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Seasonality in the Anthropocene: On the construction of Southeast Asia's 'haze season'

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Abstract

The widespread burning of tropical peatlands across regions of Malaysia and Indonesia is now considered an annual event in equatorial Southeast Asia. The fires cause poor air quality

(‘haze’) across the region, affecting the health of millions, but little has been written about how people in Southeast Asia make sense of this recurring phenomenon. In this paper, we investigate the emergent social construction of the ‘*haze season*’. Borrowing from anthropology literature, we define ‘seasons’ as a social construct that enables societies to organise their livelihoods around the expectation of recurring phenomena. The construction of ‘haze season’, in turn, reflects ongoing deliberation and contestation of the societal perception of and reaction to the causes and effects of haze. To do that, we analysed more than 35,000 news articles published in Indonesia, Malaysia and Singapore to investigate the timing of haze season reporting and key themes associated with the season. Deploying keyness analysis and structural topic modelling (STM), we find a strong distinction between the themes of articles written about the ‘haze season’ and articles that simply refer to the haze problem alone. Articles that mention ‘haze’ but not ‘haze season’ focus on the root causes of the haze crisis – peatland fires in Indonesia, oil palm plantations, deforestation – as well as geopolitical cooperation to prevent fires (e.g., through ASEAN). We found that the ‘haze season’ articles have a strong association with the effects of the haze crisis, particularly during the haze season months (June to October), suggesting that seasonality plays a role in adaptation behaviour. Outside of the haze season months, articles focus more on haze mitigation and associated political action. As a season that has emerged entirely as the result of human activity, affecting hundreds of millions of people over a spatial extent of millions of square kilometres, we argue that the ‘haze season’ is a ‘Season of the Anthropocene’. We suggest that we should expect more seasons of the Anthropocene as environmental crises and our response to those crises become more acute through this century.

Keywords

Transboundary haze, Southeast Asia, Anthropocene, Seasons, Social construction of nature

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Introduction

Haze was first documented in Singapore in 1972, when a mass deforestation event in the neighbouring Johor Bahru brought poor air quality and low visibility to the entire island (Lee, 2015). As unsustainable land clearance and agricultural practices, particularly the degradation of tropical peatlands, continued to scale up, the phenomenon regularly returned to Indonesia, Malaysia and Singapore periodically around every five years with the help of natural cycles, especially when El Niño brings exceptionally dry weather (Nichol, 1997; Remember Singapore, 2013). By the turn of the millennium, Singapore began to record an annual occurrence of haze, albeit at different scales and magnitudes (SIIA, 2020; Remember Singapore, 2013; WWF, 2019). There is growing evidence suggesting that the annual occurrence has built an expectation in societies of when haze may occur. More recently, a coalition of think tanks, NGOs, researchers and policy-makers have begun to forecast the severity of annual haze based on a combination of quantitative meteorological data and qualitative stakeholder engagement methods (SIIA, 2019, 2020). A handful of academic publications have begun to adopt the term 'haze season'. For example, Hansen *et al*. (2019) define the season to lie between August and October when the particulate matter in the atmosphere spikes. Other studies have acknowledged how perceptions of health risks from air pollution become socially amplified during the 'haze season' (Ng *et al*., 2018; Yeo *et al*., 2014). However, there has yet to be any exploration of how the concept of 'haze season' has been constructed and defined and how this relates to perceptions of air pollution risk, as well as subsequent mitigation, preventative or adaptive behaviours.

We borrow from anthropological studies where seasons are understood to be a way for communities to respond and engage with their changing surroundings (Krause, 2013). Taking this view, rather than being defined exclusively by the 'objective' observation of

meteorological patterns, seasons are instead the product of deliberation and contestation of which phenomena to observe and how to normalise such phenomena to reflect and serve matters of concern to particular societies. This fluid conceptualisation of season is especially helpful in understanding how societies respond to and engage with anthropogenic environmental change. We believe this way of thinking is useful for environmental geography because it provides a framework for understanding how contemporary society makes sense of dynamics in their surrounding physical environment and how societal action is responsible for changing and shaping those environmental dynamics. Specifically, we interrogate how society has sought to make sense (discursively constructed) of a man-made (physically constructed by capitalist agricultural activities) environmental phenomenon through the concept of 'seasonality'.

In this paper, we investigate how the 'haze season' has been constructed in the news media of Indonesia, Malaysia and Singapore, three of the Southeast Asian countries worst affected by annually occurring haze (Cheong *et al*., 2019). Specifically, this paper seeks to answer

(1) What time of the year does society define as 'haze season'?

(2) What are the key discourses surrounding 'haze season'?

(3) What role does this construction of haze 'seasonality' play in shaping people's behaviour towards haze?

To uncover the discursive constructions of the haze season in Southeast Asia, we conduct a discourse analysis of media coverage of haze in Indonesia, Malaysia and Singapore. We draw conceptually from the 'social construction of nature' to unpack how the social construction of 'season' in shaping how society makes sense of and subsequently takes (non-)action toward anthropogenic environmental degradation (Demeritt, 2001).

The findings of this paper contribute conceptually to reflections on the social construction of nature in the Anthropocene (Arias-Maldonado, 2020) within the climate-vulnerable context of Southeast Asia. Anthropogenic environmental changes will bring uneven impacts on human society. 'Haze' is a term used in SE Asia to refer to air pollution. That is, the visible, odorous, and hazardous consequence of anthropogenic degradation and combustion of cropland, tropical forests and peatlands in Southeast Asia. The recurrent disruption caused by haze provides an ideal case study of the construction of 'Seasonality in the Anthropocene'. By understanding how the haze season is constructed, we uncover whether this collective conceptualisation motivates mitigative and/or adaptive behaviour. That is, whether the conceptualisation of the haze season contributes to the construction of a 'survivable future' (Castree, 2014).

Our study also bears practical implications. Recurring haze affects the health of millions, causes economic disruption, and leads to diplomatic disputes between places that burn and the places downwind that suffer the smoke plumes from the burning (Cheong *et al*., 2019; Heilman, 2015; Glover *et al*., 2003; Narayanan, 2002; World Bank, 2015). Understanding how society perceives and interacts with haze by experiencing the phenomenon as a season, we may begin to uncover patterns and drivers of mitigation and/or adaptation action.

This paper will be organised as follows. The next section will introduce the conceptual framework of our study and provide a review of existing studies of haze seasonality in Southeast Asia. The third section details our methodology. The fourth section introduces three key findings relating to the construction of the haze season. The fifth section discusses the implications of our findings, followed by our conclusion.

Conceptualising the Construction of Seasons of the Anthropocene

The conceptual scaffolding of this article is built upon the well-established geographical literature on the social construction of nature that seeks to understand environmental problems and the social and cultural complexities within which they are constructed (Castree and Braun, 2001; Demeritt, 2002; Escobar, 1996). However, Demeritt (2002) warned of the conceptual slippage of failing to clearly define what one means by 'social construction of nature', as the phrase in itself does not make clear the ontology and, subsequently, the epistemology of what 'construction' and 'nature' mean.

'Construction of nature' could be interpreted as either the construction of our perception of nature and/or how human activities shape the process of constructing nature in the physical and material sense. In this paper, we contend that human activities, particularly neoliberal capitalist activities, have materially changed the natural environment (c.f. Castree, 1995; McCarthy and Prudham, 2004; See Fig. 1). We seek to discover how society understands and conceptualises this changing natural environment and what policy implications (on motivating mitigation or adaptation strategies to environmental change or inertia) these conceptualisations bear. That is, we see haze as a man-made environmental phenomenon caused by the deliberate (and, occasionally, accidental) burning of biomass as the result of unsustainable agricultural practices, and we are interested in how the identification and labelling of the recurring air pollution episode as 'haze' has developed into the construction of the 'haze season', and how this has subsequently shaped society's perception and reaction to this phenomenon.

How the 'haze season' is constructed bears wider implications on existing knowledge of the social construction of nature. In particular, we believe it enriches how we conceptualise human and non-human relationships in the Anthropocene as a socially-, culturally- and politically-laden topic (Brondizio *et al*., 2016; Lövbrand *et al*., 2015). The human relationship with the environment has changed from being that of a species that has had to adapt to changes

in its natural environment to one that has become a driving force in the planetary system (Zalasiewicz *et al*., 2011). As human activities began to shape and change the physical and material state of nature, the notion of ‘seasons’ could be one of the conceptual tools to help societies perceive and make sense of the (lasting) changes humans have made to the environment (Fig. 1).

The concept of ‘season’ has been drawn upon by scholars of various disciplines to understand how communities react and relate to the environment and its subsequent impact on community resilience and vulnerability. Geographers have adopted the concept of ‘seasons’ to make sense of how societies cope with environmental hazards. In development studies, Davies *et al*. (2009) found that the construction of ‘seasonality’ enhances the risk management and coping ability of subsistence agricultural communities as the expectation of environmental disturbances better prepares these communities for when an environmental stress event occurs. Similarly, Peters-Guarin *et al*. (2012) discovered that communities have formulated a seasonal perception of the manageability of flood hazards - defined by the flood water level - in Naga City, the Philippines. Social perceptions and reactions to ‘seasonality’ are not homogenous. For example, the psychologists Paton *et al*. (2006) observe that in Australia, the expectation of a bushfire ‘season’ in a specific temporal period of the year had led some to habitually adopt protective measures, while others adopted precautions only when dangerous fire weather, such as hot, dry and windy conditions, prevailed. Seasons are not restricted to recurrent environmental phenomena. By conducting two surveys outside and during the ‘tourist season’ in the Mediterranean, Bimonte and Faralla (2016) uncovered the ‘hidden cost’ of tourism on the residents' life satisfaction.

However, these studies have taken the concept of ‘season’ for granted without necessarily defining what it means or delving into how different ‘seasons’ emerge in different societies. To understand how seasons are constructed and subsequently organise society’s

conceptualisation of nature, we borrow from the field of anthropology in defining what 'season' means and how the concept of seasons is constructed and performed by societies to give social and cultural meaning to the changing natural environment.

Anthropologists have defined 'seasons' in two key ways. First, they define seasons as specific temporal blocks of the year that are typically organised around atmospheric changes (Mauss, 1950; Orlove, 2003; Young, 1988). In this view, one season follows another, each of which would bear specific characteristics specific to physical and cultural geographies, such as the association of summer with warmth and strawberries and winter with cold and Christmas in Britain. In this way, seasons are characterised by specific natural conditions and phenomena, and humans attach linguistically- and culturally-influenced labels to them. However, this conceptualisation commits a contradiction between ecological determinism and social constructivism, one that presumes that humans construct their worlds before they live in them and yet that human beings are in some way determined by these worlds (Harris, 1998).

Second, and more recently, seasons are conceptualised as 'rhythms' of life cycles (Ingold and Kurttila, 2000; Krause, 2004; Lefebvre, 2004). This view sees seasons as human activities that are interwoven with the rhythms of other more-than-human activities, such as the activities of animals, plant growth and decay, weather and alterations of day and night (Ingold and Kurttila, 2000). This conceptualisation of seasons sees a close association of human and more-than-human activities with one another – as human activities bear a material impact on other more-than-human activities. Rather than defining seasons according to a set labelled chronology, seasons blend into each other as one set of activities and ecological processes become more prominent and another fades. This view necessarily implies that human activities play a crucial part in shaping the ecological processes and the wider natural environment that comes together to create seasons.

While this 'rhythmic' conceptualisation of seasons first emerged in a study of life in

the Amazonian floodplains (Harris, 1998), it has been applied to modern settings in recent years (Krause, 2004; Whitehouse, 2017). Notably, Whitehouse (2017) presents the first study of seasonality in the context of contemporary, industrialised society against the backdrop of contemporary anthropogenic environmental change. Based on the Island of Islay in Scotland, Whitehouse observed how the observation of birdsong had become a means for birdwatchers to determine seasons. By doing so, Whitehouse (2017) shed light on how relationships between human activities and more-than-human processes could be maintained even as humans now inhabit a mostly indoors, controlled environment.

The equatorial latitudes mean that societies in the Southeast Asia region tend to have a different set of seasonal experiences to the 'typical' four seasons that are broadly known in geographies with temperate climates, but 'seasons' have nonetheless been constructed based on people's experience of the oscillation between 'dry' and 'wet' or 'rain' seasons, and worsening 'flood' season in recent years (Chuan, 2005). Existing research evidence the emergent seasonality of other collectively experienced recurring socio-environmental phenomena, for example, the seasonality of fresh produce (Spencer, 1959) and social activities (Lim and McAller, 2000).

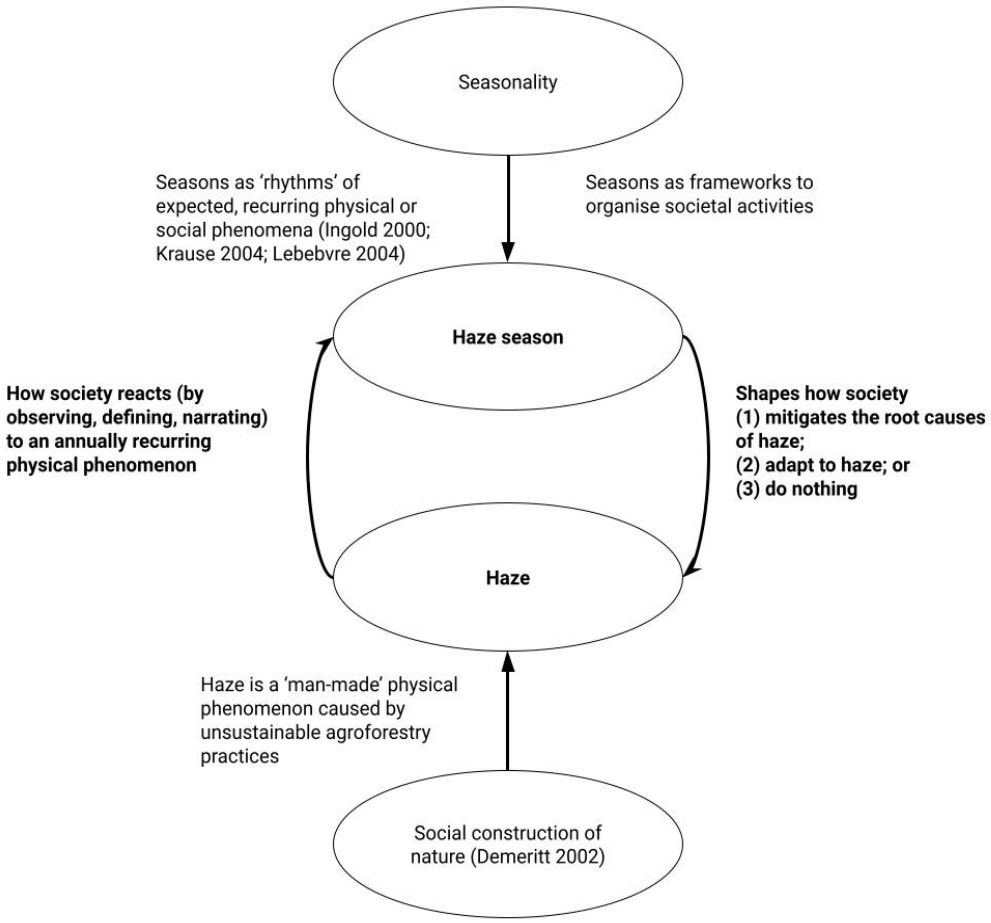

Figure 1. A visual conceptualisation of the haze season

As scientists increasingly adopt the term 'haze season' in describing the annual recurrence of haze and its impact on air quality and public health (Hansen *et al*., 2019; Ng *et al*., 2018; Yeo *et al*., 2014), there is a lack of a clear definition as to what is 'haze season'. To the best of our knowledge, there has only been one social science study that has drawn upon the concept of 'season' in explaining how Southeast Asian societies have interacted with haze. De Pratto *et al*. (2015) highlighted how the 'seasonally' recurring haze caused by forest fires is experienced differently by different groups of people. Specifically, they observed that amateur Malaysian duathlon athletes are more aware of the arrival of 'haze' because it directly impacts their ability to train outdoors. However, non-athletic Malaysians are less impacted as they conduct most of their daily lives indoors.

Despite a growing body of literature acknowledging the annual recurrence of haze and its implications for public health, there are yet to be any studies that investigate how society collectively constructs and gives meaning to this recurring event as a 'season' and, subsequently, how this construction of season shapes the way that society may adapt to or mitigate the phenomenon. Haze is a man-made pollution phenomenon, and existing studies have further highlighted that the social perception of haze shapes the way society deals with the problem and its underlying causes. Forsyth (2014) highlighted that the recurring pollution event is fuelling growing public criticism towards Indonesian palm oil and pulp and paper companies, as well as towards existing, ineffective regional policy solutions to the problem. Conversely, research in New Zealand and Australia suggests that the cultural and social interpretations of fire smoke could normalise air pollution, thus encouraging non-action towards mitigation and adaptation. Reeve *et al*. (2013) and Cupples *et al*. (2007) both found identity and emotive attachments towards traditional open fires and log burners in Christchurch, New Zealand and Armidale, Australia. These perceptions have deterred households from replacing open fires, log burners, and electrical heaters with less polluting alternatives (Cupples *et al*., 2007). By investigating how the media of Indonesia, Malaysia and Singapore has defined and constructed the 'haze season', our study seeks to uncover the conceptualisation of this seasonality and how it shapes the way society mitigates and/or adapts to the problem.

The media plays a critical mediative role in portraying and communicating complex environmental issues to the general public, especially when the issue demands individual and/or institutional behavioural mitigative or adaptive behavioural changes (Berkhout, 2010). Notably, the literature on climate scepticism and denialism finds that media portrayal delays urgent climate action by fuelling mistrust in science (Boykoff and Boykoff, 2007; Hmielowski *et al*., 2014). More recently, scholars found that media (mis)representation of anthropogenic

environmental change bears negative implications on building social resilience. Notably, (mis)representation of heatwaves in Europe of people having fun, for example, sunbathing or playing by the water, displaces and marginalises vulnerability concerns. By failing to represent images of the dangers of the heatwave, the media is responsible for excluding opportunities for imagining a more resilient future (O'Neill *et al*., 2022).

Within the context of the agroforestry sector in Southeast Asia, denialism of the negative environmental impact of the agroforestry sector provides justification for politicians and the industry alike to continue with environmentally damaging agroforestry practices, at the same time disarming civil society from holding powerful stakeholders accountable (Forsyth, 2014; Liu *et al*., 2020). While these denialist narratives closely resemble climate scepticism and denialist narratives in the West, media portrayal of climate denialism in Southeast Asia uniquely depicts post-colonial tensions and developmental priorities (Manzo *et al*., 2019). What makes Southeast Asian media particularly influential in shaping and reflecting public opinion is the state censorship of the media. Although states allow for some level of deliberation of public opinion, media outlets are also proponents of state agenda (Goldstein, 2016). As such, analysis of media content will not only provide insights into public perceptions and opinion; it also provides an indication of policy direction on key matters of concern.

Methodology

Our study focuses on printed and online media portrayal of haze and the haze season specifically to determine how 'haze season' as a concept emerged and evolved in Indonesia, Malaysia and Singapore and its implication for mitigation and adaptation. We have chosen these three countries as they are economically involved in the Southeast Asian agroforestry sector and are concurrently affected by haze caused by the unsustainable practices of the sector.

Our focus on traditional media follows past studies of public discourse and social perception of air pollution and the agroforestry sector in Southeast Asia (Forsyth, 2014; Liu *et al*., 2020; Massey, 2000; McLellan, 2001; Manzo *et al*., 2019).

Our methodology follows five key steps (See Fig. 2). First, we conducted a search on Factiva and Lexis Nexis for English-, Bahasa Melayu-, and Bahasa Indonesia-language articles containing 'haze' and 'haze season' between 1998-2021, published in Indonesia, Malaysia and Singapore. These languages have been chosen as they are the main languages spoken in these countries. Each language included two corpora. The first corpus identified articles from Singapore, Malaysia, or Indonesia, which included the phrase 'haze season'. This time frame was chosen because we could find no mentions of 'haze season' before 2001; we selected a three-year buffer to include 1998, which is a year after the first and most pronounced widespread haze season affecting the region in 1997 (van der Werf *et al*., 2004). The second corpus incorporated any article with the word 'haze' but excluded any articles with the phrase 'haze season'. In Bahasa Melayu and Bahasa Indonesia, no words describe the atmospheric pollution phenomenon that could be a direct translation of 'haze'. Instead, '*jerebu*' (fog) is used in Bahasa Melayu and '*asap*' (smoke) is used in Bahasa Indonesia, and the terms for 'haze season' are '*musim jerebu*' and '*musim asap*' respectively. We, therefore, only analysed the season terms in Bahasa Melayu and Bahasa Indonesia. Duplicate articles and false-positive articles (for instance, where the phrase 'haze season' appeared in a link to another article) were removed before analysis. Duplicate articles did not need to be identical. For instance, when an article first published in an early edition was revised and appeared as two different articles, the longer article was selected for analysis.

Following the article search, we identified the monthly distribution of newspaper articles mentioning 'haze' and 'haze season'. We plotted the distribution against Singapore's Pollution Standard Index (PSI) and Nasa's MODIS fire count - as a proxy of haze episodes - to

identify any temporal correlation between fire activity and poor air quality caused by haze with newspaper article coverage of the topic.

Then, to define the conceptual uniqueness of ‘haze season’, we identified keywords associated with ‘haze season’ by comparing the words found in the articles mentioning the term ‘haze season’ with a corpus of words drawn from general usage in the year 2020, a corpus containing over 38 billion words. Using this, we identified a list of words and parts of speech that are statistically significantly prevalent in articles covering ‘haze season’.

For ‘*musim jerebu*’ and ‘*musim asap*’ there is no general linguistic corpus available for Bahasa, so we conducted manual coding (Forsyth, 2014; Liu *et al*., 2020) to pick out keywords and themes emerging from the articles that mention these two terms.

Fourth, to compare the differences between our two distinct textual corpora (‘haze’-only and ‘haze season’), in order to discover divergent themes, we conducted a ‘keyness analysis’ between the two corpora (Gabrielatos, 2018). The keyness between the ‘haze’ and ‘haze season’ corpora was compiled using the Quanteda software package within the R software suite. However, Quanteda does not calculate the Bayesian Information Criterion (BIC) score (see below), so the analysis was supplemented using a spreadsheet created by Paul Rayson at Lancaster University, allowing calculations of additional metrics (Rayson, n.d.). Keyness can be used for both difference and similarity analyses, though the two analyses vary slightly in their calculation. A difference analysis requires both an effect-size metric and a statistical significance value, while a similarity analysis requires only an effect-size metric (Gabrielatos, 2018; Rayson and Garside, 2000). Effect-size metrics use a log-likelihood formula for calculation, while statistical significance is given using a BIC score. Before calculating the scores, common words such as ‘the’ or ‘as’, which provide little comparative insight, were systematically removed from the corpora. The words in the corpora also had their endings truncated to allow for better comparison among the same words with slightly different

endings. The Quanteda software then calculated the frequency scores between words in each corpus. Frequency scores were then thresholded based on a words-per-million frequency. Words occurring more than 80 per million times in either corpus had BIC scores and a log-likelihood score calculated using the Rayson spreadsheet. For the statistical significance of difference analysis, any BIC score greater than 6 shows strong evidence against H0 [the null hypothesis, i.e., a difference between the two corpora] and scores greater than ten show very strong evidence against H0 (Rayson, n.d.). For the effect size, the log-likelihood method was used to calculate the scores.

Finally, we conducted structural topic modelling to identify and analyse key thematics and covariates presented in the media within and outside haze seasons. This method has been used in social science research to identify document-topic and topic-word distributions to be correlated with certain metadata information that corresponds to or operationalises the independent variables of interest.

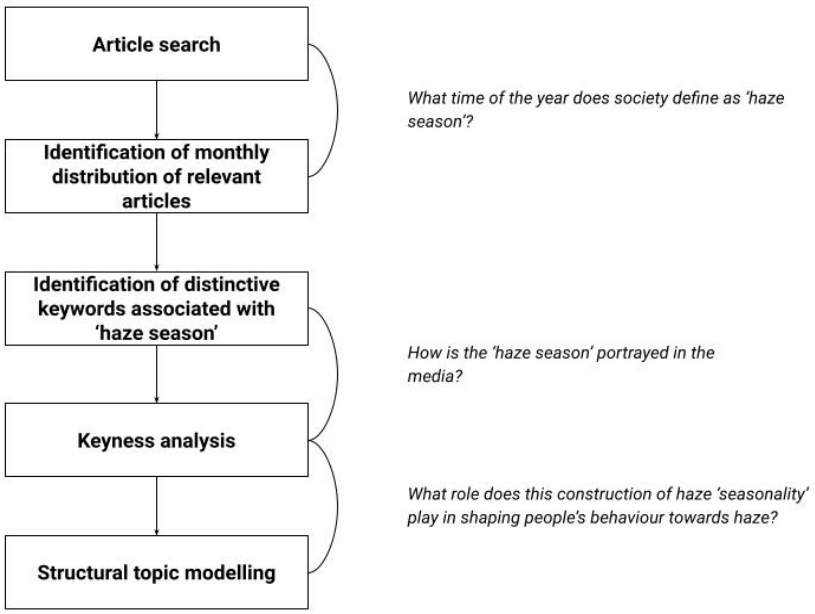

Figure 2. Research design

The Structural Topic Modelling (STM) method provides a way to identify topics associated with the haze season, avoiding the researcher's bias in determining the topics beforehand. We perform an STM analysis of English language articles published in Singapore, Malaysia and Indonesia that mention ‘haze’ to obtain structural topic models of the three newspaper corpora. We begin by specifying the number of topics to conduct the STM analysis. For each corpus, we test a range of model specifications to identify the number of topics that produces the most semantically distinct and coherent topics. For instance, for the Singaporean corpus, we decided on six topics. Fewer topics would have led to topics merging (e.g., ‘air pollution’ and ‘health’), while more topics lead to overlapping themes within multiple topics. The STM reveals the highest probability words in the topic and the *frex*, which refers to a selection of words unique to the topic. The topic labels were determined subjectively by the authors informed by the highest probability words and the *frex*. Since there still exists an element of subjectivity in deciding semantic coherence, we further validate our topic labels using word-intrusion and topic-intrusion tests (Chan and Saltzer 2020). We then investigate how the distribution of topics in each corpus changes through the year, with particular attention on whether certain topics are over- or under-represented during the haze season period from June to October. To do so, we create a binary metadata category for each article to denote whether it was published during the ‘haze season’. This allows us to identify differences in the topic prevalence of an article published during and outside the haze season. We found only a small number of newspaper articles mentioning ‘*musim jerebu*’ (n=49) and ‘*musim asap*’ (n=1), which prevented a meaningful STM analysis. Instead, we manually coded these articles in our results and discussion.

The Emergence of a Haze Season

The temporality of the ‘haze season’

We found articles mentioning ‘haze’ (n = 36580) and ‘haze season’ (n = 371), as well as ‘*musim jerebu*’ (n=49) and ‘*musim asap*’ (n=1), all of which peak in September and October, coinciding with the peak of forest fire incidents in Indonesia and peaks in air pollution (PSI) in Singapore, which could be used as a proxy for haze episodes (see Figure 3). The heightened social awareness of haze is temporally aligned with the peaks of haze pollution in the atmosphere. This indicates a seasonal organisation of social discourse around this man-made atmospheric change. News article content supports the acknowledgement of the existence of a ‘hazy’ season, as the following quote from a 2000 article published in the *International Herald Tribune* suggests its emergence:

> "There are two seasons in most of Southeast Asia wet and dry but in recent years some countries have come to expect a third: the "hazy" season, when fires set by farmers and plantation owners to clear brush send thick clouds of smoke across parts of Indonesia, Malaysia, Singapore, Brunei and southern Thailand. What was once an intermittent annoyance, occurring mostly during exceptionally dry years, is now an annual event." (International Herald Tribune, 2000)

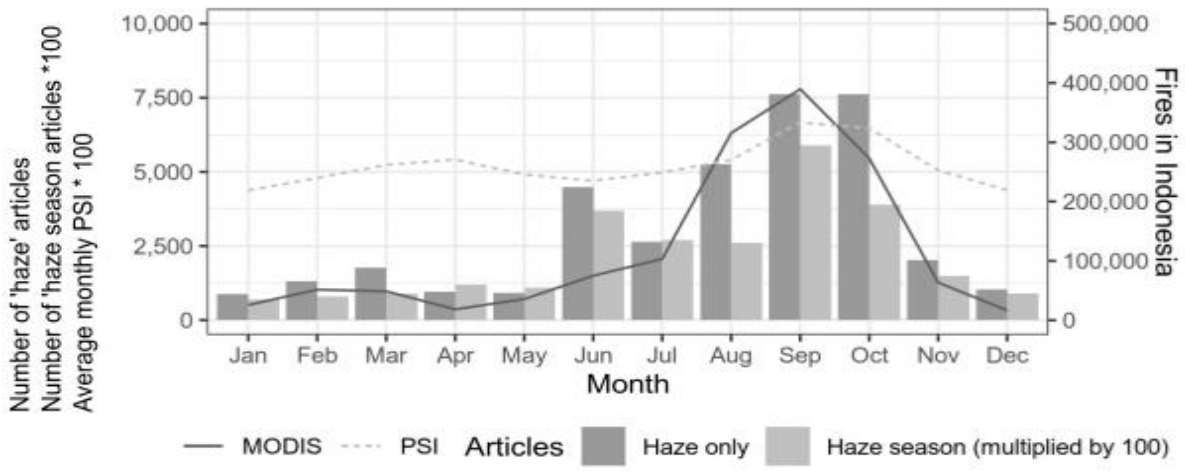

Figure 3. Articles by month compared with Indonesian MODIS fire count data and Singapore's Pollution Standards Index (PSI).

By 2006, haze is already socialised and normalised as an expected annual occurrence (although falling somewhat earlier in the year than the more frequent usage of the term since 2013), as suggested by this quote in *Today Singapore*:

> "The traditional haze season from June is expected to end by the middle of next month [July]." (Today Singapore 2006)

In 2019, the recurring haze had become normalised to the point that a Malaysia newspaper *Berita Harian* quoted an online joke that Malaysia has three seasons:

> "*Ada betulnya jenaka yang dikongsi di alam maya tidak lama dahulu mengenai tiga musim di Malaysia - musim hujan, musim jerebu dan musim durian*" (Berita Harian, 2019a)
>
> (Translation: There is a joke that was shared online not long ago about the three seasons in Malaysia - the rainy season, the haze season and the durian season)

It is worth noting that articles mentioning both 'haze' and 'haze season' are increasing over time (see Figure 4), and most articles mentioning 'haze season' were published after 2013 (n=361), suggesting the issue is gaining traction as a matter of concern in society. Similarly,

only two articles in Bahasa Melayu/ Indonesia mention '*musim asap*' or '*musim jerebu*' before 2013.

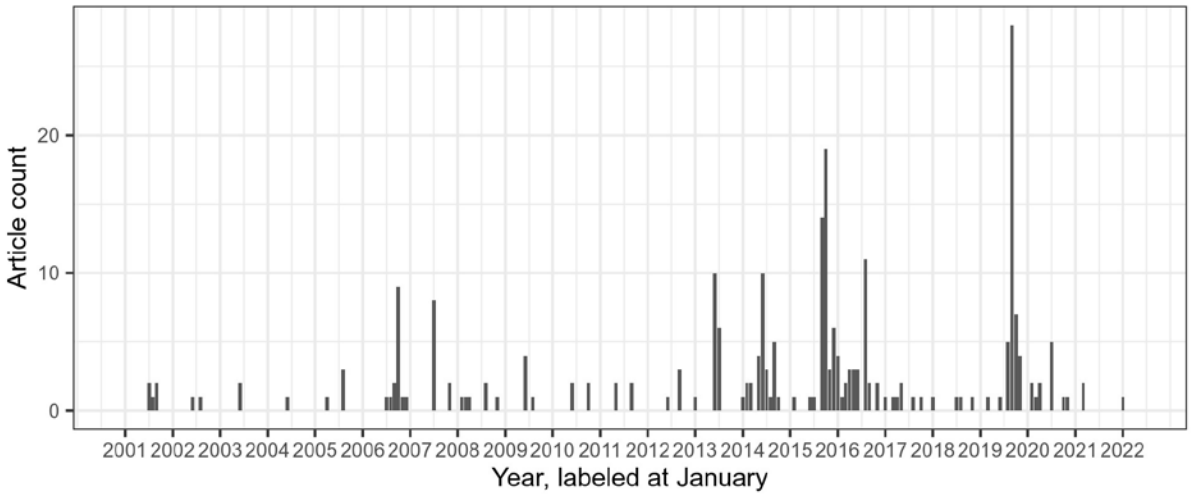

Figure 4. Mention of 'haze season' by month between 2001-2022; we could not find any articles that use the term 'haze season' published before 2001. Alternative versions of this plot for all haze articles can be found in Supplementary Materials

Divergent discourses around 'haze' and 'haze season'

Having established the temporal correlation between the occurrence of haze with newspaper article coverage of the topic and the 'season', we identified the distinctive discourse emerging out of the construction of 'haze season' (Figure 5).

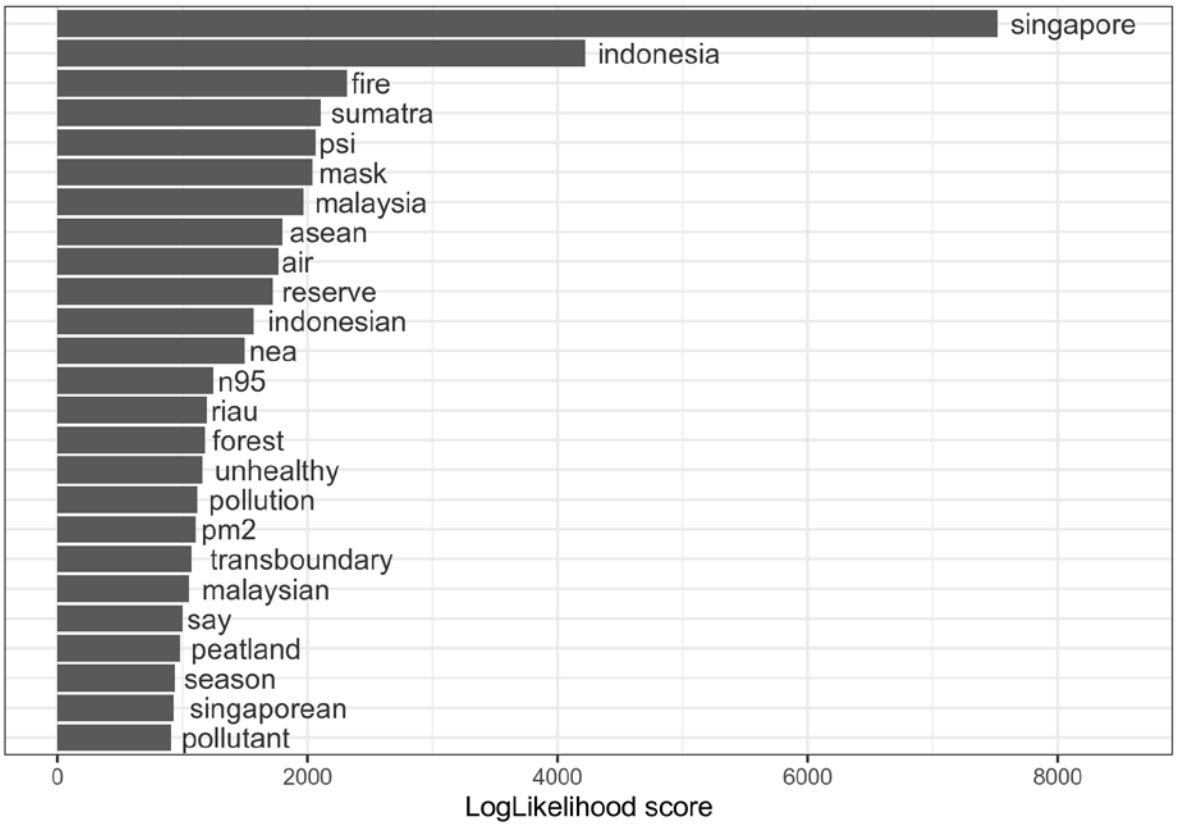

Figure 5. Top 20 most-used words in the ‘haze season’ corpus compared to the 2020 standard English corpus

Using Sketch Engine, we identified the top 20 most-used keywords in the ‘haze season’ corpus compared to the general English corpus. These keywords reflected places that are affected by haze (e.g., Singapore, Indonesia, transboundary), sources of haze (e.g., fire, reserve, forest, peatland, Sumatra, Riau), description of the pollution (e.g., PSI, air, pollution, unhealthy, PM2, pollutant), adaptation to haze (e.g., mask, N95), as well as authorities that could tackle the problem (e.g., NEA - The National Environmental Agency of Singapore, ASEAN). This suggests that the season is defined by the different facets of the shared, lived experience of haze. Interestingly, in this ‘haze season’ corpus, only a limited number of keywords related to haze mitigation strategies besides the mentions of NEA and ASEAN. Similarly, air pollution (n=42) and health (n=18) were two of the most prominent keywords found in the Bahasa

articles. Ten of the 50 Bahasa articles mention keywords such as ‘forest’, ‘peat’ and/or ‘fire’, while six articles mention keywords related to ASEAN, and only one article refers to palm oil.

The keyness analysis identified keywords that uniquely appeared significantly more frequently in ‘haze season’ articles rather than articles that refer only to ‘haze’ (Figure 6). ‘Haze season’ articles mention words associated with pollution at a much higher level of statistical significance, including mask-related words such as “*n95*” and air quality words such as “*1-hr*”, “*pm2.5*”, and “*concentr[ation]*”, as well as words related to adaptation to the pollution, such as “*filter*” and “*purify[cation]*”. In contrast, keywords from the ‘haze’-only corpus have very low chi-squared scores, meaning they do not appear in the ‘haze only’ corpus more than the ‘haze season’ corpus in a statistically significant manner. The highest-scored words in the ‘haze’-only corpus suggest a higher tendency of discussing institutional mitigative solutions to haze, such as “*meet*”, “*minist[er/ry]*”, “*financi[al]*”, and “*cooper[ation]*”. We note that ‘choice’ appeared as the most unique keyword in the ‘haze season’ corpus. This is because ‘haze season’ was mentioned in a consumer/shopping article reviewing ‘editors’’ and ‘readers’ choices’ on various digital appliances in the context of reviewing a mask with a built-in micro-ventilator which readers have found to be useful in coping with air pollution during the haze season (the word ‘choice’ appears 48 times in this article, explaining the skew in keyness for this word).

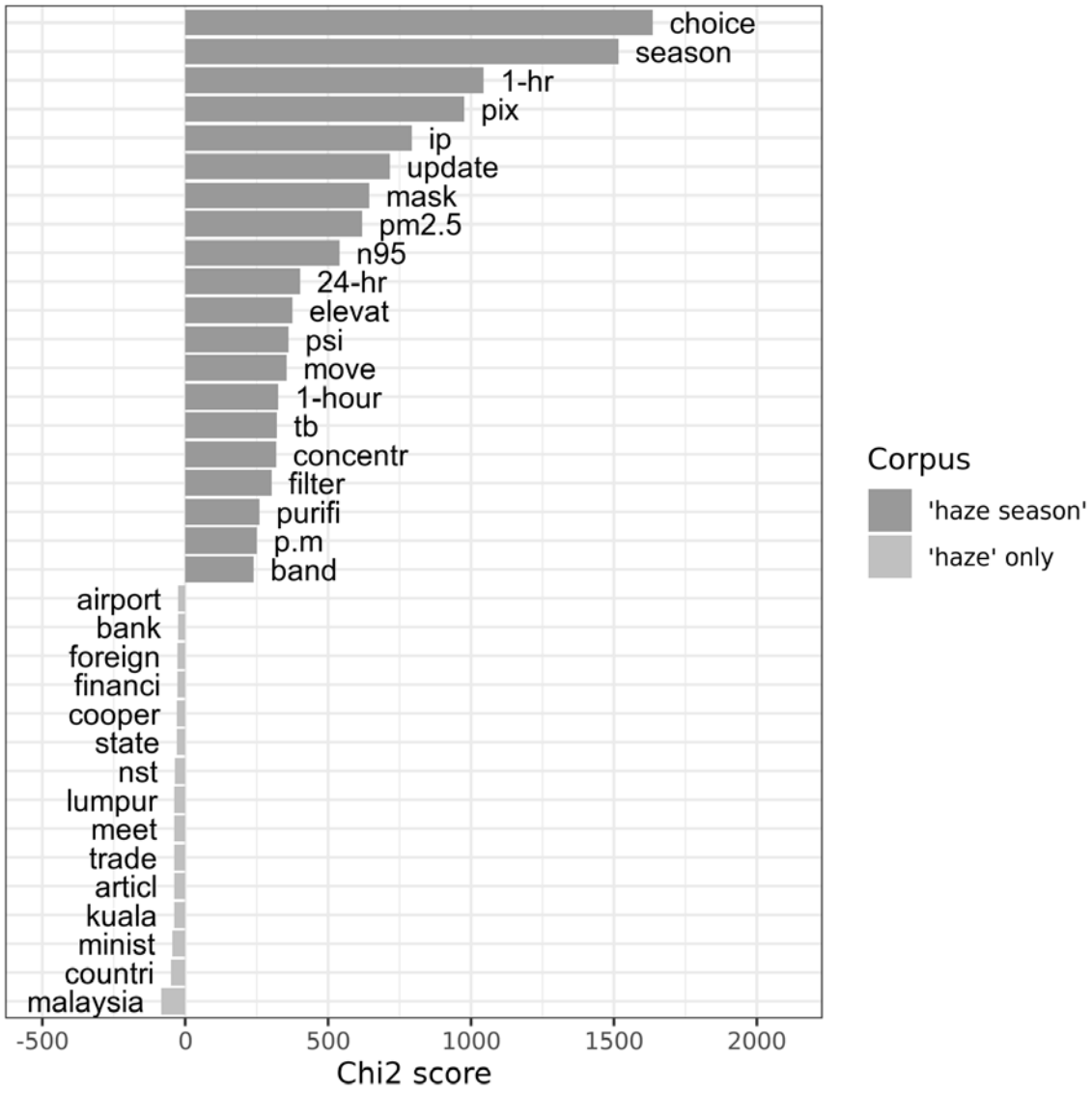

Figure 6. Chi-squared scores for most distinct words in ‘haze season’ and ‘haze’ only corpora for words occurring more than 100 times in each corpus

Seasonal approaches to the discussion of Haze

Our STM analysis provides more granular insights into the seasonality of topics associated with the term ‘haze’ for newspaper articles across the three countries affected by haze (Table

1, Figures 6 & 7, and supplementary information). Five topics were identified for Indonesia and Malaysia, and six for Singapore (see Table 1 for Singapore 'haze' article topics). "*Air pollution*", "*ASEAN*", "*palm oil industry*", and "*peat burning*" are common topics across the three countries, while the "health" topic was only identified for articles published in Singapore.

Topic Cluster	Highest probability	FREX (frequent and exclusive words)
Topic 1: ASEAN	ASEAN, minist, countri, develop, region, issu, govern	ASEAN, aec, parnham, arf, nds, rds, ASEAN-china
Topic 2: Air pollution	air, psi, nea, qualiti, pollut, read, unhealthi	mss, -hr, thunderi, inter-monsoon, myenv, souther, mid-sect
Topic 3: Health	mask, health, air, peopl, school, use, work	needi,, ecda, allerg
Topic 4: Noise	like, say, last, time, just, get, day	album, chef, esplanad, guitar, comedi, film-mak, finalist
Topic 5: Palm oil industry	per, compani, cent, busi, market, oil, product	y-oy, sgdbn, rmb, inbound, chg, biodiesel, cpi
Topic 6: Peat burning	fire, forest, compani, land, minist, problem, pollut	balthasar, kambuaya, sarwono, foead, arrmanatha, susilo, inti

Table 1. Structural topic models for the corpus of Singaporean newspaper articles (see structural topic models for the Indonesian and Malaysian newspaper articles corpus in Supplementary material).

Different topics are prevalent within and outside the 'haze season' (See Figures 7 & 8). Figure 6 illustrates the topic prevalence differences for the Singaporean, Malaysian and Indonesian corpora. In all cases, topics are significantly associated with either the haze season

(June to October) or ‘clear’ seasons (November to May), as indicated by the lack of overlap of the confidence intervals, which suggests a high probability (>95%) that the topic is more prevalent in one of these two periods. For all countries, articles appear more concerned with immediate air pollution concerns *during* the haze season, with Singaporean and Indonesian articles also including the ‘peat burning’ topic and the ‘health’ topic for Singapore also being associated with this period. While less-immediate topics addressing the root causes and mitigation of transboundary haze, such as ASEAN and the oil palm industry, are more prevalent during the ‘clear’ season. These refer to regional policy coordination through ASEAN and issues of palm oil sustainability.

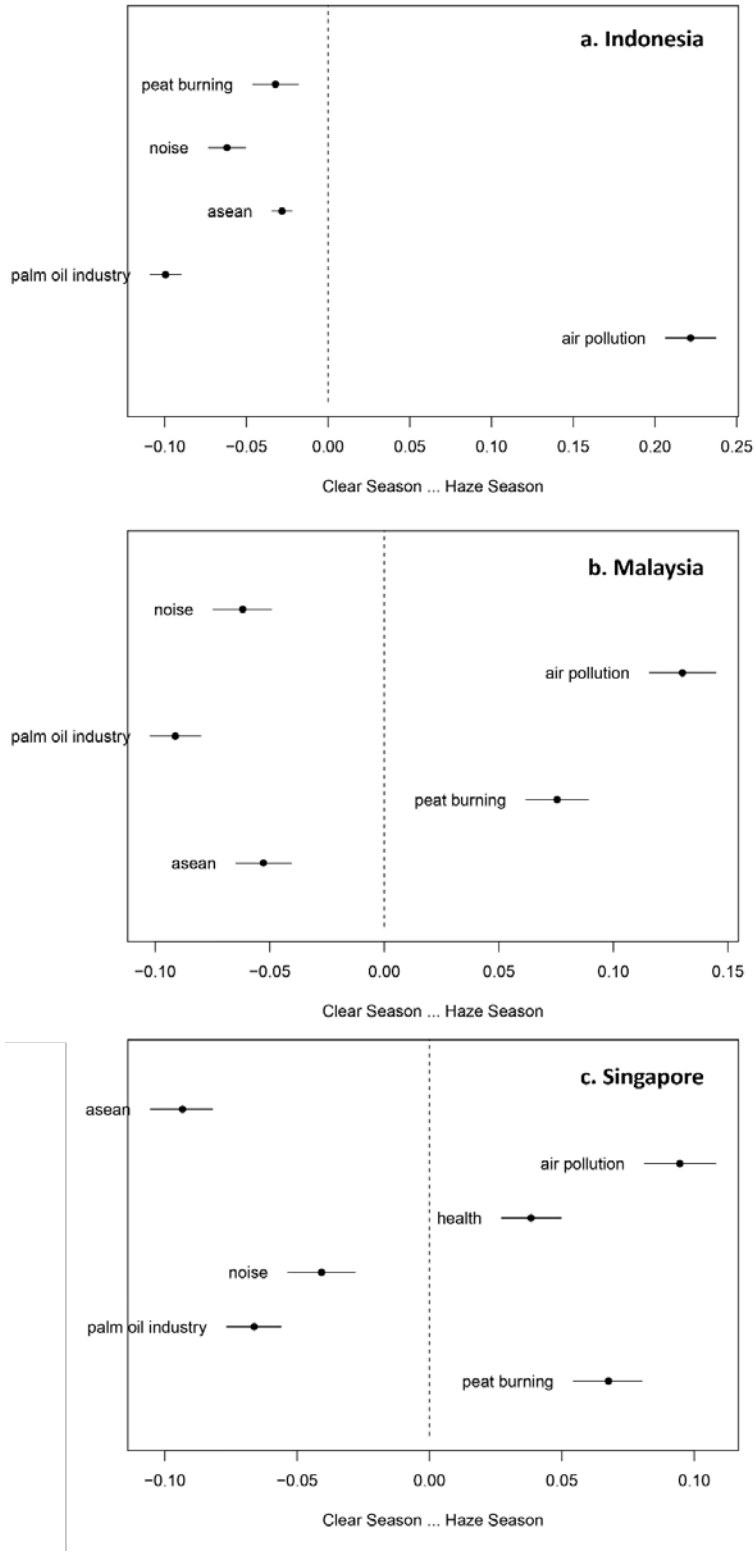

Figure 7. Effect of haze season on topic prevalence for Indonesian, Malaysian and Singaporean haze articles from 1997-2021 (from top to bottom). The values are produced by regressing on the binary variable of the article's publication during the haze season on the topic prevalence generated by the

STM model. Topics on the right are more likely to have been published in the haze season (June to October), while topics on the left are more likely to be covered in the 'clear season' (November to May). Confidence intervals (95%) account for the regression and measurement uncertainty of the STM model. Noise refers to articles that could not be classified into a cluster.

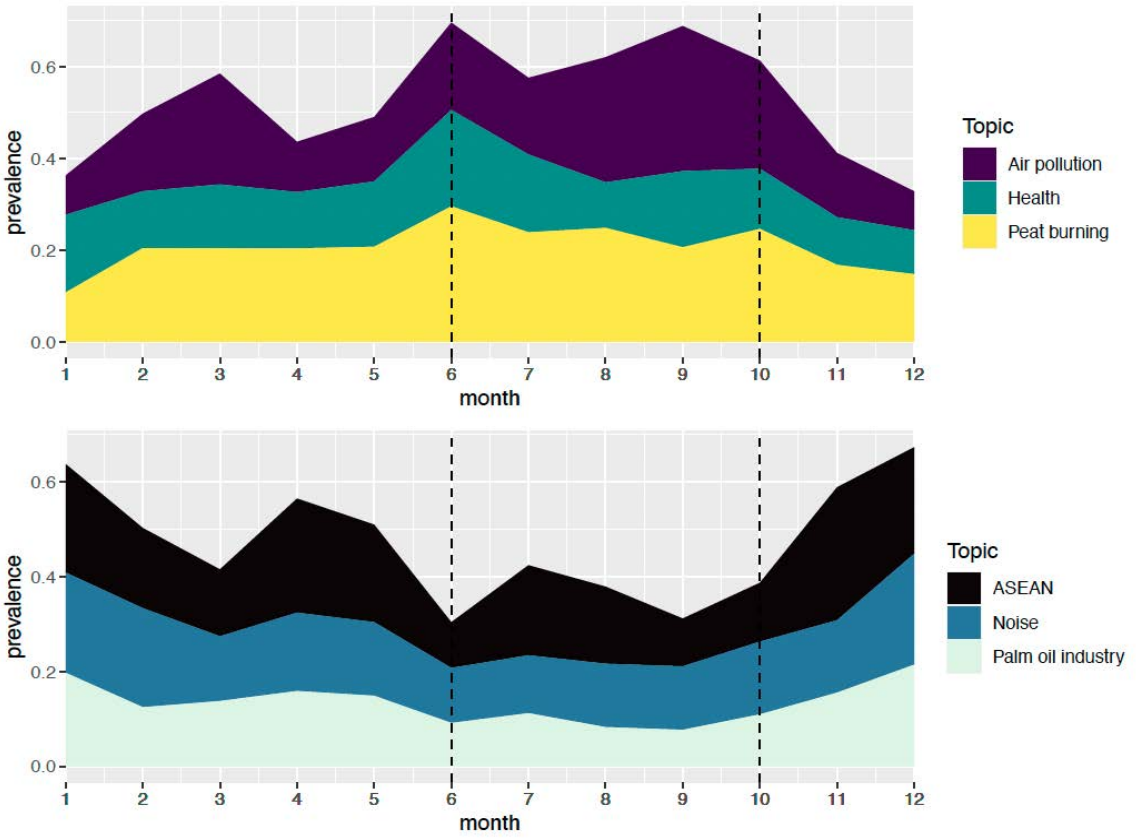

Figure 8. Monthly distribution of topics in 'haze' and 'clear' seasons in Singapore throughout the year (See depictions for Indonesia and Malaysia in the supplementary materials)

Discussions

Traditionally, in equatorial Southeast Asia, societies have made sense of temporal patterns in life through constructing 'seasons' around social and economic activities, despite not experiencing the atmospherically-driven 'four seasons' experience in temperate parts of the

world (Mauss, 1950; Orlove, 2003; Young, 1988). Our findings suggest that the ‘haze season’ has emerged as the first season defined by recurring anthropogenic environmental change. The haze season aligns with the peaks of forest fire activity in Indonesia and air pollution in Singapore, which recur from June to October annually. Over the last three decades, this temporal environmental change pattern has been integrated into people’s ‘rhythmic’ cycles (Ingold, 2000; Krause, 2004; Lefebvre, 2004) as the concept of ‘haze season’ is increasingly ingrained in social discourse, evidenced by a general uptick in news articles mentioning the term specifically. Our keyword and keyness analyses suggest that the ‘haze season’ is defined by the common lived experience of haze.

We found that discourse related to ‘haze season’ is much more likely to be related to adaptation, namely how individuals and households minimise their exposure to air pollution and/or reduce the discomfort they experience as the result of inevitable air pollution exposure. Notably, the overwhelming majority of Bahasa articles that mention ‘*musim jerebu*’ and ‘*musim asap*’ (haze season) are published during the haze season and refer to health-related issues associated with air pollution and the adaptive measures individuals can take to minimise their exposure. Interestingly, the adaptive measures covered by the newspapers are becoming increasingly interventionist. Earlier articles (2006-2013) focus on at-risk groups, such as children, athletes, and outdoor workers, with measures such as school closures and limiting working hours, concurring with the previous research by De Pratto *et al*. (2015) who identified runners as being particularly aware of the haze season. By 2015, articles began to focus on the wider population, with recommendations for mask-wearing, staying indoors and indoor air purification. In 2019, the active use of cloud seeding for clearing the air via precipitation was mentioned for the first time, presenting us with an ironic example of humans injecting particles into the atmosphere to wash away the man-made haze. This suggests the construction and increasing acknowledgement of the haze season may contribute to enhanced social resilience

to this man-made environmental phenomenon.

Furthermore, we found seasonal variation in how ‘haze’ is discussed. Within the haze season, the bulk of the discourse surrounding ‘haze’ is focused on various adaptive strategies. Comparatively, in the clear season, the discourse surrounding haze and ‘*musim jerebu*’ - and admittedly, there is much less social attention on the topic - tends to be focussed on mitigative measures. The anticipation of the haze season also creates a window of opportunity for broader behavioural and policy changes (Hajer, 1995). Discourses surrounding both ‘haze’ and ‘haze season’ outside of the haze season (note that fewer articles on these topics are published during this time) concern longer-term mitigation strategies, ranging from regional policy coordination, regulations, finance and improvement in agricultural practices. The direct cause of haze relates to poor land management approaches enabled by complex, cross-national patronage networks involving financiers, businessmen and politicians (Varkkey, 2012).

Interestingly, only one article in Bahasa mentioned palm oil and/or its patronage networks being the root cause of recurring haze. Rather, eight articles in Bahasa Melayu (making up 20% of articles mentioning ‘*musim jerebu*’) point the blame to Indonesia. This narrative of blame and finger-pointing could achieve perverse effects in mitigation (Forsyth, 2014; Liu *et al*., 2020). Our analysis is the first to find this narrative of blame in Bahasa Melayu articles, building on the work of Forsyth (2014), who had identified this narrative in English language articles in this region.

Similar to the construction of ‘cyclone season’, ‘bushfire season’ and ‘flood season’(Paton *et al*., 2006; Peters-Guarin *et al*., 2012; Walshe *et al*., 2020), the construction of ‘haze season’ is associated with the preparation for an environmental hazard. Uniquely, the recurrence of haze, caused purely by human-induced mismanagement of nature, suggests that this new socially constructed season is of the Anthropocene. Unlike previous studies that found a mismatch between the ‘scientific’ measurement of changes in physical phenomena and the

societal memory of environmental changes (e.g., Walshe *et al*., 2020), our findings suggest an alignment between scientific measurement and societal recognition of environmental change. This could be attributed to the fact that haze - unlike hurricanes and floods - affects a wider geographical area and a larger population during each episode. The annual recurrence of haze also provides regular reinforcement of societal experience and memory of the phenomenon, thus underpinning the construction of a haze season. Our findings add a temporal and rhythmic dimension to the literature highlighting the importance of the 'localisation' of environmental risk to people's understanding of the physical, social and cultural landscape in developing effective environmental management (Birkerstaff and Walker, 2001). As anthropogenic environmental changes become more intense, frequent and widespread, as climate change and environmental degradation continue to exacerbate, we may expect diverse social imaginations of phenomena of the Anthropocene.

Our analysis provides an early indication of seasonality shaping behavioural change within and outside of the haze season that bears implications for haze mitigation and adaptation strategies and policies. Engagement with the immediate causes and effects of haze within the haze season builds resilience towards haze. This growing resilience towards haze through the conception of seasonality normalises its annual occurrence, as captured by the following quote from the Malaysian broadsheet *New Straits Times*:

> "Of course, the best example of our ability to adapt is the annual haze season. It's become such a normal part of our lives that children growing up today might not believe that there was a time when we didn't have to breathe smoke particles at least once a year." ... "But while it remains a newsworthy topic that makes for good conversation, our resilient nature has helped us come to terms with the haze. So now we have a rainy season, a hot season, a durian season and a haze season."
>
> This sentiment of normalisation is echoed in the following quote published in *Berita*

Haritan in 2019, which suggests that the seasonality of haze has replaced traditional Islamic seasons:

> "Kini, September bukan lagi mengenai pemerhatian fenomena Ekuinoks Musim Luruh, tetapi lebih kepada *musim jerebu* akibat kebakaran di Sumatera dan Kalimantan." (Berita Harian 2019b)
>
> (Translation: Now, September is no longer about observing the Autumnal Equinox phenomenon but more about the haze season due to fires in Sumatra and Kalimantan)

The author then goes on to explain that the haze obscures "segala cakerawala" (the Heavens), with astronomical observations being particularly important to Islam, Malaysia's official religion.

Conclusion

This paper supports our primary hypothesis (see Figure 1) that the 'haze season' exists as a new season of the Anthropocene. That is, the shared lived experience of the recurring visible, odorous, and hazardous consequences of environmental degradation in Southeast Asia has given rise to the social construction of a season. The social construction of anthropogenic seasons is important because it can help us acknowledge the power of humans to shape nature both through our concepts and through the material practices that lead to and follow from those ways of constru(ct)ing nature.

As the concept of 'haze season' is being increasingly popularised in the lexicon of Southeast Asia, this concept has the ability to organise mitigative and adaptive behaviour in anticipation of the annual recurrence of the phenomenon. This suggests that Seasons of the Anthropocene hold a potential power in building societal resilience towards environmental changes and motivating mitigative action. Traditionally, society has used 'seasons' to cope with

changes in the ‘natural’ world. In the Anthropocene, society has re-conceptualised nature as various man-made seasons to make sense of anthropogenic environmental changes. Unlike global collective issues such as climate change and biodiversity loss, haze is a localised environmental hazard that is witnessed directly and experienced physically (Bickerstaff and Walker, 2001). At the same time, its root causes and related effects still relate to these broader global collective anthropogenic challenges. To this end, our analysis of the ‘haze season’ has proposed a new avenue to critically engage with the Anthropocene as a socially-, culturally- and politically laden topic (Brondizio *et al*., 2016; Lövbrand *et al*., 2015).

As human activities continue to materially change the physical environment, society is seeking to cope with and respond to these anthropogenic changes at the same time. The construction of the ‘haze season’ in Southeast Asia is an example of how society makes sense of the lasting changes humans have made to the environment through constructing a common language that aids the understanding of a society-induced environmental change phenomenon. The haze season, as a season of the Anthropocene, showcases how society and nature are mutually constructive (Demeritt, 2001). Through the process of constructing and iterating a season of the Anthropocene, society is galvanised to take immediate action towards adapting to the harmful impacts of haze and to make forward-looking mitigative plans. We should expect more Seasons of the Anthropocene to emerge as human societal activities continue to shape the environment. Understanding how these seasons are constructed and communicated may hold an important key to enhancing social resilience and motivating collective action to reverse some of the harmful impacts of these changes.

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Supplementary Materials

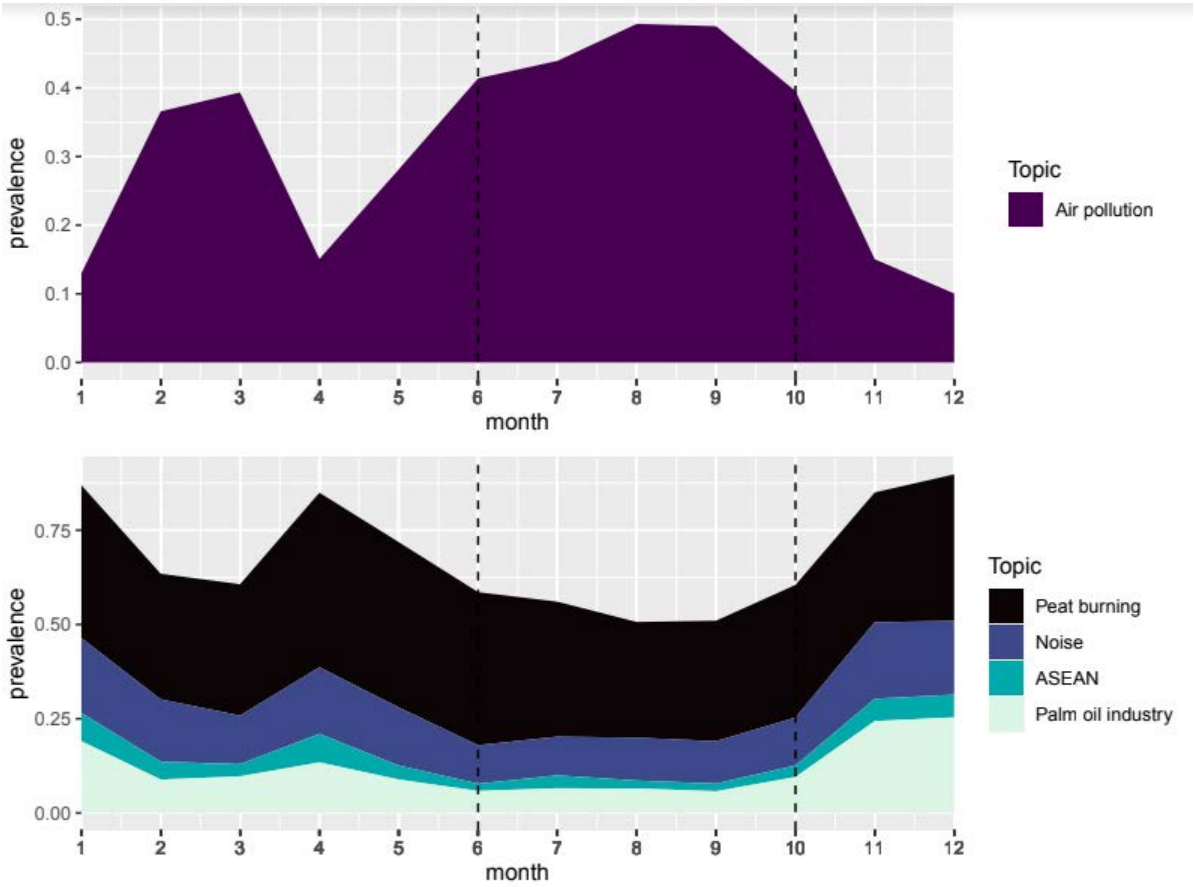
Table 1. Structural topic models for the corpus of Malaysian newspaper articles mentioning 'haze'

Topic Cluster	Highest probability	FREX (frequent and exclusive words)
Topic 1: Noise	time, game, like, peopl, may, make, day	articlebh, music, album, film, letternst, sebang, fragranc
Topic 2: Air pollution	air, read, api, depart, bernama, area, unhealthi	samarahan, seberang, rambai, manjung, sarikei, perai, baram
Topic 3: Palm oil industry	oil, palm, per, market, million, industri, compani , product	output, cpo, rspo, biodiesel, biofuel, rhb, chg
Topic 4: Peat burning	fire, forest, burn, pollut, land, smoke, air	france-press, afpr, kaban, sutopo, bnpb, dpa, nugroho
Topic 5: Palm oil ASEAN	asean, minist, countri, govern, meet, nation, environ	mou, asean', megawati, bilater, arf, aathp, asean-china

Table 2. Structural topic models for the corpus of Indonesian newspaper articles mentioning 'haze'

Topic Cluster	Highest probability	FREX (frequent and exclusive words)
Topic 1: Peat burning	fire, forest, compani, govern, minist, land, countri	pulp, errant, brg, zero-burn, foead, concess, thpa
Topic 2: Noise	peopl, say, world, presid, now, news, dayi	stout, milit, hornbil, artist, balines, cup, afghan
Topic 3: ASEAN	asean, develop, cooper, group, parti, intern, includ	nederland, financial, unfccc, rossa, postbus, us-, vert
Topic 4: Palm oil industry	oil, palm, product, temperatur, normal, emiss, increas	thundershow, anomali, heaviest, biodiesel, djcs, tonightshow, outlookscatt
Topic 5: Air pollution	fire, air, forest, agenc, kalimantan, provinc, riau	psi, bmkg, klang, indragiri, songkhla, satun, kasim

Supplementary Figure 1. Monthly distribution of topics in ‘haze’ and ‘clear’ seasons in Indonesia throughout the year



Supplementary Figure 2. Monthly distribution of topics in ‘haze’ and ‘clear’ seasons in Malaysia throughout the year