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Global Public Interest in Climate Change: Seasonal and Geographical Patterns

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Global Public Interest in Climate Change: Seasonal and Geographical Patterns

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Abstract

This study investigates the characteristics of global public interest in key search terms related to climate and energy, based on data from Google Trends across three thematically distinct but interconnected groups of search phrases for the decade 1/2015-12/2024. Each group was carefully selected to capture different aspects of the environmental discourse. The first group consists of 'Sustainability', 'Climate Change', and 'Global Warming', which serve as umbrella concepts for many subtopics with climate policy and physics. The second group, 'Greenhouse Gases', 'CO_2 Emissions' and 'Carbon Emissions' reflects a better understanding of the climate drivers. And the third group consists of 'Renewable Energy', 'Fossil Fuels', and 'Nuclear Energy' addressing the major debate over how societies should power themselves while transitioning to a sustainable future. The analysis of Google Trends time series for these keywords and for "all categories", "science" and "news", i) reveals that public interest follows a strong biannual seasonal cycle for all of these climate-related terms with the peaks taking place in spring and autumn months ii) enables the identification and interpretation of various spikes over time iii) identifies the countries with the highest relative search activity for each keyword iv) examines the correlations in searches between these search terms. The understanding of people's interest and perceptions can be useful for the design, announcement and implementation of environmental policies.

Keywords: Google Trends, Public Interest, Sustainability, Climate Change, Emissions, Energy Sources, Seasonal Variations

1. Introduction

The United Nations has identified climate change as *"the defining issue of our time."* Climate-related terms are increasingly used across a wide range of global contexts-from scientific research to policymaking. The terms chosen to be examined in this paper are: 'Sustainability', 'Climate Change', 'Global Warming', 'Greenhouse Gases', 'CO_2 Emissions', 'Carbon Emissions', 'Renewable Energy', 'Fossil Fuels', and 'Nuclear Energy'**.** Although they span a broad range of climate topics, they are closely interconnected and must all be considered when assessing public concern to climate issues. Limiting global warming requires addressing the rising concentration of greenhouse gases, particularly by limiting CO_2 emissions. In turn this is related to our energy choices-whether we rely on renewable energy, fossil fuels or nuclear energy. Numerous international conferences and agreements, such as the 2015 Paris Agreement and the 2030 Agenda, have happened aiming to guide global efforts towards sustainability. As key deadlines for targets approach, it is increasingly urgent to examine how public interest in climate-related issues has evolved over time. This is done through Google Trends, which tracks the relative frequency of search terms over time and by region. It has become a valuable scientific tool, since it draws from vast data sets, transforming the way large-scale scientometric studies are carried out (Jun et al., 2018).

Google trends have been used before in various fields, including economics, criminology, medicine, etc. It has also been used to address environmental terms (Erokhin & Komendantova, 2024; Durmuşoğlu, 2017; McCallum & Bury, 2013) as well as to examine seasonality in public interest (Simsek 2022; Vnukova et al., 2021) although in other fields. To the best of our knowledge, no studies have yet examined the periodic patterns of climate-related search terms as defined above, and how these patterns relate to global events, politics and scientific news, while also interpreting them across time and geography. It is compelling to investigate this as the urgence for climate action increases.

2. Methods and data

Data about the global interest in the terms "sustainability", "climate change", "global warming'', "greenhouse gases'', "CO_2 emissions'', "carbon emissions'', "renewable energy'', "fossil fuels'' and "nuclear energy'' were taken from Google Trends for the decade 1st January 2015-31st December 2024.

Google Trends assesses public interest in specific terms by analyzing the number of Google searches for those words or phrases. Rather than providing raw search counts, it generates Search Volume Indices (SVIs) - normalized values on a scale from 0 to 100. These indices represent the relative popularity of a search term over time and are available from 2004 onwards. The data is scaled relative to the term's own maximum search volume, and can also be compared to other terms for the same time period if explicitly selected.

Google Trends offers data across various search categories, such as "Science", "News", "Sports" etc. and a broader "All Categories" option, which encompasses all topics, including

the former two. For this study, three datasets were analyzed: searches related to “News”, “Science” and “All Categories”.

For any given search term, Google Trends also generates geographic heatmaps that visualize search interest by country. When analyzing a single term, the map uses varying color intensities to represent the relative popularity of the term in each country. There are also options to compare multiple terms regionally, but this was not used in this paper.

Typically, data from Google Trends for different word searches are studied by means of correlations (Schootman et al. 2015; Wang et al. 2015; Poletto et al. 2016; Zhang et al. 2016; Mavragani et al. 2018), which is why the use of Pearson correlation has also been made in this paper.

3. Results

3.1. Seasonal analysis of the 1st thematic group of search terms

The first group of words to be analysed are “sustainability”, “climate change’’ and “global warming’’. According to United Nations (1987), *sustainability* has the property of “meeting the needs of the present without compromising the ability of future generations to meet their own needs”. *Climate change,* as defined United Nations (1992), means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. *Global warming* is defined by Nasa as the unusually rapid increase in Earth’s average surface temperature over the past century primarily due to the greenhouse gases released by people burning fossil fuels.

Figures 1a, 1b, 1c show the global search interest in the words ‘‘sustainability’’, ‘‘climate change’’ and ‘‘global warming’’ for ‘‘all categories’’, ‘‘google news’’ and ‘‘science’’ respectively, over the time range 1/1/2015 - 31/12/2024 as calculated from Google Trends.

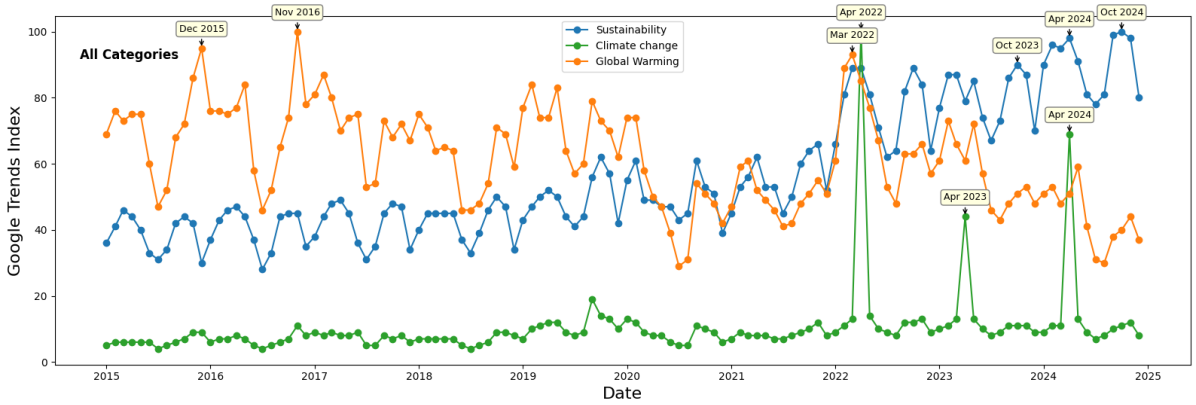

Figure 1a: Global search volumes for the terms “sustainability”, “climate change” and “global warming” for “all categories”, for the decade 1/1/2015-31/12/2024.

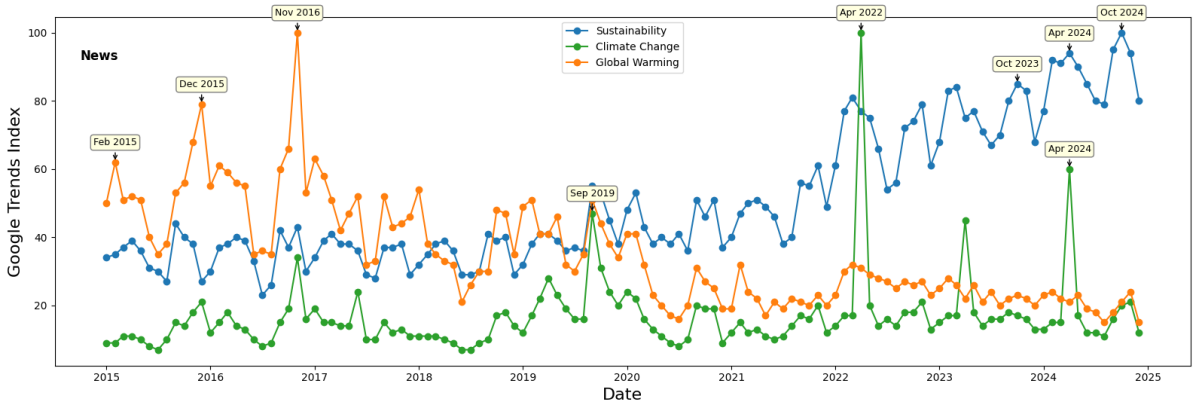

Figure 1b: Global search volumes for the terms “sustainability”, “climate change” and “global warming” for “news”, for the decade 1/1/2015-31/12/2024.

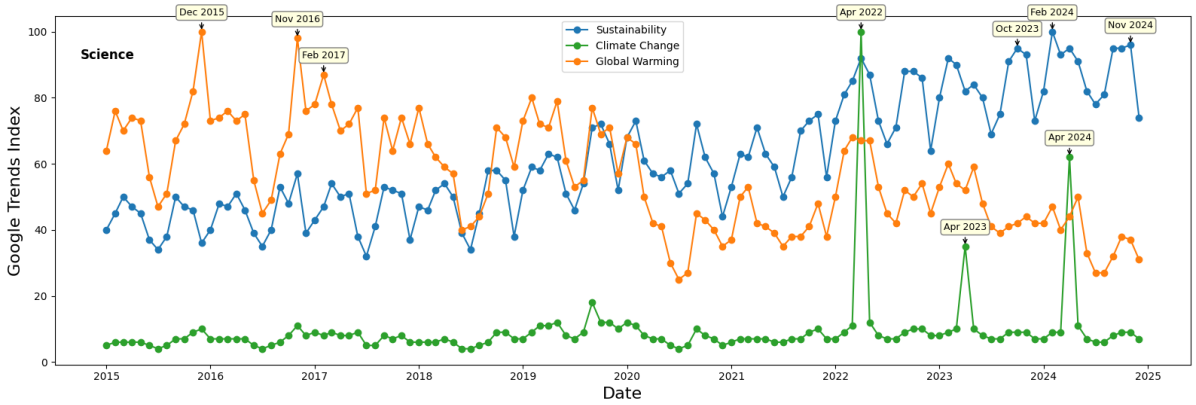

Figure 1c: Global Search volumes for the terms “sustainability”, “climate change” and “global warming” for “science”, for the decade 1/1/2015-31/12/2024.

Although sustainability can refer to broader forms of development beyond the environment, like sustainable debt, it can be seen from figure 1a that the trends for sustainability and global warming follow each other which suggests that the public associates the term with environmental protection and, by extension, the fight against global warming. We can also see an upward trend in the key word ‘sustainability’. By contrast, despite the stylised facts of climate deterioration, the key word ‘climate change’ and ‘global warming’ appear to be volatile but without a clear rise over the decade.

When decomposing the data for the three search terms into the sub-categories 'News' and 'Science', both 'sustainability' and 'climate change' appear evenly distributed across the two. In contrast, 'global warming' is searched predominantly within a scientific context - a logical outcome, given it is less broad.

i) explanation of spikes:

The December 2015 spike of the term “global warming” and particularly through ‘’science’’ (see figure 1c) can be attributed to the adoption of the Paris Agreement during the COP21

climate summit in Paris - a major global event (first legally binding agreement to limit global warming to well below 2°C, ideally to 1.5°C of pre industrial temperatures) which generated intense media coverage and public interest (Paris Agreement, 2015).

In November 2016, global search interest in all three terms increased, particularly in "global warming" and through the ''news'' (see figure 1b). This is largely due to the election of Donald Trump as U.S. President on November 8. Trump had publicly called climate change a "hoax" and pledged to withdraw from the Paris Agreement, sparking widespread international concern (BBC, 2018). The media response and uncertainty about future U.S. climate policy led to increased public engagement and online searches (Google Trends, 2016). By extension, the peak in November 2024 could also be attributed to Trump's second election, and the corresponding concerns about his climate policy.

The spike in ''climate change'' in September 2019 on the ''news'' category can be attributed to the global climate strikes 'Fridays For Future' led by youth activists and Greta Thunberg's widely publicized speech at the UN Climate Action Summit Thunberg, G. (2019, September 23), both of which fuelled global media attention.

The search term 'climate change' exhibits three pronounced peaks (in all figures 1a,b,c) in April 2022, 2023, and 2024. The IPCC released its major Working Group III report "Climate Change 2022: Mitigation of Climate Change" on April 4, 2022, a milestone in the IPCC's Sixth Assessment Report cycle which generated substantial media coverage and public interest in climate change topics. April 2022 was also characterized by an extreme heatwave (Hassan et al. 2024) across northern Asia: spanning from Israel to India and Pakistan (where temperatures reached 47.5°C) (Smith, 2022). NOAA also noted an early onset of the wildfire season (160% of average for this time of year), tornado outbreaks, and western U.S. drought, believed to be climate-induced (NOAA, 2022). The peak in April 2023 can be attributed to the record heat waves in Southern Asia and Europe, attributed to climate change (Halpin, 2023). Unsurprisingly, April 2024 also set records, reaching 1.75 °C above average in the northern hemisphere(). At the same time major climate conferences like the European Climate Summit (April 16-18), Petersberg Climate Dialogue (April 25-26) and OECD Global Forum on Environment & Climate Change (April 3-4) could have all contributed on the sharp spikes in graphs 1 a, b, c (as they represent a mixture of ''news'' and ''science''). Finally, these April spikes might have been reinforced by Earth Day, happening annually on April 22, aimed at raising global awareness and discourse surrounding environmental issues.

ii) finding periodicities:

From figures 1a,b,c, a periodic pattern appears to exist - more noticeably when examining the term "sustainability." To investigate the potential seasonality of the trends, Figure 2 reproduces figure 1a, this time with background colours corresponding to each season: blue for winter, pastel pink for spring, orange for summer, and green for fall. The minima of the trends fall in the summer (orange) months, while the peaks of the searches for these terms appear to be concentrated in the spring (pink) and fall (green) months. Although the fluctuations are somewhat less pronounced, the same seasonal pattern is observed when the

searches are filtered by the categories “News” and “Science.” The corresponding graphs are presented in Appendix A.

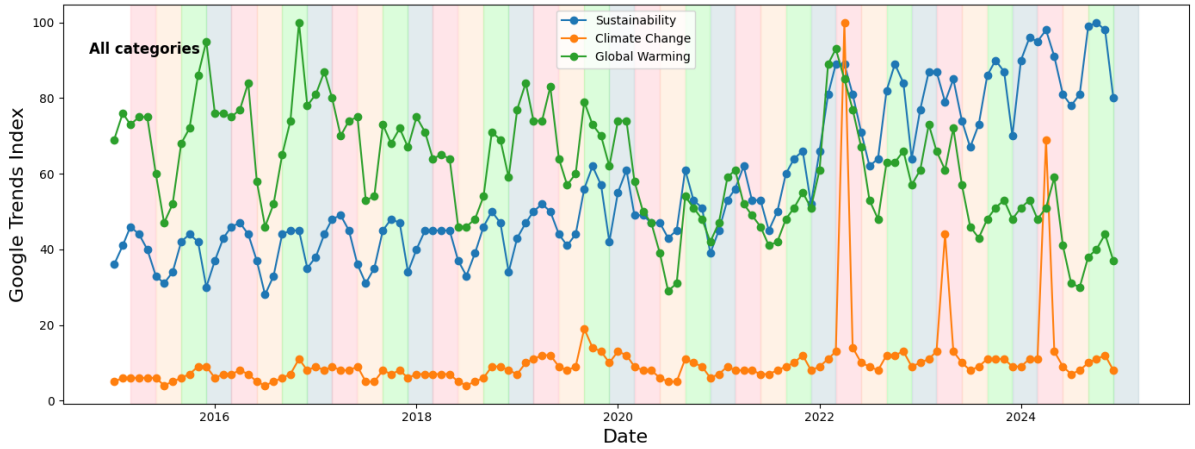

Figure 2: Seasonal separation of the search volumes for the terms “sustainability”, “climate change” and “global warming” for “all categories”, for the decade 1/1/2015-31/12/2024. Light blue corresponds to the winter months, pink to spring, orange to summer and green to autumn months.

Figures 3a, 3b and 3c show the additive search volumes taken from google trends over the decade collapsed to a single calendar year (for ‘‘all categories’’). For the key words ‘’sustainability’’ and ‘‘global warming’’, there is a noticeable decrease of interest during the summer, with the trend following an overall sinusoidal pattern. ‘’Climate change’’ also shows a decrease in the summer months although much less significant due to the very sharp peak in April.

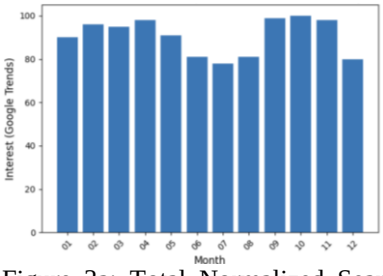

Figure 3a: Total Normalized Search Volumes for ‘‘sustainability’’ with respect to each month for the same decade

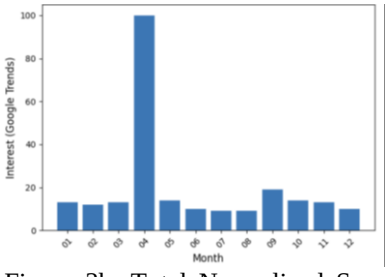

Figure 3b: Total Normalized Search Volumes for ‘‘climate change’’ with respect to each month for the same decade

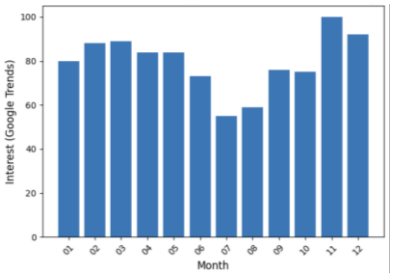

Figure 3c: Total Normalized Search Volumes for ‘‘global warming’’ with respect to each month for the same decade

Figures 3a, 3b and 3c show the additive search volumes taken from google trends over the decade collapsed to a single calendar year (for ‘‘all categories’’).

The three key words can be combined in google trends, querying for ‘sustainability + climate change + global warming ’ and the histogram of figure 4 is produced.

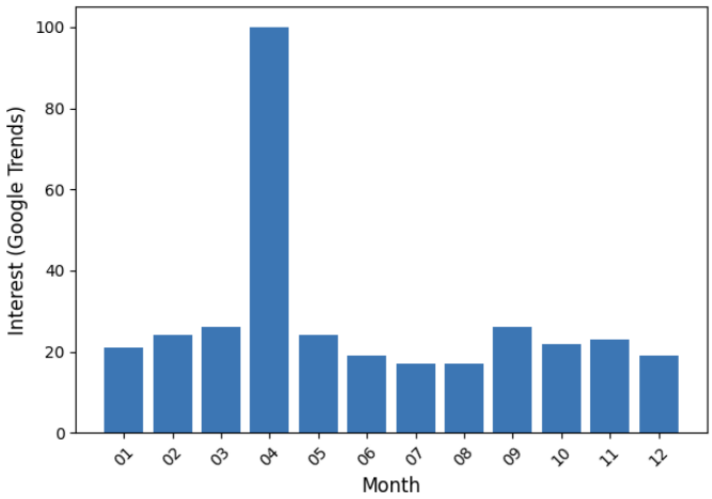

Figure 4: Total Normalized Search Volumes for ‘‘sustainability’’ + ‘‘climate change’’ + ‘‘global warming’’ with respect to each month for the same decade

A Fourier frequency analysis was performed using a real fast Fourier transform (FFT), which converts the time series into frequency components and computes the power spectrum- representing the energy (i.e., squared amplitude) associated with each frequency. The resulting periodogram, which plots power against period, is shown in Figure 5 for this group of keywords.

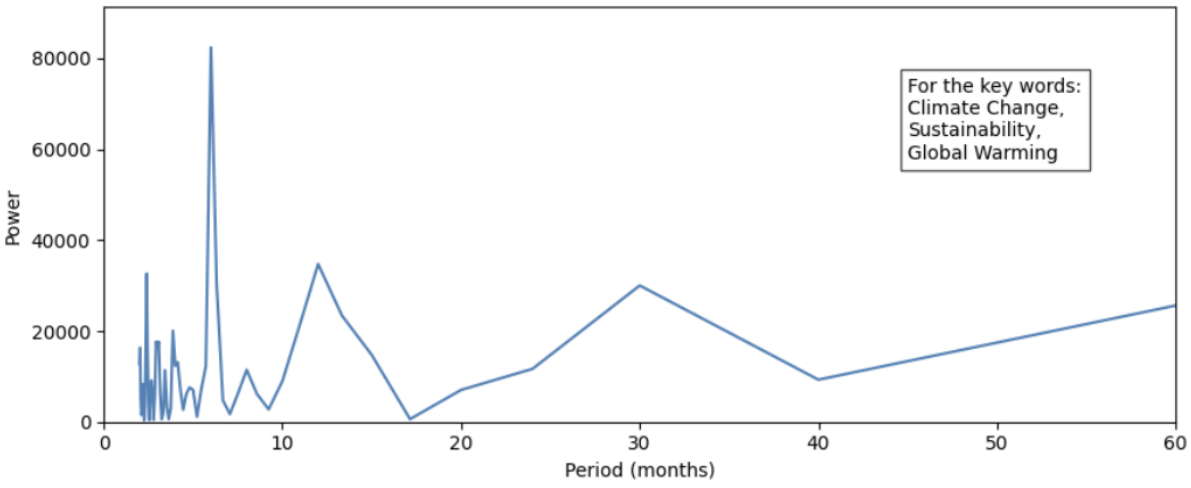

Figure 5: Periodogram of global monthly search volumes

The periodogram clearly reveals dominant peaks at 6, 12, and 30 months. The 6-month peak corresponds to increased search volumes in spring and autumn (or equivalently decrease during summer and winter), while the 12-month peak reflects the annual repetition of this seasonal pattern. Interestingly, a third prominent frequency appears at 30 months (2.5 years), for which there is no immediately obvious explanation. Nonetheless, the overall result is both unexpected and elegant: in a dataset as seemingly chaotic as Google search trends, these key words exhibit clear seasonality as well as periodicity, which is further discussed in section 4.2.

3.2. Regional analysis of the 1st thematic group of search terms

Google Trends offers a feature that identifies the geographic distribution of search interest by showing where a particular term was most frequently searched, normalized by each country's total search volume. For the keywords discussed above, using the same time period and selecting the "All Categories" filter, the results are as follows (note that this type of analysis can also be conducted within more specific categories such as "Science" or "News" for comparison).

It is important to note that Google Trends offers an option to include regions with low search volumes. This option is deliberately not used in the present analysis. The rationale is that countries with limited internet access (often lower-income nations) where environmental issues may not be a primary concern-can display artificially elevated relative search interest due to a small number of highly specialized users (e.g., scientists or academics). For example, enabling low search volume data for the term *"global warming"* shifts the top country from the Philippines to Kiribati, which likely reflects limited overall internet usage in Kiribati, rather than broader public engagement with the topic.

Given the above, for the same decade as above and 'all categories', the search result from Google Trends looks like figure 6 not 7.

Figure 6a: Map distribution of relative searches for the term 'sustainability' in the decade 1/1/2014-31/12/2024, shows the 2 highest ranked countries.

First, for the search term ‘sustainability’ Singapore unsurprisingly ranks highly because it has made sustainability a national priority-through initiatives like the Green Plan 2030. Zimbabwe also ranked highly likely due to the recent frequent droughts, floods, and heatwaves, with major events such as over 100 elephants dying in Hwange National Park due to drought (NBC, 2023) driving public awareness and search activity.

Figure 6b: Highest ranked countries for the search term ‘‘global warming’’

Figure 6c: Highest ranked countries for the search term ‘‘climate change"

Zimbabwe was also among the top countries for the key words ‘global warming’ and ‘climate change’, see Figures 6b and 6c. The heatmaps for these terms ‘climate change’ and ‘global warming’ are shown in the appendix B.

Philippines also ranked high for ‘global warming’ since apart from extreme heatwaves and strong typhoons it has one of the fastest sea-level rise rates in the world. Notably, sea levels in the Philippine Sea have risen at a rate of 5 to 7 mm per year-significantly faster than the global average of 2.8 to 3.6 mm (Climate Tracker Asia, 2024), a serious threat since the country consists of approximately 7600 islands, 2000 of which are inhabited, with roughly 60% of the population residing on the coast (ICRI).

For similar reasons Fiji was also high on ‘climate change’ searches as a Pacific island nation facing coastal erosion and rising seas. Sea levels are increasing by around 4.6-6 mm/year (Common wealth, 2022), significantly above the global average, putting infrastructure and communities at direct risk, (some villages have already been forced to relocate (Borsa, 2017)). In response, the Fijian government is pioneering robust adaptation strategies like 2021 Climate Change Act (Government of Fiji, 2021), implementing hybrid nature-based seawalls, restoring mangroves, relocating vulnerable communities, and securing international funding (e.g., US $5.7 million from the Adaptation Fund).

3.3. Seasonal analysis of the 2nd thematic group of search terms

Following the analysis of broader terms, this section shifts focus to the primary drivers of global warming: greenhouse gases, and by extension, emissions.

Incoming solar radiation, primarily in the visible spectrum, penetrates the Earth's atmosphere and is absorbed by the land, water and vegetation. Through the earth’s inherit equilibrium mechanism, a respective amount of energy is then re-emitted as thermal infrared radiation with longer wavelengths (Kaltenegger, 2017). Greenhouse gases (GHGs) like carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) absorb part of this outgoing infrared radiation, preventing it from leaving the atmosphere (Ledley et al., 1999). This ‘trapping’ of

heat at the lower atmosphere has a warming effect which under normal circumstances is what makes Earth able to sustain life. However, human activities like burning of fossil fuels, aviation, etc. have lead to a rapid increase of GHGs concentrations in the atmosphere (see Figure 7), causing global warming.

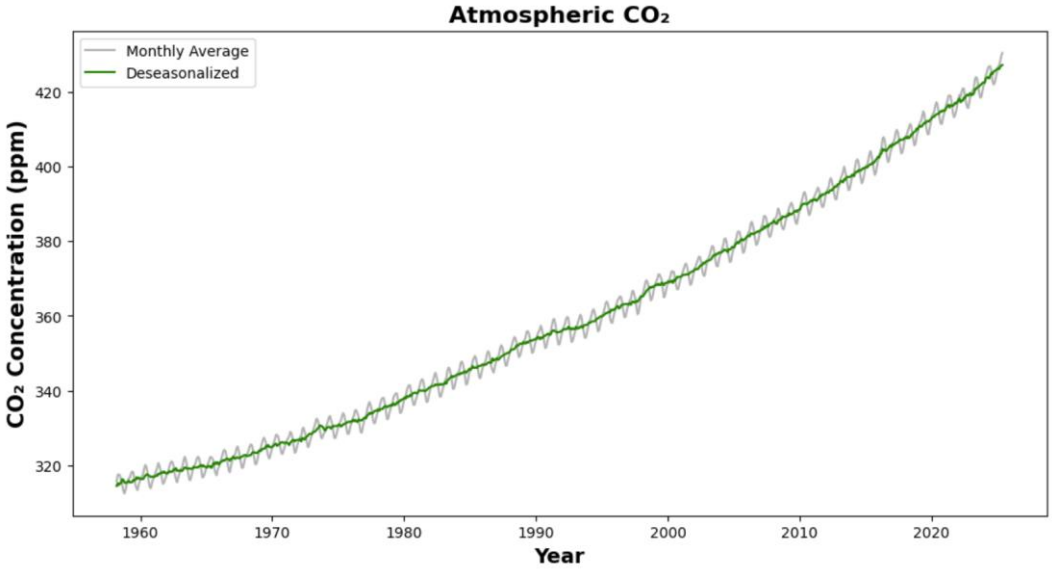

Figure 7: atmospheric CO_2 levels in the past decades

It is important to note that Methane (CH_4) has an atmospheric lifetime of approximately 12 years, whereas carbon dioxide (CO_2) can persist for decades to centuries (IPCC, 2013). Over a 20-year timescale, global methane emissions have a warming effect equivalent to more than 80% of CO_2 emissions due to methane's higher global warming potential—about 84 times greater than that of CO_2 (IPCC, 2013). Despite this, CO_2 remains the primary concern because its atmospheric concentration far exceeds that of CH_4 or N_2O.

Similarly to section 3.1, the key words analysed through google trends here are ‘‘greenhouse gases’’, ‘‘CO_2 emissions’’ and ‘‘Carbon emissions’’. While the term *“CO_2 emissions”* is scientifically more accurate than *“carbon emissions”*, the two are often used interchangeably by the general public. For this reason, both terms are included in the analysis, as users may search for the latter when referring to the former.

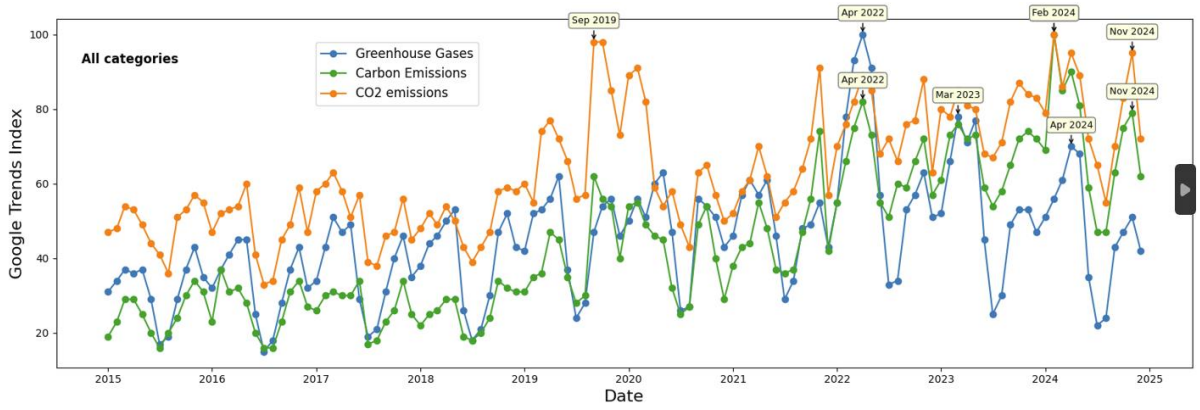

Figure 8a: Global search volumes for the terms "Greenhouse Gases", "Carbon Emissions" and "CO_2 emissions" for "all categories", for the decade 1/1/2015-31/12/2024

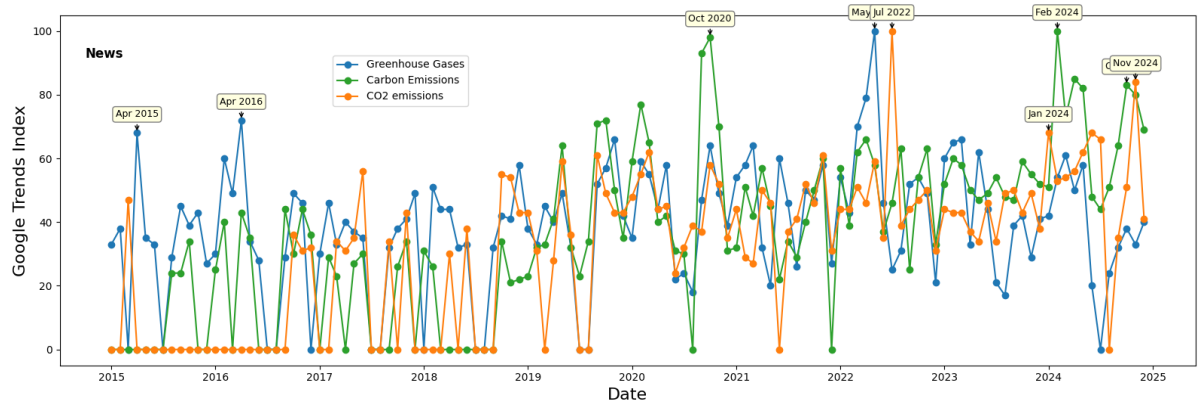

Figure 8b: Global search volumes for the terms "Greenhouse Gases", "Carbon Emissions" and "CO_2 emissions" for "news", for the decade 1/1/2015-31/12/2024

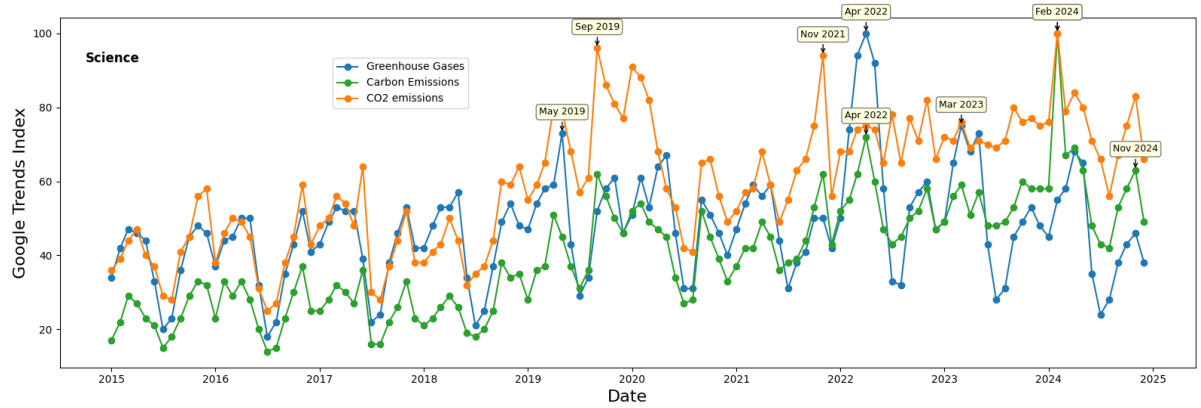

Figure 8c: Global search volumes for the terms "Greenhouse Gases", "Carbon Emissions" and "CO_2 emissions" for "science", for the decade 1/1/2015-31/12/2024

Here, unlike Section 3.1, we observe a general increase in search frequency-and thus public interest-in the keywords *"carbon emissions"* and *"CO_2 emissions"* over time. This upward

trend reflects a growing awareness of climate change and environmental issues in public discourse.

i) Explanation of spikes:

The April 2015 and April 2016 spikes in news interest in "greenhouse gases" align with major international climate policy milestones - notably the U.S. emissions pledge ahead of COP21 (Harrabin, 2015) and the formal signing of the Paris Agreement, respectively.

The May 2019 spikes reflect the impact of the IPBES biodiversity report on May 6, 2019 which warned that 1 million species are at risk of extinction, linking greenhouse gas emissions to biodiversity collapse (IPBES, 2019). At the same time, Mauna Loa Observatory recorded record high CO_2 levels in May 2019, topping 415 ppm (NOAA, 2019) which made global headlines.

A particularly prominent spike occurs in September 2019 in "CO_2 emissions" likely also linked to Greta Thunberg's widely publicized UN Climate Action Summit speech and the global *Fridays for Future* climate strikes. However, it is interesting that this spike seems to be more prominent in the ''science'' (fig. 8c) category than ''news'' (fig. 8b).

The spikes in public interest in April 2022 could have been driven by the release of a significant report from the UN Intergovernmental Panel on Climate Change (IPCC). The report, released on April 4, 2022, highlighted that average annual global greenhouse gas emissions between 2010 and 2019 were the highest in human history

The spike in May 2022 of the term 'greenhouse gas' in the news category can be attributed to the U.S. supreme court's decision not to block Biden's administration rule that the social cost of greenhouse gas emissions should be included in political regulations (Reuters, 2022).

Jul 2022 CO_2 news very sharp peak.

The peak in February 2024 for 'CO_2 emissions' and 'carbon emissions' particularly through the news category, can be linked to the respective peak for 'sustainability' and 'renewable energy' (see section 3g. for word correlations). …

The peak in November 2024 across all three search terms-particularly in the news category-can be attributed to Trump's re-election on November 5th and growing concerns over his upcoming regressive climate policies (El País, 2024). These concerns were brought into focus during the COP29 climate conference, which also took place in November (11^{th}) in Baku.

Again there seems to be a seasonal dependence, examined through figure 9: Similarly to Section 3.1, the blue is for the winter months, pastel pink for spring, orange for summer, and green for fall. The minima of the trends again seems to fall in the summer (orange) months, while the peaks of the searches for these terms usually fall in the spring (pink) and fall (green) months.

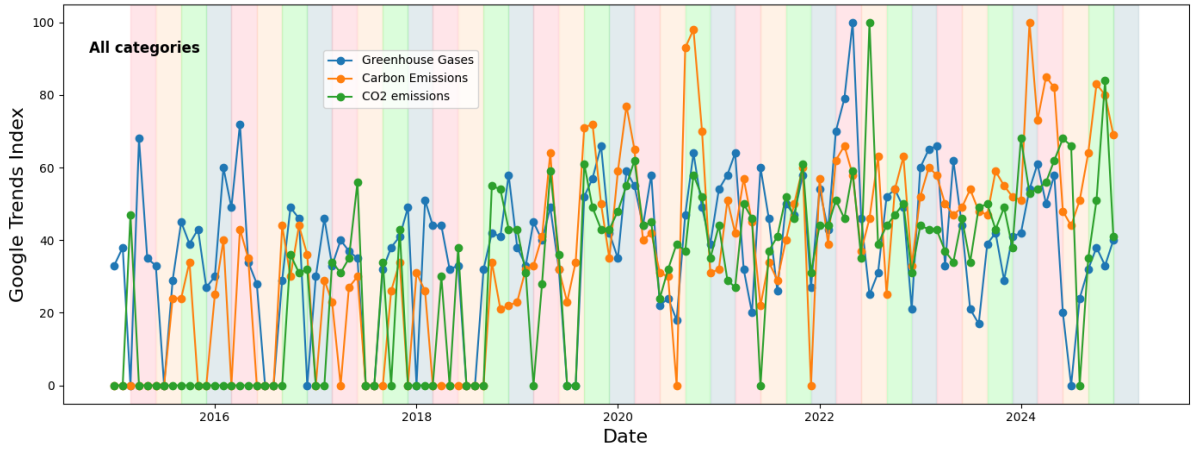

Figure 9: Seasonal separation of the search volumes for the terms "greenhouse gases", "carbon emissions" and "CO_2 emissions" for "all categories", for the decade 1/1/2015-31/12/2024. Light blue corresponds to the winter months, pink to spring, orange to summer and green to autumn months.

ii) Finding periodicities

The respective graphs for ''news'' and ''science'' are presented in appendix C.

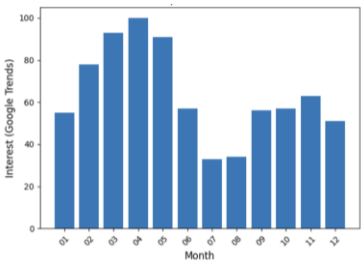

Figure 10a: Total Normalized Search Volumes for ''greenhouse gases'' with respect to each month for the same decade

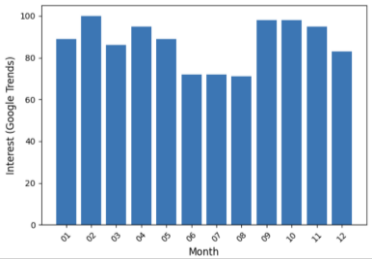

Figure 10b: Total Normalized Search Volumes for ''CO_2 emissions'' with respect to each month for the same decade

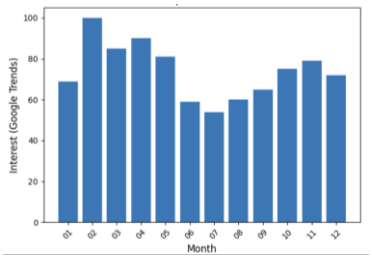

Figure 10c: Total Normalized Search Volumes for ''carbon emissions'' with respect to each month for the same decade

Although the same sinusoidal pattern as section 3.1 is evident from figures 10a,b,c for all 3 of the words, in order to simplify the frequency analysis, the three words were again combined into figure 11.

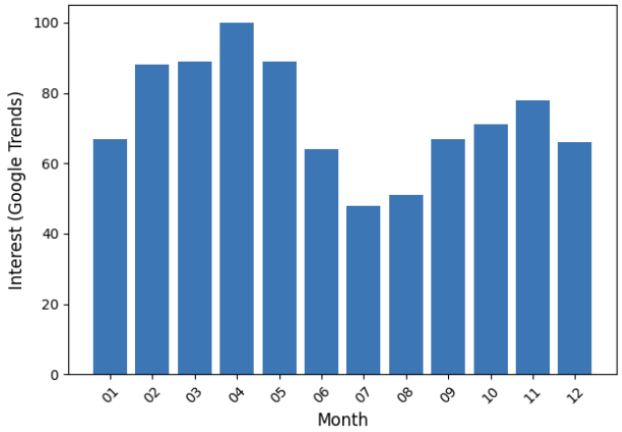

Figure 11: Total Normalized Search Volumes for ‘‘greenhouse gases’’ + ‘‘carbon emissions’’ + ‘‘CO_2 emissions’’ with respect to each month for the same decade

The same Fourier analysis (FFT) like before was made, see figure 12 with this group of words.

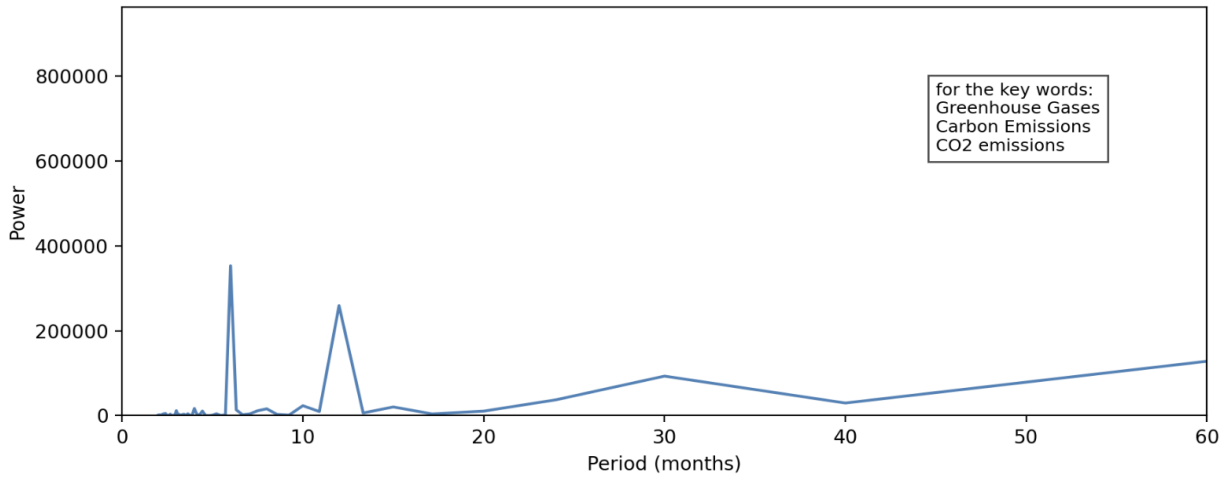

Figure 12: Periodogram of global monthly search volumes

So the dominant frequencies are indeed again 6 months (semi-annual) and 12 months (annual) confirming the periodic increase of the search volumes every spring and autumn. There is also a weaker peak at 30 months.

3.4. Regional analysis of the 2nd thematic group of search terms

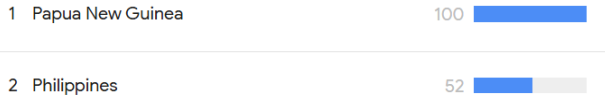

Figure 13a: Highest ranked countries for the search term ‘‘greenhouse gases’’

Figure 13b: Highest ranked countries for the search term ‘‘carbon emissions’’

Repeating the same process as section 3.2, Figures 13a,b,c show the 2 highest ranked countries for each key term. For the key phrase "greenhouse gases," Papua New Guinea ranked highest on Google Trends. With a population of 9.12 million, the country emits only 2.2 tonnes of CO_2 per person placing it 140th out of 191 countries (Boyle, 2024) in terms of per capita emissions-suggesting the high search interest is likely driven by climate awareness rather than high emissions. The Philippines ranked second, which aligns with its well-documented vulnerability to climate change explained above. When narrowing the term to "carbon emissions," (Figure 13b) countries like Singapore and China ranked highest-Singapore due to its strong policy focus on their reduction, and China as one of the world's largest emitters (e.g. contributing over 30% of global CO_2 emissions as of 2022, (Han, 2025).

Figure 13c: Highest ranked countries for the search term ''CO_2 emissions''

For the phrase *"CO_2 emissions,"* as shown in Figure 13c, Iceland and Ireland ranked highly, likely reflecting public interest in their ambitious climate targets and emissions reduction. According to the International Energy Agency, Ireland reduced its CO_2 emissions per capita by 40% between 2000 and 2022, largely due to a shift toward renewable energy and increased efficiency in the power sector (IEA, 2025). Iceland has committed to reduce greenhouse gas emissions by 40% by 2030 and achieve carbon neutrality before 2040 (Government of Iceland, 2024). The heatmaps for these 3 search terms are shown in the appendix D.

3.5. Seasonal analysis of the 3rd thematic group of search terms

The logical step after the current increase of CO_2, and establishing the need for action is to consider different energy sources. For this reason, the next group of terms to be examined was ''renewable energy'', ''fossil fuels'' and ''nuclear energy''.

According to the UN, *Renewable energy* is 'energy derived from natural sources that are replenished at a higher rate than they are consumed.' On the other hand, a *fossil fuel* is 'any of a class of hydrocarbon-containing materials of biological origin occurring within Earth's crust that can be used as a source of energy'(Kopp, "Fossil Fuel.", 2025). *Nuclear energy* is the energy released from the nucleus of atoms through two main processes: *fission* (splitting atoms) and *fusion* (combining them) (IAEA, 2022). In most current power plants, nuclear fission of uranium or plutonium generates heat, which is used to produce electricity. Unlike fossil fuels, nuclear energy produces minimal greenhouse gas emissions during operation, making it a low-carbon energy source. However, it raises concerns around radioactive waste, high costs, and safety.

Data extracted from Google trends of the interest on these key words over the decade for all categories, news and science are shown in Figures 14a, 14b, 14c for the terms “Renewable Energy”, “Fossil Fuels” and “Nuclear Energy”. The interest over time with the seasonal distinction for all categories is shown in Figure 15.

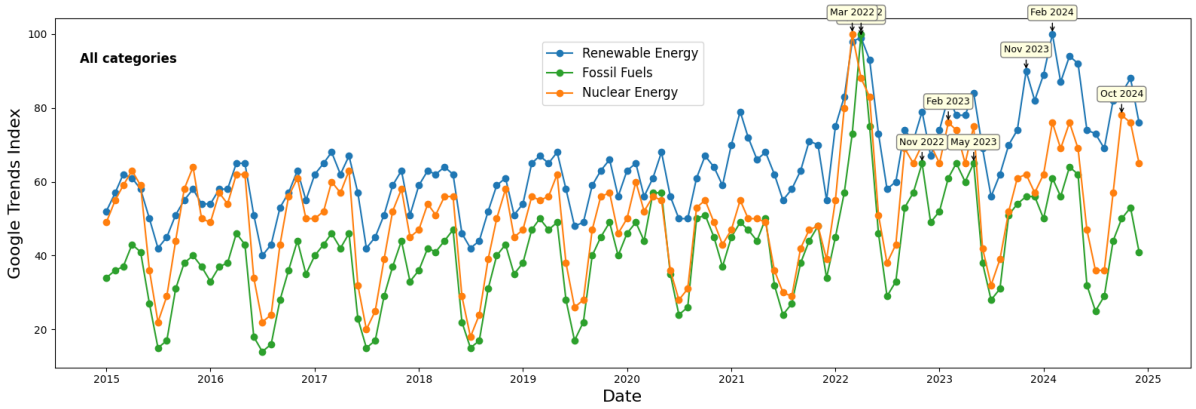

Figure 14a: Global search volumes for the terms “Renewable Energy”, “Fossil Fuels” and “Nuclear Energy” for “all categories”, for the decade 1/1/2015-31/12/2024

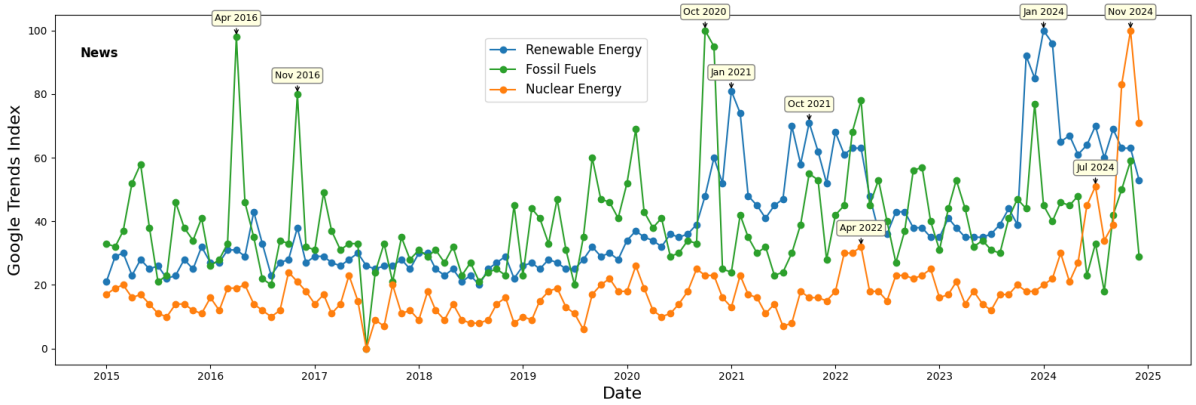

Figure 14b: Global search volumes for the terms “Renewable Energy”, “Fossil Fuels” and “Nuclear Energy” for “news”, for the decade 1/1/2015-31/12/2024

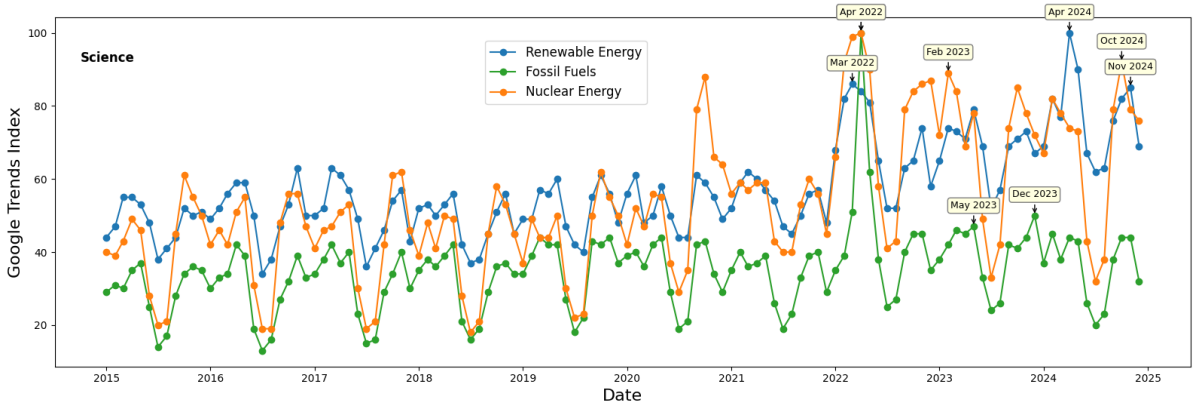

Figure 14c: Global search volumes for the terms “Renewable Energy”, “Fossil Fuels” and “Nuclear Energy” for “science”, for the decade 1/1/2015-31/12/2024

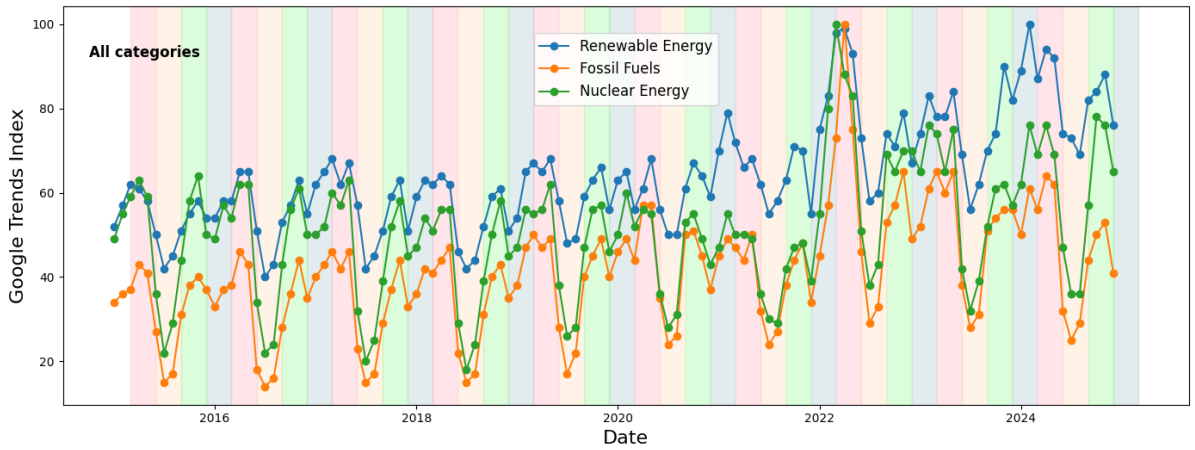

Figure 15: Seasonal separation of the search volumes for the terms “renewable energy”, “fossil fuels” and “nuclear energy” for “all categories”, for the decade 1/1/2015-31/12/2024. Light blue corresponds to the winter months, pink to spring, orange to summer and green to autumn months.

First, it is both logical and encouraging to observe a steady-albeit gradual-increase in public interest in renewable energy. The search volume for the term *fossil fuels* appears to follow a similar trend. However, it is important to note that Google Trends does not differentiate between searches related to the reduction of fossil fuel use and those concerning their continued use. This graph is particularly interesting as it reveals that all three terms exhibit a strong periodic pattern (clearest so far in this paper), there appears to be a notable correlation among the keywords, as their search volumes rise and fall in unison; and the minima tend to occur during the summer months. This suggests the same seasonal periodicity observed in sections 3.1 and 3.3, despite these terms not being explicitly related to them. The respective graphs for the categories ‘news’ and ‘science’ are presented in appendix E.

i) Interpretation of peaks:

Significant spikes in news interest on "fossil fuels" correspond to key global political events. In April 2016, the signing of the Paris Agreement by over 170 countries generated extensive media coverage on fossil fuel reduction efforts (UN, 2016). November 2016 saw renewed attention as Donald Trump’s election victory brought promises to revive fossil fuel industries and challenge the Paris commitments as explained in section 3.1. By October 2020, fossil fuel discussions surged again with China’s carbon-neutral pledge (EAF, 2020) and the U.S. presidential election spotlighting fossil fuel policies, particularly Joe Biden’s plans to transition to clean energy (Politico, 2020).

The sharp rise in interest during 2022 shown in figure 14a is likely linked to the Russia–Ukraine war and the resulting energy crisis, which brought renewed attention to the sources and security of global energy supply.

ii) Discovering periodicities

The histograms for the three words and their combination are shown in figures 16 and 17 respectively:

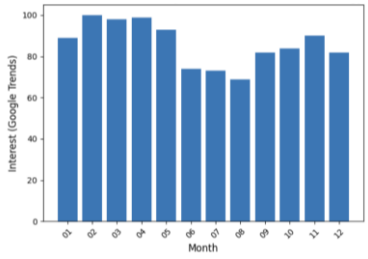

Figure 16a: Total Normalized Search Volumes for ''Renewable Energy'' with respect to each month for the same decade

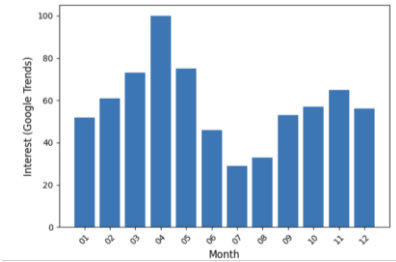

Figure 16b: Total Normalized Search Volumes for ''Fossil Fuels'' with respect to each month for the same decade

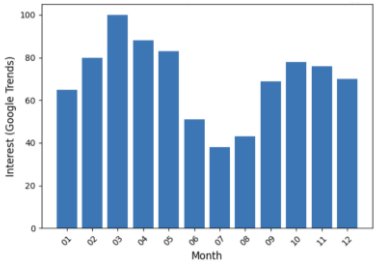

Figure 16c: Total Normalized Search Volumes for ''Nuclear energy'' with respect to each month for the same decade

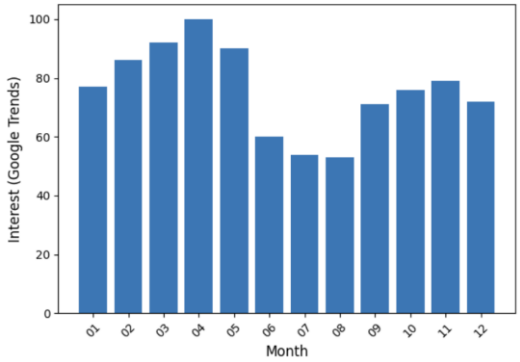

Figure 17: Total Normalized Search Volumes for ''renewable energy'' + ''fossil fuels'' + ''nuclear energy'' with respect to each month for the same decade

For each individual keyword, as well as for their combined search volume, the peaks consistently occur during the spring months-typically in March or April. This is followed by a decline over the summer and a subsequent rise in the autumn, with secondary peaks usually in October or November, before declining again. The Fourier transform (FFT) was carried out using the same method as previously (see Figure 18). Once again, the dominant frequencies correspond to 6-month (semi-annual) and 12-month (annual) cycles, indicating a clear seasonal pattern.

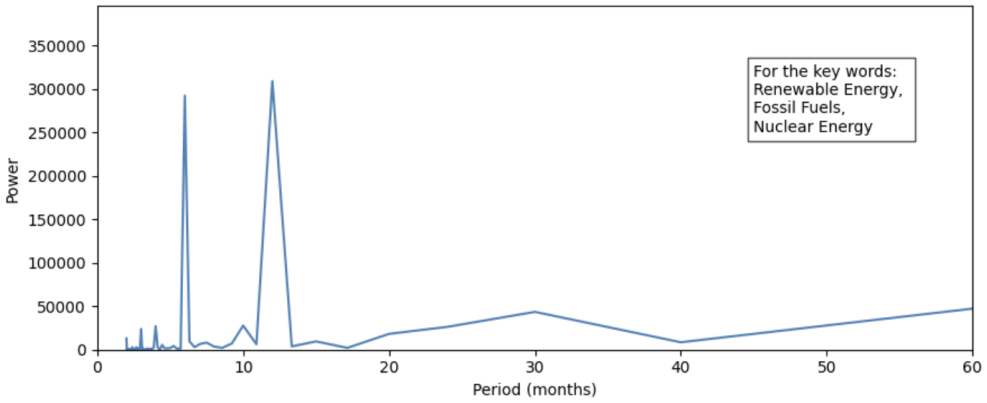

Figure 18: Periodogram of monthly google search volumes

3.6. Geographical analysis of the 3rd thematic group of search terms

The geographical analysis of this thematic group yields results (Figures 19a, 19b and 19c) that prompt for some deeper examination.

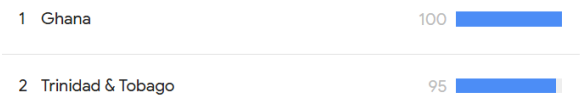

Figure 19a: Highest ranked countries for the search term ‘‘renewable energy’’

Figure 19b: Highest ranked countries for the search term ‘‘fossil fuels’’

Ghana's high ranking on Google Trends for the search term "renewable energy" reflects the country's active engagement with clean energy initiatives, despite its classification as a lower-middle-income nation. More specifically, the country relies on hydroelectric power, particularly the Akosombo Dam, on the Volta River, which provides 85% of the country’s electricity (ICE) while exporting neighbouring countries including Togo and Benin.

Trinidad and Tobago ranked highly on Google Trends for both “renewable energy” and “fossil fuels,” highlighting the country’s current reliance on hydrocarbons alongside emerging public interest in green alternatives. As the largest producer of crude oil and natural gas in the Caribbean, Trinidad and Tobago primarily relies on domestic fossil fuel production and exports its energy surplus (IMF, 2024). While its renewable energy sector remains underdeveloped, the increased search interest may signal rising awareness of the global energy transition and the country’s plans to diversify its energy mix.

For the search term “fossil fuels,” the Philippines unsurprisingly also stood out since the country used fossil fuels for 79% of its electricity demands at 2024 (Ember, 2025).

Figure 19c: Highest ranked countries for the search term ‘‘nuclear energy’’

Meanwhile, “nuclear energy” saw top search interest in Nepal and again the Philippines as presented from Figure 19c. In Nepal, this may be attributed to the reported discovery of uranium deposits in the Upper Mustang area (The scientific teen, 2023), sparking discussions on future energy potential and whether it’s feasible with Nepal’s unstable politics and lack of infrastructure. In the Philippines, search interest is likely tied to ongoing national debates about reviving the Bataan Nuclear Power Plant and reintroducing nuclear energy into the country’s energy strategy by 2032 (World Nuclear Association, 2025).

The heatmaps for these keywords are shown in appendix F.

3.7. Correlations between search terms:

Since all nine keywords seem to exhibit seasonality in their time series, it is reasonable to investigate whether these trends are correlated. While correlation does not imply causation, identifying correlations can help in attributing seasonal patterns to shared external events that affect multiple terms simultaneously. To assess this, Pearson correlation analysis is used. However, Pearson correlation assumes linear relationships between variables. To check for linearity, a pair plot was created (see Figure 20) between each pair of search terms, where the axes of each scatterplot represent the 2 search terms and each point is the value they would take at a point in time (globally and for ‘‘all categories’’). The points can form i) a straight line, this suggests a strong linear correlation, ii) a scattered "cloud" indicating little or no correlation, and iii) a curved shape implying a nonlinear relationship.

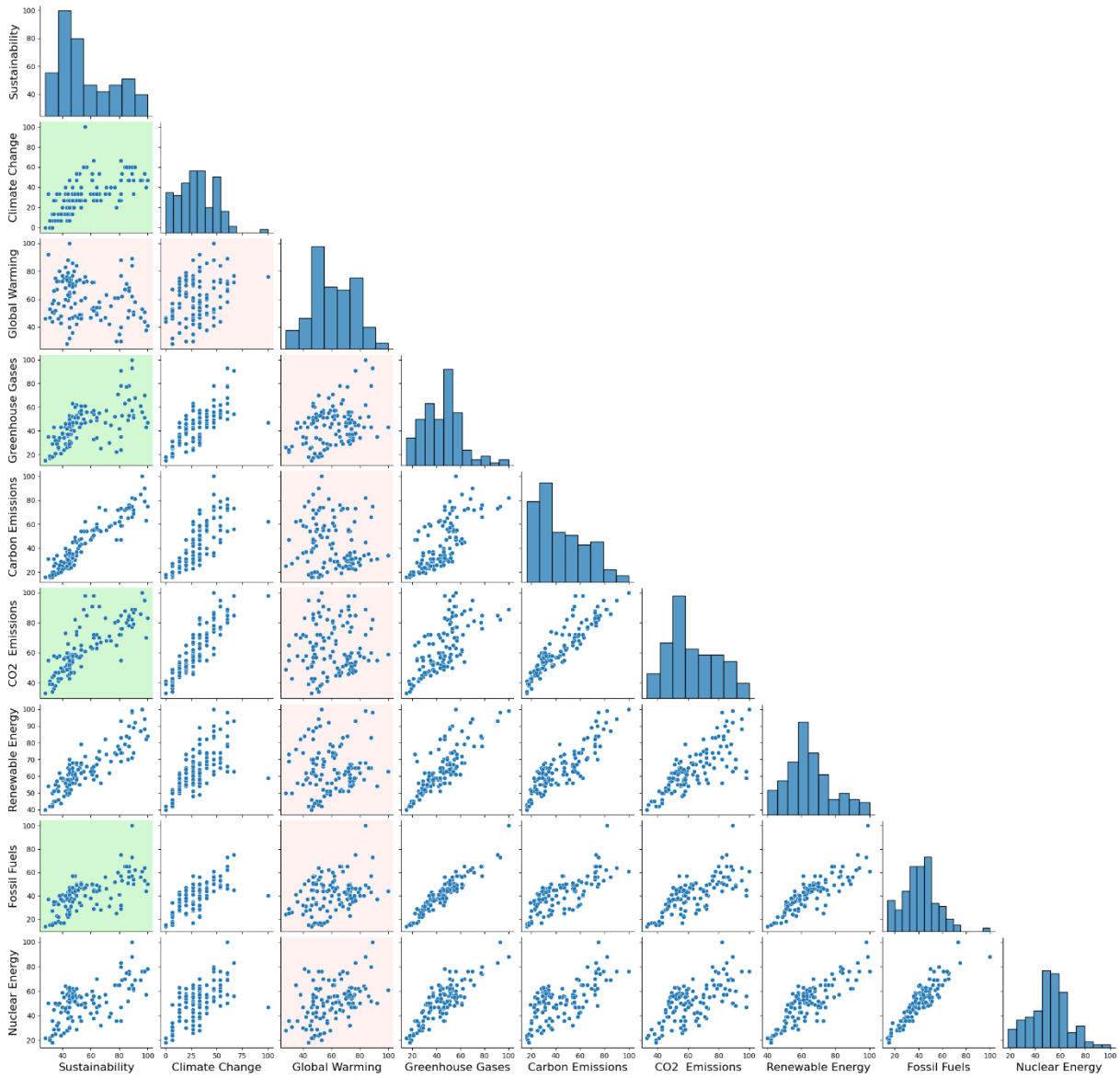

Figure 20: Pairplots for all 9 words with each other

Each scatterplot was then visually classified into one of these three categories. The classifications are illustrated in Figure 20:

- No change indicates plots with a linear trend.
- Light pink background for the scatterplots with no visible correlation,
- Green background for potential curves for nonlinear relationships.

From figure 20, it is evident that many terms have a strong linear relationship between them. For example, “greenhouse gases” and “fossil fuels” display an almost linear pattern, which suggests that people have associated these terms and tend to search them together. In contrast, “global warming” appears to be uncorrelated with the other terms, which might be due to its more technical use, alongside more technical or policy-related terms rather than everyday

interest. Interestingly, “sustainability” shows a relationship with “climate change”, “greenhouse gases”, “CO_2 emissions”, and “fossil fuels” that resembles an exponential trend..

Note that the 'climate change' trend had three extreme peaks as shown in Figure 1 and discussed previously. Because its trendline was normalized based on these high values, all the remaining points were compressed into a narrow range. This made it difficult to visually assess linearity, as the scatterplots involving 'climate change' appeared almost flat (see appendix G). To address this, Figure 20 shows the data after renormalising 'climate change' from removing the three outliers.

The Pearson correlation value was calculated for each pair and is shown in figure 21 in the form of a heatmap. Pearson coefficients range from -1 (strong negative correlation) to 1 (strong positive correlation), with values near 0 indicating weak or no correlation. No pairs have a negative correlation, which was also shown with figure 20. The stared boxes correspond to the pink or green boxes of figure 21, where Pearson correlation cannot be used to judge correlation since it only applies to linear relationships.

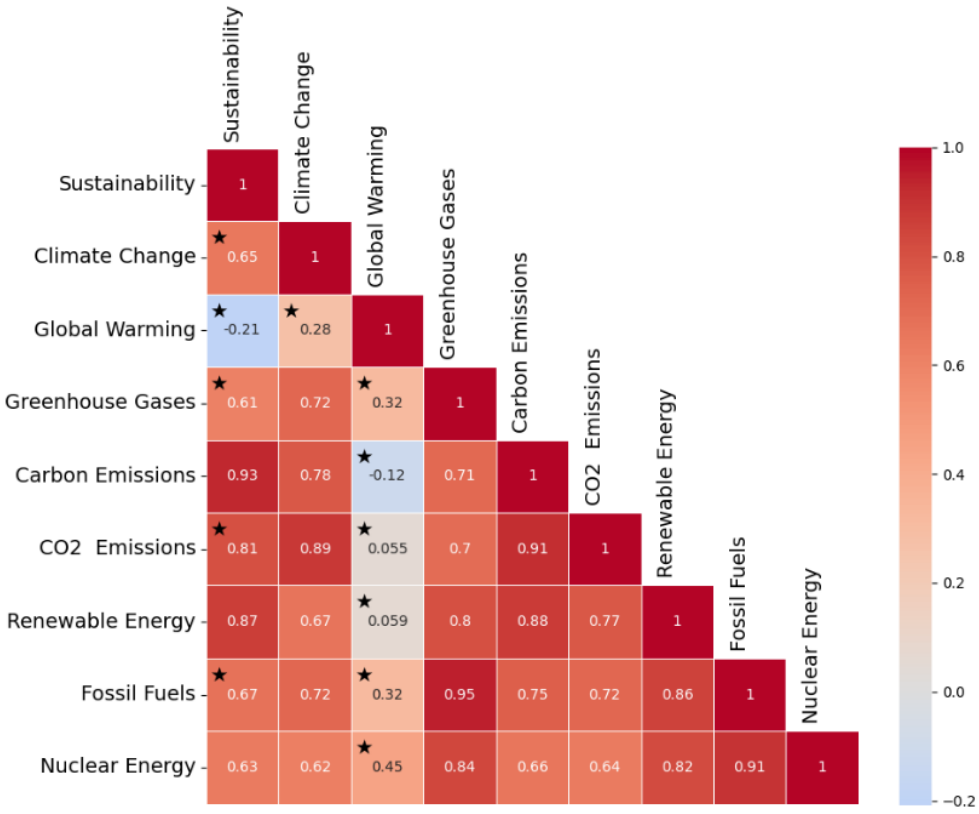

Figure 21: Pearson Correlation Matrix of the search terms, the stars show the pairs that did not have a linear correlation.

To better visualise the relationships between terms, Figure 22 displays a keyword network in which only correlations above a threshold of 0.7 are shown. The value 0.7 is chosen

arbitrarily. For a threshold of 0.8 see Appendix H. Again, this shows only the search terms with a linear relationship.

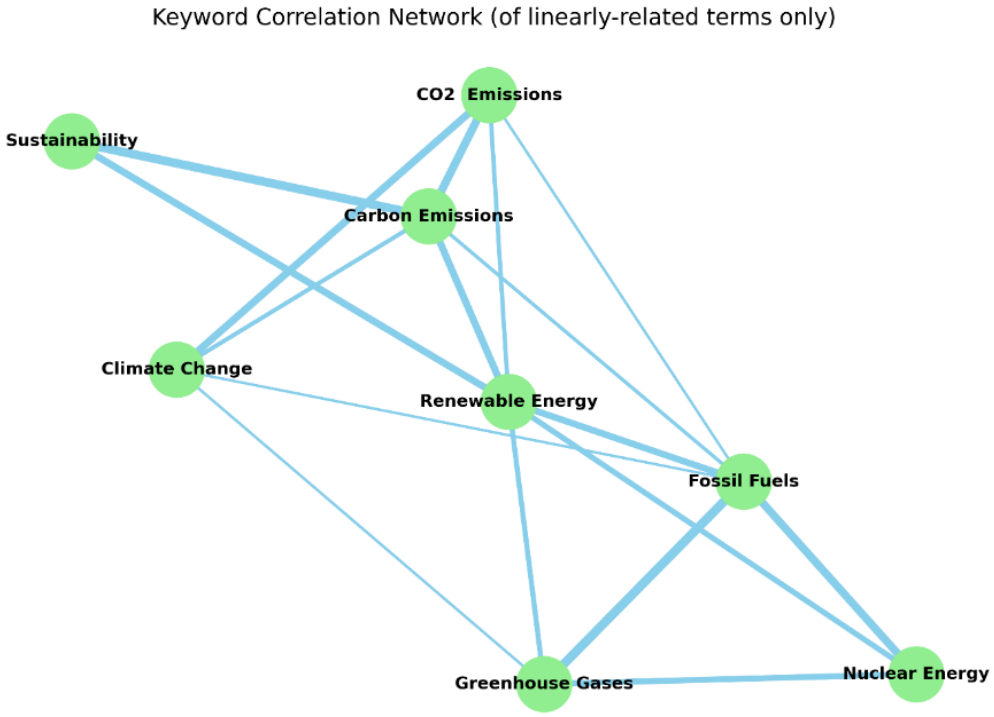

Figure 23: Keyword correlation matrix (for the linearly related terms only)

The thickness of the connecting lines reflects the strength of the correlation, with thicker lines indicating correlations with a Pearson value closer to 1. It is encouraging that most terms are strongly correlated to the other 2 words of their thematic group selected in section 3, except for sustainability which doesn't appear to have a correlation with ''global warming'', two terms that were in the same thematic group in section 3.1. However, the search trend for 'sustainability' appears to exhibit an exponential relationship with 'climate *change'* (as mentioned above), reflecting the growing awareness of global warming's impact in modern societies. The words with the strongest correlation belong in the 3rd group, of energy-sources with all terms above 0.7 in correlation. The connections between the terms seem intuitive. For instance, ''renewable energy'' is a pathway to sustainable development, which explains its correlation with ''sustainability''. Similarly, ''fossil fuels'' are often discussed in contrast to renewables, so it's reasonable that these terms also appear linked in search patterns. The correlation between ''sustainability'', ''renewable energy'', and ''carbon emissions'' suggests that people are aware of the relationships between these concepts. This indicates a level of public understanding that is encouraging and perhaps useful for policy making.

4. Discussion

4a. Limitations of Google Trends

Although Google Trends is a common tool for measure public interest, it comes with notable limitations that future research should address. First, it reflects the behaviour of computer-literate users and thus doesn't represent the global population accurately. For climate-related terms in particular, disadvantaged countries with low internet access may appear to have unexpectedly high relative search volumes-often because a privileged educated minority, more likely to be concerned with environmental issues, dominates the limited online activity, while the broader population is focused on more immediate daily needs. Language is another issue: Google trends is language specific; searches for "CO2 emissions" differ from "Émissions de CO_2" in French, leading to underrepresentation of non-English-speaking regions. This affects regional comparisons unless local language equivalents are used.

Even if we assume that the average internet user represents the general public, the way people search is inherently biased and their motivation varies. Users may search terms like "climate change" for vastly different reasons: for casual curiosity, academic research, policy development, or even because they believe it's a hoax. This makes interpreting spikes or drops of google trends complex, as they might not necessarily reflect genuine interest. Furthermore, by construction, platform algorithms take advantage of the fact that we are seeking for information with the least cognitive effort. This is the basis of 'nudge theory' (Thaler & Sunstein, 2008), which shows how changes of how information is being presented will guide searchers to particular outcomes. Hugely exploited by social media, personalised algorithms, such as suggestions, trending issues and autocomplete aim to either steer the users interest or create a filter bubble (Bakshy et al., 2015) where users are repeatedly exposed to information that reinforces their existings beliefs so in this particular case whether they care about the environment or not. Those who search for climate-related terms are typically individuals who already have an existing interest in the topic. Additionally, personalized search results based on a user's history and location (Le et al., 2019) can further mediate the search experience, making it challenging to generalize Google Trends data as an objective measure of public interest. Finally, as a google program, it is not transparent how the data from google trends are being created. Overall, it is evident that google trends comes with various limitations and should be supplemented with other means of measuring public interest.

4b. Interpreting seasonality

Seasonality is well-documented across various domains of human behaviour and psychology (Hohm et al., 2024a). For example, mood tends to decline in winter (Magnusson & Boivin, 2003), while aggression and violence increase during hotter months (Anderson, 2001). Research has shown that moral values-especially binding ones like loyalty, authority and purity also follow a biannual seasonality, with peaks in March and September (Hohm et. al., 2024b). These values are often activated in response to threats, including environmental ones, suggesting that concern and sensitivity for the climate may intensify during certain times of the year.

In general, explaining the seasonality pattern observed in all 9 search terms is not straightforward since public perception is affected by a combination of factors including scientific findings, political context, social changes, media coverage, and personal experiences. However, since these do not depend on a season, they are unlikely to account for the periodic rise in fall and spring shown through in sections 3.1, 3.3, 3.5. While certain recurring environmental events-such as Earth Day on April 22-may temporarily increase public engagement, their impact could be counterbalanced by other events like World Environment Day on June 5, which occurs outside the observed peaks. Additionally, recurring international climate conferences such as the annual United Nations Climate Change Conference (UNFCCC or COP), typically held in November or December, and the Petersberg Climate Dialogue, which takes place in the spring, may contribute to increased awareness. However, these events are unlikely to drive global public interest across such a wide range of terms-including more peripheral topics like nuclear energy. If such conferences were indeed the primary cause of the observed seasonal trends, one would expect to see sharp, localized spikes in search volume aligned precisely with the dates of these events. The broader, more gradual patterns seen in the data suggest otherwise.

Finally, there was speculation that the observed seasonality might be driven by a few large countries with high search volumes, potentially skewing the global data. However, individual country-level analyses on Google Trends - including both major contributors such as the USA, China, and Germany, as well as smaller nations like Hungary and Czechia - revealed that they all exhibited a general increase in spring and autumn months. This suggests that the seasonality is not the result of disproportionate influence from a few countries.

Overall, the authors note a lack of clear explanations for this seasonality and periodicity.

4c. Policy Takeaways

If public interest in climate-related terms peaks during spring and autumn, this seasonal rhythm can be leveraged strategically. Announcing and launching climate policies, or hosting environmental conferences during these high attention periods can amplify public engagement and media resonance. Conversely, just as politicians strategically release unfavourable news when public attention is diverted (Djourelova & Durante, 2019), they could announce climate anti-policies during seasonal troughs -summer and winter- to limit extended negative coverage. This logic may also apply to the strategic scheduling of international environmental conferences, climate outreach and educational campaigns.

5. Conclusion

This paper studied Google Trends data from the past decade for a selection of climate-related terms that capture different aspects of the climate problem. The observed peaks in search interest generally aligned with major global events, news coverage, and scientific announcements. Notably, all terms exhibited a consistent seasonal pattern, with search activity peaking in spring and autumn. This insight offers practical guidance: timing climate

policies, communication, and conferences to high-attention periods can boost visibility and impact. In addition, regional search data spotlight countries leading sustainability initiatives, or facing acute climate risks. Understanding public interest is essential for interpreting political decisions, as climate action ultimately depends on collective awareness and global cooperation. As AI is reshaping information-seeking behaviour, future work could explore how it could be leveraged both to forecast public interest and to account for its own considerable environmental footprint.

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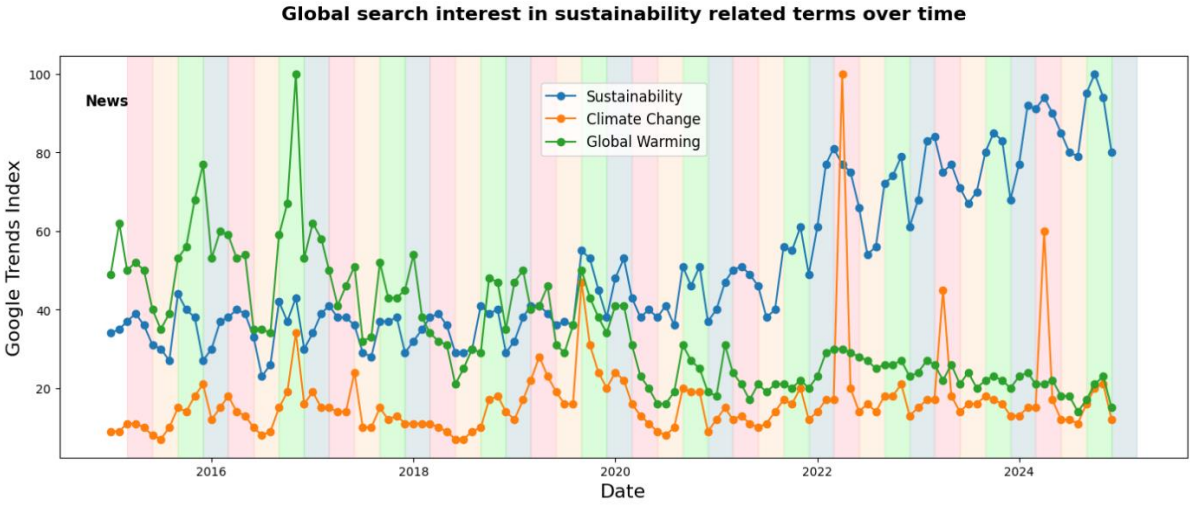
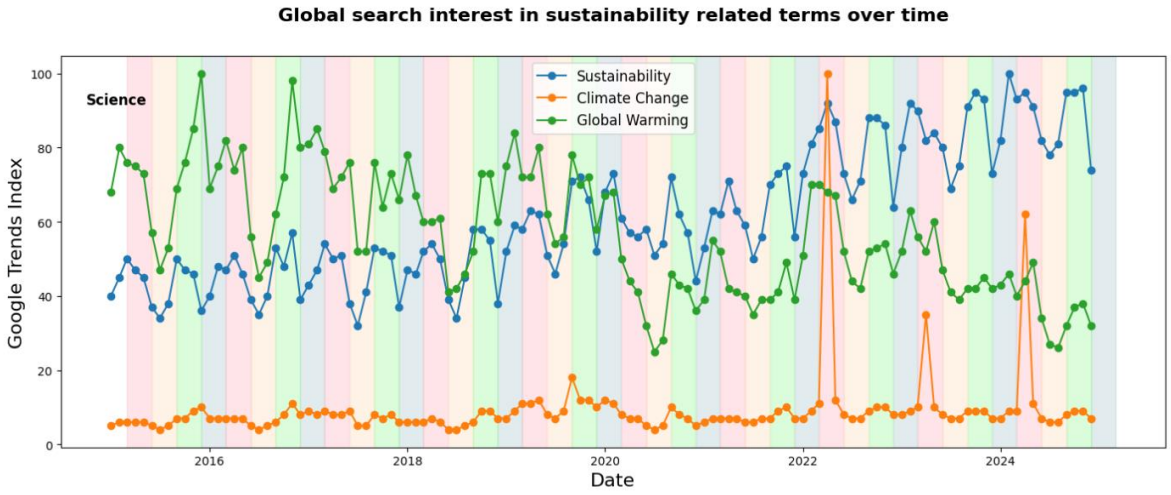
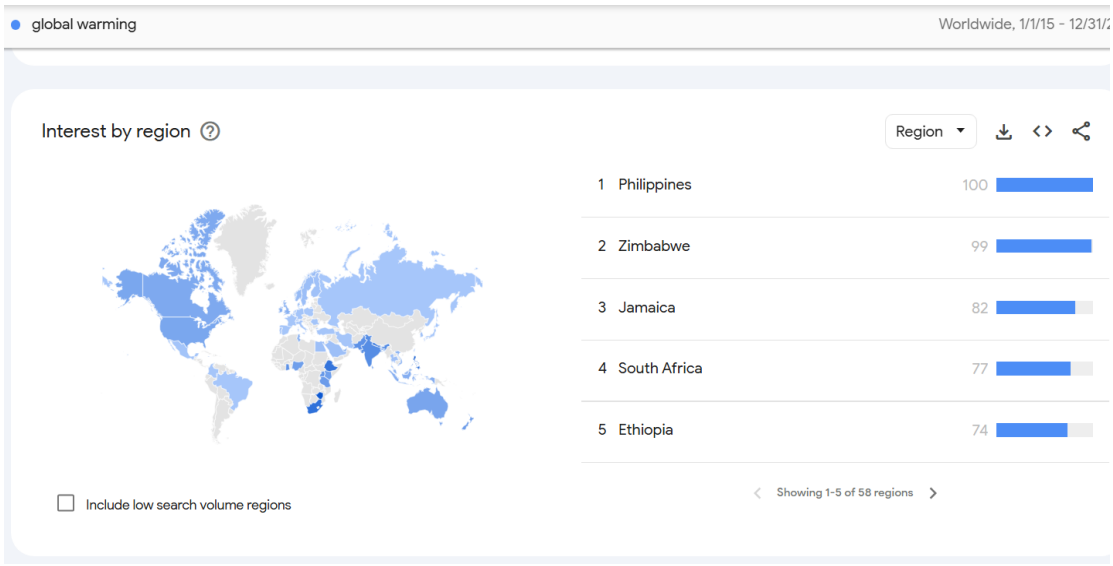
Appendices

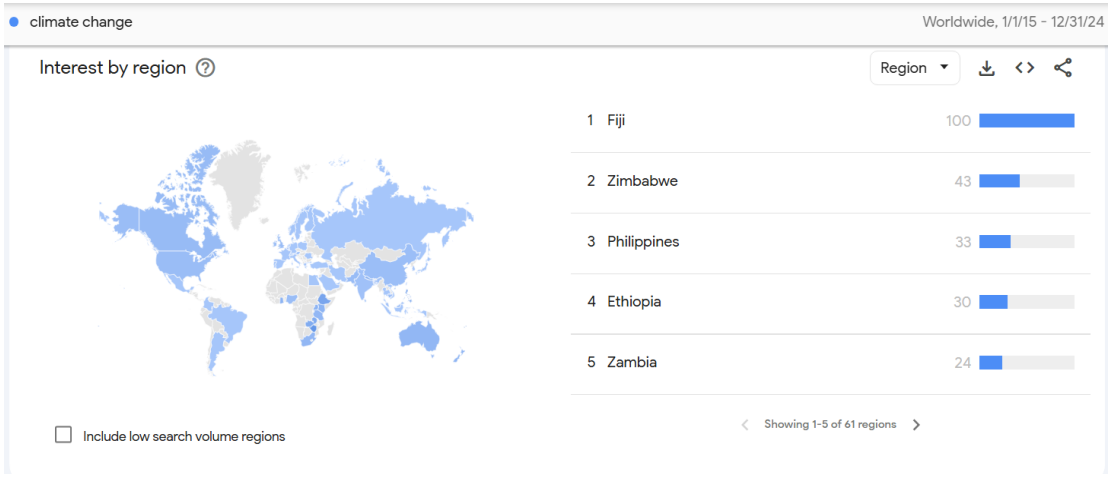
A: News and science for the first group



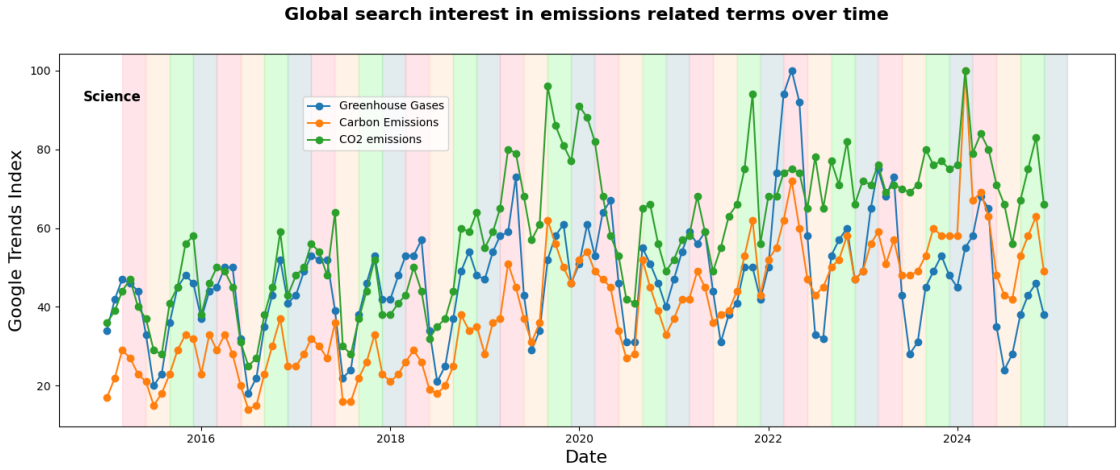


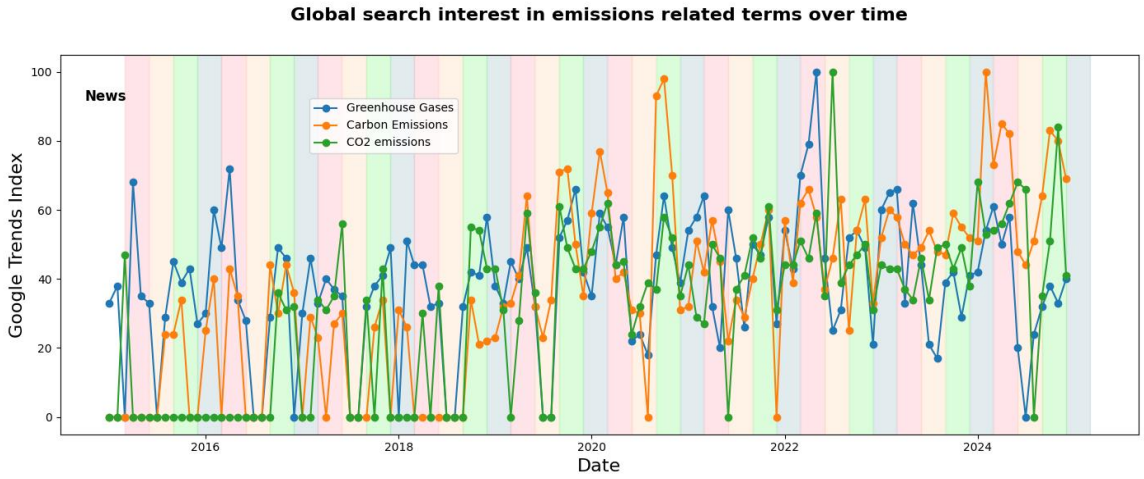
B: Heatmaps for the search terms of the first group



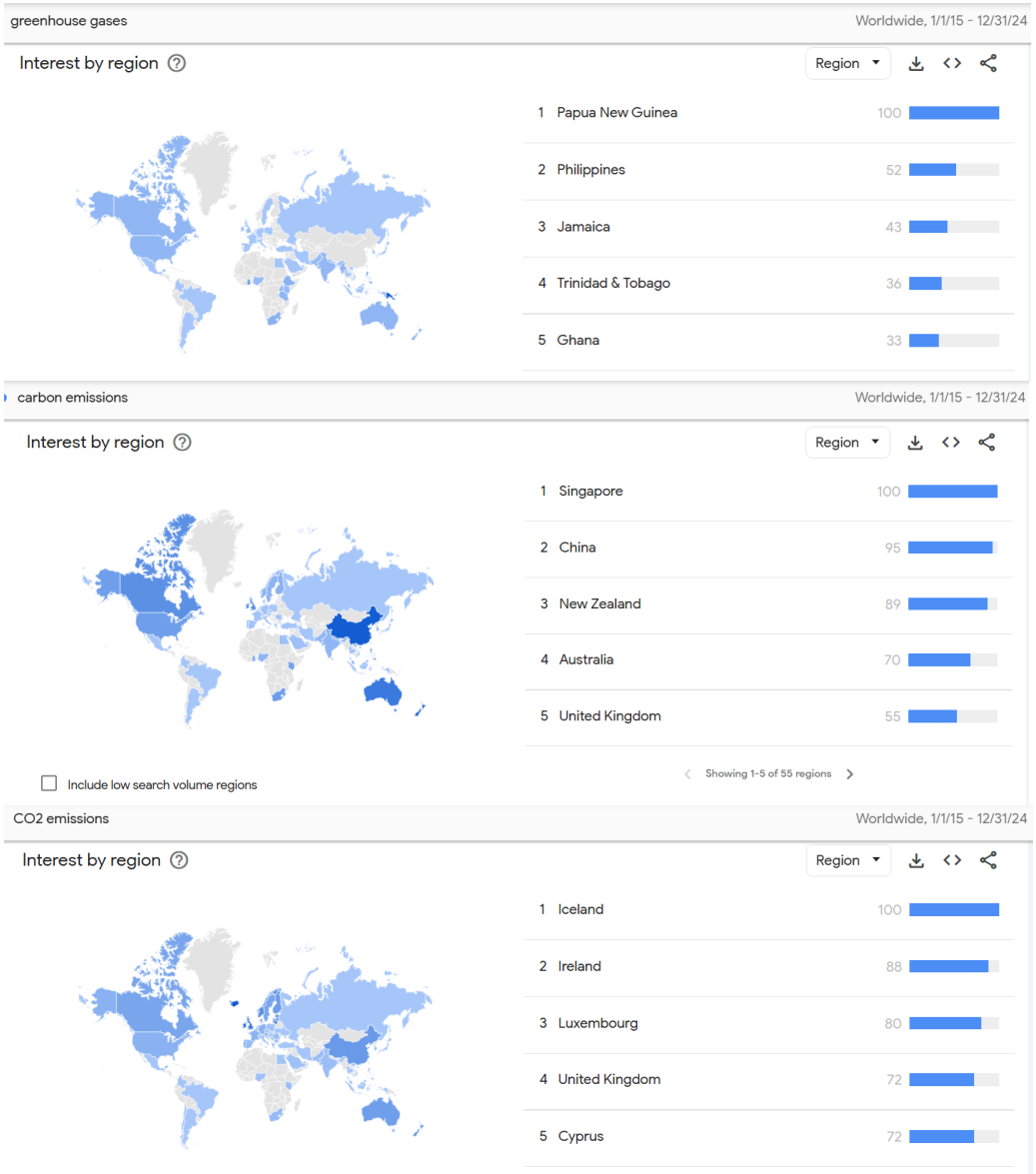


C: news' and 'science' for the second group

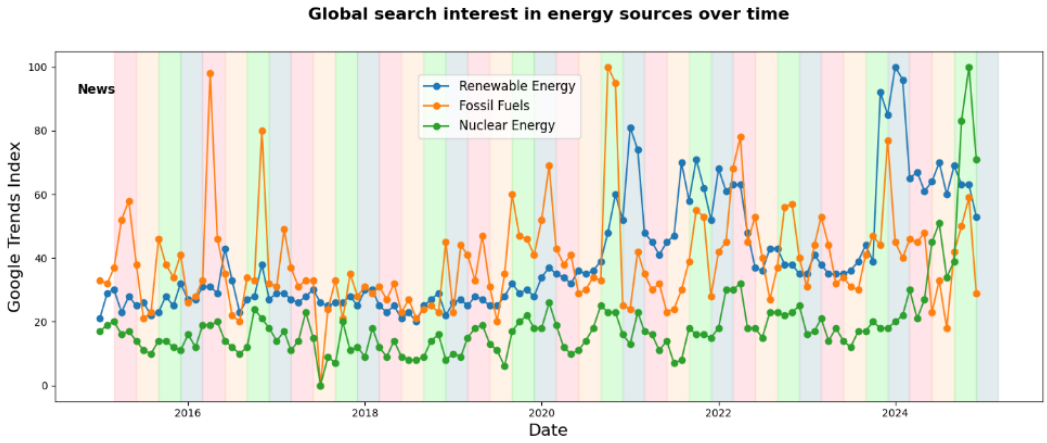


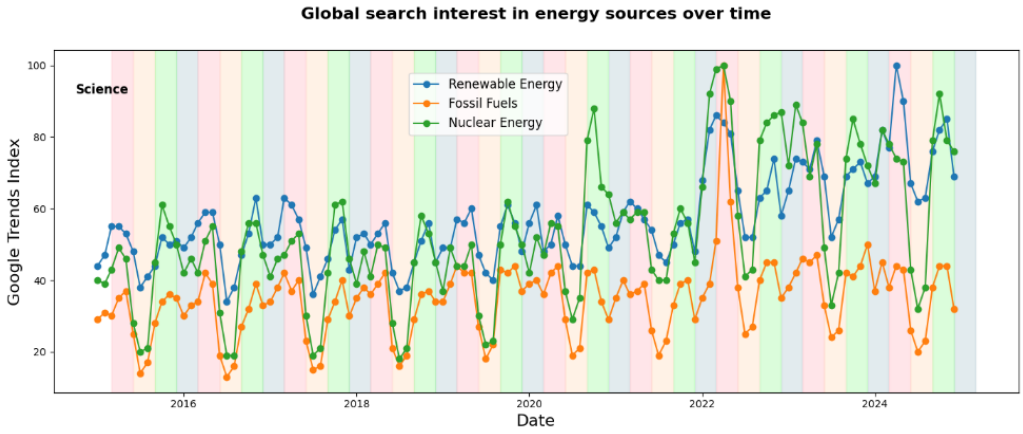


D: Heatmaps for the search terms of the second group

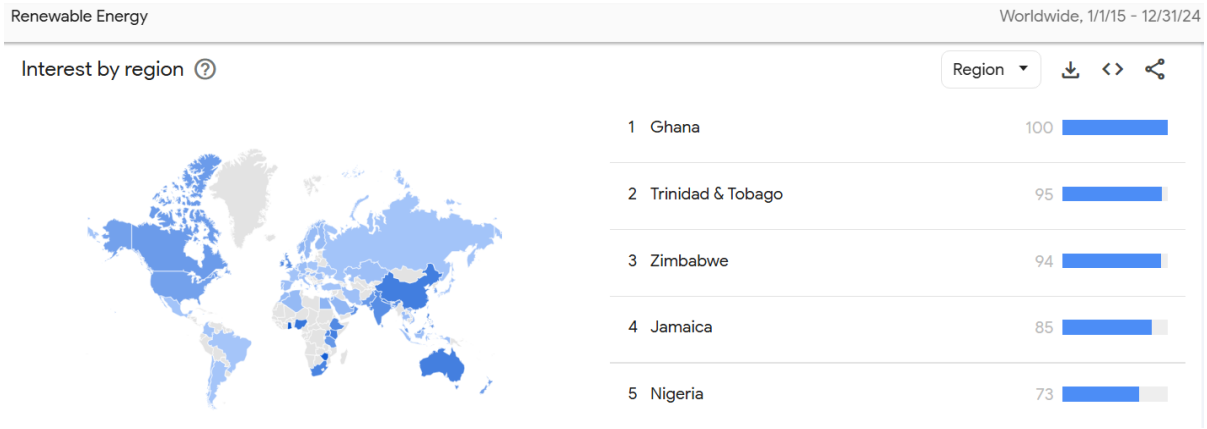


E: news' and 'science' for the third group of keywords:





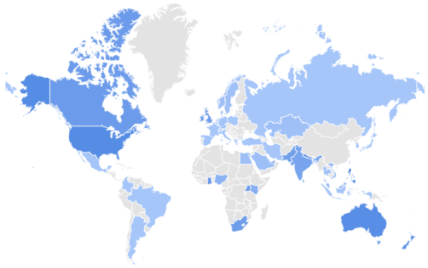
F: Heatmaps for the search terms of the third group



Fossil fuels — Worldwide, 1/1/15 - 12/31/24

Interest by region

Region

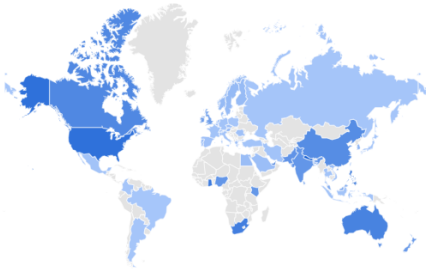


1	Philippines	100
2	Trinidad & Tobago	85
3	Jamaica	82
4	United Arab Emirates	53
5	United States	52

Nuclear energy — Worldwide, 1/1/15 - 12/31/24

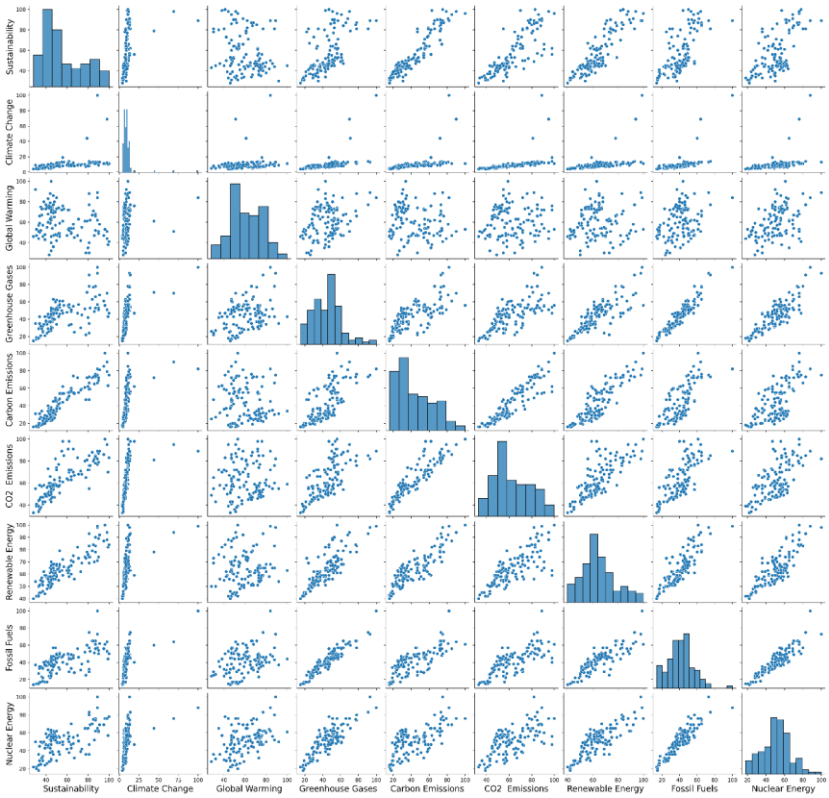
Interest by region

Region



1	Nepal	100
2	Philippines	87
3	United States	77
4	United Arab Emirates	76
5	Ghana	68

G: Original pairplot before the renormalization for ‘climate change’



H: correlation network for 0.8 as threshold