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Emerging Trends of ICT and Global Warming

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ABSTRACT

The era of information technology is now. People's lifestyles have changed as a result. Seldom is there an aspect of human existence that is unaffected by information technology. Numerous technological trends are expanding quickly, including social media, cloud computing, mobile computing, and ubiquitous computing. Every facet of environmental research has already included Internet and communication technology (ICT) techniques. Research trends and advancements in ICT help understand how ICT emerged and how it may play a role in climate change in the future. This study used network visualization, bibliometric indicators, and the Scopus database to evaluate ICT solutions in climate change research trends. Climate change poses a threat to global people' quality of life, access to essential services, economic gains, social and economic progress, and increased susceptibility. The planet is rapidly approaching the environmental "tipping point," according to recent UN data. A shift toward a circular economy (CE) is urgently needed, and information and communication technologies (ICTs) have some promise in addressing the world's most severe climate challenges. ICTs can be used as tools for both mitigating and adapting to climate change as well as for monitoring it. Emissions and solid waste from other (non-ICT) sectors of the economy can be reduced by ICTs because their primary output is information rather than tangible commodities, a phenomenon frequently referred to as "dematerialization." This paper will talk about. Emerging Trends in ICT and Global Warming.

KEYWORDS:

Global Warming, Information Technology, Cloud Computing, Mobile Computing, social media, Climate Change, Communication, Emerging Trends, Greenhouse, Economic Growth, Artificial Intelligence, Blockchain.

Introduction:

Almost every aspect of human existence, including communication, business, healthcare, education, and daily routines, has been impacted by information technology. We can gather, manage, and connect vast amounts of data and information with the use of information technology. The rapid growth of several IT technologies, such as social media, cloud

computing, and mobile computing, is altering how tasks are done. We may essentially obtain hardware and software resources on a pay-per-use basis through cloud computing. This assists both individuals and businesses in avoid the installation of heavy, expensive software on their systems. We can access platforms, apps, and infrastructure over the internet thanks to cloud computing. Users of mobile devices can access and analyze data at the same speed as a desktop computer because of mobile computing. Social media facilitates incredibly user-friendly interaction with people all around the world. These days, wireless devices are getting really popular. [1]

Global Warming:

The planet's average temperature increasing over time is known as global warming. The combustion of fossil fuels has caused this warming trend, which has been around for a long time, to accelerate up a great deal speed in the recent decade. The amount of fossil fuels burned has increased along with the human population. Burning fossil fuels, such as coal, oil, and natural gas, results in the "greenhouse effect" in the atmosphere of Earth.

The sun's rays can enter the atmosphere and cause the greenhouse effect when they reflect off surfaces, preventing the heat from escaping back into space. Heat cannot escape the atmosphere due to gases released during the burning of fossil fuels. Carbon dioxide, water vapor, methane, nitrous oxide, and chlorofluorocarbons are some examples of these greenhouse gases. world warming, as the term implies, is the gradual increase in the average world temperature due to the surplus heat in the atmosphere.

The industrialized nations have dominated the worldwide conversation over the possibility of ICT-enabled climate change mitigation. The governments are requesting large reductions in greenhouse gas emissions in this region, where the current levels of overall greenhouse gas (GHG) emissions are highest, and where a few prominent enterprises are already making contributions to the development and use of low-carbon solutions. Nonetheless, given that the world's growing economies are predicted to account for an important amount of future emissions increase, these nations urgently need to shift to low-carbon development pathways. Along this route, the global requirement to drastically reduce GHG emissions would be balanced with the need for economic growth. [2]

Over the past 70 years, the information and communication technology (ICT) industry has experienced tremendous and rapid expansion. The potential environmental implications of ICT, particularly in relation to climate change, are receiving increasing attention due to its current significance. ICT has an increasing "carbon footprint" because to greenhouse gasses (GHG) released during every stage of its life cycle. This include use or operational emissions (from energy use and maintenance), end-of-life emissions (disposal), and embodied emissions (the GHG emissions produced from the extraction of raw materials required, the manufacturing process, and transit to the business or user). Estimates of the influence of ICT, however, are hotly debated, with views varying as to whether it is actually increasing, staying constant, or even decreasing due to efficiency increases and Moore's Law. The potential of ICT to decarbonize other sectors is something that more and more recognize. Some contend that this "enablement" is a crucial component of the carbon neutrality path and that it mostly ignores or rationalizes the actual environmental impact of ICT.

One of the main concerns facing life on Earth is the effects of human activity on the environment, namely on climate change. Simultaneously, information and communication technologies (ICTs) are being quickly implemented globally. ICTs present fresh ways to both alleviate and adapt to climate change, despite their energy resource requirements. ICTs support raising awareness, preservation of the environment, carbon emission reduction, and the monitoring and analysis of both short- and long-term climate trends. [3]

This century's global research agenda is set by environmental challenges. Policies for mitigating and adapting to climate change have an impact on many facets of the national and international social and environmental discourse. In the fight against and description of research trends and readiness to address climate change, ICT, analytical tools, and frameworks for the communication of respecting challenges are essential components.

When discussing climate change, innovation, and digitalization today, sustainability and the established goals serve as the standard. Climate change and energy systems management are two topics covered under the eleventh and thirteenth sustainable development objectives, sometimes known as smart cities and climate action. ICT can offer answers, but there are also concerns about how technology is used. Concerns are voiced regarding ICT's effects on the environment, the energy needed for their administration and production, the energy systems' resilience, their life cycle, the materials used in their construction, and the escalation of their industrial output. As a result, it is crucial to concentrate on investigating the scientific information included in ICT related to climate change. Applications for the internet and communication technologies conceive issues and their solutions, as well as the dangers and consequences of climate change and global warming on water supply, agriculture, energy efficiency, renewable energy, weather phenomena, food systems, and sustainable development. Furthermore, big data and data analytics are the buzzwords of the century that followed. The integration of digital environmental sciences into ICT products offers a modern framework for addressing the views and difficulties associated with climate change.

- **Artificial Intelligence and Cybersecurity:**

Artificial intelligence, or AI, is one of the ICT developments that is expected to grow further this year. Since the main goal of this technology is to increase data security on smart networks, businesses should prioritize maximizing the security features of smart devices. AI offers proactive cybersecurity solutions, makes it possible to automate decision-making procedures successfully, and builds patterns from incomplete or altered data as its algorithms pick up on information about actual dangers. This helps cybersecurity specialists to create action protocols by enabling faster threat detection, achieving a lower margin of error, and forecasting assaults.

- **Blockchain, one of the most secure ICT trends:**

Blockchain technology ensures that data genuineness stays constant by doing away with party mediation and sole control over information thanks to its decentralized approach. To enable the automation of transactions and communications, the data are thus stored in a highly safe and encrypted way, thereby providing an unquestionable boost to digital identity.

Blockchain is extremely effective, dependable, and safe in a variety of applications, in addition to expediting verification procedures and thwarting fraud and cyberattacks. The fact that it will enhance data tracking, create new billing systems, host patents, monitor sales processes, protect health data, and other benefits makes it crucial for organizations in the years to come.

- **Machine Learning (ML):**

With machine learning, we can now extract insights from vast amounts of data, which has greatly advanced technology in recent years.

Trend: Automated machine learning (Auto ML) is still evolving.

Although machine learning has provided us with a plethora of applications recently, automated machine learning is going to be the big breakthrough in machine learning. The development of learning models for machine learning requires a significant amount of time and resources, notwithstanding its value. To lighten the load on technical resources, Auto ML automates a number of tedious and repetitive operations, like parameter selection and data cleansing. Auto ML further improves the usability of the technology for non-technical individuals by using algorithms rather than humans to create learning models.

- **Cloud Computing:**

Following spending reductions in 2021, cloud computing is seeing a resurgence and is a sector in which businesses are investing heavily, particularly in the context of digital transformations. In addition to giving company executives the ability to set access levels for their team members, cloud computing offers a practical solution for data storage. This allows employees to perform their jobs from any location. [4]

Review of Literature:

Global warming is not the only aspect of climate change. The occurrence and intensity of weather events are altered by the global climate, which also puts more strain on ecosystems and society.

Storms, fires, floods, and heatwaves are among the natural weather phenomena that are made worse by climate change brought on by human activity (CO_2, CH_4, HFCs, and N_2O emissions) (Sahil and Sood, 2021). According to the Intergovernmental Panel on Climate Change (IPCC), there will be a 1.5°C increase in global temperature and a corresponding rise in natural disasters. [5]

Mitigation:

Interest in the effects of ICTs on the environment, as well as research on their potential role in both contributing to and mitigating climate change, has increased as scientific evidence of climate change continues to emerge and awareness of the rapidly accumulating greenhouse gases (mainly CO_2) has grown.

It's critical to first determine the domains in which ICTs are impacted in order to fully appreciate their potential in the subject of climate change. In their examination of ICTs and mitigating climate change, experts in the field have proposed the following categories (Labelle et al., 2008). [6]

Global climate change cannot be overlooked or ignored. It is a stark fact, and as major climate changes are the root cause of a rising frequency of natural disaster occurrence, we will be prepared to deal with their grave effects. Global warming, altered weather patterns, a strong monsoon, unforeseen rainfall, fast urbanization, pollution, and industrialization, crop losses from periods of drought, increased river levels owing to glacier melting, and flash floods are some of the effects of climate change.

Both the environment and human activity are impacted by climate change. Climate change is defined by the IPCC (2007) as a change in climate that has an adverse effect on the environment and human existence, whether it is caused by humans or by natural processes.

The "United Nations Framework Convention on Climate Change(2007)" states that the main causes of climate change include droughts, heat waves, bush fires, and rises in the average world temperature. River water levels are rising as a result of glacier melting, and floods are becoming more intense and frequent. One of the main contributors to rising ocean temperatures and acidity is the constant absorption of heat and carbon dioxide (CO2) by sea water from the atmosphere. Bana (2013) [7]

Objectives:

- Climate change: Trends and impacts
- Emerging Trends of ICT and Global Warming
- ICT-based Climate Change Mitigation in Emerging Economies

Research Methodology:

The overall design of this study was exploratory. The research paper is an effort that is based on secondary data that was gathered from credible publications, the internet, articles, textbooks, and newspapers. The study's research design is primarily descriptive in nature.

Result and Discussion:

Using ICTs to Monitor the Global Environment/Ecosystem:

The average temperature is expected to increase by 1.1–6.4°C in the 21st century. The distribution of the effects will be unequal, with sub-Saharan Africa at risk from desertification and low-lying coastal communities from increasing sea levels.

The number of refugees from the environment will rise, putting more strain on fragile ecosystems and water sources. ICT systems used for early warning, data distribution, and monitoring of the environment and climate include:

Satellites for monitoring weather that follow typhoons and hurricanes;

- Weather radars that monitor the development of thunderstorms, tornadoes, and large-scale forest fires and volcanoes' effluent;
- Weather data collection and processing radio-based meteorological aid systems, without which the accuracy of weather forecasts both now and in the future would be severely jeopardized;
- Earth observation satellite systems that collect data on the environment, including soil moisture, vegetation, including forest management, agricultural data, ocean parameters (temperature, surface level change), and composition of the atmosphere (CO2, vapor, ozone concentration, etc.);

Disseminating information about various natural and man-made disasters (early warning) and reducing the negative consequences of disasters (disaster relief operations) are also done through satellite and terrestrial systems.

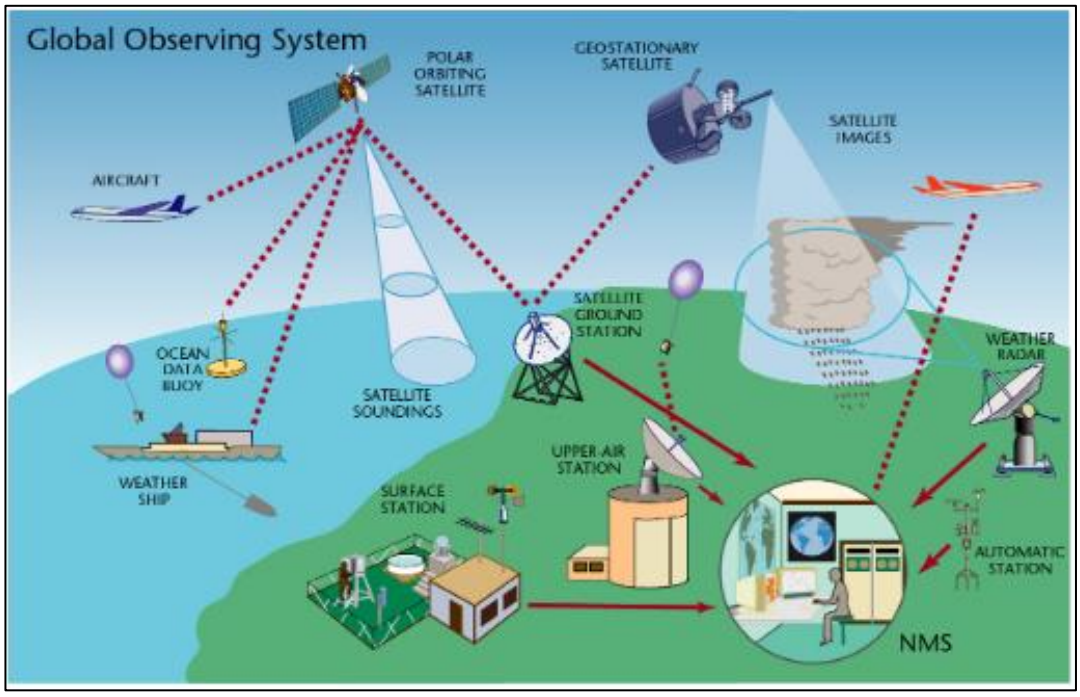

Figure 1: WMO Global Observing System (GOS) (Source: ITU/WMO Handbook "Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction"8) [8]

The Global Observing System (GOS) is made up of all these systems (Figure 1). As the principal technical information source on the Earth's atmosphere, GOS has a sophisticated network of facilities, sophisticated procedures, and methods for monitoring meteorological and environmental variables. The majority of nations use it.

The protection of people and property from extreme weather events like local storms, tornadoes, hurricanes, or extra-tropical and tropical cyclones is one of the most evident advantages of GOS. Specifically, GOS offers observational data for climatology, aviation meteorology, and agrometeorology, which includes the study of climate and global change. Additionally, GOS data are used globally to support environmental activities. [9]

ICT-based Climate Change Mitigation in Emerging Economies:

As we move toward a low-carbon, more sustainable society, ICTs will become increasingly important. They provide solutions that aid in measuring, monitoring, managing, and enabling more effective use of resources and energy, which can be applied in a variety of ways to alleviate the effects of climate change and the environment.

In addition to dematerialization, transit substitution, and more intelligent methods of living, working, and leisure, ICTs provide enormous opportunities for enhancing the performance of infrastructure and systems. By making other industries (including transportation, building, power, and industry) more efficient, the ICT sector has the potential to dramatically contribute to the fight against climate change.

Actually, compared to the ICT sector itself, the potential for reducing emissions through ICT is significantly greater. The Climate Group and the Global e-Sustainability Initiative (GESI) discovered in a report that:

By 2020 (from an estimated total of 51.9 GtCO2e if we continue on a BAU trajectory), ICTs could cut global carbon emissions by 7.8 GtCO2e, which is five times more than their own carbon footprint. The money saved by not using fuel and electricity would total €600 billion. (GESI and The Climate Group, 2008) [10]

Several methods that ICT applications can help lower global greenhouse gas emissions have been extensively discussed. These methods include:

Dematerialization is the practice of substituting "virtual" options, such video conferencing or online buying, for physical products, services, or travel.

Machine-to-machine (M2M) communication, which makes process optimization possible and allows for a significant portion of GHG emission savings. These include things like smart motor systems, smart buildings, smart logistics, and smart grids.

systemic effects, or behavioral changes brought on by ICT use in humans, such as new behaviors and consumption patterns. Customers directly control 35% of all GHG emissions through their own consumption and use, making this a crucial area for intervention. Consumers control or at least impact 60% of all GHG emissions. Global GHG emissions can therefore be significantly reduced by consumer-targeted carbon reduction initiatives.

Some of the most talked-about ICT-enabled GHG emission reductions, together with potential cost and carbon savings, are compiled in Table 1.

Table 1: ICT-based Carbon Solutions (Source: Accenture, 2009)

Areas of savings	Identified Opportunities	Carbon Savings	Cost Savings
Smart Grid	• Reduction in Transmission losses • Integration of renewable energy • Reduction in consumption	2 Gt CO_2e	$125 billion
Smart Building	• Intelligent Commissioning • Building management systems • Voltage optimization	1.52 Gt CO_2e	$442 billion
Smart Logistics	• Optimization of logistics network • Optimization of route planning • In-flight fuel efficiency	1.68 Gt CO_2e	$341 billion
Smart Motor Systems	• ICT smart motor system • ICT-driven automation of industrial processes	1 Gt CO_2e	$107 billion
Dematerialization	• Online-media, e-commerce, e-paper, • telecommuting	1 Gt CO_2e	N/A

With the rapid increase in demand for dependable electrical supplies, transportation infrastructure, and commercial buildings, developing and emerging economies confront a number of issues in providing the necessary infrastructure as their economies grow. Certain economists contend that the challenges encountered in satisfying this demand are motivating investments in more energy-efficient alternatives.

There is a fantastic chance to "leapfrog" to smarter infrastructures and processes and escape the carbon-intensive development stages experienced by established countries, as substantial infrastructure investments are being made in the world's emerging economies. [11]

Summary of ICT Trends:

The three trends we have covered have the potential to significantly increase the footprint of ICT (see Figure 2, and take note that we have expanded the term "user devices" to "devices" in this section to include embedded devices). Even though we have talked about each trend separately, it is crucial to remember that they are connected. The Internet of Things (IoT) has the potential to increase ICT emissions by, for instance, demanding more analytics and raising new concerns related to big data, data science, and artificial intelligence. It also includes gathering more data from sensors. Innovations in the ICT infrastructure will also support these development patterns. For example, the transition from 4G to 5G cellular networks will allow IoT devices to transmit data more quickly and intensively over the network, enabling even more data to be gathered, shared, and processed. Though it's unlikely that the ICT-enabled carbon reductions in other industries would surpass them, all of the aforementioned tendencies, if unchecked, have the potential to contribute to additional exponential growth.

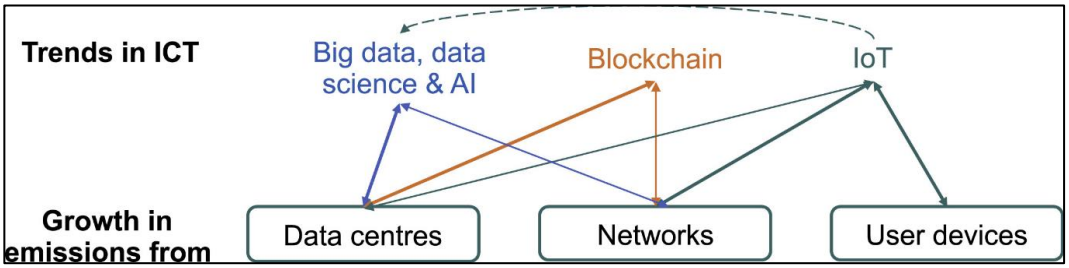

Figure 2: The impacts that trends in ICT have on growth in emissions from data centers, networks, and devices

Keep in mind that the dotted lines show the connections between the trends, thinner lines show secondary dangers, and stronger lines show major threats.

Global economies, civilizations, and cultures can be profoundly impacted by information and communication technologies (ICTs), such as wireless communication, computers, and broadband. ICTs have facilitated the development of digital networks that allow ever-increasing volumes of data and information to travel at ever-faster speeds, and they are a crucial component of the daily lives of billions of people. New models of business, communication, governance, and the environment are all developing around these data, which serve as the foundation for new technologies. Every day, 3 billion producers and consumers worldwide make a variety of decisions that are influenced by ICTs. In the upcoming years, this effect might grow even further. Global trends in ICT and telecommunication are set by the International Telecommunication Union (ITU), which is the UN's specialized body for ICTs. It was discovered that by 2019, over half of the world's population used the Internet, and by 2020, over half of all homes will have access to it. Key global ICT advances are shown in Figure 3.

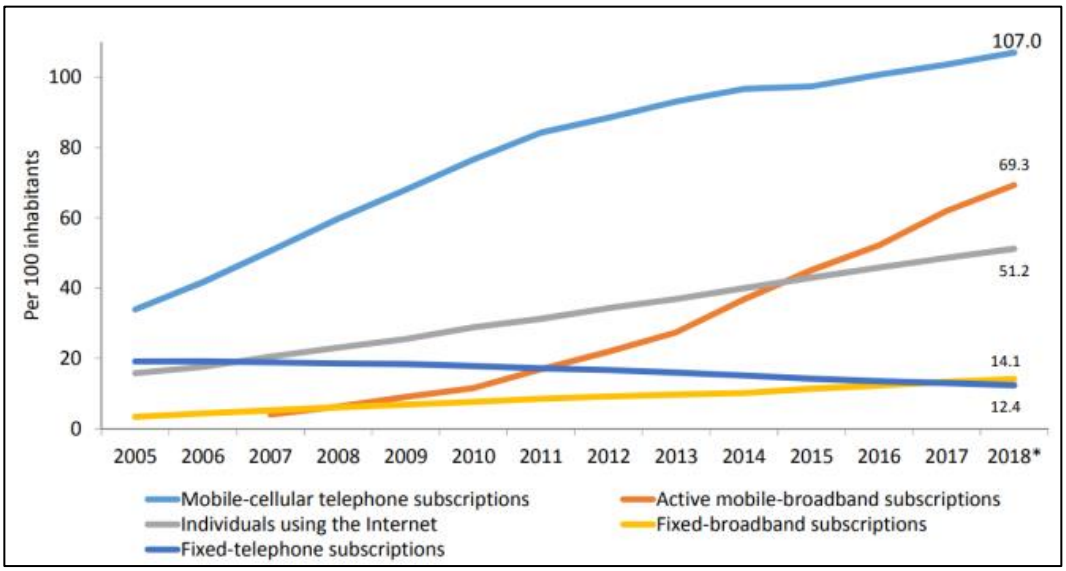

Figure 3: Global ICT developments, 2005–2018 (*ITU estimate)

Therefore, there may be a chance to help address some of the most urgent climate-related issues facing the world given the rising levels of connectivity and ICT use worldwide. Additionally, even though there is no denying that the rising use of ICTs contributes to global warming, these technologies can also be useful for monitoring, reducing, and improving measures for adapting to climate change (as outlined in later sections of this study). In particular, ICTs can help reduce emissions and solid waste that come from other (non-ICT) sectors of the economy because their primary output is information rather than physical commodities, a concept commonly referred to as "dematerialization." [12]

Climate Change: Trends And Impacts:

Figure 4: Climate Change: Trends and Impacts

As a result of the production of greenhouse gases (GHGs), mostly from carbon-based emissions, which increase the greenhouse effect by trapping more heat from the sun, there are a number of factors contributing to climate change that make the globe warmer. Between 1880 and 2012, the average world temperature rose by 0.85°C, which had the opposite effect on crop yields in the two decades that followed 1980.

The steady rise in atmospheric carbon can be seen in the NASA graph (Figure 5) that follows. A warming trend that is "proceeding at a rate that is unprecedented over decades to millennia" is what makes the current trend that correlates with this increase so major. Hurricanes, tropical cyclones, heat waves, droughts, floods, wildfires, and heavy rain and snowfall have become more common and severe as a result of the rising temperatures. The number of geophysical, meteorological, hydrological, and climatological natural loss events recorded worldwide in 2016 was said to have reached 772, which is three times the number that occurred in 1980. Poor and already vulnerable populations are probably the ones that these kinds of catastrophes will effect the most.

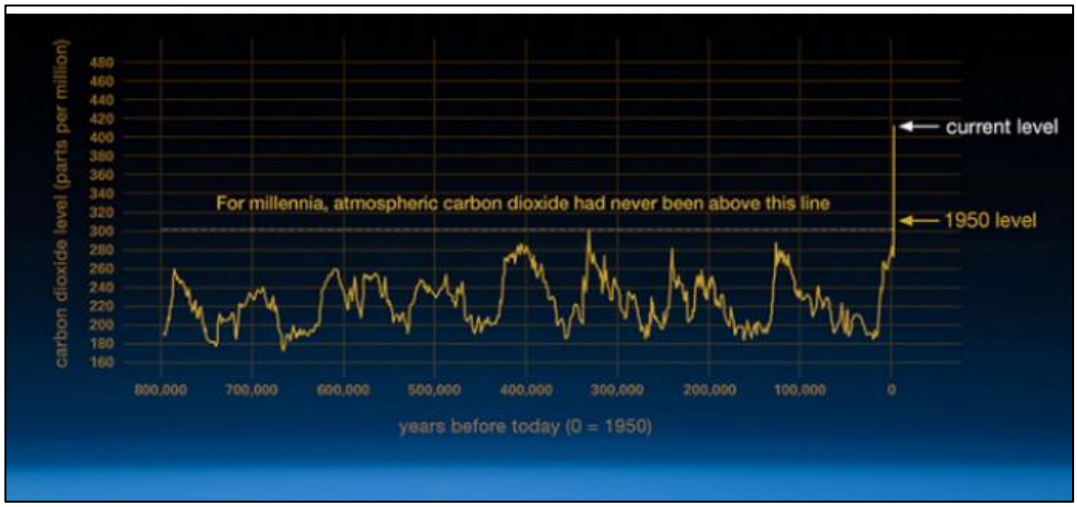

Figure 5: Increase in atmospheric carbon with time

The largest corporations in the world have demonstrated their continuous reliance on fossil fuels in spite of their pledges to transform their operations into more sustainable ones. According to research, the global tech firms' carbon footprints are expanding especially quickly.16 The world's data centers are expanding exponentially, which helps to explain some of this. It is still unknown what effects the ongoing operation, or dismantling of the old data centers, will have on the environment and climate, despite investments being made to ensure that the manufacturing and operations of these new data centers will be as environmentally sustainable as possible (e.g., through water efficiency measures, the use of renewable energy and sustainability certifications). It is still a fact that data centers have a large environmental impact and use enormous amounts of electricity. These data centers will continue to contribute significantly to global emissions unless they start using renewable energy sources in their operations. [13]

Conclusion:

The effects of climate change are significant and impressive; over time, they may have repercussions for other kinds of catastrophic events, such as catastrophes caused by nature. Adoption and integration of technology in Climate Change Monitoring, Mitigation, and Adaptation can prevent environmental damage and destruction. Regarding the climate emergency, the ICT sector has two primary challenges, which we have examined in this report: its own carbon footprint and its effect on the rest of the global economy. Global research must prioritize areas that are closely related to climate change and ICT, such as greenhouse gas emissions, climate change, ICT, agriculture, energy consumption and efficiency, sustainable development, and innovation.

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