacting people:

*"Well, they've stopped it because of the earthquakes up at Preston at the Singleton site. Unexplained earthquakes. They don't know whether they're going to get better, worse. They don't know what's causing them, so they've stopped it which seems quite a sensible thing to do." – Interviewee 20*

Yet many interviewees, who couched their views as a bit 'cynical', also suggested that the moratorium was put in place for political gain in the upcoming election:

*"We have regarded the moratorium as just that - a temporary break almost certainly nothing more than an election ploy…If there is a change of government it may become permanent but probably will be ended soon after the election if not." – Interviewee 12*

As details of the moratorium emerged, residents sought to make sense of its local implications. It was unclear that local exploration would stop as a result. Some interviewees regarded the 'actual effect' of the new policy to be minimal given certain limitations written into its details. This included how the government defined 'hydraulic fracturing,' as a few interviewees pointed out that the moratorium only applied to sites where a high volume of water was being injected into wells. Several brought up that it was their understanding that test sites were exempt from the policy. Still others had quickly confirmed that the moratorium on fracking would likely not apply to exploratory drilling sites, and foresaw the impacts of industry lobbying post-moratorium:

*"So although the fracking, the test fracking side of it has been paused, they're still saying 'Well there's still exploration that can take place,' … so if they have the site in place, as soon as you get the right, okay, you can start testing again, bang, they're off, and that is what is concerning us." – Interviewee 6*

The emerging belief that the moratorium would have little local impact was bolstered when on November 4th, 2019 the UK Government clarified that applications for new shale gas permits would still be allowed. Four interviewees discussed the extent of the policy change, mentioning a government '*turn around'* or '*U-turn'* similar to rhetoric used in news headlines at the time. However, many other interviewees were unsure about what the policy meant for fracking locally and in the UK, outside of some understanding that the government was proposing to review future shale gas proposals on a case-by-case basis.

### *3.3 Public opinion of the moratorium*

National survey data indicated that public support for the moratorium was high: 63% of national survey participants expressed support, with only 18% opposed. This figure rose to 71% when taking prior moratorium awareness into account (19% oppose). However, analyses reveal that overall levels of public support represent a convergence of different coalitions of interest. Majority support for the moratorium masks social and political polarisation linked to different reasons and perspectives, notably between Conservative party voters who supported a moratorium due to induced seismicity, and those who supported the moratorium as a first step towards a permanent ban on shale gas (who were also more likely to support opposition parties – see below). The latter is also suggested by a strong negative correlation in the survey between support for the moratorium and general support for shale gas ($r = -0.63$).

Survey analyses indicated that support for the moratorium related to agreement with the reasons for its introduction. As might be expected, agreement that 'scientific evidence of tremors' was one of the key reasons for introducing the moratorium was strongly related with support. In all instances, save for selection of 'protestors' and 'political reasons', a respondent was more likely to offer the reason if she/he expressed support for the moratorium. The Phi values (effect sizes) ranged from 0.10 – 0.20, meaning that 10-20% of the variance in moratorium support could be explained by beliefs about the rationale for the moratorium. Using chi-squared tests for comparisons between categorical variables, support for the moratorium was not found to be associated with age, social grade, or region of residence, but was associated with gender - females were more supportive than males ($X^2 = 30.5$, $p<0.001$, Phi = 0.15) and Brexit vote - remain voters supported the moratorium more ($X^2 = 50.6$, $p<0.001$, Phi = 0.21). Vote in the 2017 general election also had a strong relationship with moratorium support - an ANOVA with Bonferroni corrections, revealed higher support from Labour, Liberal Democrat, and Scottish National Party (SNP) voters compared to Conservative voters.

The majority of tweets about the moratorium can be described as information sharing, passing on the news of the moratorium to individuals or organisations in people's social networks, rather than explicit indicators of public support. While over 30% of the nearly 300 direct tweets and re-tweets

about the moratorium expressed support, only five tweets indicated opposition. Many tweets were geared toward the upcoming election, accompanied by the hashtag #BanFracking, including many linked to a petition aimed at banning fracking. As such, tweets were embedded in the larger socio-political process of the general election, for example highlighting the Labour Party manifesto which called for a ban on fracking and expressing distrust (primarily) of the Conservative Party more generally.

Most case study interviewees expressed support for the moratorium, referencing induced seismicity events at Preston New Road and local objections based on concerns about similar geology and proximity to residences. Of the residents who were asked specifically about the moratorium, seven expressed explicit support and one expressed direct opposition to it. Yet across both social media and case study datasets, strong support co-existed with deep distrust in the government and the politicians who put it into place. For example, from Twitter:

*Happy about the #frackingban but can't help but wonder about the motivation for it. #Johnson and #Tory U-turn feels suspicious as election looms. am deeply suspicious of the motivation for it. Is it Boris Johnson political plot to please England electorates as election looms? Or environmental and facts based?*

For some people, the way the moratorium was announced, when it was announced and how it was handled, coupled with the Conservative Party's previous support for fracking, meant that support for the moratorium was also associated with scepticism of its motives. This was particularly the case for local residents and those active on Twitter who wanted to see shale gas extraction stopped permanently:

*"Every day it doesn't happen is surely a good thing. I suppose I support the fact that it's on hold, I suppose the question will be what are my thoughts on the intentions? Are they honourable or*

*dishonourable? Well, I think they're completely dishonourable but do I think it's a good thing that it's not happening at the moment? Obviously, yeah." – Interviewee 5*

*A moratorium is a start but we MUST focus on protecting the environment and local communities in the UK through #cleanenergy #banfracking #banfossilfuels*

Therefore, many Twitter users and case study interviewees supported the moratorium as a policy but not the government putting the moratorium in place. As with the issues of public distrust described above, this supports Macnaghten's (68) findings that citizens tend to be sceptical of industry and government motives. While there were very few in the case study and social media data sets who expressed opposition to the moratorium, there were some objections. The sole case study interviewee who opposed the moratorium pointed to the need for domestic energy sources over a reliance on foreign countries like Russia (indirectly arising from gas imports to the UK from Europe). Similarly, of the small number of tweets indicating opposition to the moratorium, these included claims about the potential need for gas, a desire for a domestic energy source, and/or a desire for cheaper, more reliable, or greener gas.

Despite the few voicing opposition to the moratorium in social media and local case study data, these datasets aligned with the survey data in demonstrating overall public support for the moratorium. They contextualise the survey findings by highlighting that for these people, their support for the moratorium was cautious, with most interviewees describing themselves as cynical or sceptical, and expressing distrust in the government in the context of the moratorium. This distrust is unsurprising given that the interviewees also tended to express distrust of the oil and gas industry and operators when discussing shale gas development in their community and England more broadly, and, again in the context of previous research (68).

## 4 Discussion

The 2019 moratorium represents a milestone in UK energy policy. Although the pro-shale gas Conservative Party introduced the moratorium, and went on to win the 2019 general election, the moratorium on high volume extraction of shale gas remains in place at the time of writing (June 2021), with no immediate prospect of revocation. Given the UK government's commitment to achieving net zero emissions by 2050 (69), it is unclear whether shale gas will ever make a significant contribution to the UK energy mix. Even though it was not introduced for these reasons, the 2019 shale gas moratorium may represent an early example of a broader policy shift away from exploiting indigenous fossil-fuels towards zero-carbon energy sources. Given that transitions to net zero economies have significant social and behavioural dimensions (69), the lack of social science research on public responses to moratoria or bans restricting fossil-fuel exploitation is an important gap. This study aimed to shed light on this topic, with a focus on awareness, interpretations and opinions, and how these may vary across time, space and in response to ideological drivers. To address these aspects, a mixed-method approach was adopted that unusually combined national survey, social media and local case study qualitative research.

Our findings indicate high public awareness of the 2019 moratorium across the UK population, suggesting the moratorium was an important societal as well as political event. By combining national survey and social media datasets, the study provides new insights into the temporality of public responses to and support for shale gas policy at a level of granularity (i.e. over a few days) that has not been provided to date by national opinion surveys (e.g. (30,34). In the second half of 2019, only the induced seismicity in August in Cuadrilla's exploratory well in Lancashire generated a relatively high volume of public interest in shale gas across the UK, as indicated by tweet activity, yet substantially less than the moratorium. Furthermore, sustained public interest in shale gas did not occur, suggesting that the moratorium successfully reduced the issue salience (70) of shale gas during the election campaign. These temporal dynamics are central to the complexities of public responses evident in our findings, showing that social media activity rose and then declined significantly within

a few days, and remained low for the rest of the general election campaign. The convergence of different coalitions of interest led to strong public awareness of, and support for, the shale gas moratorium, yet at the same time scepticism amongst some publics that the moratorium was anything other than a political ploy intended to remove shale gas from electoral discourse, not a permanent shift in policy.

Findings reveal the interdependent dynamics of conventional and social media in public awareness raising and interpretive dynamics over key periods of time. Initial conventional reporting inaccurately suggested a ban. The assumed victory and celebratory elation of campaigners, and consequent disappointment as the temporary and limited policy change became more clear across the first weekend of November 2019, as revealed by the Twitter data, provides an emotional trajectory to the 2019 moratorium that played on existing levels of mistrust in the government (68). The timing of announcement is also a significant factor influencing some public responses, occurring during a general election campaign when different parties took opposed views on SGE in their manifestos (i.e. a ban by the Labour Party, Liberal Democrat Party and the SNP, yet support by the Conservative Party). In line with previous research (7,13), it is unsurprising that the national survey data indicated significant differences between voters of different parties, with significantly higher support for the moratorium from Labour, Liberal Democrat and SNP voters compared to Conservative voters.

Findings indicate strong public support for the moratorium, which may have contributed to the topic of shale gas extraction disappearing from public discourse during the election campaign. This is likely due to a societal consensus amongst divergent coalitions of interest that the stated reasons for the moratorium – in terms of safety and induced seismicity - were necessary and appropriate (for a discussion of similar issues in the Netherlands, see Vlek (71)), most clearly manifest by national survey and local case qualitative research.

Findings from national survey data suggest that people generally accepted the reasons cited by the UK government for the moratorium, agreeing that induced seismicity and a lack of scientific knowledge

about related tremors were central. Statistical analyses indicate that agreement with these particular reasons for the moratorium was significantly associated with support. Furthermore, there was a clear divergence amongst the reasons for support, with seismicity contrasting with political or environmental rationales (i.e. the moratorium as a response to public opinion and campaigner activities or climate change). While both factors were associated with support for the moratorium, they suggest social polarisation in how it was responded to, indicating the complexity of public responses that underpinned strong public support. Polarisation of shale gas information has been noted in previous experimental research (22) and is consistent with the concept of confirmation bias from psychological studies where information/events (e.g., energy policy announcements) are interpreted in line with prior beliefs and values (31). Since our research was not experimental, the cognitive processes underlying the observed divergent responses could be investigated in further research.

The key contribution of the local case study data is to reveal that the scale of 'public' matters in public responses – how interpretations of the moratorium, for these people, were overlaid with attempts to make sense of its local implications. Some of this relates to the fact that the case study was sited[2] in the same county (Lancashire) as the drill site where the August 2019 tremors took place, leading to continuous attempts by residents to draw comparisons, in part stimulated by local activism on the part of regional and local campaign groups (e.g. Frack Free Lancashire, The Moss Alliance). Local qualitative data indicates considerable uncertainty about whether the moratorium would, in fact, prevent local exploratory drilling. Emergent understanding of the partial nature of the moratorium, applying only to high-volume hydraulic fracturing and not preventing new applications for exploration, further contributed to local publics' scepticism about its motivations by a political party widely associated with shale gas support.

While the data are broadly consistent in showing high levels of public support for the moratorium, arguably the qualitative social media and case study data suggest significantly greater skepticism about its motivation and timing. That social media responses were divergent from the national survey data is unsurprising, as social media users have already been found to have particular social and political profiles (younger, with higher levels of formal education, more liberal and, if voting, to vote for the Labour Party, cf. (72)) by comparison with the general population. That said, it has long been recognised that 'the public' is complex, heterogeneous and difficult to capture in relation to energy transitions (73). Although nationally representative surveys are valued by policy-makers and the media as a method of diagnosing public opinion (see UK government investment in quarterly public surveys; (30), they also have many drawbacks regarding how they overlook temporal dynamics, are assumed to represent a homogeneous 'public' rather than publics, and fail to consider how energy issues are constructed in discourse (e.g. (73,74).

Turning to our third research objective, we proposed that combining methods would provide a more useful way to reveal the dynamic complexities of how 'the public' perceives and responds to shale gas policy changes than national surveys alone. Overall, this proposition is supported by the analyses. In particular, including social media data enabled the granularity of evolving public responses to the moratorium across hours and days to be captured. That said, there are clearly challenges involved in bringing disparate methods and data sources to bear on a topic. First, representativeness is a key issue, with our sample of social media users unlikely to bear similarity to the national population more closely sampled by the survey. Second, scale is an important concern, with the survey involving individuals for whom shale gas extraction has little direct, immediate consequences, unlike our local case study participants. While this increases the likelihood of divergent findings about 'the public' across methods (e.g. a stronger emphasis upon induced seismicity in national survey findings in comparison to social media analysis), looking across these matters of representation and impact, it is our contention that appropriate methods are required to capture different types of publics in understanding responses to energy policy changes. This encompasses passively engaged citizens

living at a distance from sites of extraction, local residents who are directly impacted by specific proposals, social media users and activist campaigners.

We also recognise some limitations to our methodology. First, the presentation of reasons why the UK government announced the moratorium was not randomized when presented in the national survey. This may explain why levels of agreement with each reason declined across those presented (i.e. political reasons received lower agreement than in the other datasets employed by the study) (see (75) for a discussion of this issue). Second, the local case was strongly influenced by circumstances at Cuadrilla's drill site in the same county of Lancashire, in a way that might have been less influential if the case was situated elsewhere. Third, the social media analyses draw on a subset of Twitter users relying on the Geotweet subsample, not all tweets across the time period. Fourth, the small sample of case study interviewees was not fully representative of the local community. For these reasons, we see value in future mixed method research that addresses these limitations in order to fully capture the complexities of public responses to policy change across temporal, spatial and ideological dimensions.

While our findings are based within the unique social, cultural and political context of UK shale development and policy, some findings emerge that align with or have implications for other geographical and political contexts. In many ways, the experience in the US State of New York could be viewed as similar to that in the UK. In both locations, a heated public debate that played out prominently in mass media and protests, and that was accompanied by physical environment concerns, at least partially led to a moratorium. Differences between New York and the UK lie in seismicity being a very important driver for the moratorium in the UK – via both public perceptions and political discourse – and this being a non-issue in the northeast US, especially when compared to water concerns. The UK is one of the latest governmental jurisdictions to halt SGE after a long debate. Indeed, this follows a pattern of lengthy debate leading to bans or moratoria. There are few cases, indeed none we can think of, where a lengthy public debate about SGE *before* any commercial development occurred has then led to a viable shale gas industry in that jurisdiction.

In terms of international implications of the UK moratorium, these are not fully clear due to the global disruption of energy markets that has come with the coronavirus pandemic, but a lack of gas production onshore in the UK, while UK offshore gas reserves in the North and Irish Seas dwindle, might imply, all else held equal, the need for growing imports of natural gas from European pipeline (including Russian gas) and liquefied natural gas imports from the US (shale gas). Of course, all else has not been held equal, as shown by the UK's upcoming presidency of the UNFCCC COP26. Recent climate action includes an April 2021 UK law to reduce carbon emissions by 78% by 2035. The role of continued methane use under such institutional roles and policy commitments is questionable.

In conclusion, given the dearth of research to date examining public responses to fossil fuel moratoria or bans, this research addressed an important gap. Using a mixed method approach, we investigated a novel analytical framework that conceives public responses in terms of dynamics of awareness, interpretations and opinions. Findings reveal that in contexts where a clear majority of publics support a policy change, this can be due to a convergence of coalitions of interest where the stated reasons for change (in this case, induced seismicity) are widely recognised, yet treated with skepticism by some publics due to the source, timing and limited extent of the new policy. In terms of implications, if the moratorium was a political ploy to prevent the issue from endangering the re-election of the Conservative Party, then it can be judged a success. The moratorium effectively removed the topic from public discourse during an election campaign that the Conservatives won convincingly. However, short-term electoral success may come at a longer-term cost in relation to the societal legitimacy of energy transitions and public support for emerging net zero technologies. Our findings indicate that the timing, source, initial mislabelling and limited extent of the moratoriumprovoked skeptical responses amongst many who expressed support for the policy. Shifting focus to broader transitions to low carbon energy sources, recent research indicates 'ripple effects' of shale gas on public perceptions of carbon dioxide removal, a key emerging technology for reaching net zero emissions (21). In summary, social distrust in policy makers and experts about the safety and efficacy

of sub-surface energy technologies may represent a long term impact of shale gas policy-making, and the moratorium in particular, that hinders the achievement of net zero emissions.

Second, our findings indicate the value of adopting mixed methods in diagnosing what 'the public' thinks about a particular energy policy or technology. Using mixed methods lessens ways that certain public voices (local, activist) can be overlooked in national policy making – undermining recognition justice (76) - if certain tools of data collection, notably the national opinion surveys adopted by the UK government in quarterly public attitude trackers, are privileged by policy makers. More broadly, they suggest the value of integrating social media analysis into future research on public opinions about certain policies or technologies, how they are implemented and with what outcomes. Capturing temporal granularity across hours and days opens up a novel window on public response that can be set alongside more conventional methods that capture nationally representative or locally impacted publics. A plurality of methods to capture varieties of 'the public' will be necessary to tackle the challenges of trust, legitimacy and consensus-seeking that lie ahead in achieving the rapid and extensive transformations required to meet climate change and sustainable development goals.

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**Appendix 1: Methodology**

1. Research design

Table 1: Overview of the mixed method research design

| Level | Data collection | Quantitative data and timing of data collection | Qualitative data and timing of data collection |
|---|---|---|---|
| National | Social media (collection of Tweets) | Geolocated Tweets analysed for quantity and change over time in England and the rest of the UK (15th August – 31st December 2019) | Geolocated Tweets – thematic analysis using NVIVO software (25th October – 19th December 2019) |
| | Questionnaire survey | Analysis of data completed by a representative sample of UK adults (8-9th December 2019) | - |
| Local | Participant observation, semi-structured interviews and walking interviews | - | Thematic analysis using NVivo software (September to December 2019) |

2. National Survey

1a. Procedure:

The survey was conducted using the online polling company YouGov. Participants were selected from a panel and constrained with quotas to represent key personal characteristics of UK adults: age, sex, social grade (socio-economic status), education, vote in the 2017 UK general election, vote in the 2016 EU (Brexit) referendum, level of attention paid to politics and dwelling location (UK census region). Weighting was not employed due to the quota constraints already mentioned.

1b. Questions:

*Awareness of the moratorium:*

Shale gas is a form of natural gas trapped within sedimentary rock, which is extracted using a method known as hydraulic fracturing, or 'fracking'. Before taking this survey, were you aware of the current indefinite suspension of fracking in England by the government?

*Perceived reasons for its introduction:*

Why do you think the government has suspended fracking until further notice? Please tick all that apply.

1. Tremors felt at a shale gas fracking site
2. Scientific evidence about tremors arising from fracking
3. Direct action by protestors
4. Concern for the safety of those living and working near a shale gas project
5. Political-related reasons
6. Climate change
7. Declining public support for shale gas
8. Other 'please specify'
9. None of the above
10. Don't know

3. Social media:

Quantitative analysis

Twitter has a Streaming API (Application Programming Interface) to allow developers to write software that connects to the Twitter servers to request subsets of their data. The Streaming API only makes a small proportion of all tweets available as Twitter imposes a filter to lower the data volume through this free access point. For this research we were only interested in geolocated tweets, which are tweets that have a location attribute along with the message, username, language, and timestamp. Geotweets make up only a small fraction of all tweets and therefore appear not to be filtered by Twitter, meaning we are likely to collect all of the geotweets from the UK during the study period. On average this resulted in 200,000 tweets being captured per day covering a wide range of subjects, of which only a small fraction related to fracking. The accuracy of geographic coordinates varies depending on the type of device used (e.g. laptop, mobile phone) and user settings. The highest location accuracy available is when the Tweet includes GNSS (e.g. GPS) coordinates typically locating the user to within 20m of their true location. Other geotweets are located by a coarser bounding box, which could be as large as a city. Using the

location attribute each tweet in the dataset was assigned a binary value specifying whether it was sent from within England or from outside of England whilst still being within the UK (i.e. Scotland, Wales or Northern Ireland). The distinct number of Twitter users per day was calculated by by binning the data per day, then counting the number of distinct Twitter accounts sending fracking related messages, and the number of message each account sent.

Qualitative analysis:

Once extracted, the Twitter data were transferred into NVivo for coding and thematic analysis. Initial codes were developed by Author 2 through open coding (77) of case study interviews for the same project. In turning to qualitative analysis of Twitter data, Author 2 and Author 3 reviewed the initial codebook developed by Author 2 and established a coding protocol (78). They then began axial coding of the Twitter data to explore existing and emergent themes (79). The researchers engaged in several processes to achieve inter-coder agreement (61,62), beginning with repeat coding where they separately coded the same data (approximately 5% of Tweets), then reconvened to discuss points of agreement and discrepancies. Through iterative coding and a constant comparative method, notations were exchanged via the Memo tool, highlighting new codes and flagging new trends or patterns that emerged from the data. After the first round of coding, the researchers reconvened and discussed how codes had been used throughout the dataset. Any discrepancies or oversights were identified and updated in the second round of coding. After completing the second round of axial coding, codes that came to hold particular importance for the data were identified. These codes were analysed while simultaneously looking for patterns in hashtags, external links, tagged and Twitter users. From this research a timeline of events surrounding the moratorium was developed and media influences that seemed to be relied on in our social media sample were identified. As a final check on the analysis, a word frequency report was undertaken (see Table 1); the results showed that the qualitatively important themes that emerged from the analysis aligned with phrases and concepts used frequently throughout the dataset.

Table 2: Word frequency report for the top 25 most commonly mentioned themes

| Word | Count |
|---|---|
| fracking | 382 |
| https | 218 |
| ban | 189 |
| banned | 122 |
| government | 95 |
| #fracking | 87 |
| tories | 60 |
| turn | 54 |
| amp | 48 |
| election | 47 |
| major | 45 |
| just | 44 |
| makes | 42 |
| stop | 40 |
| now | 34 |
| labour | 33 |
| moratorium | 32 |
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4. Local case study qualitative research:

In September 2019, following a period of public consultation, Aurora Energy Resources Ltd. submitted a planning application to conduct exploratory drilling for shale gas in the vicinity of the village of Great Altcar (est. population of 250) and the town of Formby (est. population of 20,000) in Lancashire. The proposal was objected to by several local and regional anti-shale gas action groups, including Frack Free Lancashire, Frack Free Formby and the Altcar Moss Alliance. Author 2 spent just over a month in Formby and Altcar, visiting local environmental sites, attending community social activities, and observing meetings held by local activist organizations and Lancashire County Council. Interviews (see Table 3) lasted between 10 and 150 minutes and were primarily conducted in person, though five follow-up interviews were conducted remotely by phone and one was conducted

over email when schedules would not allow for face-to-face meetings. Interview length varied in response to participants' availability, willingness to talk about shale gas and whether the interview was a specific follow-up on the moratorium announcement.

Key patterns were identified by analysing interviews and developing initial memos and codes using NVivo software (80). Thematic coding (60) included support for or opposition to the fracking moratorium, and questions regarding the motivations of the fracking moratorium. These built on larger questions the research project is focused on, including sense of place, community engagement, and trust in industry and the government in the context of fracking. To triangulate the research, participant observation included informal conversations with residents who did not end up participating in semi-structured interviews, casual conversations with residents in churches and restaurants during immersion in the community and local activities, and attendance at three meetings, including two action group and one planning committee meetings. Field notes from participant observation and interviews were recorded as soon as possible after the fieldwork was complete and were reviewed multiple times to check the validity of the interview coding scheme. The overall case study sample has equal proportions of males and females; however, the moratorium follow-up interviews were skewed towards male participants, which arises from the fact that we spoke to whichever interviewee was available and willing to participate again. It is also notable that Great Altcar is a farming area and while most homes were couples, some of the independent farmers were men who lived alone. The same goes for speaking with elected officials, where there are predominantly more men than women.

Table 3: Summary of interviews conducted in the local case context

| Interview number | Date of interview | Type of participant | Profession | Gender |
|---|---|---|---|---|
| 1 | 03/12/19 | Local Government | Retired | M |
| 4 | 21/11/19 | Resident | Local business owner | M |
| 5 | 09/12/19 | Resident | Local business owner | M |
| 6 | 19/11/19 | Local Government | Retired | M |
| 7 | 19/11/19 | Local government, Activist | N/A | M |
| 12 | 16/11/19 | Activist | Retired | F |
| 13 | 20/11/19 | Resident, NGO Representative | Retired | M |
| 16 | 04/12/19 | Resident | Construction management | M |
| 18 | 11/12/19 | Resident | Farmer | M |
| 20 | 21/11/19 | Resident | Wildlife management | M |
| 21 | 11/12/19 | Resident | Farmer | F |
| 23 | 19/11/19 | Resident | Retired | M |