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Climate Change and Impediments to the Implementation of COP21 Paris Agreement

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Abstract

Climate change and global warming are currently hot topics. There is no doubt that warming is taking place in some parts of the globe as evidenced by melting of ice caps and glaciers, sea level rises, temperature rises, among other changes. At the same time, skeptics are of the view that the issue is blown out of proportion, and that warming exists locally and that it is premature to conclude that it is a global phenomenon. United Nations initiatives to combat 'global warming' in the past have not produced the expected results and the recent effort at the COP21 conference held in Paris came out with the 'Paris Agreement' which many hail as a breakthrough. However, there appears to be several stumbling blocks to the enforcement of this agreement. These are related to scientific as well as non-scientific issues. In this paper, an attempt is made to revisit the issues in the light of available information, and to highlight the important role of increasing population, uncertainties in science, impact of shale revolution, delivery of financial assistance by developed countries to combat climate change in developing countries.

Keywords: Climate change, global warming, paleo-climatology, population, COP Series, Paris Agreement, future projection uncertainties, shale revolution, energy consumption and CO_2 emissions, Oil prices

Introduction

Climate change and global warming are currently hot topics. They involve not only scientific issues but more political (geo and national) and business issues. There is no doubt that discernible warming is taking place in some parts of the globe as evidenced by melting of ice caps and glaciers, sea level rises, temperature rises, among other changes. At the same time, there is another school of thought, sometimes identified as skeptics, who take the view that the issues are blown out of proportion, and that warming exists locally and that it is premature to conclude that the issues are global phenomena. Many climate scientists and politicians claim that the scientific part of climate change is settled and what is now required are actions aimed at reducing green house gas emissions to contain the global average temperature anomaly to within 2°C. Attempts by the industrialized counties and the United Nations (UN) agencies to find a global solution to a problem which the skeptics consider as a local or regional one so far have failed. The effort that received most international attention culminated in Paris on December 12, 2015 with the acceptance by consensus of the 'Paris Agreement on Climate Change' during the COP21 conference attended by delegates from some 195 countries. A timeline of developments and activities related to climate change since the effect of green-house gases on climate was first described is shown in (Table 1).

The 'Paris Agreement' was hailed as a great accomplishment in UN negotiations in recent history by the leaders who drafted it. The Agreement entered into force on the thirtieth day after the date on which at least 55 Parties to the Convention accounting in total for at least an estimated 55 percent of the total global greenhouse gas emissions have deposited their instruments of ratification, acceptance, approval or accession (Article 21 of Paris Agreement).After it is ratified by the required number of Parties, the enforcement of various articles in the Agreement may still run into obstacles as there are wide differences in interpreting the issues and recognizing the causes and responsibilities of rich and poor nations.

The earth system is dynamic. There are changes taking place spatially and temporally, some natural, and some anthropogenic. The natural changes taking place in the earth system which is not in a thermodynamically equilibrium state is not fully understood at the present time. Anthropogenic factors that contributed to climate change existed since human population evolved. Since the industrial revolution which started in the late 1700's, anthropogenic contributions to climate change have been rising unabatedly.

There are other changes taking place in the earth system. One of the main changes that have taken place in the earth system in recent years is the population explosion. The world human population which in the 1750's was 791 million has exponentially increased to one billion in 1800, 2 billion in 1930, 3 billion in 1960, 4 billion in 1975, 5 billion in 1987, 6 billion in 1999, and over 7.76 billion in April 2020. This important factor is not given the attention it deserves when addressing the issues of climate change and global warming. Many scientists attribute other changes taking place in the earth system to climate change, but in fact climate change is perhaps the effect rather than the cause.

Publicity to the issues of climate change and global warming is given mostly by developed countries and by various agencies of the United Nations. Prominent among them is the United Nations Framework Convention on Climate Change (UNFCCC or FCCC) which is an international environmental treaty produced at the United Nations Conference on Environment and Development (UNCED), also known as Earth Summit, in Rio de Janeiro, June 3-14, 1992. UNFCC have been holding annual meetings known as the Conferences of the Parties (COP's) since 1995 of which the COP21 held in Paris

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Year	Developments
1824	French physicist Joseph Fourier described the earth's natural green-house effect.
1861	Irish physicist John Tyndall showed that water vapour and certain other gases create the greenhouse effect.
1896	Swedish scientist Svante Arrhenius concludes that industrial-age coal burning will enhance the natural greenhouse effect.
1900	Swedish scientist, Knut Angstrom, discovers that even at the tiny concentrations found in the atmosphere, CO_2 strongly absorbs parts of the infrared spectrum.
1927	Carbon emissions from fossil fuel burning and industry reach one billion tonnes per year.
1958	First schematic measurement of atmospheric CO_2 at Mauna Loa in Hawaii and in Antarctica began and is still continuing.
1975	The term 'global warming' first came into public domains following a scientific paper by Broecker.
1988	IPCC established.
1990	IPCC First Assessment Report.
1992	Earth Summit in Rio de Janeiro and the agreement of the UNFCC.
1995	IPCC Second Assessment Report; COP1 in Berlin.
1997	Kyoto protocol.
1998	Warmest year on record resulting from strong El-nino combined with global warming.
2001	IPCC Third Assessment Report.
2005	Kyoto Protocol became international law for those who ratified it.
2007	315 ppm in 1958 to 380 ppm in 2008
2008	After a half a century of observations at Mauna Loa, CO_2 concentrations have risen from
2009	China became the biggest green-house gas emitter overtaking US; Copenhagen Accord.
2013	Mauna Loa Observatory in Hawaii reports that the daily mean concentration of CO_2 in
2014	IPCC Fifth Assessment Report.
2015	COP21 and Paris Agreement.
2016	COP22 Marrakesh, Morocco.
2017	COP23 Bonn, Germany.
2018	COP24 Katowice, Poland.
2019	COP25 Madrid, Spain.
2020	COP26 Glasgow, Scotland (Postponed)

Table 1: Timeline of significant events related to climate change.

during November 30 to December 11, 2015 received perhaps the most international attention. The outcome of COP21 was the 'Paris Climate Change Agreement', or simply the 'Paris Agreement' which was hailed as a breakthrough in all UN negotiations up to date. Subsequently, four other COP's were held respectively in Marrakesh, Morocco, Bonn, Germany, Katowice, Poland and Madrid, Spain. The next COP which was scheduled to be held in Glasgow, Scotland has been postponed. In this paper which follows a similar paper by the author, an attempt is made to highlight the issues related to climate change and the impediments to a successful implementation of the Paris Agreement.

Climate change

Some facts

The earth system is dynamic. There are changes taking place spatially and temporally, some natural, and some anthropogenic. Natural changes in the earth's dynamic system are caused by changes in the energy fluxes receiving from the sun including periodic or aperiodic solar activities such as solar flares, solar eruptions and sunspots. Solar intensity affects the earth climate producing periods of warming and cooling. The cyclical nature of the sun's energy output is not yet fully understood. It differs from the very slow change that is happening within the sun as it ages and evolves, with some studies pointing towards an increase of solar radiation from cyclical sunspot activity. However, solar activity alone is not the cause of climate change. It has also been shown that volcanic activity was responsible for global warming in the Eocene epoch some 55 million years ago [2]. From the 20th century onwards, it has been recognized that anthropogenic factors also contribute to climate change. The main anthropogenic factor is the emission of green-house gases. There are also other hypotheses suggested by various researchers about contributing factors to climate change. One such hypothesis put forward is that Europe's managed forests have been a net source of carbon contributing to climate warming rather than mitigating [3]. It is hypothesized that the release of carbon otherwise stored in litter, dead wood and soil carbon pools in managed forests as well as the conversion of broadleaved forests to coniferous forests which changed the albedo and evapo-transpiration contributed to warming for most of the past 250 years. Another study has shown that new growth vegetation can capture up to 11 times more carbon as old-growth forests [4].

Solar energy which keeps the earth system alive comes mainly in the form of short wave radiation which is absorbed by the oceans and land mass. A fraction of this energy radiates back into the atmosphere in the form of long wave radiation. Green-house gases (carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3) and water vapour (H_2O)) in the atmosphere absorb some of the long wave radiation and are re-radiated back in all directions. Some of the trapped radiation escapes to outer space and some return back to the earth's surface. What is re-radiated back into the earth's surface further warms the earth's surface. In the absence of green-house gases which trap the back radiation, the long wave radiation would escape into the outer space.

Carbon dioxide contribution comes from natural processes such as from volcanic activities that release the carbon trapped for millions of years and the burning of fossil fuels by human activities. The former is a slow and intermittent process whereas the latter is continuous and has taken place over a much shorter span of time in an accelerated manner. Plants absorb carbon dioxide to produce the organic matter through photosynthesis and releases oxygen as a by-product. Animal species,

including humans, operate in exactly the opposite way by taking in oxygen and releasing carbon dioxide. Growth of plants in nature has seasonal cycles in temperate climates. In the past, the release of carbon dioxide by burning fossil fuel and biomass and the uptake by plants remained reasonably constant. With the increase of population and the industrial revolution the release of carbon dioxide began to increase and the uptake by plants began to decrease. In addition to the burning of fossil fuels, other anthropogenic factors such as deforestation, desertification, and conversion of forest and agriculture areas to urban areas etc. also contribute to the increase of carbon dioxide concentration.

Very recently it has been reported that soils hold about twice as much carbon as the atmosphere and that microbes present in the soil act with carbon to release CO_2) [5]. Their experiments have revealed that soil microbial activity increases exponentially with increasing temperature in the short term suggesting that warming-induced CO_2 released from the soils is an important contributor to green-house gases. Although the exact magnitudes remain uncertain, their observation over a wide range of climatic regions (from Arctic to Amazon) point to the conclusion that microbial activity is enhanced in colder regions and in soils with high carbon to nitrogen ratios.

Some cities have shown consistent temperature rises over the past few decades [6]. Some other cities have shown consistent cooling over the past few years (For example, Jerusalem, Quebec, Antananarivu etc.). Many cities in the world show cyclic temporal patterns of temperature variation (New Orleans. Cairo, Paris, New Delhi etc.). The winter in 2007/2008 in China has been the coldest in recorded history. UN has warned that extreme winter has killed more than one million livestock animals in Mongolia in 2009/10 winter, and is likely to harm its food supply and worsen poverty. During zud (extreme winter), when the average temperature normally is about -35°C has reached -55°C.

There have been significant differences in the climatic conditions in Arctic and Antarctic. For example, in 2007, the summer minimum sea ice extent in the Arctic was 40% below the minimum sea ice extent of the 1980's and more than 20% below the recorded previous minimum of 2005. Autumn temperature anomalies were greater than +6°C relative to the 1958-1998 mean. In contrast, the sea ice extent and temperature in Antarctic within the past two decades have not been unusual in any season, except along the Antarctic Peninsula, which experienced the largest positive temperature anomalies of anywhere in the Southern Hemisphere (EOS) [7].

Paleo-climatology

The earth system has gone through cycles of warming and cooling. Changes have persisted over decades and sometimes over centuries. Although instrumental measurement of temperature started in 1850, various proxy methods (such as tree rings, ice cores, corals etc.) have been used to understand paleo-climatology. Examples include the Holocene warm period (circa 1800-4000 BP), the Roman warm period (circa 200-500 AD), the medieval warm period (circa 1000-1100 AD) and the little ice age (circa 1200-1800 AD) [8]. It has also been shown that there is a 1500 year cycle of global warming (Avery, 2008). As recorded in ice cores from Vostok, Antarctica, the temperature near the South Pole has varied by more than 20 degrees Fahrenheit during the last 350,000 years. There have been peaks of warmth approximately every 100,000 years. The temperature and the carbon dioxide concentrations at the South Pole parallel each other. The rise and fall of temperatures give rise to the ice age/interglacial cycle (Figure 1).

Detailed information on air temperature and CO2 concentrations in the past are obtained by proxy methods using ice core samples beneath the ice sheets of Greenland and Antarctica. These records obtained from European Project for Ice Coring in Antarctica (EPICA) Dome C (Dome b/w C is a site of ice core drilling by field teams of several nations) ice core on the Antarctic Plateau show a close relationship between the temperature and CO2 concentrations. An uncertainty that exists in these records is whether CO2 concentrations follow temperature or vice versa. The general observation of EPICA data from Antarctica during the last 10,000-20,000 years points to the conclusion that the peaks in CO2 concentrations lagged behind the peaks in temperature by about 1400 years. This is a strong argument against the present belief that CO2 is causing the temperature rise. A more recent study [9] suggests that the difference may be only about 200 years, but does not dispute the fact that CO2 follows temperature. The wide margin of error in the EPICA core data is due to the way air gets trapped in layers of ice [9].

Future predictions

Based on the data available up to the present time, projections into the future have been made using different types of models. These models assume various scenarios (input conditions). IPCC Report (IPCC, 2007) refers to about six scenario families identified as A1F1, A1B, A1T, A2, B1, and B2. A1 scenarios assume rapid economic growth, population increasing up to 9 billion in 2050 and then declining, efficient spread of new technologies and extensive social and cultural interactions worldwide. The sub families A1F1 assume intensive fossil fuel use, A1B attempt to strike a balanced use of all energy sources, and A1T

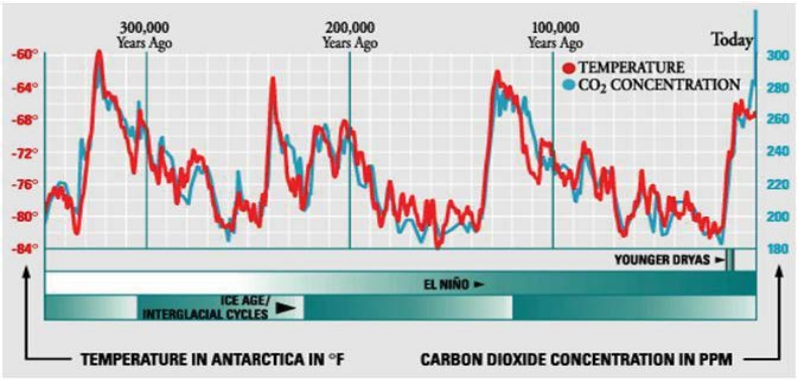

Figure 1: Climate Change in the Geological Time Scale.

emphasize on non-fossil fuels [10]. A2 scenario considers a divided world with independent, and self-reliant economic development policies with continuously increasing population. In B1 scenarios, the world is considered as more integrated and ecologically friendly with rapid economic growth and rapid changes towards services and information. They assume that population will increase to 9 billion in 2050 and decline as in A1, and aim for material conservation and introduction of clean and efficient technologies with emphasis on a global approach to economic, social and environmental stability. On the other hand, B2 scenarios consider a more divided but ecologically friendly world with continuously increasing population at a rate slower than in A2, and emphasize a local approach to attain economic, social and environmental stability at a less rapid and more fragmented approach than A1 and B1. How these qualitative input conditions are translated to quantitative numerical values is not unique and the conditions themselves may not prevail in the future world.

The climate models that most researchers and research organizations employ are atmospheric and oceanic general circulation models. They integrate land surface biosphere physics, soil hydrology, sea-ice dynamics and thermodynamics. A flux coupler integrates the fluxes at the interfaces at different time intervals. Various coupling strategies are used in different models. With such complexities of modelling and the different input scenarios, it is difficult if not impossible to make exact projections. It is also a fact that when predictions and/or projections into the future are made, the reliability of the outcomes decreases with increasing lead time. With a very short window of observations of about 2 decades, these models attempt to make predictions/projections for hundreds of years into the future. When interpreting the results of such climate models, the reliability, uncertainties associated with the model, parameterization of the processes, spatial and temporal resolutions, calibration, validation and extrapolation should be taken into account. It is also important to realize whether or not the assumed scenarios would be valid in the projected time scale.

Un-initiatives to Combat Climate Change

The UNFCC of 1992 was followed by the Kyoto protocol, which is also an international treaty (1997) that has legally binding obligations for developed countries. However, USA did not ratify the protocol. It has been agreed that there should be a reduction of green-house gases by 5.2% of the 1992 level by 2012. Under Kyoto protocol, countries that emit less than the agreed quotas would be able to sell their emission credits to other countries that exceed their agreed quotas

COP series

UNFCC Conferences of the Parties (COP's) were held annually from 1995. The first one (COP1) was held in Berlin, and the most recent one (COP25) was held in Madrid, Spain in December 2019. Not much tangible progress has been made in limiting green-house gas emissions at these annual conferences although pledges to help poor countries to adapt to changing climates have been made. For example, at COP15 held in Copenhagen an agreement called 'Copenhagen Accord' was drafted by US, China, India, Brazil and South Africa but not adopted in a debate of all participating countries. Some observers have even reported it as a disaster (e.g. http://www.sourcewatch.org/index.php?title=COP15). Agreements made were not legally binding and the conferences ended up with empty rhetoric which many view as lacking any clout. The 'Copenhagen Accord' pledged US$30 billion to the developing world over the period 2010-2012, rising to US$ 100 billion per year by 2020, to help poor countries adapt to climate change. However, nothing legally binding has been agreed.

COP 21 - Paris agreement

The most controversial and talked-about of this series is COP 21, also known as the 2015 Paris Climate Conference that aimed for the first time in 20 years of UN negotiations to achieve a legally binding and universal agreement on climate to keep global warming below 2°C. During this conference attended by official delegates from governments, intergovernmental organizations, UN agencies, NGO's and civil society representing 195 countries, the 'Paris Agreement on Climate Change' which has been hailed as a historic one was adopted by consensus on December 12, 2015.

The Paris Agreement which runs into 12 pages consists of 29 articles. Articles 2 defines the main objectives of the agreement which consist of limiting the global average temperature to well below 2°C above the pre-industrial levels and to pursue efforts to limit it to 1.5°C, adapting measures to Avert adverse impacts of climate change that will affect food production, and, making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development. It is to be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.

In summary, the 29 articles address different issues among which sustainable management of forests, adaptation guided by best science available, local indigenous knowledge and practices that should be integrated into socioeconomic and environmental policies, facilitating the enhancement of exchange of information, expertise etc. in relation to climate related disaster risk management in a transparent and verifiable manner. The most controversial and sticky issue is the requirement by developed countries to provide financial and other logistic support to developing countries to implement their nationally determined targets to combat climate change as described in articles 4, 7, 9, 10, 11 and 13. Although the articles in the draft agreement reflect good intentions, their implementation as well as enforcement may run into problems.

The Agreement which was open for signatures from April 22, 2016 to April 21, 2017 at the United Nations Headquarters became binding once the minimum required number of parties have deposited their signatures as per Article 21. The Conference of the Parties will undertake the first stock take in the year 2023 and every five years thereafter, the outcome of which shall guide the way forward.

The other issue of concern is that any reduction of emissions by sources and removals by sinks of green-house gases is voluntary and to be determined by individual Parties with no enforcement mechanism. This is a kind of 'free for all' situation which has been welcomed by all parties. Whether such an agreement can lead to the desired outcome remains to be seen. In the end, the 'agreement' may turn out to be 'no agreement'.

It is also possible for Parties that have not been signatories to the Agreement to ignore the agreement completely. There is also provision for any Party to withdraw from the agreement anytime after 3 years from the time it comes into force by giving written notice to the Secretary General of the United Nations who is the Depository of the Agreement.

Impediments to Implementation of Paris Agreement

Possible impediments for a successful implementation of the Paris Agreement come from many sources. Broadly they can be categorized as those arising from scientific factors and those arising from non-

scientific factors. Scientific factors play a vital role in understanding the issue of climate change and form the basis upon which decisions to combat its consequences should be made. Some of the scientific factors and their associated uncertainties were highlighted in earlier and are further elaborated below. Attempts are also made to highlight the prominent non-scientific factors in the sections that follow. They include but not limited to well documented facts and figures, geopolitics and business interests, national interests, human perception, and economic factors.

Uncertainties in science

The main driving force behind all climate related studies is projections made by various climate models. In fact climate change research has been dominated by modelling to the extent that approximately 55% of all modelling done and published in peer reviewed journals has been on climate change although climate change is only a tiny fraction of the whole of science. More attention has been given to studying the models rather than the physical processes governing climate science leading to confusion. There are also conflicting conclusions made by some scientists. For example, a recent paper suggests that there has been no significant change in the precipitation patterns over earth's land masses from the 18th century to 2013 which contradicts the conclusion that precipitation increased by 1% each decade in the 20th century claimed by IPCC [11]. The negative effects of increasing CO2 concentrations are well publicized but there are also positive effects such as greening of the earth, a fact that has been either ignored or overlooked [12].

Magic Number 2° C: Almost all climate change specialists, IPCC, COP, Governments, NGO's, talk about limiting the world average temperature to 2° C above what existed before the industrial revolution. How did they begin to talk about this magic number 2° C? What about 1, 1.5, or 3 or 4° C...etc?

It is not an exact scientifically established number but rather a judgment based on science and policy. There is more politics to it than science. The first mention of a 2°C threshold based on actual observations and projected changes in global average temperatures due to uncontrolled buildup of atmospheric carbon dioxide is perhaps in a paper which says 'If global temperatures were 2°C above the current values, the climate would go outside the range of temperatures observed in the last 100,000 years. With a stable climate regime, the range of normal variation is 1° C' [13, 14].

It is not the change in mean temperature that matters much but the changes in other related variables such as degree-days, precipitation, snow cover, droughts etc. that affect economic and livelihood activities.

Global average temperature: It is a fact that temperatures vary continuously in space and time. How such variations are averaged to be representative in a global sense is not easy to grasp even to a climatologist, let alone the general public. As we know, the temperature at any point has temporal variation which in any day in some places may exceed 30°C. In addition to the diurnal variation, there is also the seasonal variation which in the tropics may be not significant but is substantial in temperate regions. At a given time, the spatial variation of temperature may range from about -50°C to about 50°C from polar regions to equatorial and desert regions. There is no universally accepted definition of earth's average temperature. In fact a physically definable global average temperature does not exist. What is given as a global average temperature is just a 'statistic' which has no relationship to the physical system and has no physical meaning. A statistic can be calculated in many ways and the results may not always be the same. As a result, there are confusions and misunderstandings about the meaning of a global average temperature which is calculated from different datasets using different methods. Currently, there are four widely used datasets.

In USA, the datasets used are the **GISTEMP** series which comes via **NASA** Goddard Institute for Space Sciences (**GISS**), and the Merged Land–Ocean Surface Temperature (**MLOST)** series which comes from the National Oceanic and Atmospheric Administration (**NOAA**). In the United Kingdom (UK), the **UK Met Office Hadley Centre** and the University of East Anglia's Climatic Research Unit jointly produce **the HadCRUT4** dataset. In Japan, the Japan Meteorological Agency (JMA) produces their data set. These four data sets are the widely used ones by climatologists with the NASA GISTEMP set having the widest coverage and usage. The HadCRUT4 dataset has a temporal coverage from1850 with about 2,000 land stations spatially, the GISTEMP dataset has about 6,300 land stations and the MLOST about 7,000 land stations with a temporal coverage from 1880, and the JMA has temporal coverage from 1891 with much less spatial coverage. Actual observations of temperature are made from the air above land and ocean surfaces, by ships, buoys and also remotely by satellites. Satellite observations which measure the temperature indirectly using microwave sounding units (MSU's) are available since 1979. It is also a fact that the temperature of the lower troposphere is different from the land surface temperature.

The spatial resolution for converting the observed data to grid-based data is 2°x2° (approximately 222 km x 222 km) for the GISTEMP and 5°x5° (approximately 555 km x 555 km) for the other datasets. The grid size gets smaller and smaller as it approaches the poles. All these datasets have little or no coverage in remote parts of the world and the data themselves can have inherent errors arising from instruments, observations, communication of data to processing centres etc. Filling in the missing gaps in datasets is done using statistical methods (e.g. kriging) based on data from nearby stations in the GISTEMP dataset whereas they are left blank and filled with the global averages in the HadCRUT4 dataset. After detailed processing of raw data, each grid point in space is assigned the data value nearest to it.

Rather than the actual temperature, the collecting, reporting and disseminating agencies compute the daily 'anomaly', which is the difference between what is observed and the long-term average for that location and time. Daily anomalies are averaged to obtain the monthly, seasonal, and annual averages. Unfilled grid squares are filled using linear spatial interpolation of the anomalies from their nearest neighbours.

Improvements to data series as well as reconstruction of global data sets including the associated uncertainties have been discussed by many researchers [15]. Satellite observations also have errors associated with the orbit of the satellite not passing over a certain point at the same time of the day. Orbits tend to drift away from the original path due to friction caused by gas molecules in space.

There are also differences in the way the anomalies are calculated. Some use the 20th century average (1901-2000) as the reference base whereas World Meteorological Organization (WMO) recommends the use of the most recent 30 year average. WMO also defines the daily average temperature at a location as the average of the maximum and minimum temperature over a 24 hour period. In some situations such as when the maximum (or minimum) temperature prevails for a longer time of the day, the average temperature should be more closer to the maximum (or minimum) rather than to the mean. There are many

such uncertainties associated with the averaging process which tend the make the averaged value not representative of the real condition.

The values of certain variables when added together gives the magnitude of the total of that variable which when divided by the number of records gives the average. Examples of this type include mass, length, area, volume, energy etc., because the sum of several masses, lengths, areas, volumes, energy etc. is physically equal to the total mass, length, area, volume, energy etc. which when divided by the number of units gives an average value that has a conceptual meaning. On the contrary, the average temperature obtained by adding the temperatures of several places does not give the same meaning since a total temperature has no conceptual meaning. For example, two locations which have different temperatures will not have a total temperature equal to the sum of the two temperatures when the two locations are combined. The concept of a total temperature is meaningless. This paradox in the context of climate change has been described in detail in a recent publication [16]. It is further stated that in the case of non-equilibrium thermodynamics, temperature averages fail in the most basic role of an average, which is for one value to represent many [16]. In their study with datasets from 12 stations worldwide for the period 1979-2000, trend analysis of derived data as opposed to raw data (raw data has also been averaged to get the monthly means) showed positive (warming) and negative (cooling) trends for the same data set depending on the averaging process they employed.

The dynamics of the earth system which is thermodynamically not in an equilibrium state are not driven by globally estimated average 'statistics' of system variables. They are driven by gradients of physically identifiable process variables which in the context of climate change are gradients of temperature and other physical parameters.

Uncertainties in future projections: All climate related research carried out in the recent past use data generated by various atmospheric and oceanic general circulation models referred to in Earlier They all have inherent uncertainties arising from assumptions made, representation of the physical/biological system by mathematical equations, approximations made to the governing equations to enable them solvable, representation of the boundary and initial conditions (governing equations are transient), numerical scheme used to solve the approximate equations, validation of the results obtained with real observations etc. It is also uncertain whether the scenarios assumed for future will prevail or not. The world is changing at different rates in different countries in different ways including economic, technological, political, societal etc. and how such qualitative changes are incorporated quantitatively to climate models (models always deal with numbers!) is not unique and not made known to most model users. It is also a fact that any model prediction or projection made into the future becomes less and less reliable as the lead time increases. The statement that 'the global average temperature in the year 2100 is 2°C higher than today' has a lot to be imagined.

Facts and figures

The information given in this sub-section is based on facts and figures available mostly in public domains. However imprecise they may be such information is used by governments and other institutions to prove (or disprove) certain types of hypotheses.

Population growth and non-equitable energy consumption: All anthropogenic contributions to green-house gas emissions and other forms of climate change are caused by human population which, currently and is projected to increase to about 8 billion by the year 2025 and to about 7.7 billion by mid-century. The present average annual per capita energy consumption in the world is about 3132 kWh (2014 data). In the two most populous countries, China and India, where the present per capita energy consumption is low (3927 kWh in China and 805 kWh in India; see also the paragraphs below) it is likely and fair to expect increases in the near future whereas in countries where the present per capita consumption is high (for example in Iceland it is over 53,000 kWh), it is likely to remain static or may perhaps even go down slightly. Any reduction in the per capita consumption is offset by the new additions to the population. In developing countries, most of the energy is derived from fossil fuels and with increasing population their contribution to green-house gas emissions is likely to go up in the future. With their expectations for fair and equitable use of earth's resources, it would be unreasonable to expect a reduction of their per capita consumption but rather to promote a more logical and practical policy of achieving zero population growth. The unfortunate fact of human nature is that no one is voluntarily willing to lower the present level of living for the sake of the unseen future population.

Fossil fuel resources: Until recently the impression given by geologists and other related scientists are that oil will run out in about 50 years. Some even gave time frames of 10-20 years. These predictions have not been proven to be right. It is also a fact that new sources of energy have been discovered and began to be extracted. Such phenomena reinforce the belief that 'necessity is the mother of invention'. Human species have survived for about 200,000 years. Adaptations to changing environments need not be dictated by global policies.

Disparity in energy consumption and emission of CO_2. ***(a) Energy consumption:*** The amount of green-house gas emissions has a direct relationship with the amount of energy consumed. Energy production comes from fossil fuel, nuclear fuel, hydro power, geothermal, wind, tidal, and solar power. Of these, fossil fuel which includes oil, gas, shale, wood and other burnable substances contribute to CO_2 emissions. The biggest energy consumers in terms of quantities are China, US, Russia, India, and Japan in that order. However, the story becomes completely different when the annual per capita consumptions of energies are compared. The Nordic countries, namely Iceland, Norway and Finland take the lead in per capita energy consumption in kWh which can be attributed to their local cold conditions. Their respective per capita consumptions are 53,832, 23,000, and 15,200 kWh. Qatar, which belongs to OPEC has a per capita consumption of 14,782 kWh. Canada, which is also a high latitude country comes next with a per capita consumption of 15,588 kWh followed by Kuwait (an OPEC country), Sweden (a Nordic country) and USA with respective per capita consumptions of 15,591, 13,480 and 12,994 kWh. On the other end of the spectrum are the least developed countries such as Haiti, Ethiopia and Congo which have the least per capita energy consumptions of 50, 57 and 105 kWh respectively (not listed in Table 2). The two most populous countries in the world, China and India respectively have per capita consumptions of 3,475 kWh and 744 kWh. These statistics, however imperfect they are, show that a person in Iceland on average consumes more than 1000 times the average energy consumed by a person in Haiti. The question then is who is to blame and who should take the responsibility to fix the problem. The crux of the climate change issue rests on this disparity, not only on the total consumption by each country. The present arguments used by developed countries as a way forward to curb green-house gas emissions are based on the total emissions (related to energy consumptions) by each country without giving due recognition to the per capita consumption as a more important criterion (Table 2).

Country	Per capita energy consumption (kWh) (2015 average)[1]	Per capita energy consumption (kG equivalent of oil) (2015 average)[2]	Per capita CO_2 emissions (Metric tons) (2014 average)[3]
Denmark	5,859	2,817	5.9
Norway	23,000	5,818	9.3
Sweden	13,480	5,103	4.5
Iceland	53,832	17,479	6.1
Finland	15,250	5,925	8.7

Table 2: Annual per capita energy consumption and CO_2 emissions in Nordic countries.

(b) CO_2 Emissions: In terms of CO_2 emissions the OPEC Middle East counties take the lead with Qatar, Trinidad and Tobago, Kuwait, Brunei, Aruba, Luxembourg, United Arab Emirates, Oman, Saudi Arabia and Bahrain at the top .The countries outside Middle East with very high per capita CO_2 emissions are Luxembourg in EU, and Trinidad and Tobago and Aruba island in the Caribbean. USA comes next with China and India very much lower. The per capita emission of USA is approximately ten times that of India and about two and a half times that of China, and that of Luxembourg more than twelve times that of India and more than three times that of China.

The US Energy Information Administration in their recently released "International Energy Outlook 2016" projects that the world energy consumption will grow by 48% between 2012 and 2040 with the major growth in non-OECD countries driven by strong economic growth with China and India accounting for more than half. Fossil fuels still account for more than three-quarters of world energy consumption although the use of non-fossil fuels is expected to grow faster than fossil fuels. The CO_2 emissions from such increases in the consumption of fossil fuels are therefore expected to increase through the projected period (Table 2-6). .

Shale revolution: Shale gas has been in use in USA since the late 1990's and early 2000's although it has been extracted in small quantities as far back as the 1880's. Green-house gas emissions from shale gas are similar to those from natural gas and believed to be much less than from burning coal. Shale has low permeability and therefore requires fracturing to extract the gas. Shale gas has been extracted for many years using natural fracturing but the present boom is due to technological advances in hydraulic fracturing, or fracking, and horizontal drilling which are techniques of creating artificial fractures over vast fields of shale formation. Unlike conventional oil fields, shale formations exist in many parts of the world. With the rapid advances in fracking, and other associated techniques involved in extraction and refining, it is likely that shale oil and gas may dominate the fossil fuel market in the world in the near future. The United States, once an importer of fossil fuel is now in a position to export energy. The distribution of shale gas does not require costly pipelines used for transporting crude oil. The United Kingdom is just embarking on a shale exploration plan by preventing communities from blocking anti-fracking programs by classifying fracking wells as 'nationally significant infrastructure'. As a result, conventional crude oil prices which once were over $140 a barrel have plummeted to about $30 despite various types of political turmoil in the major oil producing countries, mainly in the Middle East. It is also surprising to note that oil prices plummeted to negative terrain for a while during the COVID-19 pandemic around April 2020. With such a glut of affordable fossil fuel, efforts to go for green energy have taken a backseat, at least for the time being. Driven by economic factors and incentives, the green-house gas emissions are likely to continue to rise causing an impediment to the implementation of the Paris Agreement.

Build-up of coal-fired power plants: Many states in the US produce electricity using coal-fired power plants. b/w A Very recent revelation on coal-powered plants in the US is that the Supreme Court has turned down the US President's Clean Power Plan to cut emissions by 32% by 2030 until legal challenges by 27 states, utilities and coal miners who allege that the plan was an infringement of state rights, were heard [17,18]. This appears to be a major setback for the implementation of the Paris Agreement. China, on the other hand, is building (or has already built) several coal-fired power plants in many developing countries despite their pledge to cut down their own emissions by 2030. Based on 2015 World Bank data, the major coal-fired electricity generating countries as a percentage of their total generating capacity include Kosovo (97.5%), Botswana (96.4%), South Africa (92.7%) and Mongolia (92.7%) which have sufficient coal reserves in their own countries. It is unlikely that these countries will change to other forms of electricity generation in the near future. Any change to alternative forms of electricity generation is most likely determined by economic factors and not by climate change.

Slowdown of green energy initiatives: The term 'green energy' has become a household name in recent years among scientists, economists, politicians, NGO's and some governments. However, when one talks about green energy, not much is talked about how the 'green energy' is produced, the cost associated, the transmission of 'green energy' to the consumer and the problem of storage. For example, most green energy promoters recommend the use of electric vehicles in preference to fossil fuel driven vehicles but fail or ignore the pollution and emissions generated at the source of the electricity generation. Recent studies at Tsinghua University in China have come with the conclusion that electric vehicles used on campus add significantly to the smog in Beijing, although the emissions do not come out of the exhaust pipes. Similar observations can be seen in the Netherlands where electric vehicles have been promoted and grown faster than in many other places. What is ignored is that the electricity needed to run electric vehicles is generated in coal-fired power stations. With the rock bottom oil prices and the shale revolution, green-house gas emissions are likely to continue to increase in the near future since each country will give priority to the economics of energy generation over global warming. It is also reported that some big investors are ignoring climate change risks despite warnings from the Bank of England. Another setback for green energy is the news that Yingli Green Energy Holding Co., once one of the world's biggest solar manufacturers, has recently been heading toward bankruptcy.

Falling oil prices: Oil prices which at one time was over US$140 a barrel has plummeted to less than US$30 a barrel (now hovering around US$30) due to a number of reasons. Firstly, there is a glut of oil and gas as a result of the US shale revolution. Secondly, Saudi Arabia, the biggest producer among OPEC countries is not willing to cut down their production to boost prices but prefers to keep its market share even at the expense of the current low prices. Thirdly, China which has been a major consumer of oil and gas has slowed down her industrial production. Fourthly, the United States which once was a major importer of oil and gas has become an exporter of shale oil and gas at a much lower price than crude oil. All these factors add to a glut of fossil

Country	Per capita energy consumption (kWh) (2015 average)[1]	Per capita energy consumption (kG equivalent of oil) (2015 average)[2]	Per capita CO_2 emissions (Metric tons) (2014 average)[3]
Norway	23,000	5,818	9.3
Australia	10,071	5,484	15.4
Switzerland	7,520	2,960	4.3
Netherland	6,913	4,233	9.9
USA	12,994	6,804	16.5
Germany	7,035	3,818	8.9
New Zealand	9,026	4,445	7.7
Canada	15,588	7,631	15.2
Singapore	8,845	5,122 (2014)	10.3
Denmark	5,859	2,817	5.9
Ireland	5,672	2,820	7.3
Sweden	13,480	5,103	4.5
Iceland	53,832	17,479	6.1
United Kingdom	5,130	2,764	6.5
Hong Kong	6,083	1,970 (2014)	6.4
South Korea	10,497	5,413	11.6
Japan	7,820	3,429	9.5

Table 3: Annual per capita energy consumption and CO2 emissions in developed countries.

Country	Per capita energy consumption (kWh) (2015 average)[1]	Per capita energy consumption (kG equivalent of oil) (2014 average)[2]	Per capita CO_2 emissions (Metric tons) (2014 average)[3]
Algeria	1,363	1,328	3.7
Angola	312	545	1.3
Ecuador	1,376	889	2.8
Indonesia	812	884	1.8
Iran	3,022	3,060	8.4
Iraq	1,328	1,438	4.9
Kuwait	15,591	9,179	25.8
Libya	1,811	2,809	9.0
Nigeria	145	764	0.5
Qatar	14,782	17,923	43.9
Saudi Arabia	9,401	6,906	19.4
United Arab Emirates	11,088	7,648	22.9
Venezuela	2,719	2,309	6.2

Table 4: Annual per capita energy consumption and CO2 emissions in OPEC countries.

Country	Per capita energy consumption (kWh) (2015 average)[1]	Per capita energy consumption (kG equivalent of oil) (2014 average)[2]	Per capita CO_2 emissions (Metric tons) (2011 average)[3]
Afghanistan	N/A	N/A	0.4
Angola	312	545	1.3
Bangladesh	320	229	0.5
Benin	100	417	0.6
Bhutan	N/A	367 (2007)	1.4
Berkina Faso	N/A	N/A	N/A
Burundi	N/A	N/A	0.0
Cambodia	271	417	0.4
Central African Republic	N/A	N/A	0.1
Chad	N/A	N/A	0.1

Table 5: Annual per capita energy consumption and CO2 emissions in least developed countries.

fuel far exceeding the demand resulting in economic benefits to the consumers and financial losses to the producers. For example, India and Japan which are major importers of oil will benefit from low oil prices but the oil exporters are experiencing a hard time to balance their budgets. Oil exporting countries on average will need a price of US$112 a barrel to balance their budgets with some variation from country to country. It has also been reported that nearly 150 oil platforms in the United Kingdom North Sea are expected to be scrapped over the next 10 years (http://www.bbc.com/news/uk-scotland-scotland-business-35512217).

How do the low fuel prices affect climate change? In the short-term, the green-house gas emissions are likely to increase because each country which is free to determine the emission targets will go for cheap fossil fuel. In several countries which have subsidized green energy projects such as solar and wind are cutting down such subsidies

thereby making it economically unattractive for industries to embark and continue investing in green energy projects. As a result, it is unlikely that the intended objectives of the Paris Agreement could be achieved in the short-term.

Geo-politics and business

It is well recognized that the issue of climate change is highly politicized. All political leaders, as well as their constituents are more interested in their own well-being and their own economies. They are unlikely to implement actions which may be globally environmentally friendly at the expense of their own economies. This can be seen in the key topics of discussion at the recent World Economic Forum held in Davos, Switzerland during January 20-23, 2016. High on the agenda at the Davos Forum were digitalization of industry also known as 'Industry 4.0', terrorism and refugee crisis. Climate change and global warming were not among the four key topics discussed. Automation, which aims to replace human energy by electrical energy through robots will only add to current energy demands thereby adding further emissions by industrialized countries. It has also been argued by the chairman of the Senate Environment and Public Works Committee of the United States that the Paris Agreement will be no more significant to the United States than was the Kyoto Protocol, and that the climate goals are not legally binding and therefore the United States and other countries have no obligation to abide by them. (http://thehill.com/policy/energy-environment/267077-gop-chairman-paris-climate-agreement will-fail). More recently (April 21, 2016), the Majority Staff White paper published by the US Senate Committee on Environment and Public Works highlights many reasons and concludes that the Paris Agreement will fail national economies and the climate. India has emphasized the fact that temperature rise has taken place over a period of 150 years which cannot be ignored and that historical emissions are responsible for the present problem.

Developing countries are blaming the developed countries for failing to deliver the $100 billion per annum promised at the Copenhagen summit. Political parties are blaming each other for their actions and non-actions. The world recognizes that climate change is a problem that needs to be addressed but the reality is that there are more pressing problems in each country. In developed countries they include, terrorism, refugee problem as can be seen in Europe in recent months, energy scarcity, economic instability, among others. Climate change does not pose as a high priority area although the leaders portray it as a high priority area globally. In developing countries, particularly in least developed countries, the priorities are basic needs such as clean water, sanitation, and their daily bread. Those living in such countries have no time to spare for 'climate change'.

A more serious problem facing humankind particularly in developing countries is the lack of safe drinking water and proper sanitation. According to World Health Organization, over 785 million inhabitants of the world lack basic drinking-water service and over two billion inhabitants use drinking-water sources contaminated with feces resulting in over 485,000 deaths per year. Such deaths are caused by water borne diseases which are preventable (https://www.who.int/news-room/fact-sheets/detail/drinking-water).Climate change has not killed anyone so far. The question is 'where should the priority in channelling resources be?'

A new issue dominating the media and global attention is the COVID-19 pandemic which has so far (as of June 8, 2020) infected over 7 million people worldwide causing over 400,000 deaths. The pandemic is likely to dominate global attention in the near future over and above climate change.

Human perception

Despite the more than adequate attention and publicity given to the issue of global warming and climate change, the perception of people from different regions have different attitudes to these issues. A recent global survey conducted by YouGov (Ref: https://today.yougov.com/news/2016/02/01/global-survey-us-among-least-worried-about-climate/) in 17 countries covering North America, Asia, Middle East, Australia and Europe have come up with a result that globally they are not issues of highest concern. Terrorism, poverty, hunger and thirst are issues of higher concern globally. In USA, climate change is the issue of eighth concern. Their main concern is terrorism. Other issues of global concern are armed conflicts, economic stability, population growth, spread of diseases, energy scarcity and proliferation of nuclear weapons. Although such surveys may not reflect the absolute reality and that the sample size may be too small, yet the results give some indication of how people perceive the various issues of concern from their individual points of view.

Uncertainty in the flow of financial and logistic support from developed countries to developing countries

According to articles 4, 7, 9, 10, 11 and 13 of the Paris Agreement, the developed countries are required to provide financial and other logistic support to developing countries to implement their nationally determined targets to combat climate change. This appears to be the most sticky issue of the agreement. Developing countries may (and most likely will) disregard the agreement if such financial support is not forthcoming. Whether or not the developed countries will fulfill their obligations unconditionally also remains to be seen. Furthermore, there is no need for developing countries to reduce their CO2 emissions since the Paris Agreement explicitly provides them a legal basis for them to decide their own targets.

Concluding Remarks

Climate change is not new. Over geological times, changes in climate as well as other changes have taken place. There have been pseudo-periodic warming and cooling which persisted over decades and sometimes over centuries. In the present context, it appears that it is too premature to conclude that the trends that we observe today will continue to the future as well. Projections made into the future climate have many uncertainties. These include model uncertainties, data length and their representativeness, calibration and validation issues, and the logic of projecting into 100 years or more into the future with a relatively short window of observations.

There is very little doubt about what has been observed in the attempt to describe and quantify the past and present states of climate change. However, there appears to be some unclear issues about the representativeness of the data used. For example, temperature varies spatially and temporally (about -50°C to +50°C) and the variation is greater in the higher latitudes than in the equatorial regions. With such extreme variability and the sparse distribution of measuring stations globally, a 'globally averaged temperature' is not representative. Instrument calibration is another issue. Is it fair to compare measurements made in the early days with the measurements made today? There have been significant changes in the way temperatures are measured and their levels of accuracies. In many urban areas, the 'heat island' effect can raise the temperature locally. It would also be more prudent to look at climate change locally or regionally rather than globally. A global climate is only an abstract concept because climate varies from region to region (sometimes within the region also) within

the globe. It is better to measure any climate change locally and be convinced than being told that there is climate change.

Attempts by industrialized countries and UN agencies to address and resolve this issue have not produced any tangible results so far. The main reason for not been able to reach a unified approach is the fragmented nature of the world. There are more pressing and unique problems in each country that require and carry higher priorities than the global climate change problem. For that matter, there is no global citizen. The world is composed of individuals, families, communities, nations, and sometimes groups of nations with common interests. Human nature is such that self-interest (in a broader sense) takes priority. In this context, the Paris Agreement is a step forward as it allows for reflecting equity and the principle of common but differentiated responsibilities and respective capabilities in the light of different national circumstances. However, there are many impediments to a successful enforcement of the Paris Agreement. As highlighted in earlier above, they include the effects of population growth, uncertainties in science, availability of affordable fossil fuel, human perception, disparity in energy consumption and CO_2 emissions, shale revolution, setbacks for green energy, geo-politics, and most importantly whether or not the anticipated financial flow from the developed countries to the developing countries will take place.

Current attention is focused mainly on the green-house gas emissions as evidenced by the agenda of the ongoing series of COP conferences. Little or no attention is directed towards the impacts on the water environment as well as food security which will be highly influenced by any climate change. The current interest and actions to combat climate change is not just a matter of science but also a matter of geopolitics. Finding a global solution to problems that exist regionally or nationally is next to impossible. This is demonstrated in the failures of every UNFCC Conferences of the Parties held so far. What is certain is that the COP series will continue with a break in 2020.

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