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Statistical Analysis of Global Climate Change

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Abstract:- Global climate change is very sensitive and important; its ramification is threatening the very existence of human being on the planet earth. In this paper, we brought to the fore the evidence of climate change and its main characteristic: global warming which can be seen everywhere. Fossil fuel burning to generate electricity, power factories, drive transportation industries and their attendance emission of greenhouse gases (e.g carbon dioxide) which are the bane of temperature rise in the world were discussed. Other causes of global climate change which include, deforestation and livestock farming were also mentioned. The paper emphasized the fact that, the effects of the change in the climate could be observed on the oceans, water resources, precipitations and glaciers. We also provided information in the paper that global climate change mitigating factors could be taken to reduce and slow down anthropogenic induced temperature rise. The mitigation, we showed in the article could encompass introducing new technologies and renewable energies. The article also enumerated global climate change protocols such as the Kyoto Protocol and Paris Agreement. These protocols as shown could be used to monitor and regulate activities that promote temperature rise. The researchers accentuated their results based on the usage of fossil fuels and carbon dioxide emission by the continents (Asia, Europe, America and Africa) in 2020 and 2021. The results in the write-up showed that Asia powered by China consumed the most fossil fuels and emitted the highest carbon dioxide than the rest of the continents.

Keywords:- *Global Warming, Global Climate Change, Fossil Fuel, Electricity, Greenhouse Gases, Deforestation, Carbon Dioxide, Anthropogenic, Kyoto Protocol.*

I. INTRODUCTION

Global climate change is the large-scale, long-term shift or change in average weather conditions or patterns across the world over periods ranging from decades to millions of years **[1].**Weather is therefore the condition in the atmosphere that happens in a place over a short period of time. The duration of a weather condition could be minutes, hours, days or weeks. Its effects include winds, floods, thunderstorms, rain, snow or clouds and it is influenced by oceans, land surfaces and ice sheets. The duration of weather condition, the atmosphere together with oceans, land surfaces and ice sheets form the climate system. Climate is therefore the statistical description of the state of the climate system. In other words, climate is long-term regional or even global average of temperature, humidity and rainfall patterns over seasons, years or decades. Global climate change is generally influenced by the earth's temperature heating up by averagely one degree Celsius ($1^{o}C$) over the last century. It is attributed to natural processes and human activities such as burning of fossil fuels. The human specific impact is what is actually known as climate change; and this change is what is causing global warming. The terms global warming and climate change are often used interchangeably**.** However, they have different meaning; global warming is the upward temperature trend across the entire earth since the early 20th century**;** whereas global climate change is a significant variation of the global average weather conditions; weather conditions becoming warmer, wetter, or drier over several decades or more.

Global climate change is so dear to the world that a week (October 14^{th} - 20^{th}) has been set aside to educate people and engage policymakers on its ramification **[2].**A change in climate will alter the weather condition, making it dangerous and erratic. The rise in temperature makes some part of the world excessively drier and other parts excessively wetter. These weather conditions put food security at rick since crops and animals would find it difficult to adapt to this changing climatic conditions.

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II. GLOBAL CLIMATE CHANGE

Global climate change is an issue that is paramount to the world, policy makers, world leaders, scientists, policy activists and almost everybody is trying to find antidote to its menace. Discussion on this section of the paper is devoted to: evidence of global climate change, its causes, its effects, its mitigation factors and protocols.

A. Evidence of Global Climate Change

Global warming is the main characteristic of climate change; before the advent of the Industrial Revolution in the mid-1800s (1850), the global average temperature was stable at about 14°C **[3].**This temperature began to rise with the burning of fossil fuels (coal, petroleum and natural gas) to generate energy to power factories. These fuels emitted (in fact, continue to emit) greenhouse gases which include carbon dioxide, methane, and nitrous monoxide into the atmosphere. These gases are the major contributors to the rise of temperature in the world. The level of carbon dioxide in the atmosphere rose by 40% during the 20th and 21st century and is now over 400 ppm (400 parts per million) and this level of carbon dioxide is higher than at any time in the past 800,000 years **[4].** This is evidently shown in figure 1 that illustrates global temperature change anomaly from 1850 to 2018 as compared to the 1961-1990 average temperature.

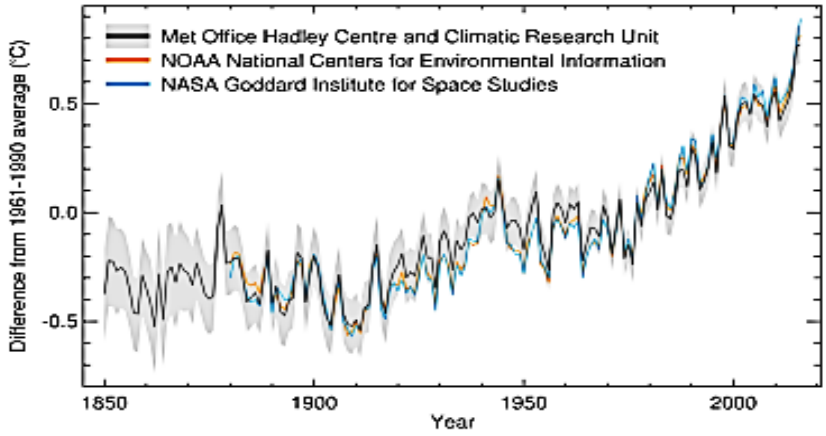

Fig. 1: Global Temperature Change from 1850 to 2018, Compared to the 1961-1990Average Temperature

Figure 2 also depicts the rising level of carbon dioxide in our atmosphere since 1960.

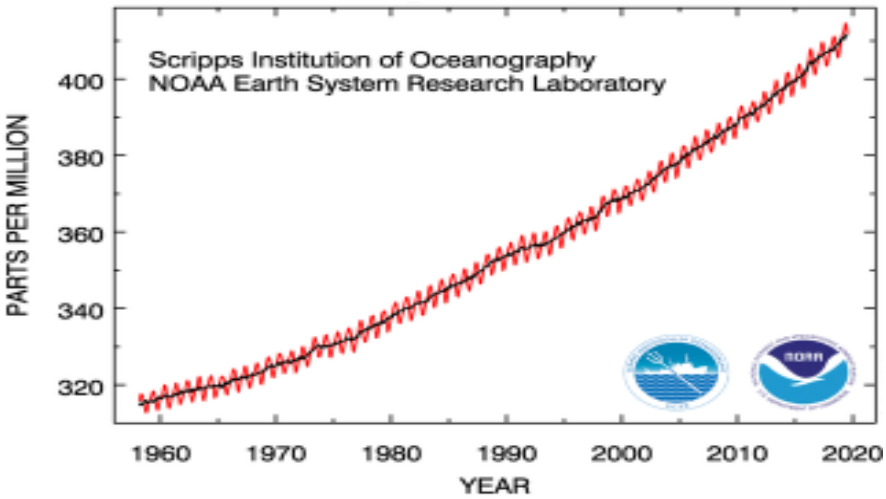

Fig. 2: Rising Level of Carbon Dioxide in the Atmosphere since 1960

The average global temperature rise after the Industrial Revolution is about 1°C; this change in temperature is sharp and affected the climate system. The warming in the world differs from country to country; in some countries the rise in temperature is more or higher than 1°C **[5].** Figure 3 shows average global temperature for each month, from 1850 to 2017. In this graph, there is increase in temperature as one moves from the centre of the circle.There are other evidences to show that the global climate is changing fast, this includes the rise in sea levels, acidification of the oceans (ocean absorbing CO_2 and becoming more acidic),changes in the hydrological cycle and the melting of the polar ice caps and the glacier.

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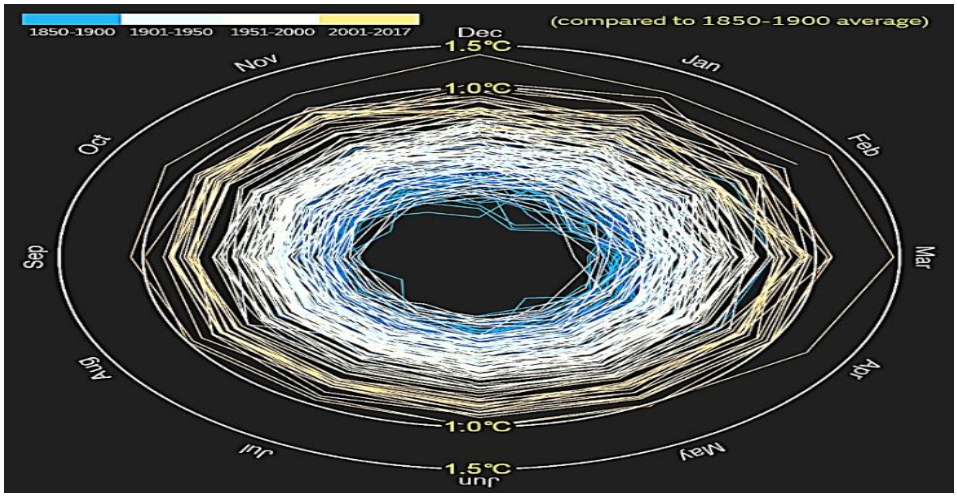

Fig. 3: Average Global Temperature for each Month, from 1850 to 2017

B. Causes of Global Climate Change

The sun is a vital component for the sustenance of human existence on earth, since the weather and climatic condition on earth is driven by the energy from the sun. The heat from the energy of the sun warms the surface of the earth and to maintain the balance and the necessary heat that the earth can tolerate; it naturally radiates part of the energy back to space. The atmosphere contains gases such as water vapour and carbon dioxide (CO_2). These gases which are atmospheric gases trap some of the outgoing or radiated energy that result in warming of the earth's surface; this is the 'greenhouse effect'. By this natural phenomena, the earth retains more heat than it would without the atmosphere. If it were not for this natural 'greenhouse effect', the temperature of the earth would be lower than it is now and will make life unbearable on earth.

Natural climate change does not harm the earth climate system since the amount of greenhouse gases release during these natural phenomena are not enough to alter the climatic balance of the earth. The causes of natural climate change include the slow shift in the earth's orbit, solar changes and volcanic activities. The(CO_2) emitted by volcanic activities annually is estimated to be between 130 and 230 million tons **[6]**. This release is insignificant as compared to the one released by anthropogenic (human) activities.

The main cause of global climate change is the release of greenhouse gases (GHGs) produced through anthropogenic activities. The activities that exacerbate the greenhouse gases include fossil fuels (coal, petroleum and natural gas) burning, deforestation (especially cutting down of trees in the rainforests), livestock farming, application of fertilizers that contain nitrogen and producing of fluorinated gases. Fluorinated gases are powerful greenhouse gases which are synthetic in nature and produced from variety of industrial processes. Examples of these include: Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs),Sulfur Hexafluoride (SF_6) and Nitrogen Trifluoride (NF_3). Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O) and Water Vapour (H_2O), are the other greenhouse gases that are emitted into the atmosphere through exploitation. Figure 4 depicts greenhouse gases emission or that trapped heat in the atmosphere in the US in 2021. In this illustration, $CO_2$is identified as the principal greenhouse gas and fluorinated gases as the least.

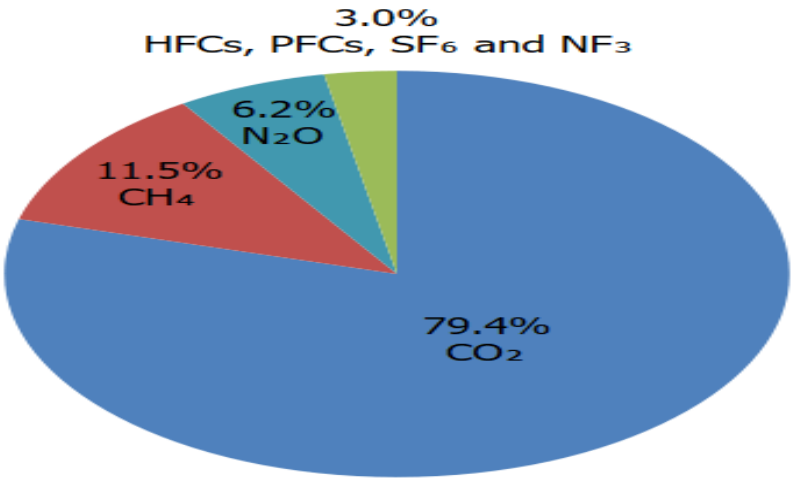

Fig. 4: Greenhouse Gases that trapped Heat in the Atmosphere in 2021

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- *Carbon dioxide:*

This gas emanates from fossil fuels burning and deforestation; it contributes to about 64% of man-made global warming. Its atmospheric concentration is currently about 40% higher than when industrialization started. The annual global release of CO_2 into the atmosphere was approximately 37.9 billion tons in 2021 more than 100 times the annual CO_2 release into the atmosphere by volcanic activities **[7]**. CO_2 is among the gasses that block heat from escaping into space; it does not respond to physical or chemical changes in temperature, it is a long-livedor long-lasting gas that remains semi-permanent in the atmosphere, it is described as "forcing" climate change (gas that forces climate to change).

- *Methane:*

It is responsible for 17% of man-made global warming **[8]**. It emanates from the decomposition of wastes in landfills, agriculture, (especially rice cultivation), ruminant (cow, sheep) digestion and manure management associated with domestic livestock. On a molecule-for-molecule basis, methane is a far more active greenhouse gas than carbon dioxide, but also one which is much less abundant in the atmosphere. $CH_4$is approximately 21 times more potentthan$CO_2$and has an atmospheric lifespan of roughly 12 years.

- *Nitrous Oxide:*

It is responsible for 6% of man-made global warming **[9]**. It emanates from soil cultivation practices (application of commercial and organic fertilizers), fossil fuel combustion, nitric acid production, and biomass burning. $N_2O$is approximately 310 times more potent than $CO_2$and has an atmospheric lifespan of 120 years.

- *Water Vapour:*

It responds physically or chemically to changes in temperature and is regarded as "feedback" **(**it acts as a feedback to the climate). Water vapor increases as the Earth's atmosphere warms, so does the possibility of clouds and precipitation, making these some of the most important feedback mechanisms to the greenhouse effect.

- *Chlorofluorocarbons:*

It is synthetic compounds, entirely manufactured from the industry. It is used in diverse applications including freezers or refrigerators and air conditioners. Its release into the atmosphere contributes significantly to the destruction of the ozone layer. Currently its production is being regulated by international agreement.

- *Hydrofluorocarbons:*

It is synthetic compounds, entirely manufactured from the industry, it is used as replacement for the ozone-depleting substances. HFCs are 140 to 11,700 times morepotent than $CO_2$and have atmospheric lifespans of 1–260 years.

- *Sulfur Hexafluoride:*

It is synthetic compounds, entirely manufactured from the industry. It is used in some industrial processes and in electric equipment. SF_6 is approximately 23,900 times more potent than $CO_2$and is extremely long lived with very few sink.

- *Nitrogen Trifluoride:*

It is also synthetic compounds, entirely manufactured from the industry. It is inorganic, colourless, non-flammable and toxic gas with a slightly musty odour. NF_3 is used to manufacture flat-panel display, photovoltaics and LEDs (Light Emitting Diodes). It is 17,200 times more potent than CO_2. Nitrogen Trifluoride has a life expectancy 740 years.

Population growth is also one of the causes of global climate change. The world's population exceeded 7 billion in March, 2012 and is expected to surpass 8 billion people by 2025 **[10]**. It can be concluded that, the basic cause of global climate change is too many people consuming too much carbon-based energy. The combination of individual impacts times the number of individuals is overwhelming the equilibrium of the Earth's Systems. Figure 5 shows relatively stable human world population through most of our history; and then the beginnings of a steady population increase around 8000 years ago with the advent of the Agricultural Revolution. Another rapid increase in the mid-1800s in response to the Industrial Revolution. Finally, the population explosion in the mid-1900s primarily due to lower death rates and increased longevity as a result of the introduction of antibiotics; and the distribution of insecticides, medicines and other health care to the developing nations following the World War II.

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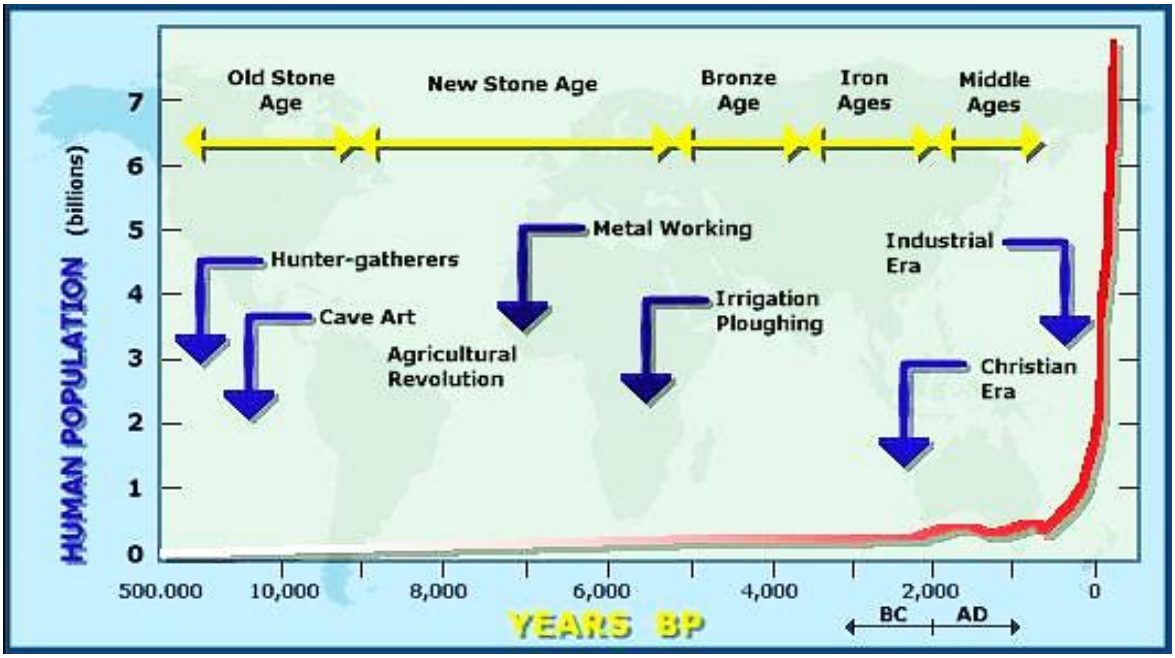

Fig. 5: World Population throughout the History of Mankind

The population dynamics between the developed nations and the developing nations of the world now drastically differ, with a predicted stabilizing and then a slight decline in the developed nations in sharp contrast to continuing rapid growth continuing in the developing nations until the second half of the century. At that point, the world's population growth will eventually be halted, and reversed, as we will have exceeded the limits of the planet to sustain civilization**[11].**

C. Effects of Global Climate Change

The weather has suffered immensely from climate change; this is attributed to greenhouse effect. The global climate is interlink, therefore any negative happenings anywhere in the world are felt everywhere. The effect of emitting greenhouse gases means increasing their concentration in the atmosphere, the net effect is the amount of heat in our world would increase. The effect of high heat in the atmosphere gives higher or warmer temperatures. The effect of warmer temperature would be felt in the oceans, water resources and precipitations, glaciers and ice caps.

➢ *Effects of Global Climate Change on the Oceans*

The oceans take greater proportion of all heat energy added to various parts of the climate system due to global warming as illustrated in figure 6. The effects of global warming on oceans provide information on the various effects that global climate change has on the oceans. Global warming can affect the sea levels, coastlines, ocean acidification, ocean currents, seawater, sea surface and temperature**.** The effects of global climate change or global warming also affect tides, the sea floor, and the weather and trigger several changes in ocean bio-geochemistry; all of these affect the functioning of a society.

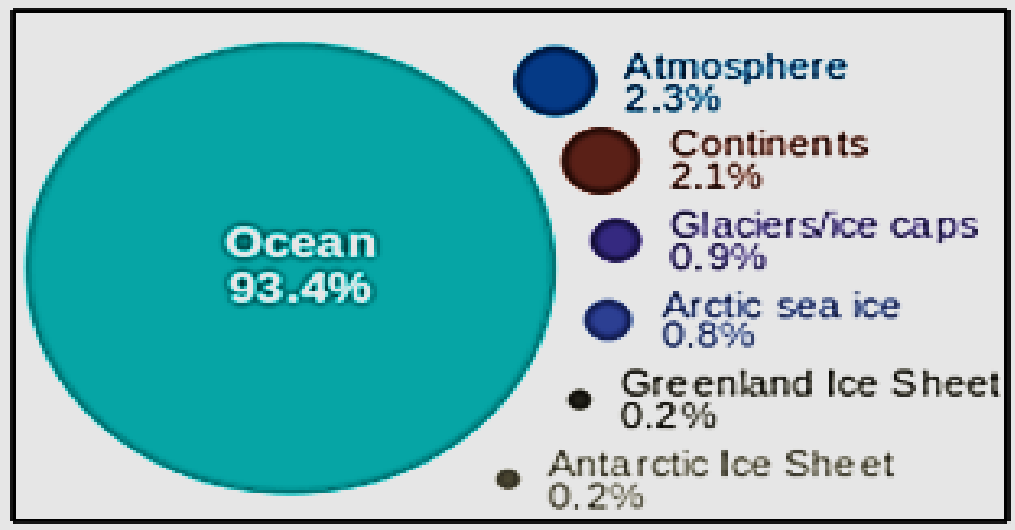

Fig. 6: Heat Added to Various Parts of the Climate System due to Global Warming

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Warmer temperatures result in warmer water in the oceans and the effect of these are that; hurricanes, typhoons, tropical storm and tornados become aggressive and largely more intense. Warmer atmosphere results in more energy in the atmosphere; when hurricanes start, they usually pick up energy from the oceans and become more violent as a result of warmer oceans.Colder water gives less energy to hurricanes and make it less intense. Oceans today absorb about one-third of the carbon dioxide humans send into the atmosphere, about 22 million tons a day [**12**]. This great service, which has substantially slowed global warming, has been accomplished at great cost. This cost includes ocean acidification which is now more than 30 times greater than natural variation and average surface ocean pH. The standard measure of acidity, has dropped by 0.1 unit; that is 25-percent increase in acidity. Ocean acidification is a state whereby the pH of the Earth's oceans decrease, this happens when the ocean takes or accumulates carbon dioxide from the atmosphere. Increased atmosphericcarbon dioxide levels result in increased ocean absorption of carbon dioxide. Increased ocean carbon dioxide absorption causes a deficit of the carbonate ionsthat coralsand other marine organisms need to build their skeletons.It should be noted that the ocean and the atmosphere constantly act to maintain a state of equilibrium, so a rise in atmospheric carbon dioxide naturally leads to a rise in oceanic carbon dioxide, this is illustrated in figure 7.

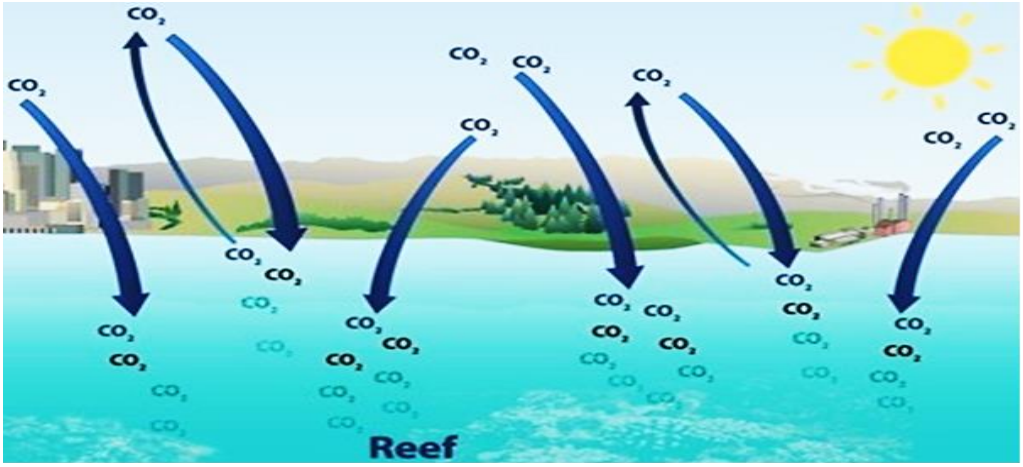

Fig. 7: Atmospheric Carbon Dioxide Levels

Higher acidity damages many ocean species that use calcium carbonate to form their skeletons and shells. Studies have shown that calcium carbonate formation is disrupted if water becomes too acidic. Ocean acidification also appears to be affecting the whole ecosystems, such as coral reefs, which depend on the formation of calcium carbonate to build reef structure. The reef structure in turn provides homes for reef organisms. Coral reefs are large underwater structures composed of skeletons of colonial marine invertebrates.

The effect of ocean acidity causes the corals that are sensitive to increases in temperature to become bleached. Coral bleaching is evident in the Great Barrier Reef in Australia where the corals are dying.Coral bleaching is when unicellular organisms that help make up the coral begin to die off and leave the coral giving it a white appearance as shown in figure 8.

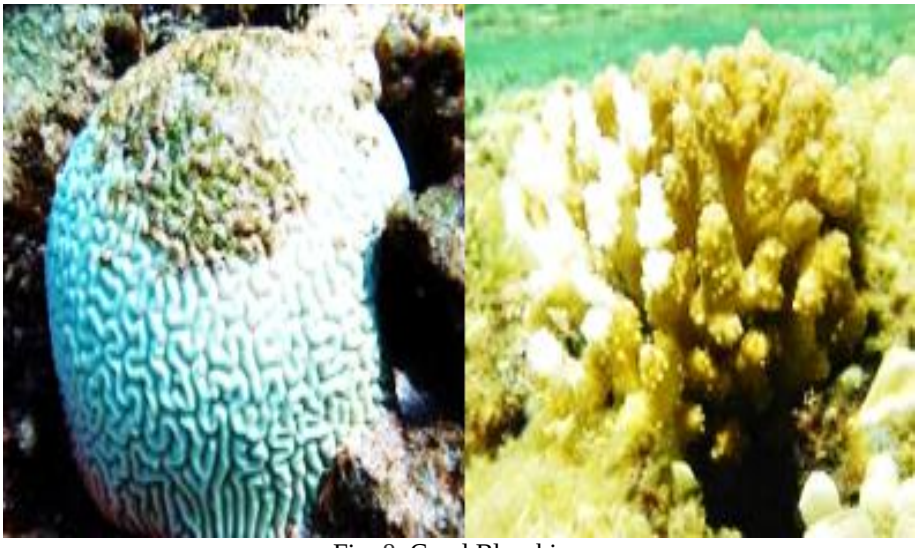
Fig. 8: Coral Bleaching

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➢ *Effects of Global Climate Change on Water Resources and Precipitations*

Warmer temperature means the atmosphere holds more water vapour and that makes rainfalls more extreme and intense. This buttresses the fact that climate change impacts the amount of water in the atmosphere and increases violent downpours instead of steady showers when it rains. As water temperature increases, water pollution problems will increase, and many aquatic habitats will be negatively affected. The effect of warmer temperature on water resources can also be noticed in the increasesinpathogens, nutrients, concentrations of some pollutants such as ammonia and pentachlorophenol due to their chemical response to warmer temperatures and invasive species.

The quality of water is affected by climate change since the timing, intensity and duration of precipitation can cause flooding. Runoff water during flooding transports large volumes of water and contaminants into waterbodies. Flooding can also damage infrastructure, overload storm, combined sewer and wastewater systems, resulting in untreated pollutants directly entering waterways. Reduced rainfall can also result in more frequent bush fires or wildfires, and land areas where wildfires have occurred are more vulnerable to soil erosion and even drought. Droughts affect water levels in rivers making it difficult for river transportation and generation of electricity from hydro source as illustrated in figure 9.

Fig. 9: Dying up of Water Body due to Drought

Droughts also gives good conditions for bushfires or wildfires and negatively affects livestock and crops productions as depicted in figure 10.

Fig. 10: Drought Affecting Crop Production

➢ *Effects of GlobalClimate Change on Glacier, Ice Sheet, Ice Berg, Ice Shelf and Ice Cap*

- **Glacier:** A glacier is a persistent body of dense ice that is constantly moving under its own weight. It is made up of fallen snow that remains in one location over many years, often centuries, compresses into large, thickened ice masses. Due to its sheer mass, glacier flows like very slow river. Some glaciers are as small as football fields, while others grow to be dozens or even hundreds of kilometers long.
- **Ice Sheet:** An ice sheet, also known as a continental glacier, is a mass of glacial ice that covers surrounding terrain and is greater than 50,000 km². The only current ice sheets are found in Antarctica and Greenland.
- **Ice Berg:** An icebergis a large piece of freshwater ice that has broken off a glacier or an ice shelf and is floating freely in open (salt) water or sea. Small bits of

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disintegrating icebergs are called "growlers" or "bergy bits".

- **Ice Shelf:** An ice shelf is a thick suspended platform of ice that forms where a glacier or ice sheet flows down to a coastline and onto the ocean surface. Ice shelves are only found in Antarctica, Greenland, Canada, and the Russian Arctic. The thickness of ice shelves can range from about 100 m to 1,000 m.
- **Ice Cap:** Ice caps are miniature ice sheets, covering less than 50,000 km². They are formed primarily in polar and sub-polar regions that are relatively flat and high in elevation.

The effects of climate change on glacier is illustrated in figure 11. This graphic shows the Gangotri Glacier, situated in the Uttarkashi District of Garhwal Himalaya. Currently 30.2 kilometers long and between 0.5 and 2.5 kilometers wide, Gangotri glacier is one of the largest in the Himalaya [**13**]. Gangotri has been receding since 1780, although studies show its retreat quickened after 1971. Note that the blue contour lines drawn here to show the recession of the glacier's terminus over time are approximate. Over the last 25 years, Gangotri glacier has retreated more than 850 meters with a recession of 76 meters from 1996 to 1999 alone.

Fig. 11: Glacier Retreat Boundaries

The effects of global climate change are most readily apparent in the melting of perennial and permanent ice, and because most glaciers are small relative to vast ice sheetsand expansive sea ice, glaciers are important indicators of climate change **[14].** Approximately 160,000 glaciers are found on Earth; more than 40 have been monitored since (at least) the 1980s. One of these monitoring projects is Global Land Ice Measurement from Space (GLIMS), which uses laser altimetry to help determine glacier volume. The outcomes of these observations show that Earth's glaciers are disappearing. The following are also effects of global climate change:

- Over the past 100 years, global average sea level has been rising at an average rate of 1 to 2 millimeters per year.A possible contributor to sea-level rise, is increased melt water from snow, glaciers, ice sheets, ice caps, icebergs, and sea ice.
- Glaciers in Alaska and neighboring Canada, with a combined area of approximately 90,000 square kilometers accounts for about 13 percent of mountain glaciers on Earth have thinned substantially. Over the last 40 years, thinning has been on the order of 50 to 100 meters at lower elevations of glacier occurrence, and about 18 meters at higher elevations.
- Many glaciers in South America's Andes are melting so fast that, between 30 to 50 percent of its ice cover has shrunk in the last forty years. The region's most vulnerable glaciers have already disappeared. The Quelccava glacier in Peru retreated 32 times faster during the period 1983-2000 than in the 20 years from 1963 to 1983. In the Patagonian ice fields of Argentina, glaciers have receded 1.5 kilometers since 1990.

The ice and snow of glaciers tell an environmental story the way tree rings do. Periods of glacier melting as shown in figure 12 will be discernible from periods of growth (i.e., snow and ice build-up) by physical differences in the snow and ice layers. The horizontal "stripes" of sediment within the glacier indicate seasonal patterns of snow and ice accumulation and melting.

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Fig. 12: Glacier Melting

- In Africa, Mount Kilimanjaro's ice fields have shrunk by at least 80 percent since 1912. Mount Kenya's ice cap has shrunk by 40 percent since the 1960s.
- The 15,000 glaciers of the Himalayas, which collectively constitute the largest body of ice outside the polar caps, are reported to be receding faster than anywhere on Earth. Some 2,000 have melted since the 1950s. Instead of snow accumulation in winter, Himalayan glaciers are being hit by summer monsoon rains. The Dokriani Barnak glacier has receded about 0.8 kilometer since 1990. If Himalayan glaciers continue to recede at this rapid rate, they will be gone by 2035.
- In the European Alps, several glaciers have disappeared entirely since the 1960s.
- Permanent sea-ice cover in the Arctic Ocean is shrinking by an area the size of the Netherlands each year. The Arctic ice cap thinned from 3 meters (10 feet) in 1970 to 2 meters in 2000.
- In the Antarctic, rising temperatures have resulted in the collapse of massive ice shelves, some of which have been there for 20,000 years.
- In Glacier National Park in Montana, the number of glaciers has dropped from an estimated 150 in 1850 to only 50 in 2000. At this rate of decline, all of the glaciers in the park will be gone by 2030.

D. Mitigation Measures of Global Climate Change

Global climate change mitigation is the efforts being made to reduce or prevent anthropogenic emission of greenhouse gases into the atmosphere. Mitigation can mean using new technologies and renewable energies, making older equipment more energy efficient, or changing management practices or consumer behaviour. It can be as complex as a plan for a new city, or as simple as improvements to a cook stove design. Efforts underway around the world range from high-tech subway systems to bicycling paths and walkways. Mitigation can also be achieved by increasing and enhancing the capacity of carbon sinks **[15].** Carbon sinks are elements such as the oceans, the soil and the forests that accumulate greenhouse gases for storage. In our view, reforestations, stop burying toxic waste in the soil, cleaning the oceans of all plastic waste, decease dumping of raw fecal matter and solid waste into the oceans are the clear ways of enhancing the capacity of the carbon sinks.

The goal of mitigation is to avoid significant human interference with the climate system and stabilize greenhouse gas levels in a timeframe sufficient to allow ecosystems to adapt naturally to climate change, ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner **[16].** Mitigation policies can substantially reduce the risks associated with human-induced global warming**.** 'Mitigation is a public good; climate change is a case of the 'tragedy of commons'. Effective climate change mitigation will not be achieved if each agent (individual, institution or country) acts independently in its own selfish interest, suggesting the need for collective action. Some adaptation actions, on the other hand, have characteristics of a private good as benefits of actions may accrue more directly to the individuals, regions, or countries that undertake them, at least in the short term. Nevertheless, financing such adaptive activities remains an issue, particularly for poor individuals and countries."**[17].** Some of the global climate change mitigation factors are as follow:

- Phasing out electricity generation from fossil fuel sources (coal, petroleum, natural gas) to renewable energy sources (hydro, solar, wind, and biomass). In Australia, for example, US Company Tesla is building the world's largest lithium-ion battery to store power from wind farms and solar plants. The 100-megawatt battery will be able to power 30,000 homes [18].
- The use of solar cookers instead of electric, gas or charcoal cookers is depicted in figure 13.

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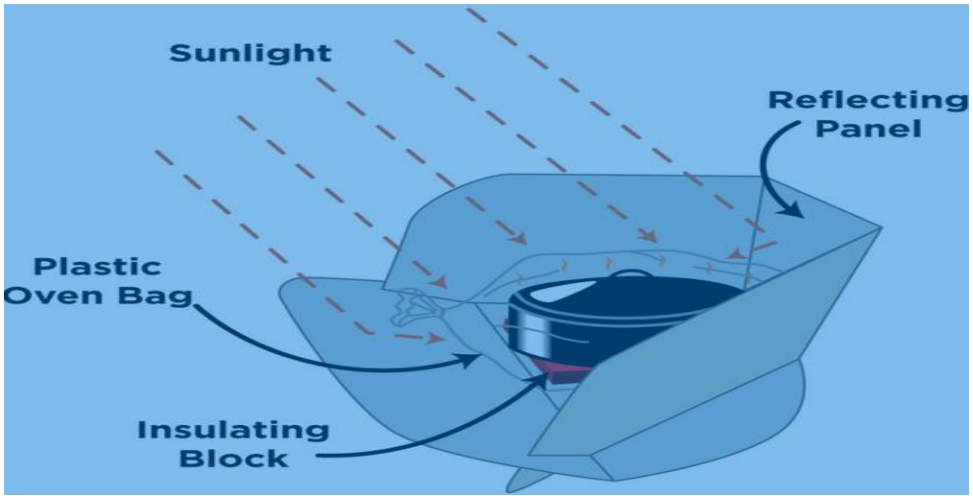

Fig. 13: Solar Cooker uses Sunlight as Energy Source for Outdoor Cooking

- Installing LED (Light Emitting Diode) lightings or natural sky windows reduce the amount of energy required to attain the same level of illumination as compared to using traditional incandescent light bulbs, this is good example of energy efficiency **[19].** LED lamps use only about 10% of the energy an incandescent lamp requires; figure 14 shows how LED lamp can reduce the cost of electricity bill.
- Improved energy efficiency in building, industrial processes and transportation could reduce the world's energy needs in 2050 by one third, and help control global emissions of greenhouse gases **[20].**


Fig. 14: A 230-Volt LED Light Bulb, with an E 27 Base (10 Watts, 806 Lumens)

- The efficient usage of energy in buildings can be achieved by retrofitting the buildings to increase the level of insulation; upgrading windows; minimizing air leakage; and installing energy efficient appliances and equipment**.**
- Climate change mitigation can also be achieved through the mode of movement- transportation. There are basically two approaches by which transportation related greenhouse gas emissions may be reduced:
- Reduce auto mobile use by encouraging electric public transit, bus rapid transit, light rail transit, subways, commuter rail, walking and cycling.
- Promote the use of low emission vehicles, including electric cars, by providing the necessary infrastructure and offering financial incentives to vehicle owners to change behaviour.

E. Global Climate Change Protocols

The international community is making every effort not to allow the increase in global climate to go above 1.5°C (2.7°F). The current global average temperature increase is about 0.89ºC higher than it was in the late 19th century **[21].** Each of the past three decades has been warmer than any preceding decade since records began in 1850**.** The world's leading climate scientists think human activities are almost certainly the main cause of the warming observed since the middle of the 20th century.

An increase of 2°C (3.6°F) compared to the temperature in pre-industrial times is seen by scientists as the threshold beyond which there is a much higher risk that dangerous and possibly catastrophic changes in the global environment will occur **[22].** For this reason, the international community has recognized the need to keep the increase in warming to below 2°C (3.6°F). The world mostly through the United Nations have organised several conferences and seminars aimed at keeping the increase in

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global average temperature to well below 2 °C and making every effort to limit the increase to 1.5 °C.

Among these conferences, the two most prestigious are the one held in Japan,Kyoto on 11 December 1997 dubbed Kyoto Protocol and the one held in France, Le Bourget near Paris on 22 April 2016 dubbedParis Agreement**.** 192 parties or countries (Canada withdrew from the protocol) signed the Kyoto Protocol, among these 144 state parties ratified the treaty**.** The Kyoto Protocol implemented the objective of the United Nations Framework Convention on Climate Change (UNFCCC), an agency of the UN to reduce the onset of global warming by reducing greenhouse gas concentrations in the atmosphere to "a level that would prevent dangerous anthropogenic interference with the climate system. The main goal is to control emissions of the main anthropogenic (human-emitted) greenhouse gases (GHGs) in ways that reflect underlying national differences in GHG emissions, wealth, and capacity to make the reductions**.** The agreement came into force on 16 February 2005 and expired 31 December 2012**.**

The Paris Agreement was the world's first comprehensive climate agreement. 195 countries signed the Paris Agreement with 55 ratifying it**.**Under the Paris Agreement, each country must determine, plan, and regularly report on the contribution that it undertakes to mitigate global warming **[23].**No mechanism forces a country to set a specific target by a specific date but each target should go beyond previously set targets**.** In June 2017, U.S. President Donald Trump announced his intention to withdraw the United States from the agreement. Under the agreement, the earliest effective date of withdrawal by the U.S. was November 2020, shortly before the end of President Trump's 2016 term. In practice, changes in United States policy that are contrary to the Paris Agreement had already been put in place**.**Thank God this did not materialized due to change in presidency in the United States in 2020. The aim of the Paris agreement is to decrease global warming by "enhancing the implementation" of the UNFCCC article 2 through**:**

- Holding increase in global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit temperature increase to 1.5 °C above pre-industrial levels, recognizing that these would significantly reduce the risks and impacts of climate change;
- Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production;
- Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

This strategy involved energy and climate policy including the so-called 20/20/20 targets, namely the reduction of carbon dioxide (CO_2) emissions by 20%, the increase of renewable energy's market shares to 20%, and a 20% increase in energy efficiency **[24]**. Countries furthermore aim to reach "global peaking of greenhouse gas emissions as soon as possible". The agreement has been described as an incentive for and driver of fossil fuel divestment **[25]**.

III. OBJECTIVE

The aim of this paper is to bring to the fore the major contributing countries and regions to the global climate change in the world.

IV. METHODOLOGY

The method to be employed by the researchers include but not limited to divulging the volume of crude oil, natural gas and coal consumed by some countries in the world in 2020 and 2021. These countries were selected based on the large tonnage of fossil fuels they consumed in a year. Crude oil, natural gas and coal are raw materials for electricity generation and heating whilst the transportation industries make do with crude oil and natural gas. The researchers would also demonstrate the quantity of carbon dioxide these countries emitted into the atmosphere in 2020 and 2021.

Four continents (Europe, America, Asia and Africa) were used for this project. Australia was added to Asia for the purpose of this research. Ten high fossil fuels consumption countries were selected from each continent except the African continent where all the countries were factored into the research. The global energy consumption and carbon dioxide emission are increasing sharply putting demands on available energy supplies and underlining the instabilities in the system. The primary energy consumed in 2021 and its attendance CO_2 emitted into the atmosphere surpassed those of 2020**[26].** These accessions are illustrated in tables 1a and 1b.

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Table 1(a): Volume of Fossil Fuels Consumed & CO_2 Emitted by Ten Selected Countries in 2020

2020					
		Tera Joules (TJ) = 10^{12} J			Million Tons
No	Countries	Oil	Gas	Coal	CO_2
ASIA					
1	China	28,740,000	12,120,000	82,380,000	9,974.30
2	India	9,080,000	2,180,000	17,400.00	2,281.20
3	Japan	6,490,000	3,750,000	4,570,000	1,029.50
4	South Korea	5,060,000	2,070,000	3,020,000	588.8
5	Saudi Arabia	6,540,000	4,070,000	0	569.2
6	Iran	3,220,000	8,430,000	70,000	645.4
7	Singapore	2,960,000	450,000	20,000	211.6
8	Indonesia	2,700,000	1,350,000	3,250,000	560.8
9	Thailand	2,260,000	1,690,000	760,000	270
10	Australia	1,880,000	1,550,000	1,690,000	378.2
	EUROPE				
1	Russian Federation	6,340,000	15,250,000	3,290,000	1,456.20
2	Germany	4,220,000	3,140,000	1,810,000	600.8
3	France	2,680,000	1,460,000	190,000	251.6
4	United Kingdom	2,350,000	2,630,000	200,000	316.9
5	Spain	2,210,000	1,170,000	120,000	223.6
6	Italy	2,110,000	2,430,000	210,000	283.8
7	Turkey	1,840,000	1,660,000	1,700,000	373.9
8	Netherlands	1,510,000	1,300,000	170,000	174.6
9	Poland	1,290,000	760,000	1,720,000	284.2
10	Belgium	1,150,000	610,000	100,000	105.5
AMERICA					
1	United States	32,520,000	29,950,000	9,200,000	4,420.60
2	Brazil	4,220,000	1,130,000	590,000	390.5
3	Canada	4,110,000	4,080,000	530,000	517.3
4	Mexico	2,470,000	3,010,000	240,000	357.7
5	Argentina	1,070,000	1,580,000	40,000	164.8
6	Chile	700,000	220,000	260,000	84.4
7	Colombia	560,000	470,000	170,000	80.9
8	Venezuela	570,000	780,000	0	82.8
9	Peru	410,000	260,000	40,000	46.4
10	Ecuador	400,000	20,000	0	28.7
AFRICA					
1	Egypt	1,180,000	2,100,000	30,000	203.3
2	South Africa	960,000	140,000	3,560,000	437.2
3	Algeria	760,000	1,570,000	20,000	133.3
4	Morocco	490,000	30,000	280,000	62.1
5	Rest Of Africa	3,840,000	1,690,000	280,000	386.7

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Table 1(b): Volume of Fossil Fuels Consumed & CO_2 Emitted by Ten Selected Countries in 2021

2021					
		Tera Joules (TJ) = 10^{12} J			Million Tons
No	Countries	Oil	Gas	Coal	CO_2
	ASIA				
1	China	30,600,000	13,630,000	86,170,000	10,523.00
2	India	9,410,000	2,240,000	20,090,000	2,552.80
3	Japan	6,610,000	3,730,000	4,800,000	1,053.70
4	South Korea	5,390,000	2,250,000	3,040,000	603.8
5	Saudi Arabia	6,590,000	4,220,000	0	575.3
6	Iran	3,250,000	8,680,000	70,000	660.5
7	Singapore	2,930,000	480,000	30,000	215.7
8	Indonesia	2,830,000	1,330,000	3,280,000	572.5
9	Thailand	2,250,000	1,690,000	810,000	269.4
10	Australia	1,930,000	1,420,000	1,630,000	369.4
	EUROPE				
1	Russian Federation	6,710,000	17,090,000	3,410,000	1,581.30
2	Germany	4,180,000	3,260,000	2,120,000	628.9
3	France	2,910,000	1,550,000	230,000	273.6
4	United Kingdom	2,500,000	2,770,000	210,000	337.7
5	Spain	2,450,000	1,220,000	160,000	245.7
6	Italy	2,350,000	2,610,000	230,000	311.2
7	Turkey	1,860,000	2,060,000	1,740,000	403.3
8	Netherlands	1,510,000	1,260,000	230,000	178.2
9	Poland	1,380,000	840,000	1,880,000	309.1
10	Belgium	1,300,000	610,000	100,000	114.7
	AMERICA				
1	United States	35,330,000	29,760,000	10,570,000	4,701.10
2	Brazil	4,460,000	1,460,000	710,000	436.6
3	Canada	4,170,000	4,290,000	480,000	527.4
4	Mexico	2,560,000	3,180,000	230,000	373.8
5	Argentina	1,230,000	1,650,000	70,000	181.7
6	Chile	730,000	230,000	260,000	87
7	Colombia	700,000	450,000	130,000	86.5
8	Venezuela	590,000	860,000	0	89.2
9	Peru	520,000	290,000	50,000	56
10	Ecuador	490,000	20,000	0	35.5
	AFRICA				
1	Egypt	1,280,000	2,230,000	50,000	219.6
2	South Africa	1,040,000	140,000	3,530,000	438.9
3	Algeria	790,000	1,650,000	20,000	139.7
4	Morocco	550,000	30,000	310,000	68.9
5	Rest Of Africa	4,200,000	1,870,000	300,000	423.7

These volumes of fossil fuel consumed and carbon dioxide emitted into the atmosphere are also tabulated into continents as shown in table 2.

Table 2: The Fossil Fuels Consumed by Each Continent and the Corresponding CO_2 Emitted in 2020 and 2021

	2020				2021			
	Tera Joules (TJ)			Million Tons	Tera Joules (TJ)			Million Tons
Continents	Oil	Gas	Coal	CO_2	Oil	Gas	Coal	CO_2
Asia	68,930,000	37,660,000	95,777,400	16,509.00	71,790,000	39,670,000	119,920,000	17,396.10
Europe	25,700,000	30,410,000	9,510,000	4,071.10	27,150,000	33,270,000	10,310,000	4,383.70
America	47,030,000	41,500,000	11,070,000	6,174.10	50,780,000	42,190,000	12,500,000	6,574.80
Africa	7,230,000	5,530,000	4,170,000	1222.6	7,860,000	5,920,000	4,210,000	1290.8

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V. PRESENTATION OF RESULTS AND DISCUSSIONS

This section of the paper delves into the results and discussions from the statistical analyses on fossil fuels (crude oil, natural gas and coal) consumed by the selected countries in each continent in 2020 and 2021. The section also threw light on the carbon dioxide emitted by these countries during the years under review.

A. *Fossil Fuels consumed and Carbon Dioxideemitted in 2020 and 2021: Asi*

In the year 2020 and 2021, China consumed more fossil fuel than any other country in Asia; Chain burnt 28,740,000 Tera Joules of oil for generation of electricity and running of the transportation industries in 2020. This consumption inched up to 30,600,000 Tera Joules in 2021. In 2020, Australia consumed the least in Asia, it burnt 1,880,000 Tera Joules and 1,930,000 Tera Joules in 2021. China consumed gas amounting to 12,120,000Tera Joules in 2020 mainly to drive the power generation industries, this usage also went up to13, 630,000 Tera Joules in 2021. Singapore burnt the least among the ten countries selected for the study in Asia, it consumed 450,000 Tera Joules in 2020 and 480,000 Tera Joules in 2021. China, the largest consumer of fossil fuel in the world, also burnt 82,380,000 Tera Joules of coal obsessively to produce electricity in 2020 and dispensed in the year 2021 for the same purpose 86,170,000 Tera Joules. Saudi Arabia is the only country selected for the study that did not consumed any coal in 2020 and 2021.With this consumption of this fossil fuel and other factors, China emitted in 2020 carbon dioxide of 9,974.30Million Metric Tons into the atmosphere. Its emission into the environment increased to 10,523.00 Million Metric Tons in 2021. Singapore is the least emitter of carbon dioxide in Asia, it emitted 211.6 Million Metric Tons in 2020 and 215.7 Million Tons in 2021. This makes China the highest emitter of CO_2in the world. Figure 15 depicted the fossil fuel consumed and carbon dioxide emitted by the ten countries selected in 2020 and 2021for the study.

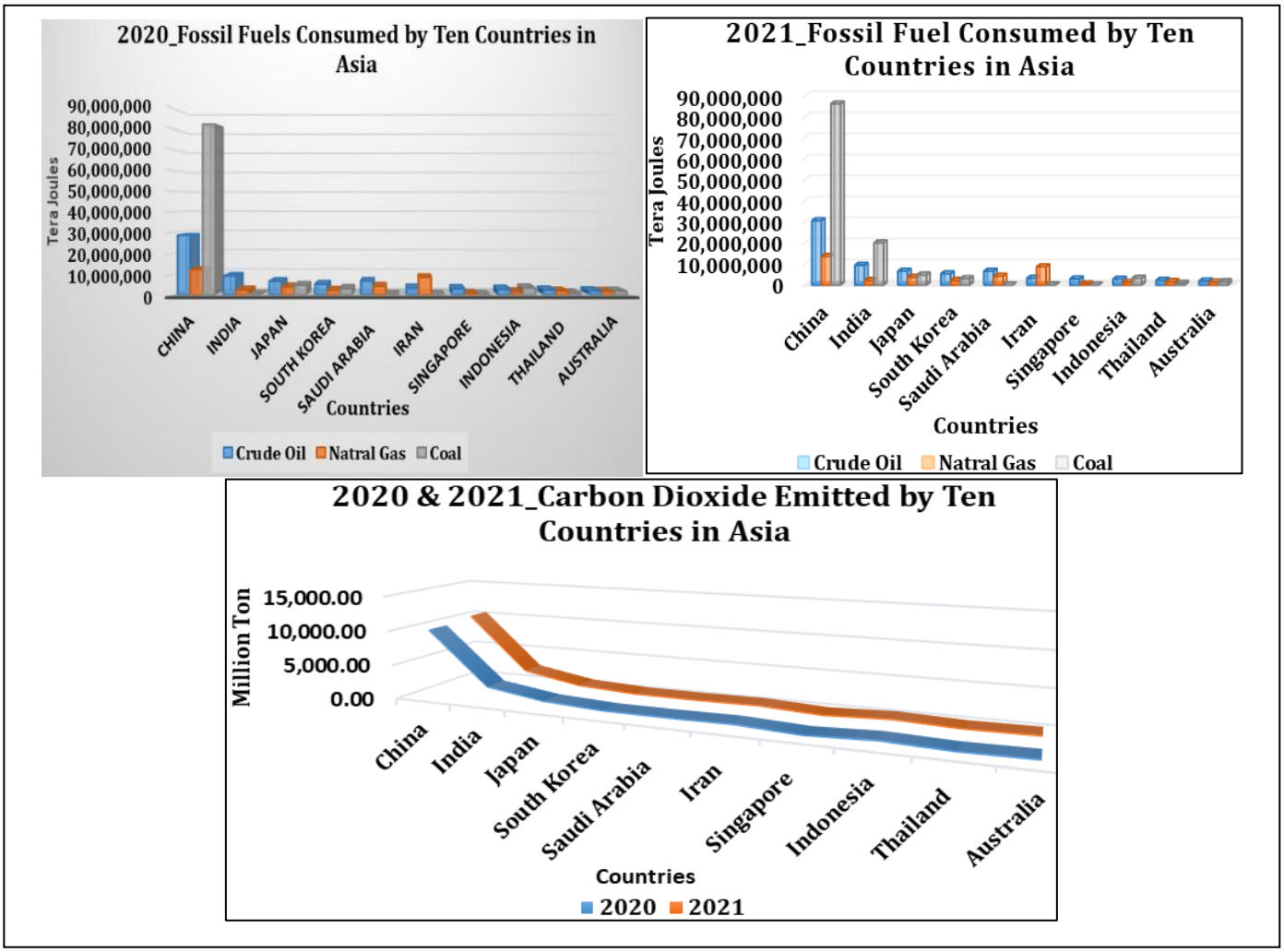

Fig. 15: Fossil Fuels Consumed & CO_2 emitted by Ten Countries in Asia in 2020 and 2021

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B. Fossil Fuels consumed and Carbon Dioxide emitted in 2020 and 2021: Europe

Russian Federation is the country that consumed more fossil fuel than any other country in Europe in 2020 and 2021. This country also emitted the most carbon dioxide into the atmosphere in these two years. In 2020, the Russian Federation burnt 6,340,000 Tera Joules ofOil and 15,250,000 Tera Joules of gas to produce electricity**,** power the transport industries and domestic usage. It used3,290,000 Tera Joules of Coal to generate electricity. Its fossil fuel consumption increased in 2021; it burnt 6,710,000 Tera Joules of Oil, 17,090,000 Tera Joules of Gas and 3,410,000 Tera Joules of Coal. With this consumption and other factors, the Russian Federation emitted 1,456.20 Million MetricTons of carbon dioxide into the atmosphere in 2020 and 1,581.30 Million MetricTons in 2022 respectively. Belgium is the country that consumed less fossil fuel and emitted the least carbon dioxide among the ten States selected in Europe for the analysis. In 2020, it dispensed 150,000 Tera Joules of oil, 610,000 Tera Joules of gas and 100, 000 Tera Joules of coal. In the same year, it emitted 105.5 Million Metric Tons of carbon dioxide into the atmosphere. In 2021, while Belgium usage of oil increase to 1,300,000 Tera Joules, its gas and coal consumption remained the same as that of 2020. Belgium's carbon dioxide emission inched up to 114.7 Million MetricTons in 2021. Figure 16 illustrated the fossil fuel consumed and carbon dioxide emitted by the ten countries selected in Europe in 2020 and 2021 for the analysis.

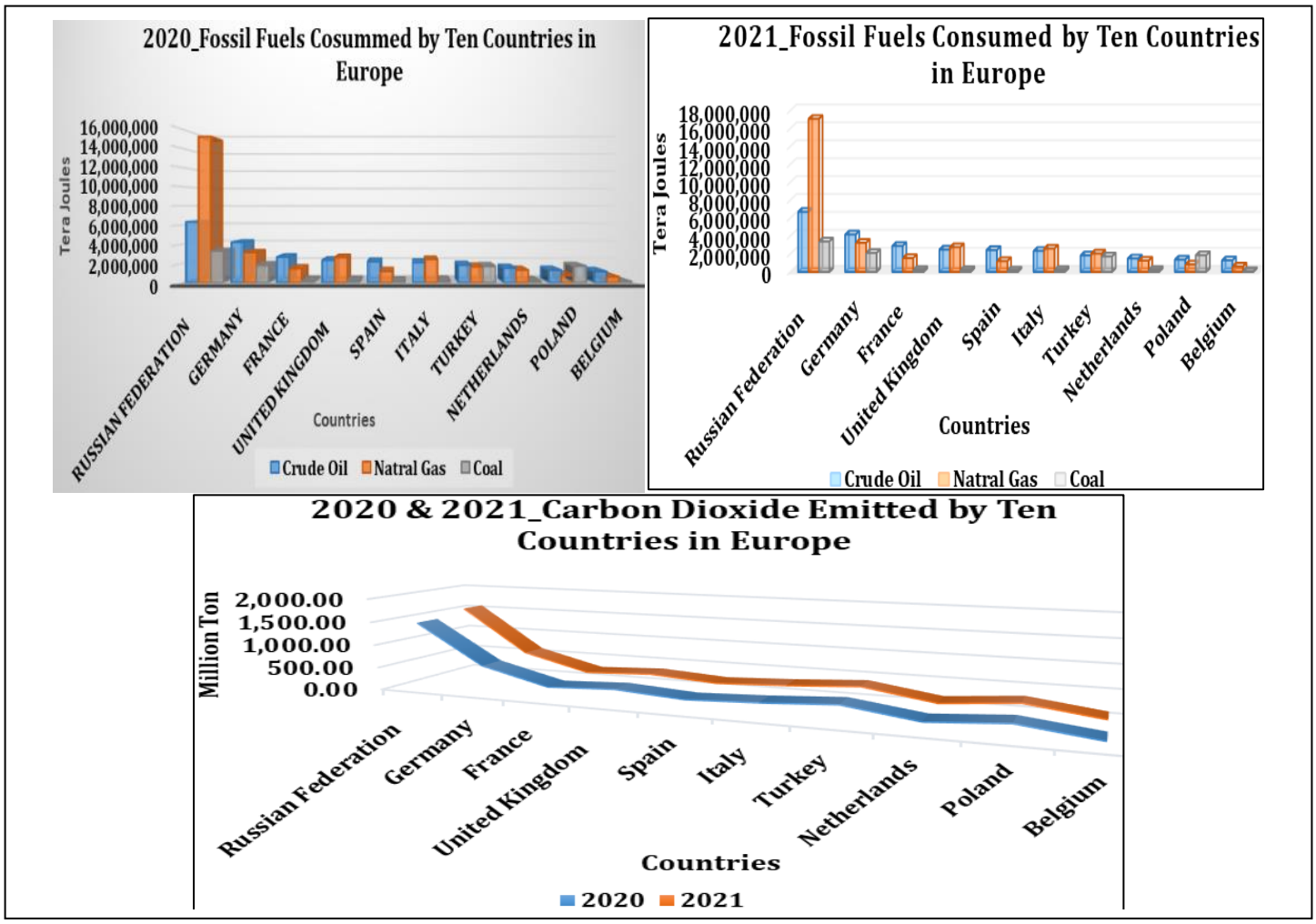

Fig. 16: Fossil Fuels Consumed &CO_2 emitted by Ten Countries in Europe in 2020 and 2021

C. Fossil Fuels consumed and Carbon Dioxide emitted in 2020 and 2021: America

Just as China in Asia, the Russian Federation in Europe, the United States was also the largest consumer of fossil fuel in America in 2020 and 2021. It burnt 32,520,000 Tera Joules of Oil to power its electricity generation and transportation sectors in 2020. The US increased its usage to 35,330,000 Tera Joules in 2021. Its gas consumption in 2020 was 29,950,000 Tera Joules. Gas utilization in the United States was mostly seen in the electric power generation, transportations and domestic usage sectors.Gas usage in the US decreased to 29,760,000 Tera Joules in 2021, in the same year, however, its coal consumptionobviously for electricity production increased to 10,570,000 Tera Joules from 9,200,000 Tera Joules in 2020.The United States emitted 4,420.60 Million MetricTons of carbon dioxide into the atmosphere in 2020 and 4,701.10 Million MetricTons in 2021 due to utilization of fossil fuel and other factors including agriculture. Ecuador consumed the least oil

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and gas; emitted the least carbon dioxidewhile Venezuela did not consume any coal among the ten countries selected for the study in 2020 and 2021 respectively. In 2020, Ecuador burnt 400,000 Tera Joules of oil; this usage inched up to 490,000Tera Joules in 2021. Gas utilization in Ecuador in 2020 and 2021 remained the same at 20,000 Tera Joules.It emitted 28.7 Million MetricTons and 35.5 Million MetricTons of carbon dioxide into the environment in 2020 and 2021 respectively. Figure 17 demonstrated the fossil fuel consumed and carbon dioxide emitted by the ten countries selected in America in 2020 and 2021 for the study.

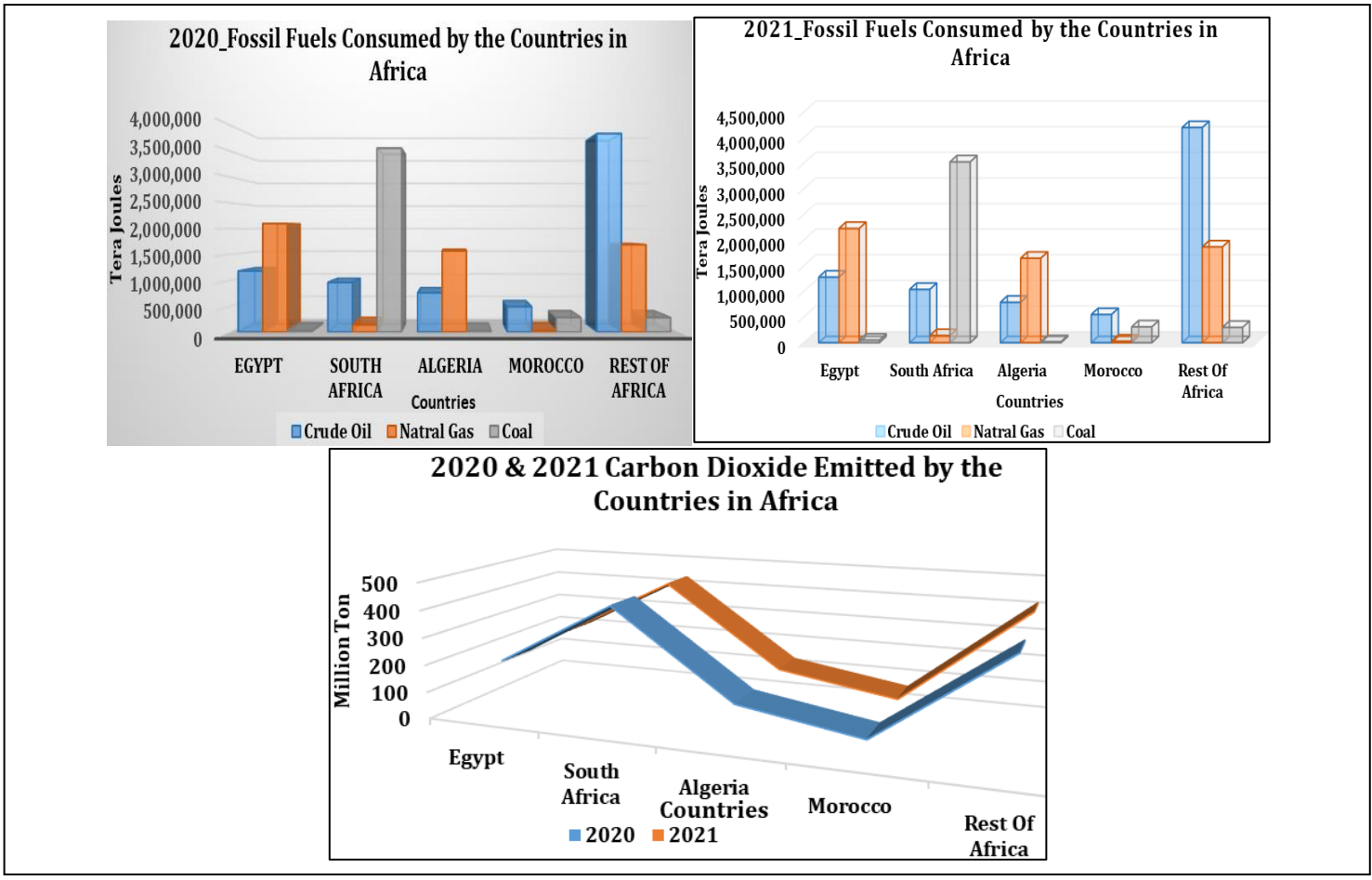

Fig. 17: Fossil Fuels Consumed &CO_2 emitted by Ten Countries in America in 2020 and 2021

D. Fossil Fuels consumed and Carbon Dioxide emitted in 2020 and 2021: Africa

Apart fromEgypt, South Africa, Algeria and Morocco, the rest of the African countries all together consumed 3,840,000 Tera Joules of oil in 2020 and 4,200,000 Tera Joules in 2021. This consumption was as a result of mostly electricity generation and transportation industries. Egypt consumed more gas than any other country in Africa; in 2020,it burnt 2,100,000 Tera Joules of gas to produce electricity, drive the transportation industry and domestic functions such as cooking. In 2021, gas consumption in Egypt increased to 2,230,000 Tera Joules. In 2020, South Africa consumed more coal than all the African countries put together; it burnt 3,560,000 Tera Joules to generate electricity. Its usage of coal in 2021 decreased marginally to 3,530,000 Tera Joules. South Africa emitted 437.2 Million MetricTons of carbon dioxide in 2020 mainly from its consumptionof fossil fuel; its emission inched up marginally to 438.9 Million MetricTons in 2021. This discharge to the atmosphere was more than any other African country emission in 2020 and 2021. Morocco consumed the least oil products in 2020 and 2021. It burnt 490,000 Tera Joules in 2020 and 550,000 Tera Joules in 2021. Morocco also consumed the least gas; its consumption in 2020 and 2021 remained the same at 30,000 Tera Joules. Algeria consumed the least coal both in 2020 and 2021; it burnt 20,000 Tera Joules in 2020 and the same Tera Joules in 2021. Morocco emitted the least carbon dioxide into the environment in 2020 and 2021. Its discharge in 2020 was 62.1Million MetricTons, this emission increased to 68.9 Million MetricTons in 2021. Figure 18 depicted the fossil fuel consumed and carbon dioxide emitted by the countries in Africa in 2020 and 2021.

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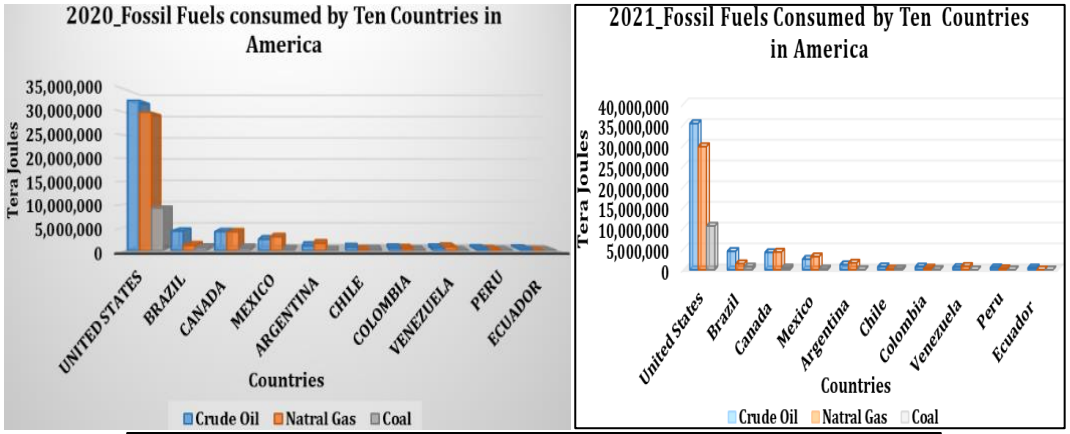

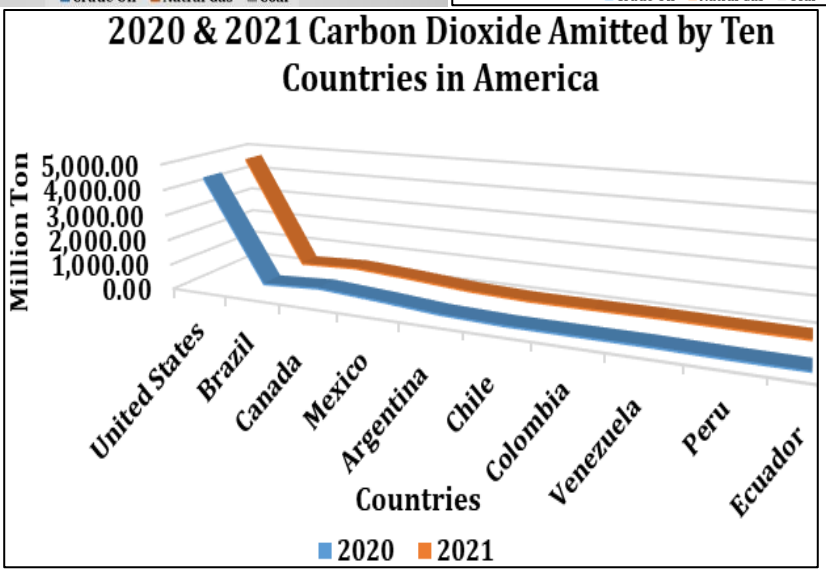

Fig. 18: Fossil Fuels Consumed &CO_2 emitted by the Countries in Africa in 2020 and 2021

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E. Consumption of Fossil Fuel and CO_2 Emission by the Continents in 2020

In 2020, Asia consumed 46% of oil extracted in the world, follow by America at 32%, Europe 17% and Africa at a distance last of 5%. America burnt-out the most gas at 36%, Asia 33% followed by Europe at 26% and Africa at 5%. Coal consumption was very pronounced in Asia, it consumed 80% of this fossil fuel mined in the world. America remotely, burnt-out 9% followed closely by Europe at 8% and Africa at a distance 3%. For carbon dioxide emitted into the atmosphere in 2020, Asia led the pack with 59%, followed by America at 22%, Europe 15% and Africa remotely at 4%. These measurements of fossil fuel consumption and carbon dioxide emission can be found in figure 19.

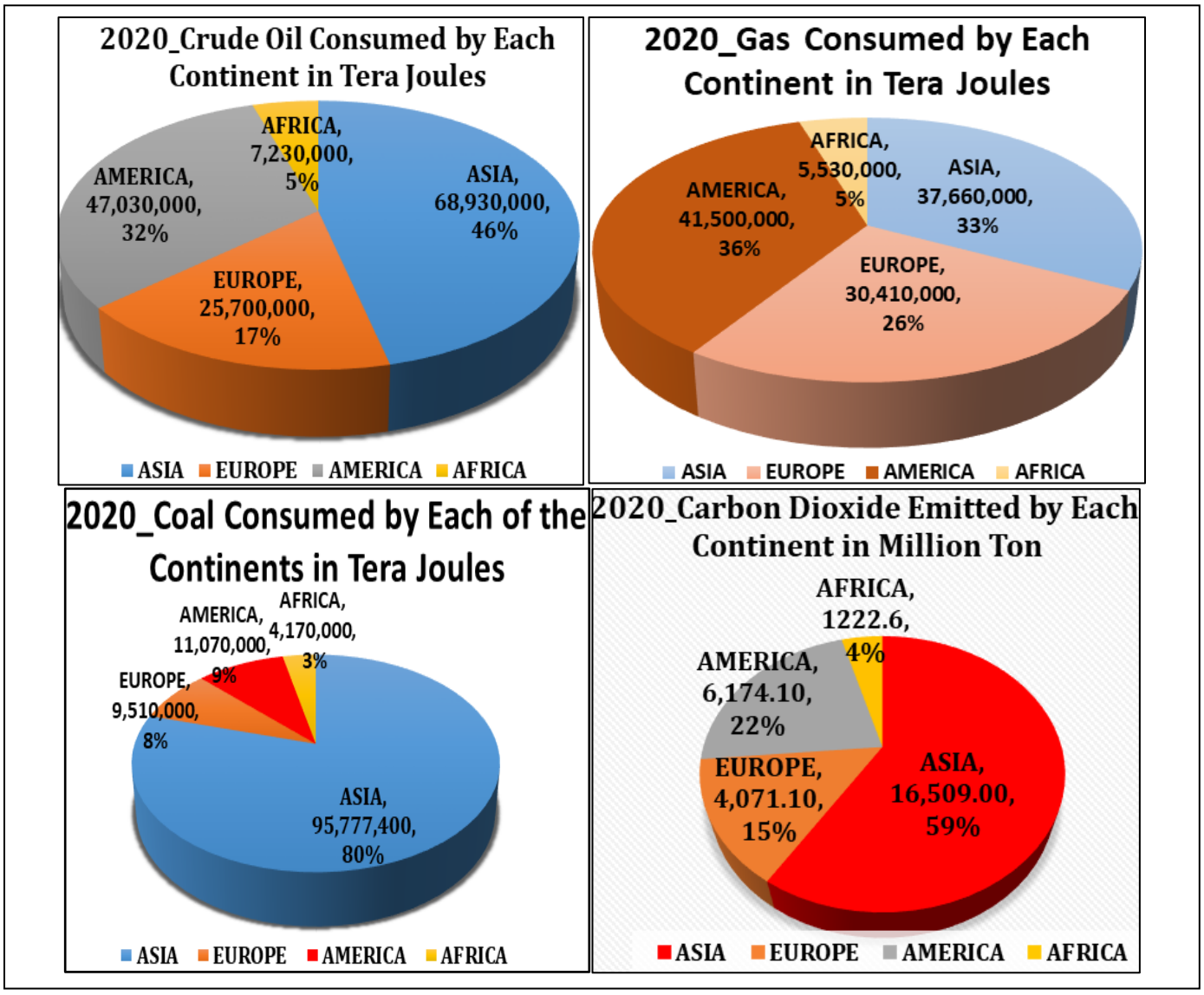

Fig. 19: Diagrams illustrating Fossil Fuel Consumed & CO_2 Emitted by Each Continent in 2020

F. Consumption of Fossil Fuel and CO_2 Emission by the Continents in 2021

In 2021, the trend of oil consumption and carbon dioxide emission in the world did not change, all the continents maintained their percentage usage as in 2020. America reduced its gas consumption by 1% ending the year with 35%; Asia and Africa maintained their usage as in 2020. Europe inched up its gas consumption marginally to 27%. Asia increased its coal consumption by 2% and ended 2021 with a colossal 82%. America and Europe reduced their consumption by 1% each with reference to 2020 usage. The percentage coal consumption in Africa in 2021was the same as in 2020.These indicators of fossil fuel consumption and carbon dioxide emission can be found in figure 20.

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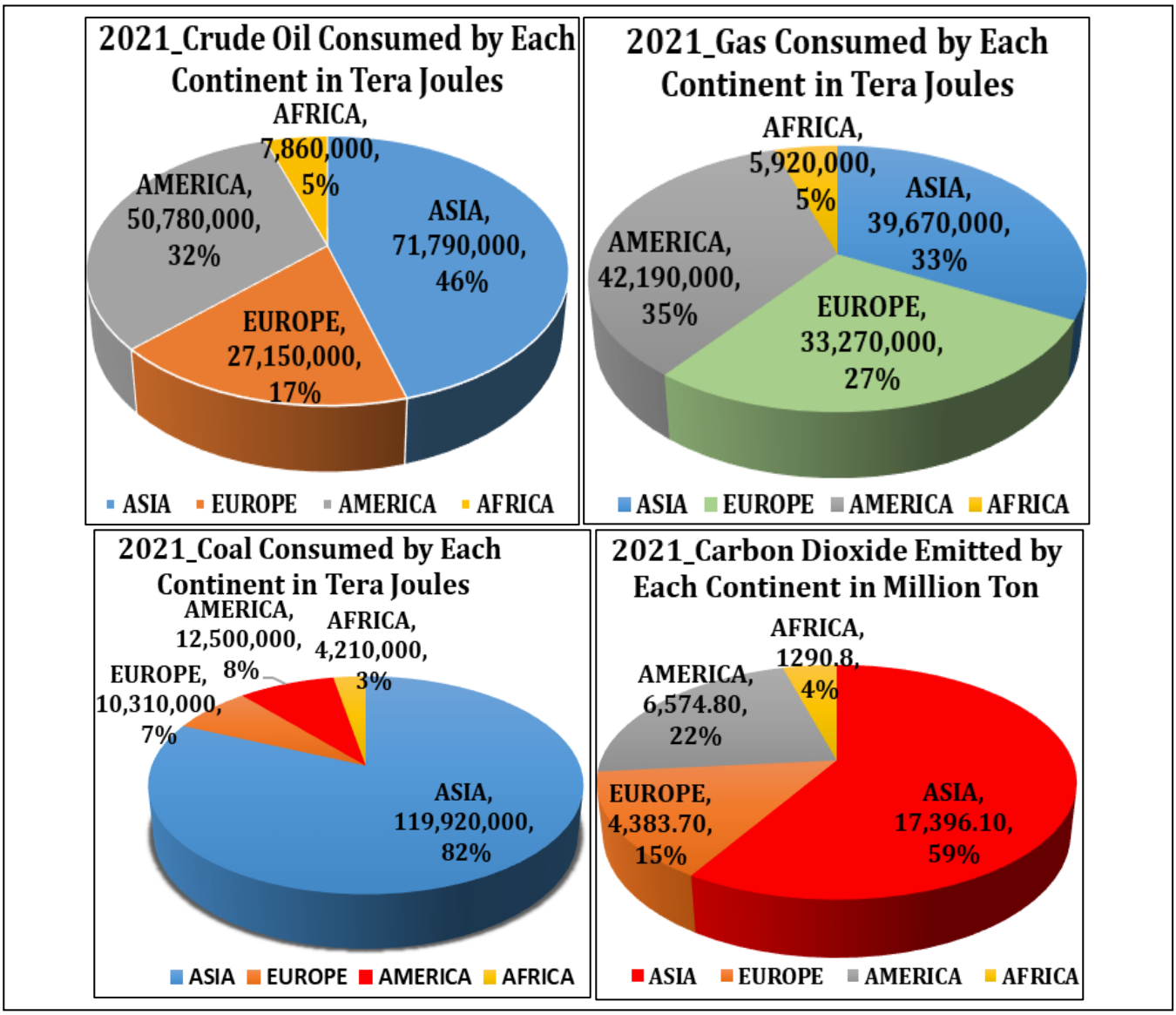

Fig. 20: Diagrams illustrating Fossil Fuels Consumed & CO_2 Emitted by Each Continent in 2021

To sum up the discussion, there is no doubt that the anthropogenic manifestation in the world has resulted in the emission of carbon dioxide into the atmosphere and its attendance climatic imbalance. The African continent is the most affected by this phenomena even though it produces less carbon dioxide. Coal which is a major contributor to emission of carbon dioxide is mainly used for electricity generation. The only country in Africa that used much coal is South Africa; today, 80% of electricity produced in South Africa comes from coal. In tonnage term, this comes nowhere near what countries such as China, United States, India and others are using for electricity generation. As already alluded to, Africa emits a paltry 4% of CO_2while 10% of the world's richest population are accountable for over half of CO_2 emissions annually. Africa however, suffers much from the effects of climate change. Climate change in Africa affects the regions differently; while the east and the Horn of Africa (Kenya and Somalia) suffer from locust inversions, the south and the west suffer from floods (Mozambique, Nigeria and Ghana) and the north suffers from drought (Algeria and Tunisia).

VI. CONCLUSION

In this research, anthropogenic consumption of fossil fuels and emission of carbon dioxide thereof by ten countries in each continent except Africa where all the countries were taken into consideration were studied. If concrete seriousness is not taken, the rate at which carbon dioxide is emitted into the atmosphere, the 2 degrees threshold will be crossed in no time. Even though, there are other greenhouse gases such as fluorinated gases, methane and nitrous oxide, their effects on the environment are not as massive as carbon dioxide to change the global natural climatic balance. The war in Ukraine is largely taking the shine away from issues pertaining to climate change and global warming. Wars are also contributing factors to climatic imbalance in the world. In this era of increasing CO_2 emission by all countries, especially G20, BRICS and G7 countries, climate mitigation and adaptation measures must be taken. This measure could include increasing aggressively the usage of nuclear power and renewable energies to generate electricity. Other mitigating actions such as non-hydrocarbon energy usage and improving

energy efficiency could go a long way to reducing significantly CO_2 emission. The world must adapt strategies to minimize damages that are caused by climate-related disasters such as severe droughts, wildfires, flooding and violent storms. Other adaptation measures could include imposing environmental taxes and carbon tax on fossil fuel consumption. The money accrued from these taxes could be used to compensate vulnerable countries especially in Africa that suffer most from the effects of global climate change. Agreements and protocols are needed to prevent the menace caused by global climate change. The scare caused by the former president of the US, Donald Trump to redraw United States from the Paris Agreement in 2017 was unfortunate. The intended stepping away, when succeeded could have caused a huge setback to the fight against climate change. As analyzed in this paper, currently China is at pole position in the consumption of fossil fuels and emission of carbon dioxide into the atmosphere. If China could reduce fossil fuel usage especially coal by at least half, this could lessen the cantankerous fight against climate change. The researchers of this paper have come to the realization that treaties, agreements, pieces of scientific advice and coerciveness are not sufficient enough to revert or minimize or stop the anthropogenic activities that are causing the climate to change. Rather, matters concerning the climate, the atmosphere and to a large extend the environment should be accorded the same respect as those given to human beings.

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