

Climate Research Report

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2023-11-29

Project 3 - Part 2 (Group 15):

Exploring climate related data sets

The relationship between economic expansion, climate change and health expectancy

In this comprehensive analysis, our objective is to investigate the influence of economic growth - specifically, how the economy of a country influences their viewpoints pertaining to climate change and how a more developed economy may have different viewpoints on climate change as opposed to a developing or an underdeveloped one. Furthermore, we aim to delve into how economic growth and signs of climate change, such as storms relates to or affects human health and overall life satisfaction.

Economy and climate awareness:

We chose to analyze an article from the International Monetary Fund titled 'Poor and Vulnerable Countries Need Support to Adapt to Climate Change' by Kristalina Georgieva, Vitor Gaspar and Ceyla Pazarbasioglu, (2022, March 23), IMF Blog. Overall, the article emphasized on the urgent need for international support to provide financial help to the poorest African countries to adapt to the impacts of climate change, as the research suggests that the slightest occurrence of natural disasters could significantly impact the economy of these agricultural nations.

Our primary interest from the article was the challenges that climate change poses to economic expansion. This prompts us to question the correlation - is climate change the byproduct of economic growth or is it simply a natural occurrence that nations have to overcome? Moreover, how do the perspectives differ between those experiencing the consequences firsthand and those who are not?

Data and cleaning

World region list: The data is obtained from World Regions Classification. Here we split `regionclassification` and create a new data frame `regionclassification_1` with three columns : *country*, *region* and *Global north/south* division for ease of use in later comparisons.

```
## # A tibble: 248 x 3
##   country          region          north_south
##   <chr>            <chr>            <chr>
## 1 "Andorra "       "Europe "         Global North
## 2 "United Arab Emirates " "Middle east "    Global South
## 3 "Afghanistan "   "Asia & Pacific " Global South
```

```
## 4 "Antigua and Barbuda " "South/Latin America " Global South
## 5 "Anguilla " "South/Latin America " Global South
## 6 "Albania " "Europe " Global North
## 7 "Armenia " "Europe " Global North
## 8 "Netherlands Antilles " "South/Latin America " Global South
## 9 "Angola " "Africa " Global South
## 10 "Antarctica " "Asia & Pacific " Global South
## # i 238 more rows
```

Opinions on climate data from Meta: This dataset contains aggregate response data from the ‘2022 Climate Change Opinion Survey’. This survey was a partnership between the ‘Yale Program on Climate Change Communication and Data for Good’ at Meta. We have selected the `climate_awareness`, `climate_beliefs` and `harm_personally` sheets in the data package and have done some cleaning to the three data sets.

```
## # A tibble: 110 x 7
##   country      'no awareness' 'little awareness' 'moderate awareness'
##   <chr>          <dbl>          <dbl>          <dbl>
## 1 Albania         9.99         43.0         33.1
## 2 Algeria        23.2         37.6         26.0
## 3 Angola         19.1         43.0         23.5
## 4 Argentina       8.25         37.4         43.8
## 5 Armenia         9.18         51.4         25.8
## 6 Asian.&.Pacific.Islan~ 13.3         40.1         24.8
## 7 Australia        1.13         26.4         48.1
## 8 Austria          1.34         16.4         48.6
## 9 Azerbaijan       6.19         42.4         35.9
## 10 Bangladesh     24.5         36.2         16.2
## # i 100 more rows
## # i 3 more variables: 'extensive awareness' <dbl>, 'refused to answer' <dbl>,
## #   '(Unweighted Base)' <dbl>
```

```
## # A tibble: 110 x 8
##   country      'human activities' 'natural changes' both human and natur~1 other
##   <chr>          <dbl>          <dbl>          <dbl> <dbl>
## 1 Albania         42.3         12.9         32.0  5.76
## 2 Algeria         37.4         14.8         27.6  7.83
## 3 Angola         33.4         22.3         34.8  1.79
## 4 Argentina       55.4         13.8         26.5  1.83
## 5 Armenia         35.2         13.0         26.5 13.4
## 6 Asian.&.Pa~     43.4         14.9         33.2  2.69
## 7 Australia       49.8         10.4         32.7  2.51
## 8 Austria         49.2          7.15         39.3  1.74
## 9 Azerbaijan      38.1         17.8         32.1  4.61
## 10 Bangladesh     39.4         12.0         27.2  8.68
## # i 100 more rows
## # i abbreviated name: 1: 'both human and nature'
## # i 3 more variables: 'dont believe in climate change' <dbl>,
## #   'refused to answer' <dbl>, '(Unweighted Base)' <dbl>
```

```
## # A tibble: 110 x 8
##   country      'great harm' 'moderate harm' 'little harm' 'no harm' unaware
##   <chr>          <dbl>          <dbl>          <dbl>    <dbl> <dbl>
## 1 Albania         23.9         28.6         12.2      4.59  27.8
```

```
## 2 Algeria 27.3 24.2 11.6 8.07 26.7
## 3 Angola 50.2 20.8 11.2 5.24 12.4
## 4 Argentina 39.1 28.4 12.9 6.38 12.3
## 5 Armenia 15.5 28.1 22.6 9.43 24.0
## 6 Asian.&.Pacific~ 44.9 22.5 12.0 2.91 17.1
## 7 Australia 21.2 33.4 21.6 14.8 8.86
## 8 Austria 24.7 37.9 22.7 5.17 9.59
## 9 Azerbaijan 16.8 34.8 13.6 11.5 23.2
## 10 Bangladesh 45.8 22.0 6.86 4.11 18.1
## # i 100 more rows
## # i 2 more variables: 'refused to answer' <dbl>, '(Unweighted Base)' <dbl>
```

We joined the three data frames together for ease of comparison, removing all the *Unweighted Base* and *Refused Answers* for the purpose of trimming down unessential data for our analysis. In this data, participants were asked three questions to determine:

- Their awareness of climate change, from 'no awareness' to 'extensive awareness'.
- The causes of climate change, from 'human activities' to 'dont believe in climate change'.
- How climate change harms them personally, from 'great harm' to 'unaware'.

The country level statistics reflects the percentage of respondents in each country providing a response to each question, it is calculated in percentage. We name our new data frame `climate_opinion`.

```
## # A tibble: 110 x 14
##   country 'no awareness' 'little awareness' 'moderate awareness'
##   <chr>      <dbl>      <dbl>      <dbl>
## 1 Albania 9.99 43.0 33.1
## 2 Algeria 23.2 37.6 26.0
## 3 Angola 19.1 43.0 23.5
## 4 Argentina 8.25 37.4 43.8
## 5 Armenia 9.18 51.4 25.8
## 6 Asian & Pacific Islan~ 13.3 40.1 24.8
## 7 Australia 1.13 26.4 48.1
## 8 Austria 1.34 16.4 48.6
## 9 Azerbaijan 6.19 42.4 35.9
## 10 Bangladesh 24.5 36.2 16.2
## # i 100 more rows
## # i 10 more variables: 'extensive awareness' <dbl>, 'human activities' <dbl>,
## # 'natural changes' <dbl>, 'both human and nature' <dbl>,
## # 'dont believe in climate change' <dbl>, 'great harm' <dbl>,
## # 'moderate harm' <dbl>, 'little harm' <dbl>, 'no harm' <dbl>, unaware <dbl>
```

NOAA Storm data for Atlantic and Pacific basins: This is the NOAA hurricane data up to year 2022, many of the cleaning was done in Project 2 and Project 3 - Part 1. Here, we drop the columns with duplicates data, such as the *NameYear* and *ObservYear* and columns with NA values for ease of use. We name our new data frame `cyclones`.

```
## # A tibble: 84,601 x 12
##   Basin Number NameYear Month Day status latitude longitude max_wind num_lat
##   <chr> <int> <int> <int> <int> <chr> <chr> <chr> <dbl> <dbl>
## 1 AL 1 1851 6 25 HU 28.ON 94.8W 80 28
```

```
## 2 AL 1 1851 6 25 HU 28.0N 95.4W 80 28
## 3 AL 1 1851 6 25 HU 28.0N 96.0W 80 28
## 4 AL 1 1851 6 25 HU 28.1N 96.5W 80 28.1
## 5 AL 1 1851 6 25 HU 28.2N 96.8W 80 28.2
## 6 AL 1 1851 6 26 HU 28.2N 97.0W 70 28.2
## 7 AL 1 1851 6 26 TS 28.3N 97.6W 60 28.3
## 8 AL 1 1851 6 26 TS 28.4N 98.3W 60 28.4
## 9 AL 1 1851 6 26 TS 28.6N 98.9W 50 28.6
## 10 AL 1 1851 6 27 TS 29.0N 99.4W 50 29
## # i 84,591 more rows
## # i 2 more variables: num_long <dbl>, category <ord>
```

World Happiness Report Score: The World Happiness Report is an annual report with scores computed based on how happy people are with their current life. We drop the unnecessary columns for the purpose of trimming the data. The new data frame `world_happiness` consists of the columns:

- *life ladder*, with 0 being the worst possible life and 10 being the best possible life.
- *log GDP per capita*, a country's economic output per person.
- *social support*, with 0 being the worst and 1 being the best.
- *healthy life expectancy at birth*, the average number of years a person would expect to live in good health.

```
## # A tibble: 2,199 x 6
##   country      year 'life ladder' 'log GDP per capita' 'social support'
##   <chr>      <dbl>      <dbl>          <dbl>          <dbl>
## 1 Afghanistan 2008         3.72          7.35          0.451
## 2 Afghanistan 2009         4.40          7.51          0.552
## 3 Afghanistan 2010         4.76          7.61          0.539
## 4 Afghanistan 2011         3.83          7.58          0.521
## 5 Afghanistan 2012         3.78          7.66          0.521
## 6 Afghanistan 2013         3.57          7.68          0.484
## 7 Afghanistan 2014         3.13          7.67          0.526
## 8 Afghanistan 2015         3.98          7.65          0.529
## 9 Afghanistan 2016         4.22          7.65          0.559
## 10 Afghanistan 2017         2.66          7.65          0.491
## # i 2,189 more rows
## # i 1 more variable: 'healthy life expectancy at birth' <dbl>
```

Analyzing Data

I. Does economic expansion influence perspectives?

Firstly, we identify the top 15 economies with the highest average GDP per capita from 2008 to 2022 as a sample size for our analysis on climate opinions of developed economies.

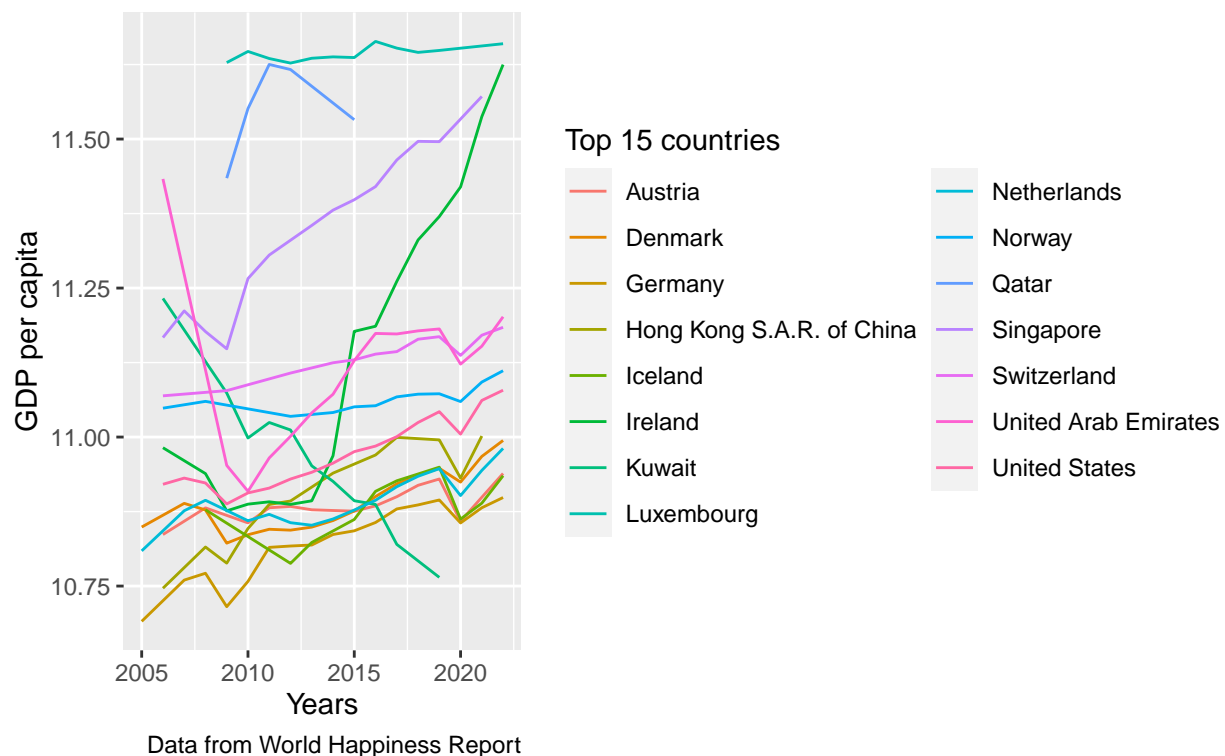
```
## # A tibble: 15 x 2
##   country      'average GDP'
##   <chr>      <dbl>
## 1 Luxembourg 11.6
## 2 Qatar     11.6
```

##	3	Singapore	11.3
##	4	Ireland	11.1
##	5	Switzerland	11.1
##	6	United Arab Emirates	11.1
##	7	Norway	11.1
##	8	United States	11.0
##	9	Kuwait	11.0
##	10	Hong Kong S.A.R. of China	10.9
##	11	Netherlands	10.9
##	12	Denmark	10.9
##	13	Austria	10.9
##	14	Iceland	10.9
##	15	Germany	10.8

We have identified the top 15 economies with the highest average GDP per capita over the last 14 years which are: Luxembourg, Qatar, Singapore, Ireland, Switzerland, United Arab Emirates, Norway, United States, Kuwait, Hong Kong, Netherlands, Denmark, Austria, Iceland and Germany.

Then, we plot a line graph to see the changes and assess the overall trend in their GDP per capita from 2008 to 2022.

Top 15 countries with the highest average GDP per capita
From 2008 to 2022

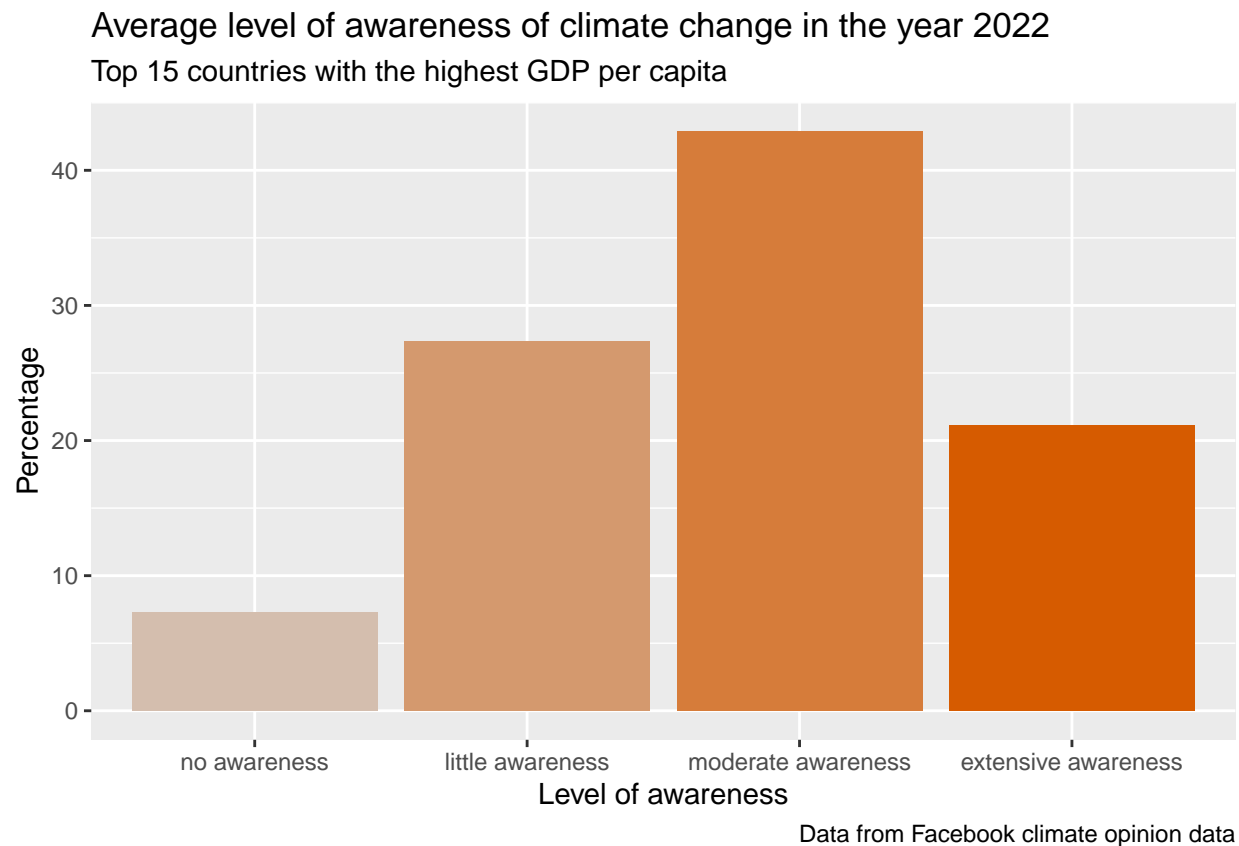


In general, even though the majority of the countries from the provided list are regarded as having ‘matured economies’, we could clearly see that there was an incrementation in most observations. Therefore it suggests that despite these nations possessing a high GDP per capita, they continue to experience economic growth.

Subsequently, we seek to identify the perspectives regarding climate change held by the populations within these nations. First, we calculate the average level of awareness based on the response of these 15 countries.

```
## # A tibble: 4 x 2
##   awareness      percentage
##   <chr>          <dbl>
## 1 no awareness      7.31
## 2 little awareness  27.4
## 3 moderate awareness 42.9
## 4 extensive awareness 21.1
```

Then, we visualize it with a bar graph.



Upon evaluation, the evidence does not explicitly denote outstanding levels of climate change awareness, given that nearly 27% of the population within these nations reportedly possess ‘minimal awareness’ of the ongoing climatic shifts. Nonetheless, it is noteworthy to mention that the segment of the population with ‘no awareness’ is relatively minor, with approximately 7%.

For the purpose of comparison, we apply the same procedures to developing and under developed countries.

First we pinpoint the nations with emerging economies, characterized by a fast rate of growth in their GDP per capita.

```
## # A tibble: 15 x 2
##   country      'GDP growth'
##   <chr>        <dbl>
## 1 Bangladesh    0.696
## 2 Ireland       0.686
## 3 Vietnam       0.675
## 4 India         0.633
```

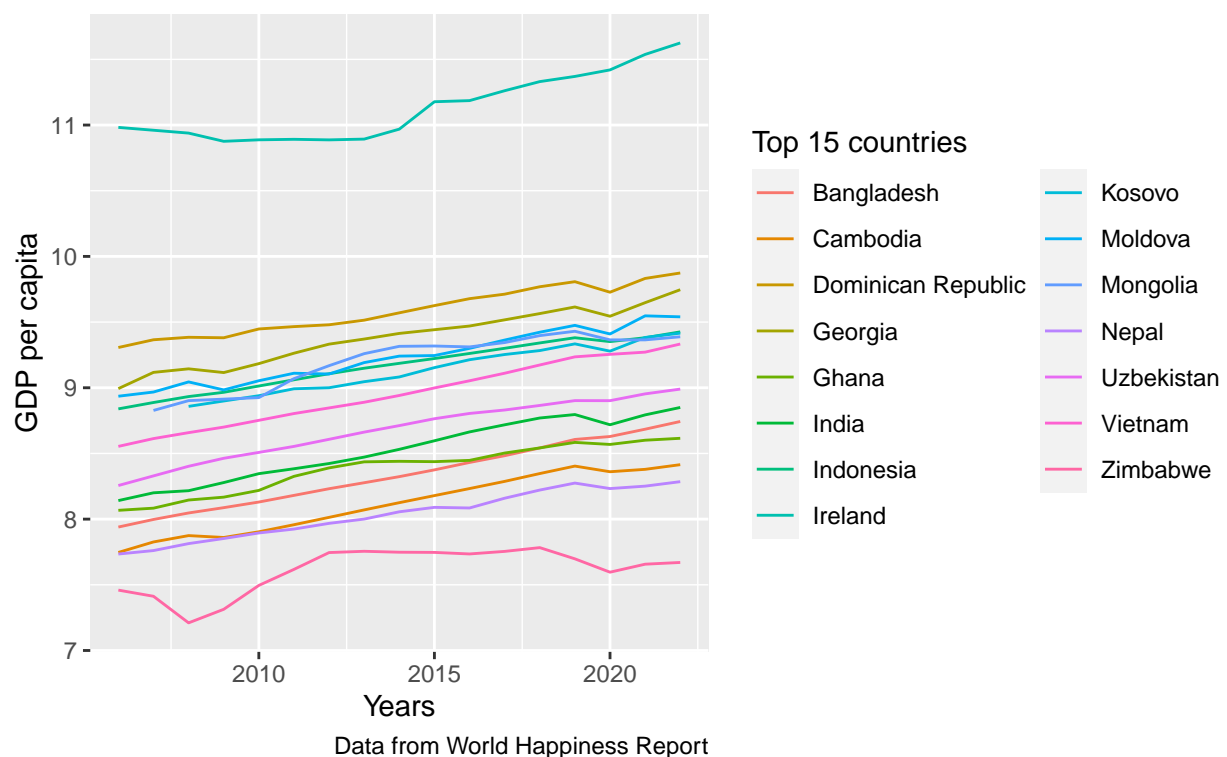
```
## 5 Georgia 0.602
## 6 Uzbekistan 0.587
## 7 Kosovo 0.557
## 8 Cambodia 0.540
## 9 Moldova 0.496
## 10 Indonesia 0.492
## 11 Dominican Republic 0.489
## 12 Mongolia 0.486
## 13 Nepal 0.472
## 14 Ghana 0.470
## 15 Zimbabwe 0.460
```

We have identified the top 15 economies with the highest GDP growth per capita from 2008 to 2022 which are: Bangladesh, Ireland, Vietnam, India, Georgia, Uzbekistan, Kosovo, Cambodia, Moldova, Indonesia, Dominican Republic, Mongolia, Nepal, Ghana and Zimbabwe.

Now we visualize the growth using a line graph, just to confirm.

```
## Warning: Removed 1 row containing missing values ('geom_line()').
```

**Top 15 countries with the highest average GDP growth per capita
From 2008 to 2022**



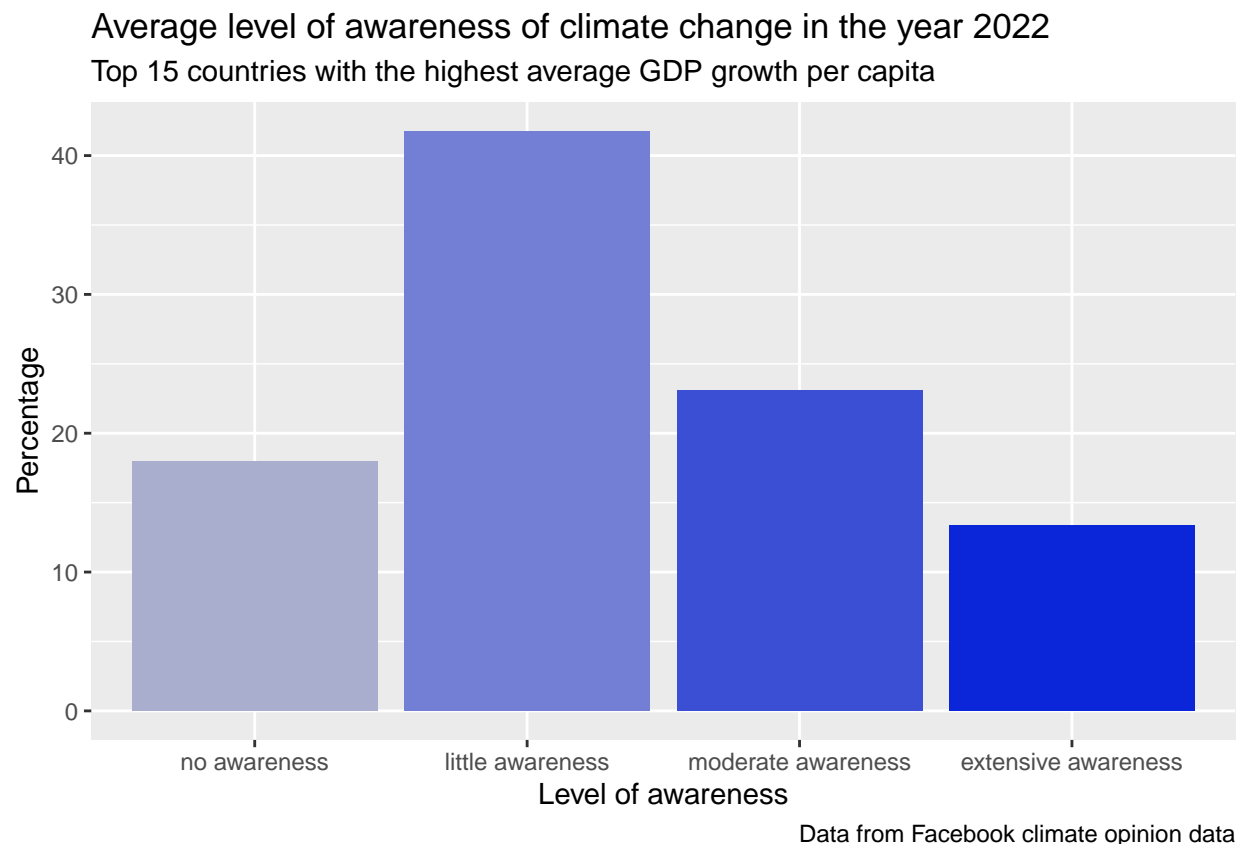
Despite their lower starting point (with the exception of Ireland, which showed in both data frames), these emerging economies witnessed a far more consistent growth with less economic dips and fluctuations as opposed to the more developed countries.

Now we identify the awareness of climate change of the population of these nations.

```
## # A tibble: 4 x 2
```

```
## awareness      percentage
## <chr>           <dbl>
## 1 no awareness    18.0
## 2 little awareness 41.8
## 3 moderate awareness 23.1
## 4 extensive awareness 13.3
```

And we visualize using a bar plot.



We could join the data sets representing emerging and matured economies together for ease of comparison.

```
## # A tibble: 4 x 3
## awareness      'matured economies' 'emerging economies'
## <fct>           <dbl>           <dbl>
## 1 no awareness    7.31            18.0
## 2 little awareness 27.4            41.8
## 3 moderate awareness 42.9            23.1
## 4 extensive awareness 21.1            13.3
```

Observations shows that countries with a developing economy often has lower awareness of climate change compared to developed economy. With the former having almost 60% population with 'little to no awareness' as opposed to the 34% of the latter.

Therefore, we might come to the conclusion that economic growth does not necessarily result in a low awareness of climate change. Rather, we argue that the average GDP per capita dictates this, in which lower average GDP means lower awareness and higher average GDP means higher awareness.

We prove our point by again, selecting a sample size of 15 countries with the lowest average GDP per capita from 2008 to 2022.

```
## # A tibble: 15 x 2
##   country          'average GDP'
##   <chr>          <dbl>
## 1 Burundi        6.68
## 2 Congo (Kinshasa) 6.87
## 3 Central African Republic 6.89
## 4 Somalia        6.92
## 5 Niger          6.99
## 6 Mozambique      7.04
## 7 Malawi          7.24
## 8 Liberia        7.29
## 9 Madagascar      7.33
## 10 Sierra Leone  7.35
## 11 Chad           7.41
## 12 Rwanda         7.43
## 13 Burkina Faso   7.51
## 14 Togo           7.53
## 15 Ethiopia       7.54
```

We have identified the top 15 economies with the lowest average GDP per capita which are: Burundi, Congo (Kinshasa), Central African Republic, Somalia, Niger, Mozambique, Malawi, Liberia, Madagascar, Sierra Leone, Chad, Rwanda, Burkina Faso, Togo and Ethiopia.

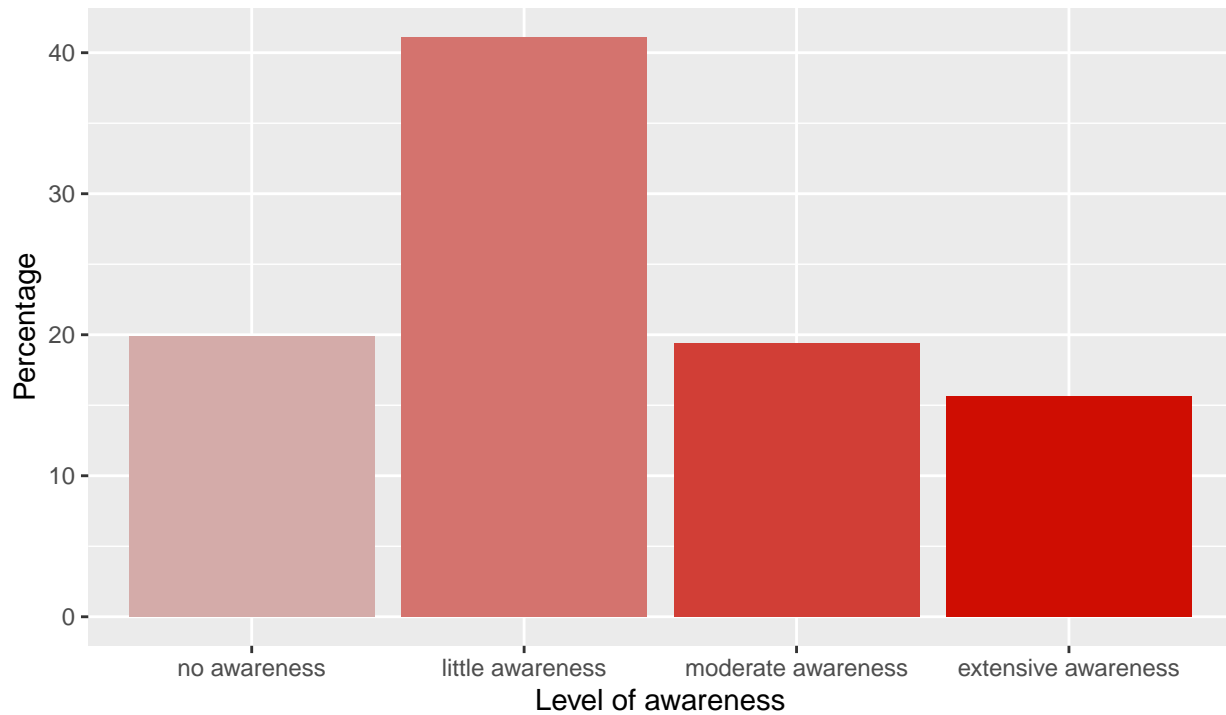
Now we identify the awareness of climate change of the population of these nations.

```
## # A tibble: 4 x 2
##   awareness      percentage
##   <chr>          <dbl>
## 1 no awareness    19.9
## 2 little awareness 41.1
## 3 moderate awareness 19.4
## 4 extensive awareness 15.7
```

And visualize the data with a bar graph.

Average level of awareness of climate change in the year 2022

Top 15 countries with the lowest average GDP per capita



Data from Facebook climate opinion data

Again, we join the climate awareness for the lowest average GDP and the highest average GDP for ease of comparison.

```
## # A tibble: 4 x 3
##   awareness      'matured economies' 'emerging economies'
##   <fct>                <dbl>                <dbl>
## 1 no awareness          7.31                 19.9
## 2 little awareness     27.4                 41.1
## 3 moderate awareness   42.9                 19.4
## 4 extensive awareness  21.1                 15.7
```

The pattern is consistent, nations with higher average GDPs tend to have higher levels of awareness of climate change, whereas those with lower average GDPs tend to be lower. We could plot a map to see where the distribution of high and low GDP.

Firstly, we find and fix the mismatch between some names of the same regions in the two data sets `world` and `GDP_distribution`.

```
## # A tibble: 12 x 1
##   country
##   <chr>
## 1 Congo (Kinshasa)
## 2 Congo (Brazzaville)
## 3 State of Palestine
## 4 Eswatini
## 5 Turkiye
```

```
## 6 Trinidad and Tobago
## 7 Czechia
## 8 United Kingdom
## 9 Taiwan Province of China
## 10 Hong Kong S.A.R. of China
## 11 United States
## 12 Somaliland region
```

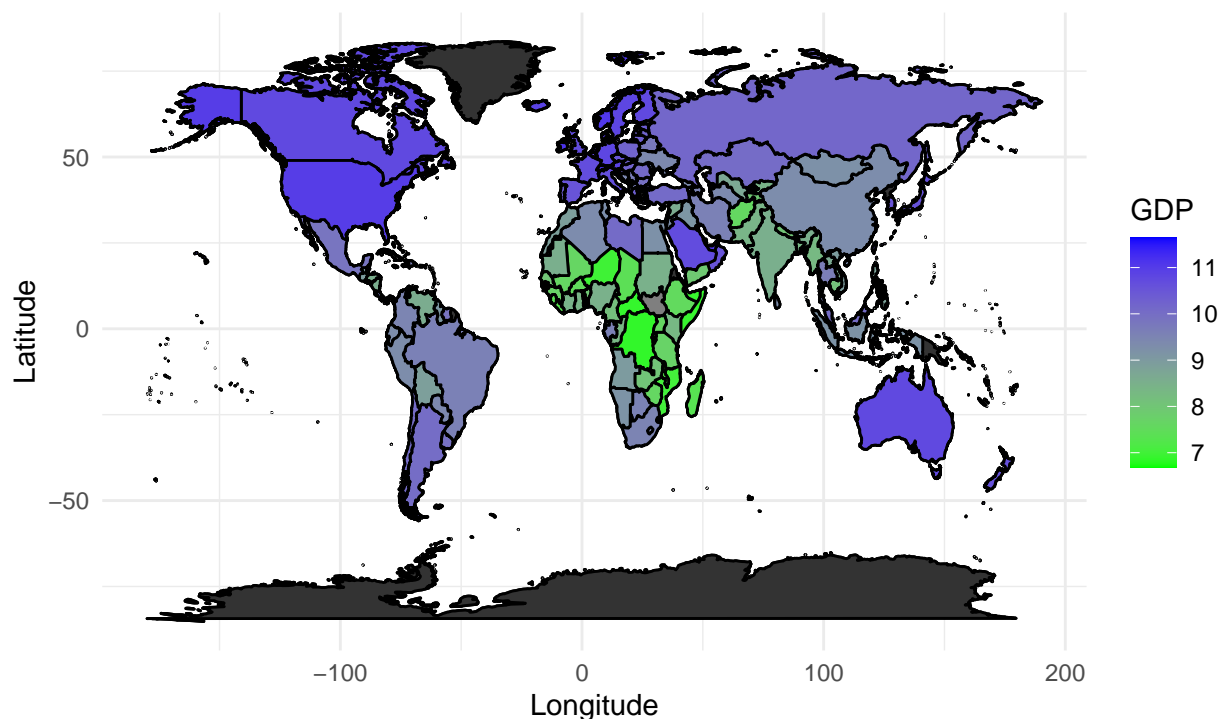
Then we plot the map.

```
## Warning in geom_map(data = world, map = world, aes(x = long, y = lat, map_id =
## region), : Ignoring unknown aesthetics: x and y
```

```
## Warning in geom_map(data = world, map = world, aes(x = long, y = lat, map_id =
## region), : Ignoring unknown aesthetics: x and y
```

World average GDP per capita map 2008 – 2022

Calculated from average GDP per capita from 2008 – 2022



Data from World Happiness report

Then, we can plot a map of the climate awareness level of the world. Firstly, we find and fix the mismatch between some names of the same regions in the two data sets `world` and `climate_opinion_1`.

```
## # A tibble: 13 x 1
##   country
##   <chr>
## 1 Asian & Pacific Islands
## 2 Bolivia (Plurinational State of)
## 3 Caribbean
```

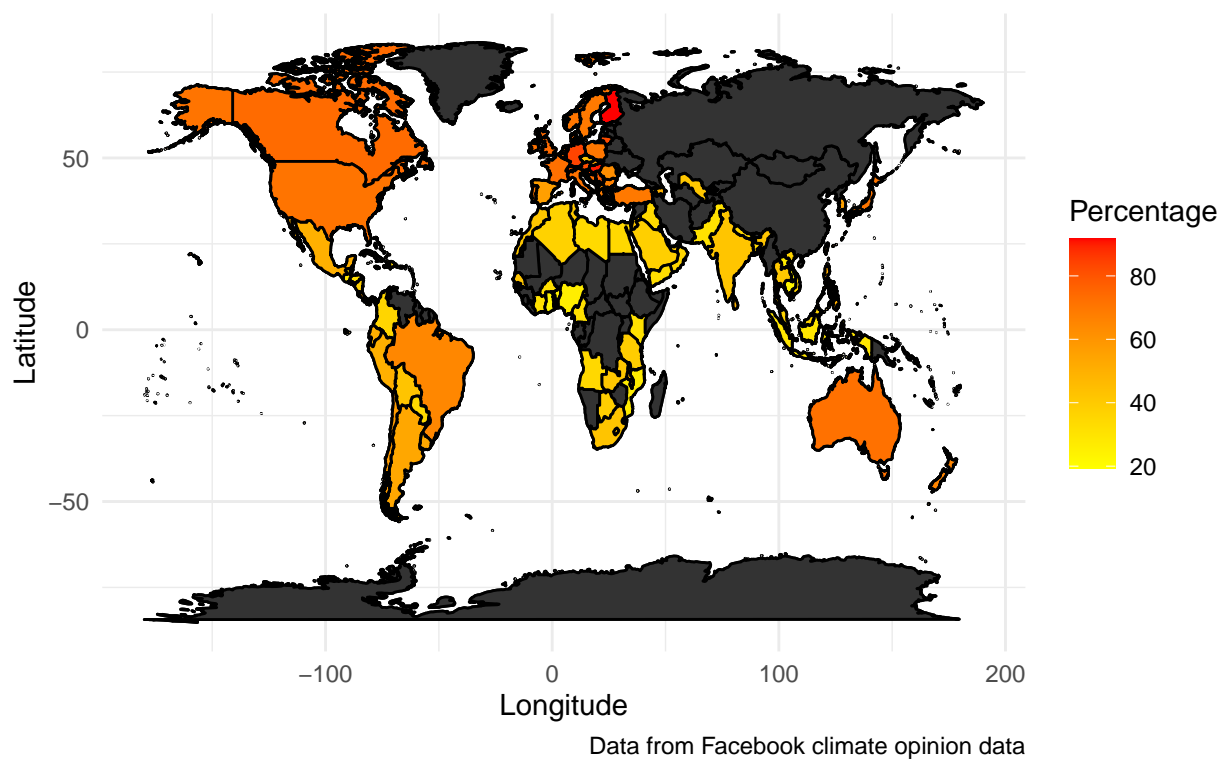
```
## 4 Congo (Democratic Republic of the)
## 5 Cote d'Ivoire
## 6 Czechia
## 7 Hong Kong
## 8 Lao People's Democratic Republic
## 9 North Macedonia
## 10 Sub-Saharan Africa
## 11 Trinidad and Tobago
## 12 United Kingdom
## 13 United States
```

Finally, we plot the map.

```
## Warning in geom_map(data = world, map = world, aes(x = long, y = lat, map_id =
## region), : Ignoring unknown aesthetics: x and y

## Warning in geom_map(data = world, map = world, aes(x = long, y = lat, map_id =
## region), : Ignoring unknown aesthetics: x and y
```

Percentage of population with awareness about climate change 2022
Calculated on 'moderate' to 'extensive' of awareness



Though numerous countries are absent from the climate data survey conducted by Meta, upon comparing the two maps, it is apparent that more economically developed nations are in the EU and NA region. Their economic prosperity translated into moderate to extensive levels of climate change awareness, while the opposite was true for regions with less economic power, such as SEA, SA and Africa.

From the analysis above, we can confidently say climate change awareness and economic power are directly proportional. Which makes it is quite fascinating, since despite the article highlighting that impoverished

nations are the most affected by climate change, our data analysis reveals that they are in fact the least aware of the circumstances. Conversely, it is intriguing to observe that wealthier countries, which experience minimal impact from climate change, are the most knowledgeable about it.

Is it possible that there are other factors at play, such as the availability of education, the literacy rate or communication within a population? Alternatively, could it be that wealthier countries are better equipped to handle the impacts of climate change, resulting in less damage to their economies?

II. What is the correlation between economic power and exposure to natural disasters?

In order to ascertain whether economic power mitigates the impact of natural calamities, we shall conduct an in-depth analysis of the NOAA Storms dataset.

Our focus now is to explore storm data further and analyze the severity and distribution of storms across various regions. To begin with, we divide them into Pacific and Atlantic basins and count the total amount from 2008 to 2022.

```
## Warning: There was 1 warning in 'filter()'.
## i In argument: 'Basin == "AL" & NameYear == "2008":"2022"'.
## Caused by warning in 'NameYear == "2008":"2022"':
## ! longer object length is not a multiple of shorter object length

## Warning: There was 1 warning in 'filter()'.
## i In argument: 'Basin == "EP" & NameYear == "2008":"2022"'.
## Caused by warning in 'NameYear == "2008":"2022"':
## ! longer object length is not a multiple of shorter object length

## Warning: There was 1 warning in 'filter()'.
## i In argument: 'Basin == "CP" & NameYear == "2008":"2022"'.
## Caused by warning in 'NameYear == "2008":"2022"':
## ! longer object length is not a multiple of shorter object length

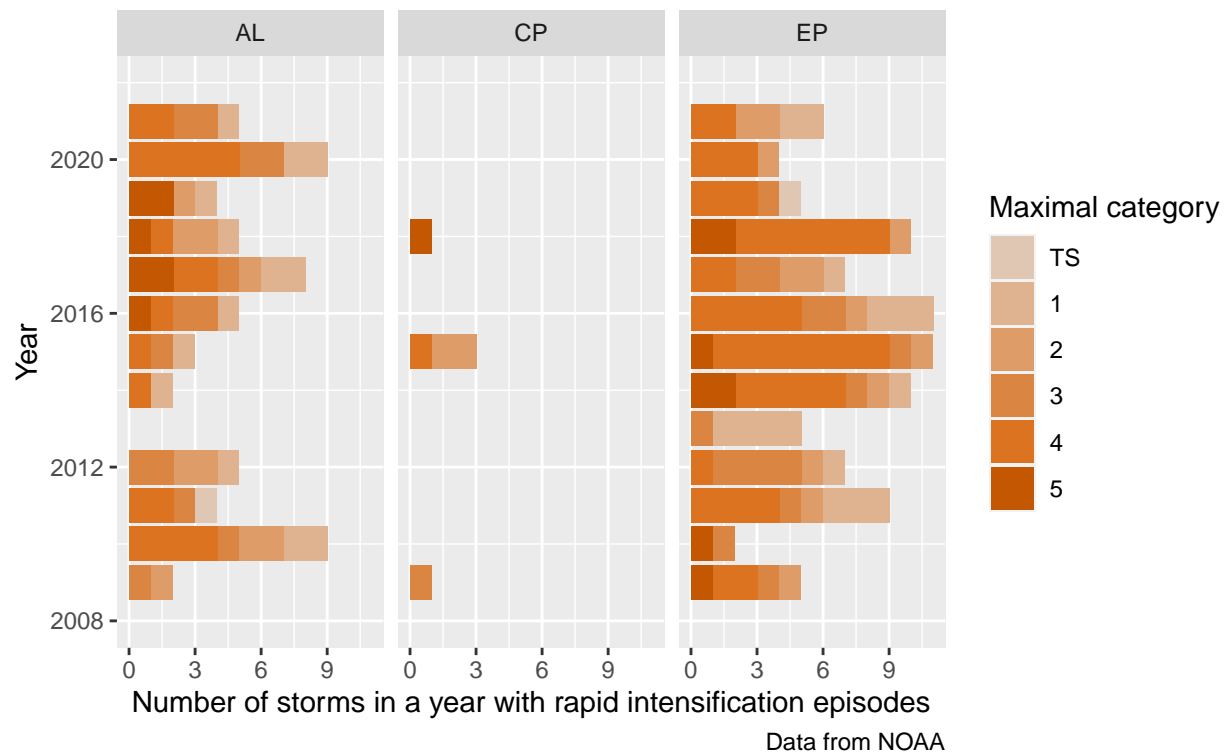
## # A tibble: 3 x 2
##   basin 'total storms'
##   <chr>         <dbl>
## 1 AL             529
## 2 EP             546
## 3 CP             53
```

Overall, there is little difference between the number of storms in the Atlantic compared to the Pacific Basin. We could try to apply the same approach as in Part 1 to detect storms that are rapidly intensifying in each Basin, we identify storms with rapid intensification from 2008 to 2022.

```
## Warning: Removed 722 rows containing non-finite values ('stat_count()').

## Warning: Removed 13 rows containing missing values ('geom_bar()').
```

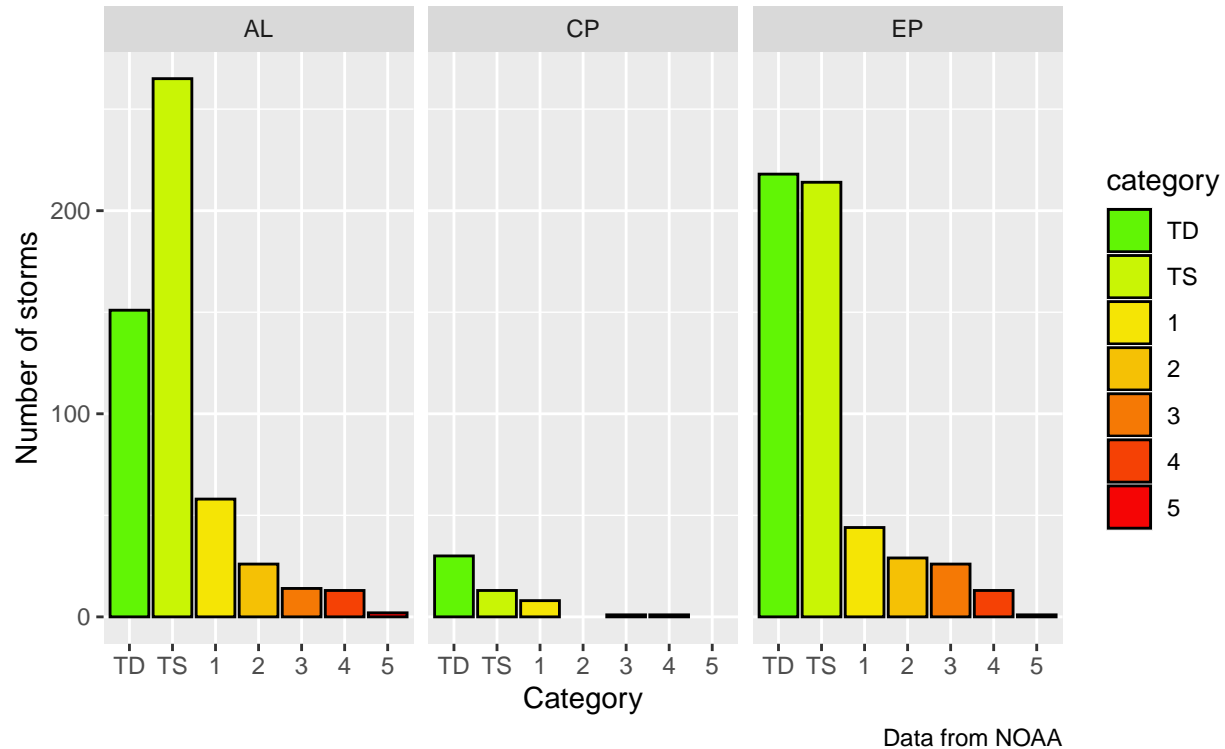
Number of storms having rapidly intensifying episodes increases in all basins From 2008 to 2022



There seems to be more rapidly intensifying storms in the Pacific basin, now we want to determine the frequency of heavy storms, or even catastrophic storms in each basin, we visualize it with a bar plot for each basin starting from 2008.

```
## Warning: There was 1 warning in 'filter()'.
## i In argument: 'NameYear == "2008":"2022"'.
## Caused by warning in 'NameYear == "2008":"2022"':
## ! longer object length is not a multiple of shorter object length
```

Number of storms based on category in each basin
From 2008 to 2022



During this time period, it appears that the Pacific basin has experienced a slight increase in severe storms. Nevertheless, the total number of storms with hurricane force in both basin remains relatively identical. Therefore, we might consider using coordinates to narrow down the storm distributions for each region by finding the frequency of storms in the Northern and Southern hemisphere, we classify them based on their latitude in both basins. The horse latitude of 30 degrees north of the equator is used to distinguish regions with more developed economies (NA and EU) from less developed and developing economies (SA, SEA, Africa).

```
## # A tibble: 2 x 2
##   region   'total storms'
##   <chr>         <int>
## 1 Northern         648
## 2 Southern       83953
```

From observation, there is clear difference between the frequency of storms that occurs below the 30 degree north latitude. Although we are missing alot of data, it is safe to say that there are less occurrence of storms around the northern region (NA, EU) as opposed to the southern regions (SA, SEA, Africa), which implies that these nations suffers more from catastrophic events.

Results

To summarize, while the aforementioned analysis indicates that climate change has adverse economic implications for Southeast Asia, South America, and Africa, we cannot assert with absolute certainty as our focus was primarily on tropical storms, which are prevalent and exacerbated in hot and humid regions. Numerous other indicators of climate change, such as droughts, tornadoes, and flooding, were not considered.

Nevertheless, we agree with the article's viewpoint that financially supporting economically disadvantaged nations to adapt to climate change is more crucial than attempting to reverse its effects. However, we also think that it is important to raise the awareness of these population about climate change so that they could even further prevent and minimize the effect of it.