GIS Applications

Calculate Greenhouse gas emissions per country, development within the last decade

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Abstract

Greenhouse gas emissions are the driving factors of global warming with consequent climate change precipitating extreme weather events such as drought, flood, and cyclone. The main objective of this study was to evaluate the GHG emissions per country within the ten-year period (2005-2015) through GIS application. The changes of greenhouse gas emissions within this decade have been presented through maps and graphs which were generated by the help of QGIS, R studio software, ggplot2 and dplyr packages. Reduction in greenhouse gas emission has been observed in countries like the USA, Canada, Greenland, Australia, Germany and Japan whereas increase has taken place in China and India. The continent- wise percentage change graph revealed that the percentage change of GHG emission increased in the case of the South American continent to the extent of 5.33% compared to Asia, Africa and Europe. The industrially developed countries with high per capita income have all along been held responsible for large GHG emissions, indicating a correlation between GHG emission and GDP. These countries while reducing their GHG emission have recently been switching from fossil fuels to renewable energy sources in order to maintain their energy consumption and hence the GDP. Even then we have been able to find a relationship between GDP and GHG emissions. In the USA, GHG emission was reduced from 24.05 to 20.14 tonnes CO 2 equivalent per capita per year in 2015, which resulted in a decrease of GDP from 0.49 to 0.38 tonnes CO 2 equivalent per kUSD per year in 2015.

Introduction

It is common knowledge that greenhouse gas (GHG) emissions are responsible for global warming. As the glass walls prevent infrared radiation from coming out of green houses, so do these gases (CO_2, CH_4, N_2O, SF_6, HFC and PFC) act as barriers to the dissipation in outer space of infrared radiations emanating from the earth. Infrared radiation which is known for its heating effect causes global warming, the consequences of which are enormous (climate change, sea-level rise, extreme events like floods, droughts, storms, and heat waves, altered crop growth, disrupted water systems, health effects, ecological damage like bleaching of corals, etc.). By far, the greatest culprit of the GHGs is CO_2 which comes out when fossil fuels are burnt to produce electric power among other things. Thus, there is a correlation between the stage of development of a country and the emission of CO_2, as more electric power is needed to run industrial factories and household electrical appliances. In order to save the world from the fallouts of climate change, the Kyoto protocol in 1997 set limits to emission of greenhouse gases for different countries. The United Nations through its IPCC

(Intergovernmental Panel on Climate Change) and UNFCCC (United Nations Framework Convention for Climate Change) monitors and reports on GHG emissions, temperature rise, ice melting, sea-level rise, etc. on a regular basis. In recent years GIS (Geographical Information System) is being increasingly applied for calculating GHG emissions. GIS can not only help locating the emission and absorption sites, it can also suggest better management options (Asdrubali et al., 2013; Kuonen, 2015; https://www.gim-international.com/content/news/gis-to-monitor-greenhouse-gas, 2009). In the present context we are going to calculate the percentage change in GHG emissions by different countries over the 10-year period from 2005-2015 and apply GIS to have the scenario clearly depicted geographically. Results would be interpreted in terms of the development status of a country and other relevant factor.

Methodology

In the first phase, we had used QGIS software to create the world map layout from 2005 to 2015 of GHG emission. The all country's layer had been collected via www.naturalearthdata.com for creating map by applying QGIS. For routing the names of countries and the countries geographic characteristics, we had followed attribute table. Also, via https://edgar.jrc.ec.europa.eu/, the yearly GHG gas emission data had been gathered for creating GIS map of GHG emission. Per capita GHG emission for every country had been taken as a basement in this project. We used ten years data from 2005 to 2015 GHG emission per capita in tons. For accounting and converting GHG emission into percentage alternation, we had taken the time span of 10 years from the set of data. For percentage change in GHG emission for 2005 to 2010, we calculate the percentage change by following this equation ((2015 GHG value – 2005 GHG value) *100)/ 2005 GHG value. For comparing the continent wise GHG emission, we took 2005 and 2015 values for each country GHG emissions and then we categorized 258 countries into 8 continents. For getting individual continents value, we summed up all of the country's values for 2005 and 2015 respectively. Then we calculated the percentage change of GHG emissions by following this equation: ((2015 GHG value – 2005 GHG value) *100)/ 2005 GHG value. In addition, for comparing GDP with GHG emission we took only 12 countries value and, in this case, we did not take the percentage values of GDP or GHG. We took exact values of GDP and GHG for illustrating the graph.

In the second phase, we had used R studio by applying ggplot2, dplyr and reshape2 packages to show the bar graphs of continent wise percentage change of GHG emission (2005 – 2015), comparison of GHG emission values (2005 -2015). We had also used R studio by applying patchwork package for the scattered plot graph of country wise comparison of GDP and GHG (2005 – 2015).

Results & Discussion

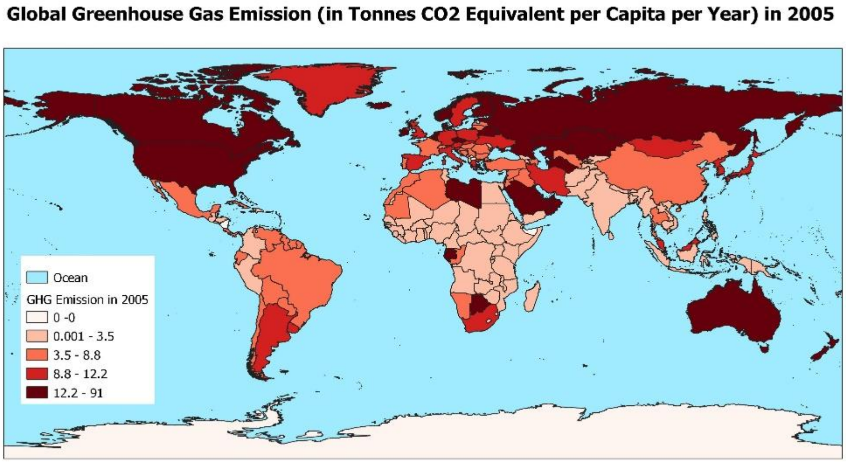

Figure 1: Global GHG Emission in 2005

Countries with the highest greenhouse gas emissions in 2005 were North America, Europe, Russia, Canada and Japan. In contrast, African countries like Zambia, Libya, Kenya, Ethiopia and South Asian countries such as Bangladesh, Pakistan, India, Iran emits less, which is clearly visible from this map. The GHG emissions were higher in the dark regions (12.2-91 metric tons) in 2005.

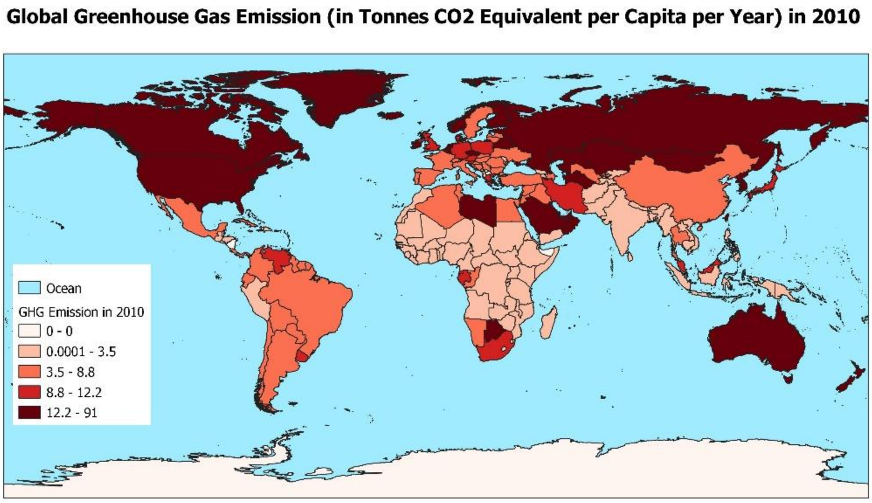

Figure 2: Global GHG Emission in 2010

If we make a comparison of greenhouse gas emissions in 2005 and 2010, there were no noticeable changes except Greenland (8.8-12.2 and 12.2-91 metric tons in 2005 and 2010 respectively).

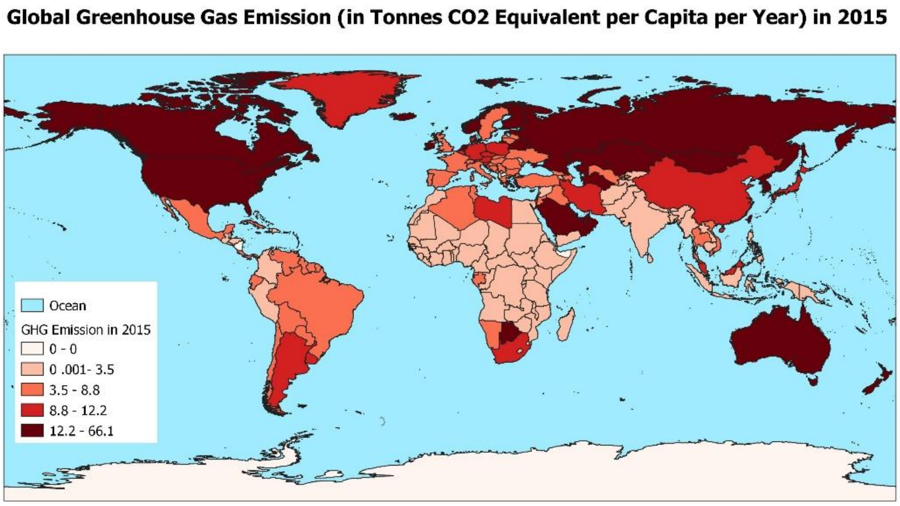

Figure 3: Global GHG Emission in 2015

Changes can be noticed in the year 2015 where Libya was able to reduce its emission but in case of China it increased. Other countries in the map remained more or less same.

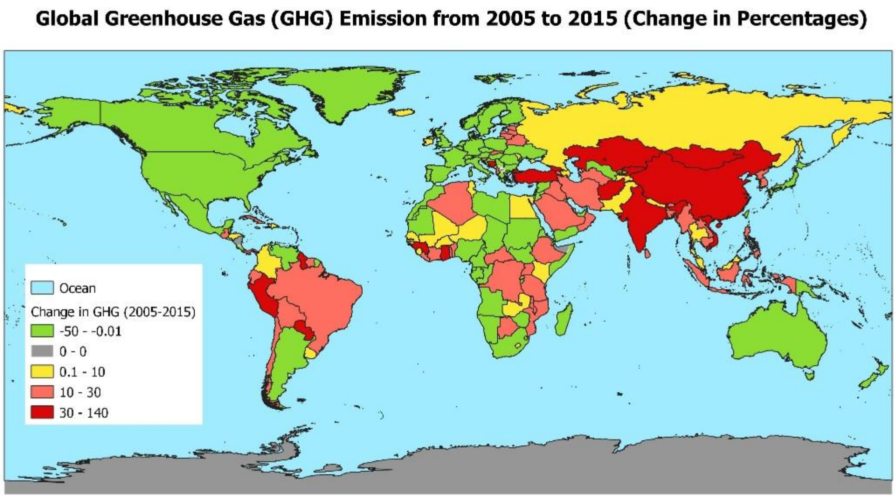

Figure 4: Percentage Change of Global GHG Emission (2005 – 2015)

We can observe massive changes in percentage of GHG emissions over the 10- year period. The green legend with negative values indicates these countries, namely North America, Canada, Greenland, Australia, Germany, Japan, Libya and Argentina, which were able to reduce greenhouse gases due to strictly following the Kyoto Protocol. Therefore, these countries were enlisted as eco-friendly countries. The legend Gray colour indicates that Antarctica was remaining stable toward emitting GHG. Russia, Egypt, Niger, Mali and Colombia belong to moderately eco-friendly countries. Moreover, due to less environmental impacts, Brazil, Bolivia, Chile, Algeria, Congo and Saudi Arabia were enlisted as moderately environmentally hazardous countries. Few countries, belonging to dark regions in the map (China, Mongolia, Kazakhstan, India, Peru) were responsible for high emission over the last decades due to population booming, urbanization, industrial revolution as well as GDP growth (Frohlich and Blossom, 2019).

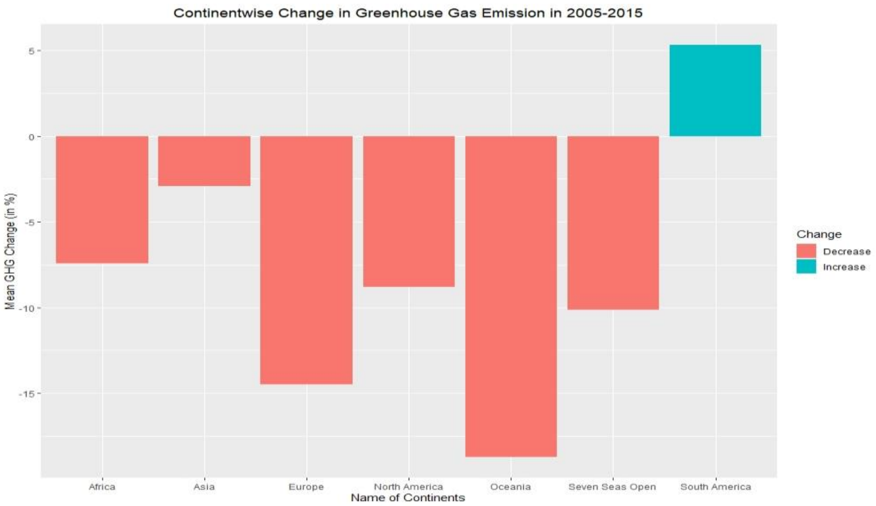

Figure 5: Continent wise Percentage Change of GHG Emission (2005 – 2015)

Worldwide GHG emission had been raised firmly from 1990 to 2015 approximately 32.8 Gt CO_2eq/yr to 49.1 Gt CO_2eq/yr via fossil CO_2 amounts and the net raised GHG emission was ca 50% (Crippa et al., 2019). For illustrating this graph, we took 2005 and 2015 values for each country GHG emissions and then we categorized 258 countries into 8 continents. For getting individual continents value, we summed up all of the country's values for 2005 and 2015 respectively. Then we calculated the percentage change of GHG emissions by following this equation: ((2015 GHG value – 2005 GHG value) *100)/ 2005 GHG value. The unit of GHG emission was in tonnes CO_2 equivalent per capita per year. For getting this bar graph, we used R studio as well as ggplot2 and dplyr packages. From the graph, we can see that percentage change of GHG emission has increased in case of South America continent which has increased

5.33%. Due to demographic increases, high economic developments, peoples wage conditions, soil utilizations, poor climatic situations, gas emissions such as CO_2, CH_4, N_2O, percentage change of GHG emission has increased in case of South America continent (EPA, 2016). From the graph, we can also see that the most decreased percentage change is 18.73% in Oceania continent which includes countries like New Zealand, Australia, Fiji, Kiribati etc.

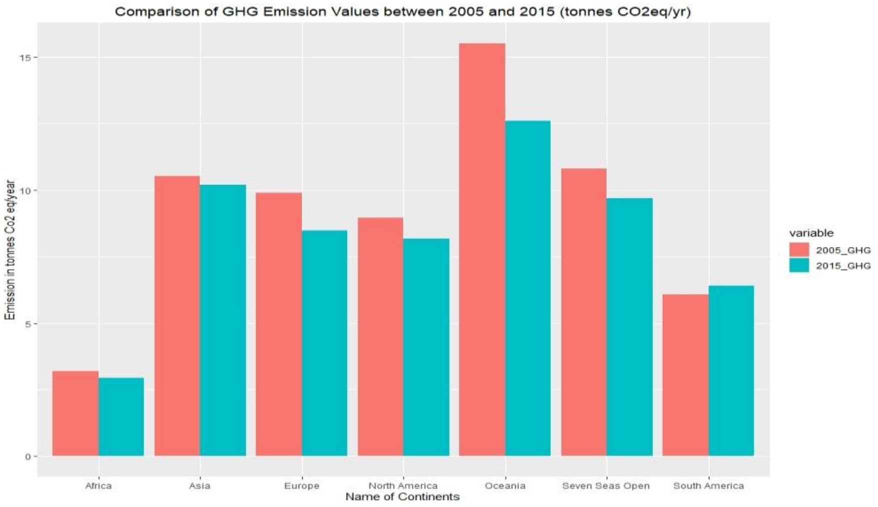

Figure 6: Comparison of GHG Emission Values (2005 -2015)

In this bar graph, we had taken actual 2005 and 2015 GHG values of the countries according to continent basis. We didn't show any kinds of percentage changes in this graph. The unit of GHG was tonnes CO2 equivalent per capita per year. In this graph, we can see that among the all continents, only the South Americas GHG emission was comparatively higher in 2015 which was 6.399 tonnes CO2 equivalent per capita per year than 2005. Also, in case of Oceania, the amount of GHG emission rate was significantly reduced from 15.51 to 12.61 tonnes CO2 equivalent per capita per year in 2015.

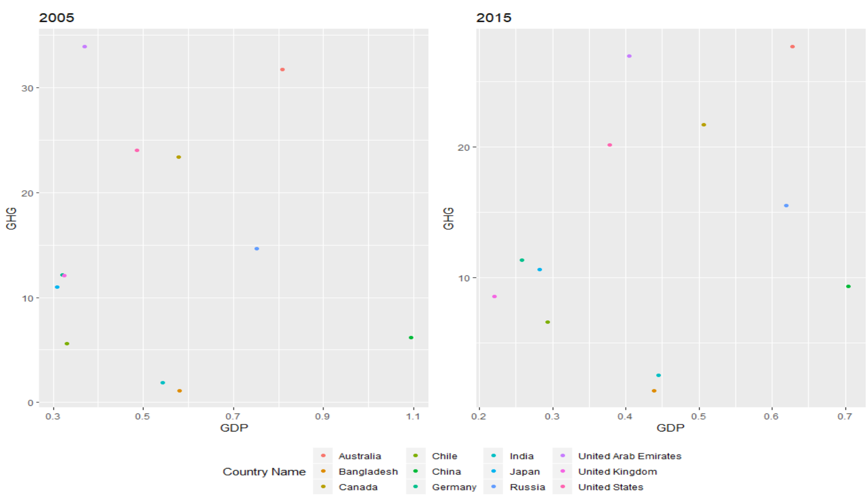

Figure 7: Country wise Comparison of GDP and GHG (2005 – 2015)

According to transverse sectional observations in 69 high manufacturing countries and 45 low developed countries, if GDP in every capita rises, GHG emissions also rises (Cederborg & Snöbohm, 2016). This can be visible in this graph. In USA, GHG emission was reduced 24.05 to 20.14 tonnes CO_2 equivalent per capita per year in 2015 which results in decrease of GDP from 0.49 to 0.38 tonnes CO_2 equivalent per kUSD per year in 2015. In Canada, GHG emission was reduced 23.39 to 21.69 tonnes CO_2 equivalent per capita per year in 2015 which results in decrease of GDP from 0.5 to 0.51 tonnes CO_2 equivalent per kUSD per year in 2015.

Conclusion

Greenhouse gas emissions are the vital factors of global warming with consequent climate change precipitating extreme weather events such as drought, flood, and cyclone. The main objective of this study was to evaluate the GHG emissions per country within the ten-year period (2005-2015) through GIS application. The main result is like reduction in greenhouse gas emission has been observed in countries like the USA, Canada, Greenland, Australia, Germany and Japan whereas increase has taken place in China and India. We had considered 10 years data from 2005 to 2015 but we should have used more updated data. The methodical drawback of this report is like we should have considered population densities with GDP to calculate GHG emission. The failing of this report is like though GDP has increased but GHG emission has decreased for some countries. We were unable to explain why the GHG emission has decreased for these countries. The positivity of this report is like anyone can get a clear idea of GHG emission from the last decade with their GDP. More further researches must be needed for updated data and parameter to understand the accurate scenario of GHG emission, to create a correlation between GHG, GDP and population densities and also why the GHG has decreased for some countries though GDP has increased.

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