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Eco-Friendly Building Construction For Reduction 0f Global Warming

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Abstract: **The 'Introduction' explains that global warming is the most important science issue of the 21st century, challenging the very structure of our global society. The problem is that global warming is not just a scientific concern, but encompasses economics, sociology, geopolitics, local politics, and individuals' choice of lifestyle. Global warming is caused by the massive increase of greenhouse gases, such as carbon dioxide, in the atmosphere, resulting from the burning of fossil fuels and deforestation. Global warming is considered one of the greatest challenges worldwide. International environmental agreements have been developed in response to climate change since the 1970s. The construction industry is considered to be one of the main contributors to global warming. According to the Inter governmental Panel on Climate Change not only is the construction industry responsible for about 40% of global energy consumption, it is also responsible for 30% of global green house gas emissions per annum. Furthermore, it is common for most countries to construct high-rise buildings and larger-sized facilities, due to the rapid growth of population Considering the materials consumption costs, durability, and the environmental impacts, a more in-depth study is necessary to evaluate the influence of the concrete cover thicknesses over the structure's life cycle. Studies that evaluate the environmental impacts of reinforced concrete slabs are relatively scarce (Paik and Na, 2019). Besides that, there are very few studies investigating the concrete cover thickness as a principal subject, and none thus far evaluate its effect on the structure's life cycle. The cement production and steel are the main contributors to many environmental impacts in structures of conventional concrete (Paik and Na, 2019) and the production of steel and concrete has a higher embodied energy than the other materials as found by Life Cycle Costs and impacts of massive slabs with varying concrete cover systems. In this study, reinforcing bars were the main contributor to lowering the carbon dioxide emissions in the flat plate slab and voided slab systems. The results of this study show that amongst all the three different slab systems, the voided slab system shows the greatest reduction potential. Moreover, replacing the ordinary reinforced concrete slab system by alternative methods would make it possible to reduce the carbon dioxide emissions in building projects.**

The devastating environmental changes like global warming, acidification, smog formation, ozone layer and natural resources depletion, biological diversity losses, waste accumulation, etc. are highlighting construction industry as a worldwide agitating sector. More than 40% of world's natural resources and energy are consumed by buildings and about 33% of the total carbon dioxide (CO2) is emitted by buildings.

Index Terms– **Construction industry, Carbon dioxide, life cycle assessment, Reinforced concrete slab, Flat plate slab, Voided slab, Development, Global warming, Methane, Rain, Temperature, Weather, Intergovernmental Panel on Climate Change**

I. INTRODUCTION

Global warming is a term used for the observed century-scale rise in the average temperature of the Earth's climate system and its related effects. Scientists are more than 95% certain that nearly all of global warming is caused by increasing concentrations of greenhouse gases (GHGs) and other human-caused emissions.Within the earth's atmosphere, accumulating greenhouse gases like water vapor, carbon dioxide, methane, nitrous oxide, and ozone are the gases within the atmosphere that absorb and emit heat radiation. Increasing or decreasing amounts of greenhouse gases within the atmosphere act to either hold in or release more of the heat from the sun.In order to mitigate global warming effects, the construction industry has been exploring various approaches to mitigate the impacts of carbon dioxide emissions over the entire life cycle of buildings. The application of different structural systems is considered a means of reducing the carbon dioxide emissions from building construction. The purpose of this research is to assess the environmental performance of three different slab systems during the construction phase. In this study, a process-based life cycle assessment (LCA) method was applied in order to evaluate the level of performance of the three slab systems. The results showed total CO2 emissions of 3,275,712, 3,157,260, and 2,943,695 kg CO2 eq. for the ordinary reinforced concrete slab, flat plate slab, and voided slab systems, respectively. The manufacturing of building materials is by far the main contributor to CO2 emissions, which indicate 3,230,945, 3,117,203, and 2,905,564 kg CO2 respectively. Comparing the building materials in the three slab systems, reinforcing bars and forms were significant building materials to reduce the CO2 emissions in the flat plate slab and voided slab systems. In this study, reinforcing bars were the main contributor to lowering the carbon dioxide emissions in the flat plate slab and voided slab systems. The results of this study show that amongst all the three different slab systems, the voided slab system shows the greatest reduction potential. Moreover, replacing the ordinary reinforced concrete slab system by alternative methods would make it possible to reduce the carbon dioxide emissions in building projects.

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Life cycle assessment (LCA) is a very familiar methodology to measure the environmental effects of any products where all the process associated with the products from cradle to grave was analyzed and the possible emission to environment can be identified. In this study we applied LCA on three traditionally constructed reinforced concrete buildings (one five storied residential building, one three storied office building and one three storied educational building) where no environmental issues were considered during design and construction period. The aim of this research is to evaluate and compare energy consumption and carbon emissions of three different types of buildings from their materialization stage to the end-of-life stage. This paper also describes the step-by-step process of quantifying the overall carbon emission from a building systematically. There is an overview of how emission varies according to buildings material, construction process and objective of buildings. The result shows that the operational phase is mainly responsible for maximum carbon emission due to maximum energy consumption among three phases of life cycle assessment. However, it is also found from the study that the materialization and operation stages together contribute more than 97% of total emissions. Since a huge amount of operational energy is required for commercial building compare to other two buildings, it consumes energy comparatively higher than

residential and educational building which results in 13.6% more emission than residential building and 19% more than educational building.

Fig.1

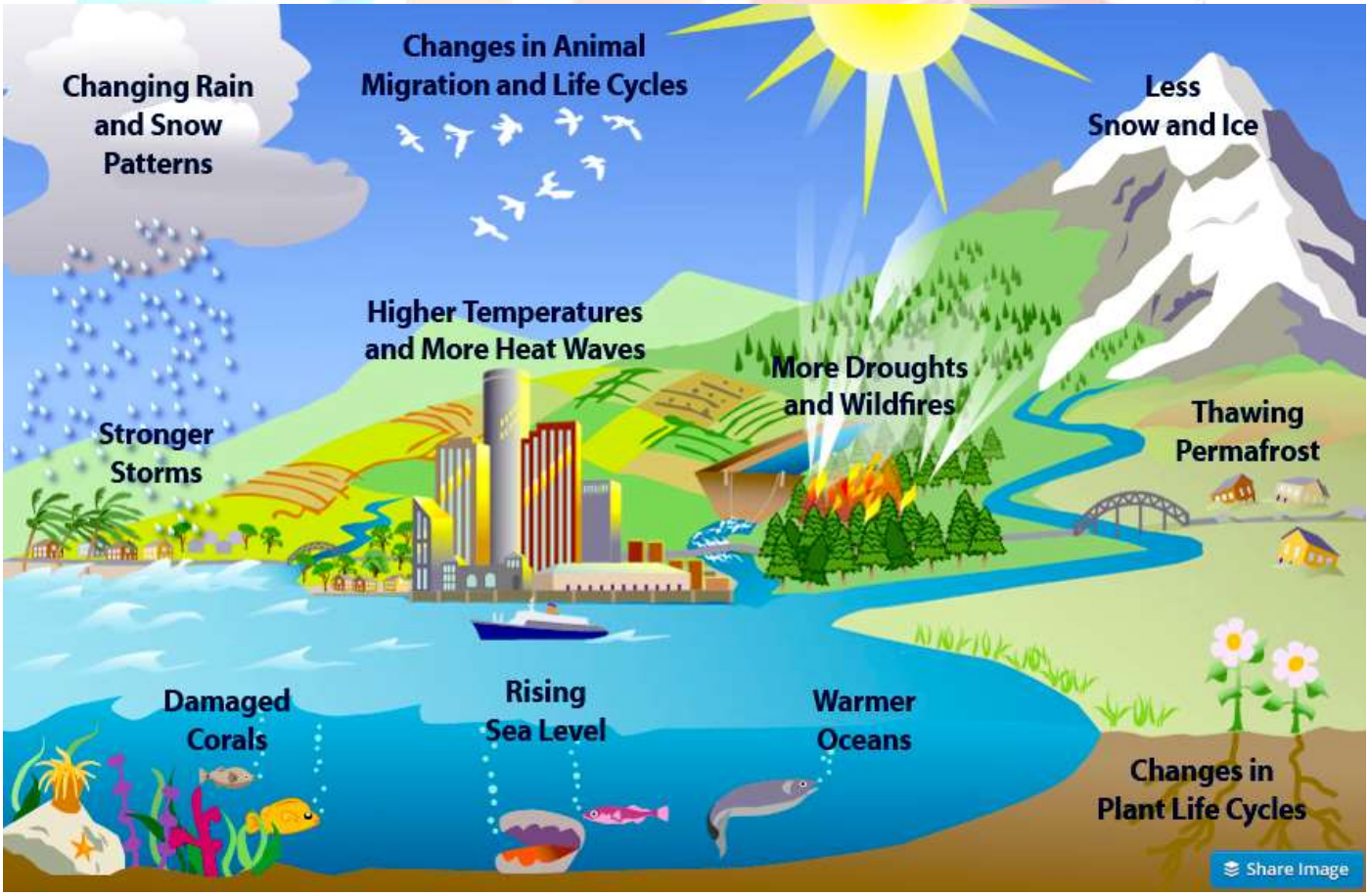

Fig.2

Fig.3

2. LITERATURE REVIEW

2.1. INTRODUCTION:

Global Warming Importance:

Global Warming is important since it helps determine future climate expectations. Through the use of latitude, one can determine the likelihood of snow and hail reaching the surface. You can also be able to identify the thermal energy from the sun that is accessible to a region. Global Warming is the scientific study of climates, which is defined as the mean weather conditions over a period of time. A branch of study within atmospheric sciences, it also takes into account the variables and averages of short-term and long-term weather conditions. Global warming is the unequivocal and continuing rise in the average temperature of Earth's climate system. Since 1971, 90% of the warming has occurred in the oceans. Despite the oceans' dominant role in energy storage, the term "global warming" is also used to refer to increases in average temperature of the air and sea at Earth's surface. Since the early 20th century, the global air and sea surface temperature has increased about 0.8 Â°C (1.4 Â°F), with about two-thirds of the increase occurring since 1980. Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. Global Warming uses from OMICS Group are an open access journal named as Journal of Climatology and Weather Forecasting which strives to release issues quarterly and is adamant to publish new findings related to the field of Global Warming. The mission of the Global Warming uses provides a forum for publishing new findings on Environmental principles and technology. Currently our primary research objective is to encourage and assist the development of better and faster measures of Environmental activity. In cases where we believe we can contribute directly, as opposed to through highlighting the work of others, we are producing our own measures of Global Warming.

Key Facts About Global Warming:

Global warming describes a change in the world's overall climate that results in rising temperatures over long-term periods of time and across the planet. Facts about global warming, including effects of global warming.

Carbon Dioxide Leads Among Greenhouse Gases:

Scientists agree that the main cause of global warming is greenhouse gas emissions, with carbon dioxide in first place ahead of other gas sources. One big contributor of greenhouse gas emissions is power stations, followed by industrial processes, transportation fuels and agricultural byproducts.

Animal Flatulence Creates Methane Gas:

In addition to carbon dioxide, methane is a significant greenhouse gas contributing to climate change. Agricultural byproducts generate about 40 percent of methane emission, followed by 30 percent from fossil fuel retrieval, distribution and production, according to the Emission Database for Global Atmospheric Research. Through normal digestion, animals such as cows, goats and sheep produce large methane amounts through their flatulence.

Deforestation Causes Global Warming:

Because trees and plants help to regulate the climate by absorbing carbon dioxide and releasing oxygen, deforestation is a major cause of global warming. It reduces the number of trees available to release clean oxygen.

Ancient Evidence Shows Global Warming Exists:

Ancient evidence such as tree rings, coral reefs, ocean sediments and sedimentary rock layers show that current global warming is happening. And it's occurring about 10 times faster than the average rate of warming during the Ice Age, according to NASA.

Warmer Oceans Mean More Tsunamis:

Ocean temperatures have risen nearly 20 degrees Fahrenheit since 1955, aCC0rding to the U.S. Environmental Protection Agency. Warmer ocean waters means tsunamis occur more frequently.

Global Warming Causes Glaciers to Melt:

Not including Antarctica and Greenland's large ice sheets, the world has about 150,000 glaciers that cover about 200,000 square miles of Earth's surface. In the last 40 years, the glaciers have lost what's equal to a layer of ice 70 feet thick due to global warming-related causes, aCC0rding to a 2019 New York Times article.

Fossil Fuels Contribute to Forest Fires:

Fossil fuels possibly have created climate change consequences, such as London fog and forest fires in the United States. When fossil fuels are burned for human activities, it can warm Earth's atmosphere.

Global Warming Affects Hydroelectricity:

Global warming affects hydroelectricity because it changes rivers and ecosystems. When their patterns change, they may not power dams the same ways they did before.

Polar Bears Are Starving:

Scientists warn that polar bears are at an increased risk of starving due to melting sea ice. As the ice melts, it becomes increasingly difficult for polar bears to hunt for seals.

Global Warming Causes Catastrophic Floods:

Global warming contributes to rising sea levels and disasters such as catastrophic floods and flowing debris. Flooding can lead to economic disasters, too.

Fig.4

Chances are you won't make it in person to the March for Science in Washington DC, but you can be part of the ongoing Earth Day campaign to educate everyone about climate change, and its unprecedented threat to our planet. The theme of this year's Earth Day, on 22 April, is Environmental and Climate Literacy. The Earth Day Network, which coordinates the global awareness-raising day, is launching an ambitious drive to ensure every student in the world is"climate literate" when they leave high school - by Earth Day 2020. You certainly don't need to be a climatologist to talk knowledgeably about climate change, but it helps to have the key facts about global warming at your fingertips. So here's a handy guide to get you up to speed on the climate change basics. The Earth has been getting warmer - for 627 months in a row2016 was the hottest year on record, according to separate analyses by scientists at NASA's Goddard Institute for Space Studies (GISS) and the National Oceanic and Atmospheric Administration (NOAA). It was also the third year in a row to set a new record for global average surface temperatures. This record-breaking heat is part of a long-term warming trend. The Earth's average surface temperature has risen about 1.1 degrees Celsius since the late 19th century, when modern record-keeping began, and is projected to rise further over the next hundred years or so. The warming, most of which has happened in the past 35 years, is being driven largely by increased carbon dioxide and other man-made emissions into the atmosphere. We've now had 627 months warmer than normal, when compared with an 1881-1910 baseline. If you were born later than December 1964, you've never known a month cooler than average, according to Climate Central.

The Paris Agreement:

Years in the making, the Paris Agreement, signed by 196 nations in 2015, aims to keep global temperature increase well below 2 degrees Celsius above pre-industrial levels, and if possible, below 1.5 degrees Celsius. This can only be achieved if countries stick to their commitments to significantly reduce greenhouse gas emissions. During his campaign, President Donald Trump promised to withdraw the US from the landmark agreement.

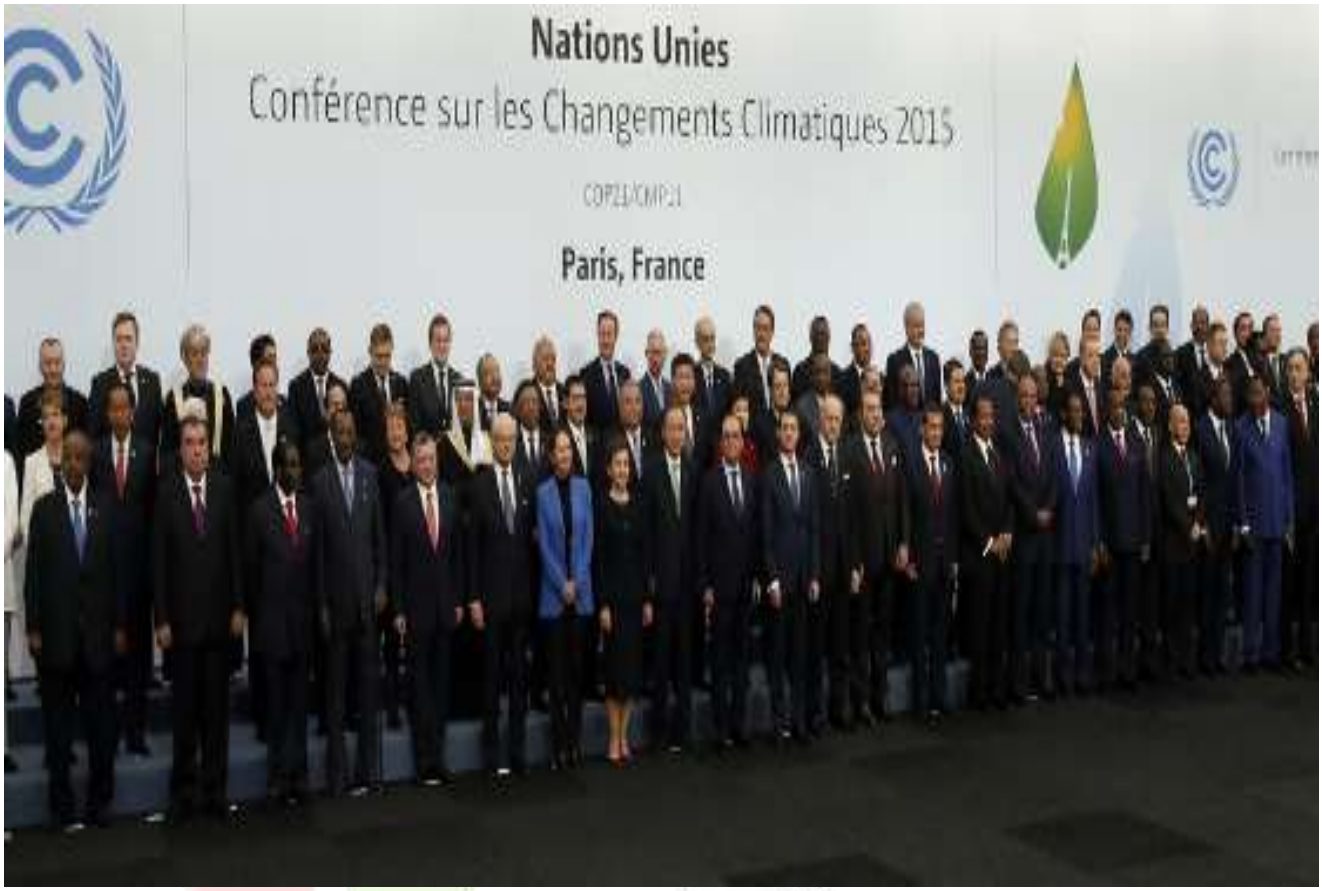

Fig.5- Facts about global warming: Paris Climate Agreement aims to keep global temperature increase below 2 degrees.

Carbon dioxide emissions:

Air bubbles in glaciers provide a record of temperature and carbon dioxide stretching back 800,000 years, so scientists know the planet has experienced global warming before. But this "paleoclimate" evidence also shows that the current warming is happening much more rapidly than in the past. The primary cause is the emission of greenhouse gases into the atmosphere, mostly carbon dioxide, which form a blanket that traps heat at the Earth's surface. Human activities such as burning oil, coal and natural gas and deforestation have increased the amount of carbon dioxide by more than a third since the Industrial Revolution began.

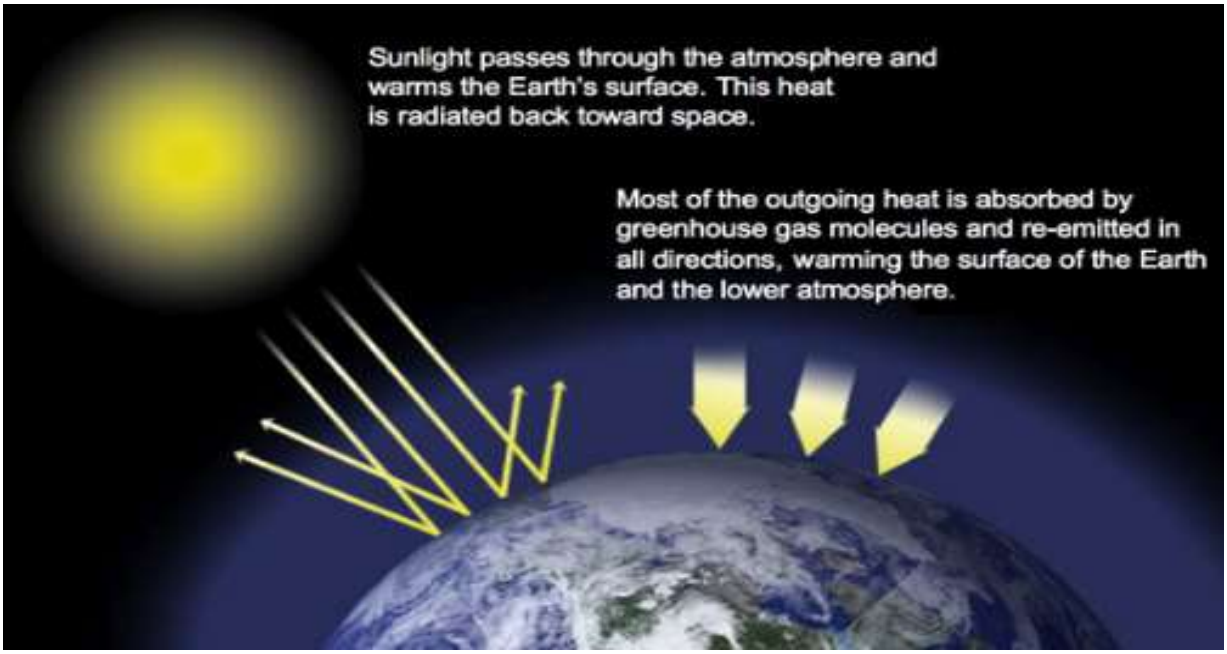

Fig.6 - Facts about global warming: The current warming is happening at a much faster rate

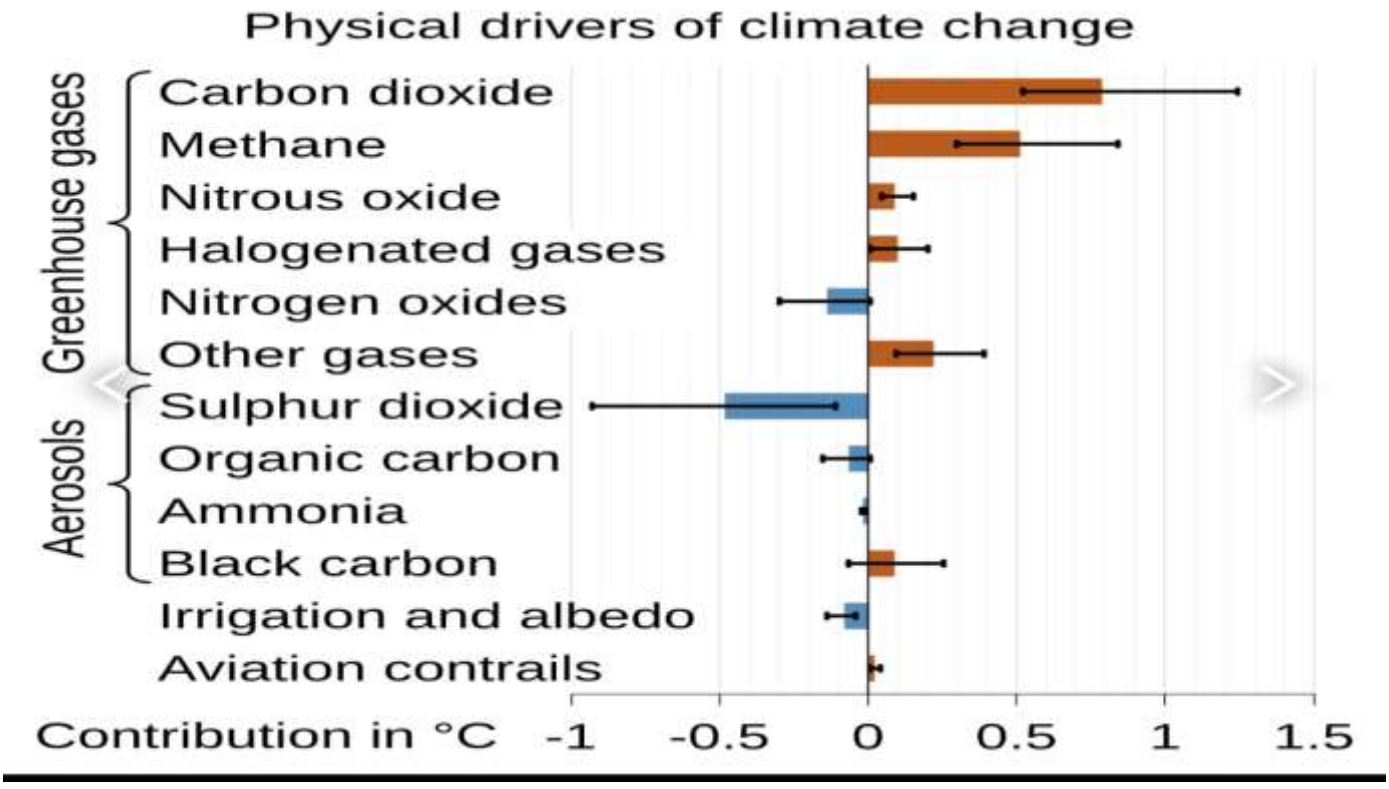

Fig.7

<u>Freak weather</u>:

Another global warming fact is that rising global temperatures affect rainfall in many places and increase the chances of extreme weather events such as floods, droughts or heat waves occurring. Climate-related disasters worldwide have more than tripled since 1980. The US experienced 32 weather events between 2011 and 2013 that each caused at least $1 billion in damage.

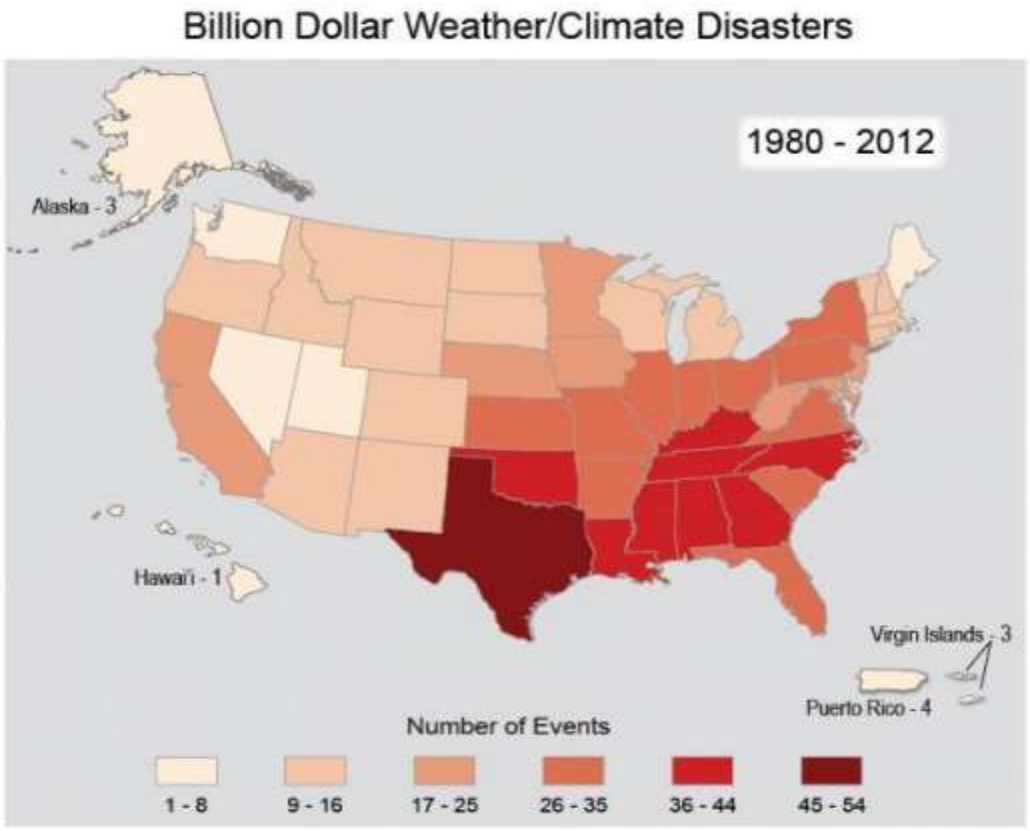

Fig.8- Rising sea levels due to global warming

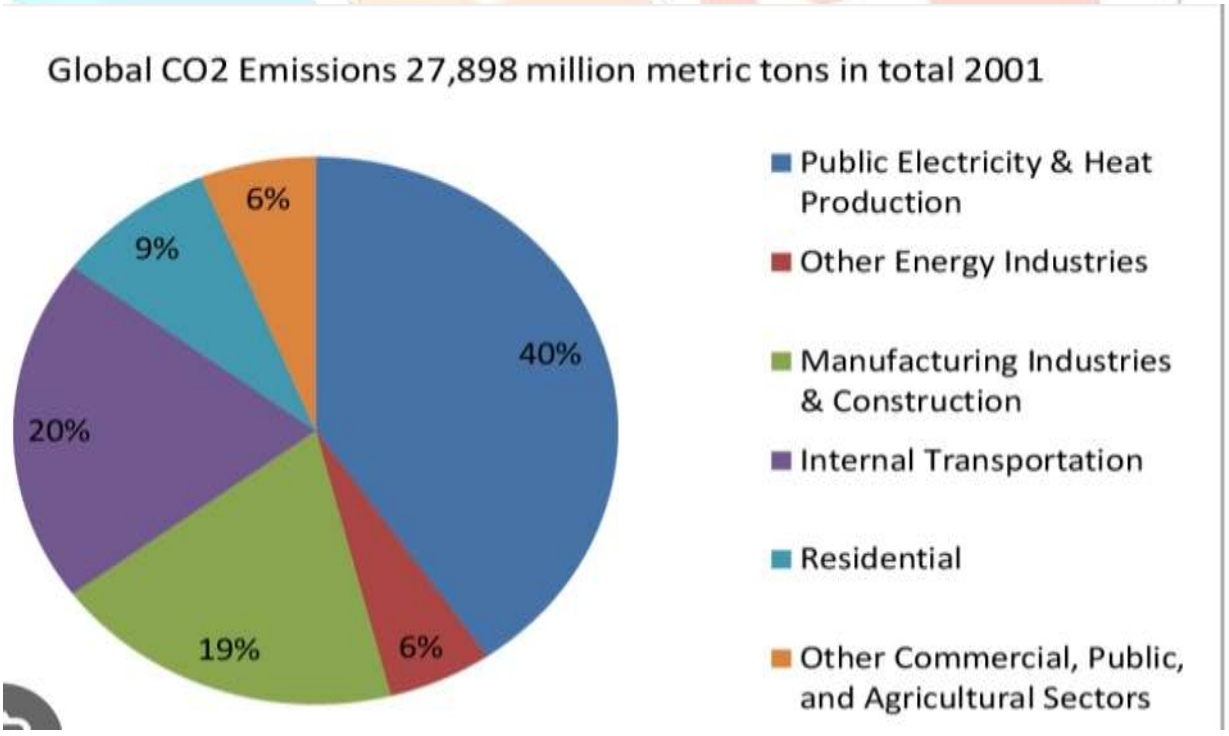

Fig.9

The planet's oceans are also seeing big changes – they're becoming warmer and more acidic, glaciers and ice sheets are melting and sea levels are rising. The Intergovernmental Panel on Climate Change (IPCC) projects a sea-level rise of 52-98cm by the end of this century if greenhouse gas emissions continue to grow, or of 28-61cm if they're significantly reduced.

Polar ice:

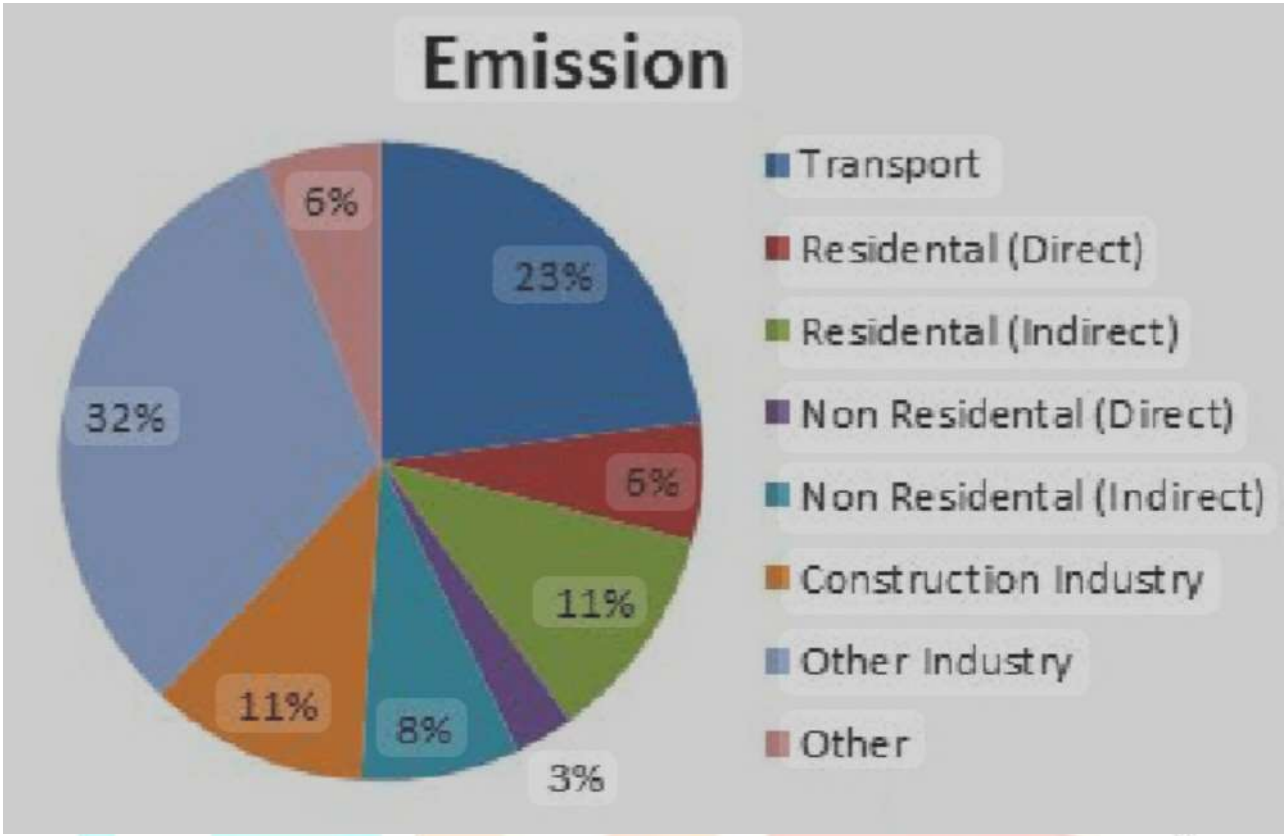

Fig.10

Another fact about global warming is about polar ice. Arctic sea ice is not only shrinking, but the oldest ice is melting, which makes it even more vulnerable to melting in future. But the real climate wildcard is Antarctica's ice sheet. The IPCC estimated it could contribute about 20cm of sea-level rise this century, but also warned of the possibility it could be several tens of centimetres more if the ice sheet became rapidly destabilized. Technology can help us to save our oceans. Here are three reasons why The previous industrial revolutions broke the environment. Can the current one fix it? This is who's responsible for the Arctic?

Deforestation:

Fig.11

Trees absorb carbon dioxide as they grow, acting as a "carbon sink". Cutting them down means more greenhouse gases entering the atmosphere, which speeds up the pace and severity of climate change. One of the important facts about global warming with respect to forests is that it still covers about

30% of the land, but some 50,000 square miles of forest are lost each year. That's equivalent to 48 football fields every minute. In the Amazon, for example, around 17% of the forest has been lost in the last 50 years.

Fig.12- Facts about global warming: 17% of the forest has been lost in the last 50 years

Fig.13

Coral reef bleaching:

In the past 30 years, the world has lost 50% of corals and it is estimated that only 10% will survive beyond 2050, and is one of the most noteworthy facts about global warming is for real. Climate change and rising ocean temperatures are the

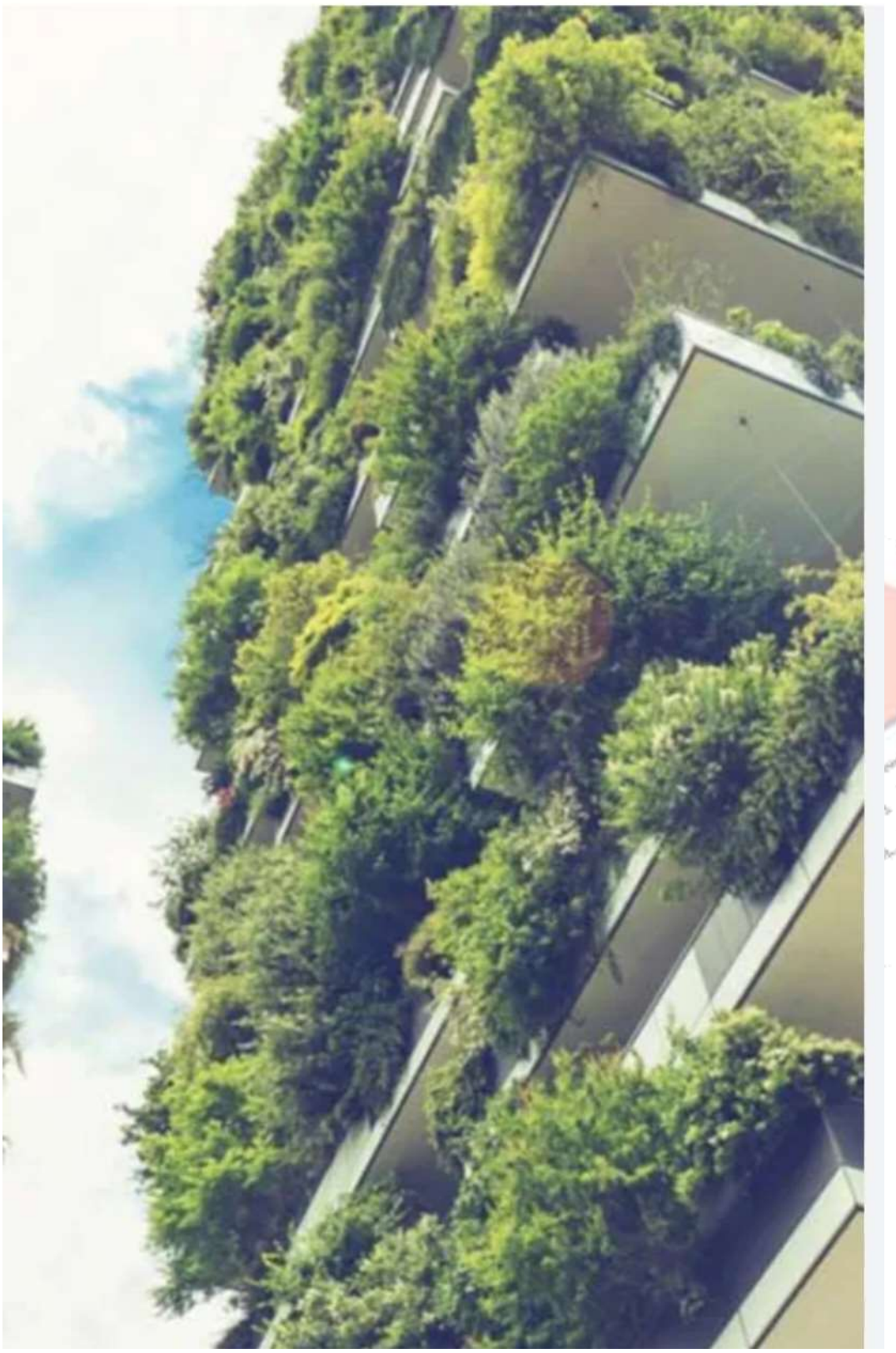

Fig.14

greatest threat and are behind the mass bleaching along Australia's Great Barrier Reef for the second year in a row. Bleaching occurs when extreme heat, pollution or low tides cause coral to expel algae living in their tissues, turning them white. Coral can recover from bleaching events, but they are under more stress and if the algae loss continues they eventually die.

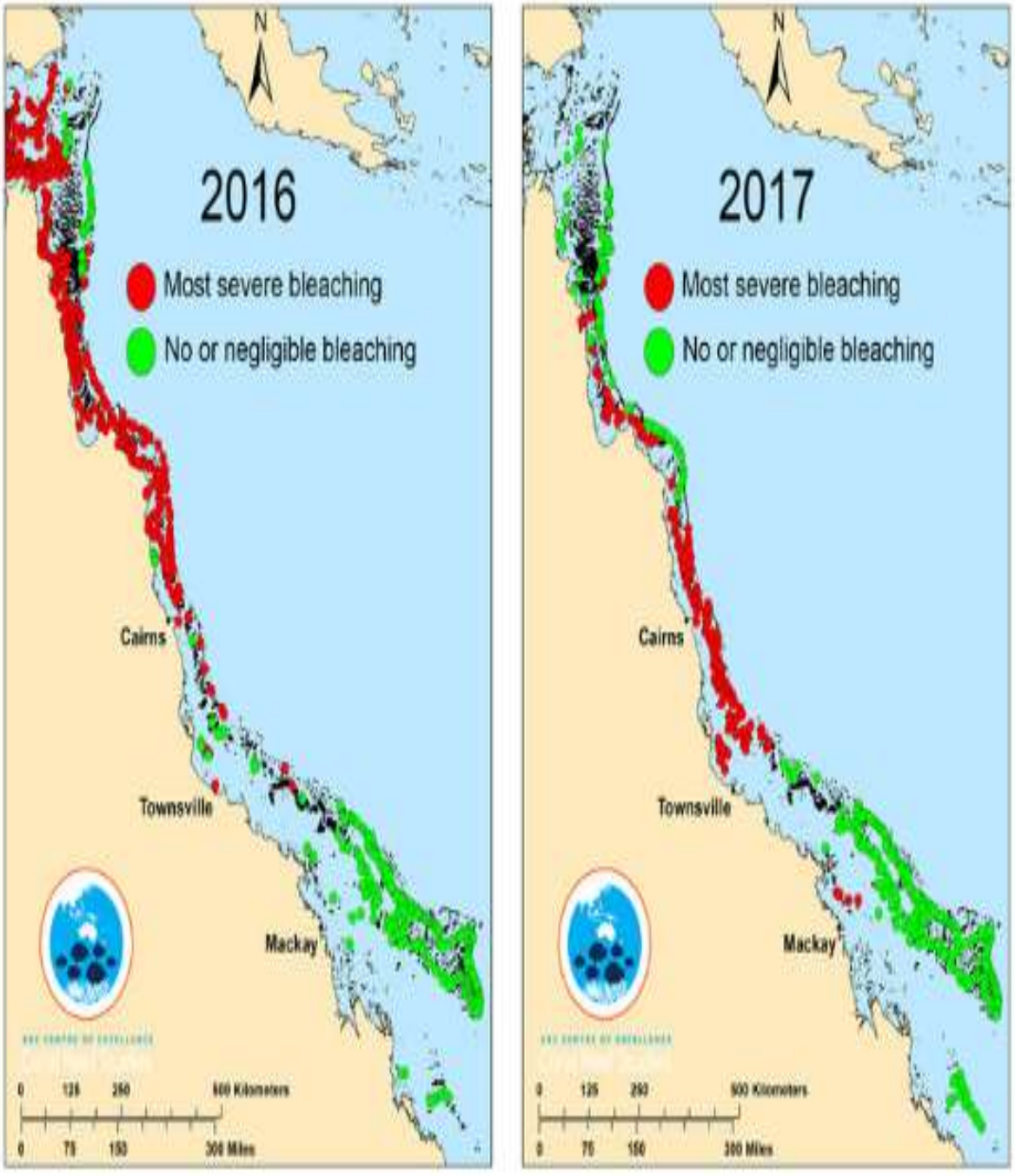

Fig.15- Facts about global warming: The world has lost 50% of its corals

<u>The impact of global warming on humans and animals:</u>

People are already suffering the consequences of climate change. Around 22.5 million people were displaced by climate or weather-related disasters between 2008 and 2015, according to the UN Refugee Agency (UNHCR). Climate change is also a factor in conflicts driving people from their homes which is an often ignored fact related to global warming. The UNHCR says that natural

resources such as drinking water are likely to become more scarce and food security will become an even bigger concern in future because some crops and livestock won't survive in parts of the world if conditions become too hot and dry, or cold and wet. Climate change is also threatening wildlife: using satellite data from NASA, scientists estimate a possible 30% drop in the global population of polar bears over the next 35 years. That's because sea ice is their main habitat, and it is shrinking.

Fig.16

Fig.17- Facts about global warming: Climate change is threatening both humans and wildlife

Global warming is considered one of the greatest challenges worldwide. International environmental agreements have been developed in response to climate change since the 1970s. The construction industry is considered to be one of the main contributors to global warming. According to the Inter governmental Panel on Climate Change not only is the construction industry responsible for about 40% of global energy consumption, it is also responsible for 30% of global green house gas emissions per annum. Furthermore, it is common for most countries to construct high-rise buildings and larger-sized facilities, due to the rapid growth of population Considering the materials consumption costs, durability, and the environmental impacts, a more in-depth study is necessary to evaluate the influence of the concrete cover thicknesses over the structure's life cycle. Studies that evaluate the environmental impacts of reinforced concrete slabs are relatively scarce (Paik and Na, 2019). Besides that, there are very few studies investigating the concrete cover thickness as a principal subject, and none thus far evaluate its effect on the structure's life cycle. The cement production and steel are the main contributors to many environmental impacts in structures of conventional concrete (Paik and Na, 2019) and the production of steel and concrete has a higher embodied energy than the other materials as found by Life Cycle Costs and impacts of massive slabs with varying concrete cover systems. In this study, reinforcing bars were the main contributor to lowering the carbon dioxide emissions in the flat plate slab and voided slab systems. The results of this study show that amongst all the three different slab systems, the voided slab system shows the greatest reduction potential. Moreover, replacing the ordinary reinforced concrete slab system by alternative methods would make it possible to reduce the carbon dioxide emissions in building projects. The devastating environmental changes like global warming, acidification, smog formation, ozone layer and natural resources depletion, biological diversity losses, waste accumulation, etc. are highlighting construction industry as a worldwide agitating sector. More than 40% of world's natural resources and energy are consumed by buildings and about 33% of the total carbon dioxide (CO2) is emitted by buildings . In the traditional method. Green building also known as green construction or sustainable building refers to both a structure and the application of processes that are Environmentally responsible and resource-efficient throughout a building's life-cycle: from planning to design, construction, operation, maintenance, renovation, and demolition. This requires close cooperation of the contractor, the architects, the engineers, and the client at all project stages. TheGreen Building practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building also refers to saving resources to the maximum extent, including energy saving, land saving, water saving, material saving, etc., during the whole life cycle of the building, protecting the environment and reducing pollution, providing people with healthy, comfortable and efficient use of space, and being in harmony with nature

Buildings that live in harmony. Green building technology focuses on low consumption, high efficiency, economy, environmental protection, integration and optimization. Leadership in Energy and Environmental Design (LEED) is a set of rating Systems for the design, construction, operation, and maintenance of green buildings which was developed by the U.S. Green Building Council. Other certificate systems that confirm the sustainability of buildings are the British BREEAM (Building Research Establishment Environmental Assessment Method) for buildings and large-scale developments or the DGNB System (Deutsche Gesellschaft for Nachhaltiges Bauen e.V.) which benchmarks the sustainability performance of buildings, indoor environments and districts. Currently, the World Green Building Council is conducting research on the effects of green buildings on the health and productivity of their users and is working with the World Bank to promote Green Buildings in Emerging Markets through EDGE (Excellence in Design for Greater Efficiencies) Market Transformation Program and certification. There are also other tools such as Green Star in Australia, Global Sustainability Assessment System (GSAS) used in the Middle East and the Green Building Index (GBI) predominantly used in Malaysia. Building information modeling(BIM) is a process involving the generation and management of digital representations of physical and functional characteristics of places. Building information models (BIMs) are files (often

but not always in proprietary formats and containing proprietary data) which can be extracted, exchanged, or networked to support decision-making regarding a building or other built asset. Current BIM software is used by individuals, businesses, and government agencies who plan, design, construct, operate and maintain diverse physical infrastructures, such as water, refuse, electricity, gas, communication utilities, roads, railways, bridges, ports, and tunnels. Although new technologies are constantly being developed to complement current practices in creating greener structures, the common objective of green buildings is to reduce the overall impact of the built environment on human health and the natural environment by:

1. **Efficiently using energy, water, and other resources.**

2. **Protecting occupant health and improving employee productivity.**

3. Reducing waste, pollution, and environmental degradation Natural building is a similar concept, usually on a smaller scale and focusing on the use of locally available natural materials Other related topics include sustainable design and green architecture. Sustainability may be defined as meeting the needs of present generations without compromising the ability of future generations to meet their needs. Although some green building programs don't address the issue of retrofitting existing homes, others do, especially through public schemes for energy efficient refurbishment, Green construction principles can easily be applied to retrofit work as well as new construction.

A 2009 report by the U.S. General services Administration found 12 sustainably-designed buildings that cost less to operate and have excellent energy performance. In addition, occupants were overall more satisfied with the building than those in typical commercial buildings. These are eco-friendly buildings.

THE ROLE OF DEFORESTATION IN CLIMATE CHANGE AND HOW CAN 'REDUCING EMISSIONS FROM DEFORESTATION AND DEGRADATION' (REDD+) HELP:

The scale of deforestation and its role in climate change:

Fig.18

Fig.19

Fig.20

Deforestation refers to the purposeful clearing or thinning of trees and forests. When deforestation occurs, much of the carbon stored by trees is released back into the atmosphere as carbon dioxide, which contributes to climate change. In the last decade, the largest amounts of deforestation occurred across the humid tropics, mostly in Africa, followed by South America. The UN Food and Agriculture Organisation (FAO) estimates that around 420 million hectares of forest were lost between 1990 and 2020 (or 178 million hectares net, i.e. taking into account afforestation and the natural expansion of forests). The annual rate of deforestation has since slowed but was still 10 million hectares per year between 2015 and 2020. The most important driver of deforestation is the global demand for

agricultural commodities: agribusinesses clear huge tracts of forest and use the land to plant high-value cash crops like palm oil and soya, and for cattle ranching.

Land use change, principally deforestation, contributes 12–20% of global greenhouse gas emissions. Forest degradation (changes that negatively affect a forest's structure or function but that do not decrease its area), and the destruction of tropical peatlands, also contribute to these emissions. As a result of deforestation and degradation, some tropical forests now emit more carbon than they capture, turning them from a carbon 'sink' into a carbon source. For example, the south-eastern part of the Amazon Rainforest is now considered a net carbon source by scientists.

Where does 'REDD+' come in?

Scientists have recognised the value of protecting forests in tackling climate change. In response, policymakers have developed a family of policies – collectively known as 'reducing emissions from deforestation and degradation' (REDD) – to provide a financial incentive to governments, agribusinesses and communities to maintain and possibly increase, rather than reduce, forest cover. The plus in 'REDD+' refers to "the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries". Under REDD+, incentives for forest protection are offered to countries, communities and individual landowners in exchange for slowing deforestation, and carrying out activities that promote reforestation and sustainable forest management. Where local people are properly involved in the REDD+ process it may also help alleviate rural poverty. The principles of REDD+ were further reinforced in the Paris Agreement on climate change.

REDD+ policies operate through a variety of mechanisms, including those administered by the United Nations (UN-REDD) and the World Bank (the Forest Carbon Partnership Facility). REDD+ finance is also considered in the international climate change negotiations, remains a key component of international climate finance discussions, and is often channelled through the voluntary carbon markets and via activities implemented by for- and non-profit organisations.

How fair, effective and efficient is REDD+ :

While experts have demonstrated how REDD+ has the potential to reduce CO_2 emissions, it is not without its problems. For example, some question the fairness of a scheme that focuses on reducing emissions caused by some of the world's poorest people while emissions continue to rise in richer countries. Some developing countries may be wary of foreign interference in their land use policies. Researchers also highlight operational concerns – such as the difficulty in monitoring and measuring deforestation rates, or attributing changes in deforestation to REDD+ finance. Variations in local circumstances and institutional capacities mean that not all countries that have tropical forests possess the capabilities to address these challenges.

How much REDD+ finance has been pledged :

Estimates of the global cost of REDD+ vary greatly, but at least US$15 billion would be needed annually to address tropical deforestation across the world. Current funding remains far off this mark: according to a 2020 review, between 2015 and 2019 an average of US$220 million a year of funding was approved. The Amazon Fund, with US$720 million of approved projects, remains the largest dedicated REDD+ fund. Without sufficient finance, it can be difficult to protect forests, as alternative land uses (such as for palm oil) can offer more immediate and guaranteed cash returns. Consequently, many experts have called for a scaling up of commitments and finance flows, although some have argued that even if large-scale REDD+ finance does materialise it may still struggle to compete with other land uses – especially as and when commodity prices rise. Whatever becomes of REDD+ in the future, experts agree it should focus first on areas that can most efficiently provide CO_2 reductions (such as tropical peat swamp forests) while also offering the potential for biodiversity conservation and poverty alleviation. This Explainer was updated in February 2023 by Charles

Palmer, Natalie Pearson and Georgina Kyriacou. The original was reproduced from: *What's REDD and will it help tackle climate change?*, a collaboration between the Grantham Research Institute and the Guardian, © The Guardian 2012, used under a Creative Commons No Derivative Works licence.

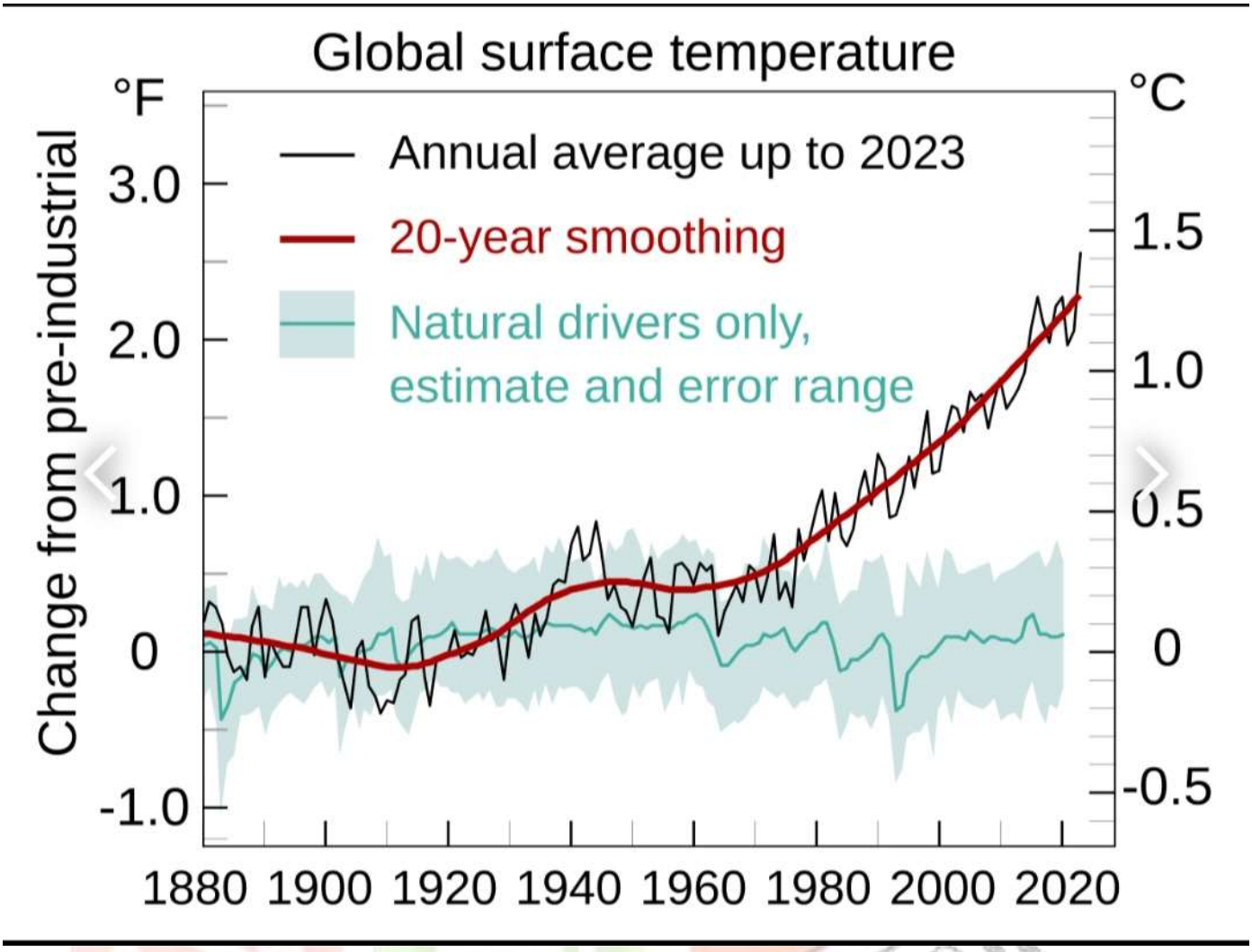

Fig.21

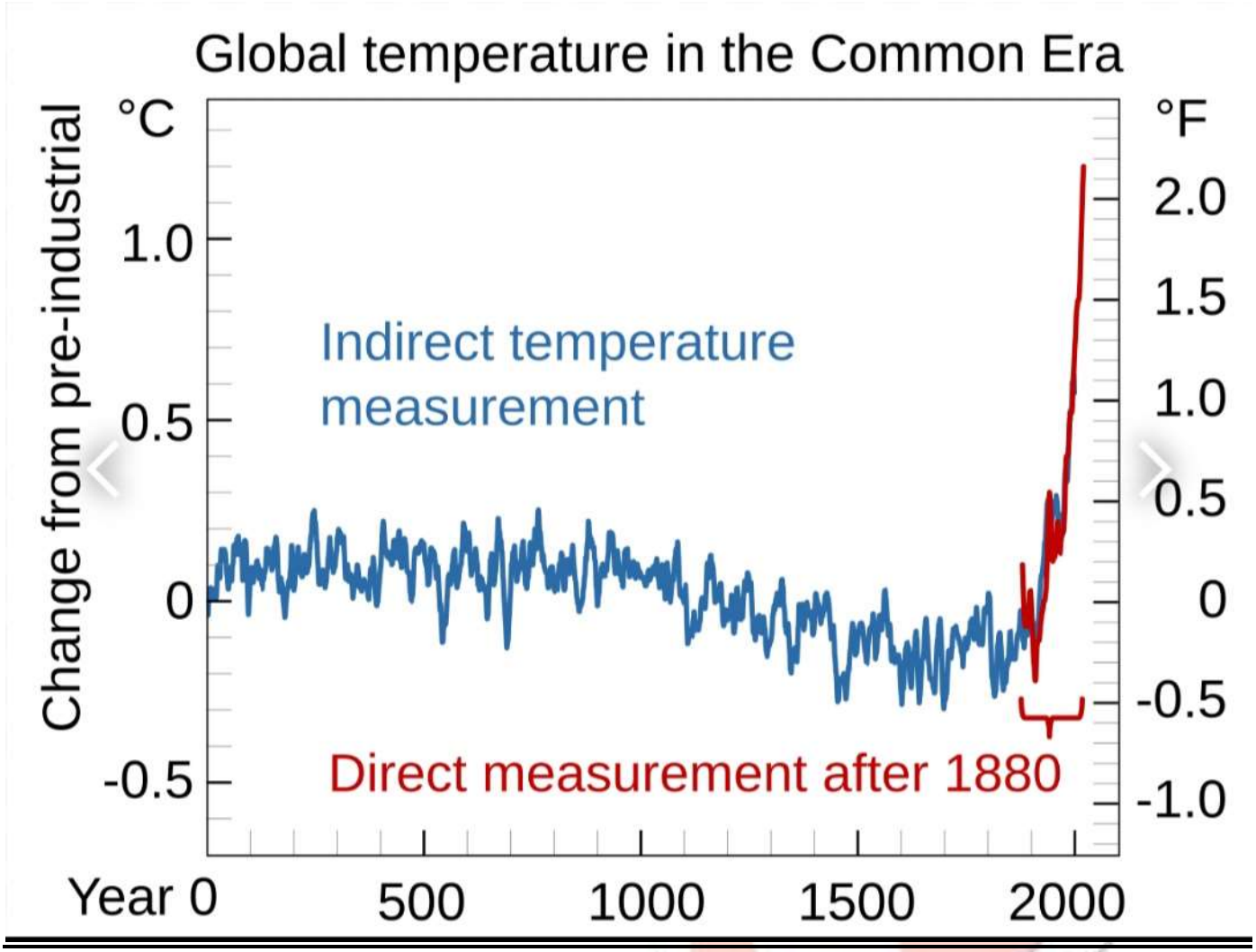
Global temperature in the Common Era
Change from pre-industrial
°C
1.0
0.5
0
-0.5
°F
2.0
1.5
1.0
0.5
0
-0.5
-1.0
Indirect temperature measurement
Direct measurement after 1880
Year 0
500
1000
1500
2000

Fig.22

Fig.23

Conclusion:

1. **Environmental action cannot wait. We are positioned as the global leader in driving integrated climate solutions for public and private organizations around the world.**
2. **Changes in surface air temperature over the past 50 years. The Arctic has warmed the most, and temperatures on land have generally increased more than sea surface temperatures.**
3. **Earth's average surface air temperature has increased almost 1.5 °C (about 2.5 °F) since the Industrial Revolution. Natural forces cause some variability, but the 20-year average shows the progressive influence of human activity.**
4. **Changes in global surface temperature from 1880 to 2023 (black line) relative to 1850–1900 average. Annual data from NASA here: https://climate.nasa.gov/vital-signs/global-temperature/. IPCC anomaly is 1.09 C average from 2011 to 2020 as per IPCC AR6 WG1 SPM pp5 A.1.2, so NASA data is offset to that number. Data does not go back to 1850 as datasets differ from 1850 to 1880 for NOAA, others (NASA starts in 1880, and all tend to agree from that point forward). 20-year LOWESS smooth matched to 20 year moving average as per IPCC AR6 standard for determining current warming levels. Natural influence based on CMIP6 climate model simulations of the temperature response to natural drivers only (solar and volcanic activity, green). Colored shade shows the "very likely" range of simulations. Source: IPCC AR6 WGI, Figure SPM.1b, p. SPM-7. See File:Global Temperature And Forces.svg for a version without Fahrenheit.**
5. **Climate Impact X: Comprehensive Marketplace for Carbon Credits and Environmental Solution. Our Easy-To-Use Platform Features A Wide Range Of Quality Projects From Around The World. CIX Marketplace: Join Now. Offset carbon footprint. Make a difference, today! Join the climate movement.**
6. **Weekly rain prove - Finding Water Source Is a Research, but Making It Rain Is an Invention.**
7. **Global warming describes a change in the world's overall climate that results in rising temperatures over long-term periods of time and across the planet.**
8. **Most scientists agree that man-made climate change, or global warming, began in earnest during the industrial**

   revolution, which occurred between the 18th and 19th centuries.
9. **Global warming occurs when the levels of greenhouse gases in the atmosphere increase, causing more solar energy to be trapped in the climate system.**
10. **Global warming occurs when carbon dioxide (CO 2) and other air pollutants collect in the atmosphere and absorb sunlight and solar radiation that have bounced.**

Fig.24

Fig.25

Fig.26

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