

# THE DYNAMICS OF MAN'S HISTORY AND ECONOMIC DEVELOPMENT: A REFOCUS ON ECOLOGICAL DISTURBANCE AND CLIMATE CHANGE

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## **ABSTRACT**

*Man's history and developmental endeavour have been advancing alongside a trail of ecological ramifications and climate change. Since prehistoric times, scientists have not recorded an accelerated shift in ecology during any other epoch beside that of modern man on the planet. The paper seeks to explore how man's history and development affects ecology and climate. It uses desk analysis to recollect data from global assessment reports and runs a One paired Sample Means t-Test, 1 tailed, 8 df, at Pearson Correlation value 0.458 and 0.5  $\Omega$  level. Findings show that, there is global climate change, seen in global warming trends; and imbalance in ecological footprint, seen in depletion of air, water and land sinks. The t-Test reveals significant net loss of global forest cover. The study also, found that at present, processes of development generally tend to damage ecology. Therefore, the study recommends a refocus to sustainable means of development.*

## **KEYWORDS**

*Ecological Footprint, Climate Change, Sustainable Development, Built Environmental, Integrated Planning*

## **1. BACKGROUND AND INTRODUCTION**

The evolution of man from one age to another has been proliferated by significant stages of development. According to mainstream history, man has long been advancing himself to find better means of meeting his needs (Arlt and Daviau, 2009). Unlike his earlier days on the planet, man's motivation for development is now driven by a plethora of multiple contingencies (Ibid, 2019; Wengrow, 2018). From the pre-Neolithic age when man's urge to develop was primarily driven by survival instinct, today man's motivation for development is driven by factors such as pleasure, luxury, pride, and superiority (Hale Hale, Ricotta, Freed, Smith, and Huang, 2019; Burbank and Cooper, 2010; Arlt and Daviau, 2009). The evolution of man followed a development path from the early, middle and late stone age, to the early and late iron age (Muhanna, 2017). From there, it advanced to the industrial revolution and the computer age or the age of Artificial Intelligence (AI) (Mazlish, 2001). The landmarks of evolution redefine the motivations of people and significantly alter the way mankind works, produces, packages, trades, consumes and disposes. This has had negative impact on ecology. It is the endeavour of the study to show how the compromise in modes of production, consumption and disposal of waste, can be projected on the future of the planet. The study uses a systematic analysis of how history can teach us a lesson about how mismanagement of natural resource can compromise the ecological base for continued

growth and development. The study plots the manner in which human development has been advancing side by side with the speedy loss of the ecological footprint and climate change.

The first part of the paper defines the scope of the study area and outlines the problem statement; aim; objectives; hypotheses; research questions and rationale of the study. The second, defines the key concepts and draws a review of their interplay to show how they each influence each other. The third part outlines the methodology of the study indicating the target area and populations of the study and revealing how sampling was done as well as outlining how data was collected and analysed. The fourth chapter presents and discusses the findings of the study. The fifth chapter draws the conclusions and makes recommendations about the findings of the study.

### **1.1 Scope of the Study**

The study has taken a global perspective of climate change because, first, the phenomenon can be established when the multiplicity of variables defining it are gathered across a relatively wide geographic scale (Harvey, 2018). Second, the matter of climate change is of global implication. The analysis selects some parts of the world where there are indicators pointing to climate change.

### **1.2 Statement of the Problem**

Human evolution has seen the development of man from one age to another. Civilization with its unyielding quest to make life easier made operations easier and speed up processes in raw material extraction, transport and communication, manufacturing and processing industries, trade and commerce, consumption of goods and services as well as waste disposal. The industrial revolution of Europe in the late 1700s came with mass production and with it, mass generation of waste (Clark, 2014). The unprecedented effects were hazardous -pollution, environmental degradation and climate change. The consequences of these hazards are unforgiving -global warming; disturbance in weather patterns; loss of catchment, flooding, heightened frequency of tropical storms; loss of fresh air and water; outbreak of epidemics and disease; overcrowding in urban centers; urban gentrification and depletion of green spaces (Rymarczyk, 2020). It is the endeavour of the study to highlight this predicament in the light of man's evolution. Although some studies have been done to show the trend in climate change and its ramifications, their still remains much to be exploited about history's direct contribution to the matter of climate change and environmental degradation.

### **1.3 Aim**

The aim of the study is to establish the extent to which human development has contributed to climate change and the erosion of ecological footprint over the past 500 plus years, and show how all this has affected quality of life on earth.

### **1.4 Objectives**

- i. To explore the dispensations of human civilization over the past five plus centuries
- ii. To determine the extent of climate change over the past five plus centuries
- iii. To establish the correlation between human development and climate change
- iv. To assess the net change in global vegetative cover in the period from 1948-2015
- v. To ascertain the ecological ramifications of climate change on wildlife and the quality of human life

## 1.5 Research Questions

*Objective (i)*

What are the most important stages of human development in the past 500 years?

*Objective (ii)*

Has there been climate change on earth within the past 500 years of human history?

*Objective (iii)*

Is there a correlation between human historical development and climate change?

*Objective (v)*

What impact has climate change had upon the ecology, biodiversity and quality of human life?

## 1.6 Hypotheses

*Objective (iv)*

**H<sub>0</sub>:** There has not been global net loss in the vegetative spatial cover during the 67-year period from 1948-2015.

**H<sub>1</sub>:** There has been global net loss in the vegetative spatial cover during the 67-year period from 1948-2015.

## 1.7 Significance of the study

The study endeavours to surface information that can contribute to the debate about human development versus climate change. It assembles a collection of data sources that show a clearer perspective about the way human history interweaves into the fabric of ecological transformation and climate change. Such knowledge can bridge the gap in literature concerning how human evolution plays a role in the path of sustainable development. The study can also provide global institutions, agencies, and NGOs with relevant data that can help them to prepare world trajectories for climate change. Information gathered from the study can also furnish planners and technocrats from environmental agencies with grassroot indicators that can be used for risk assessment, as well as to build instruments for measuring ecological depletion. This way, technocrats can better inform policy. The study can also provide an integrated planning approach for planners at the physical planning unit of city and municipal councils. The historical background of man's development provides warning signs against impending doom to communities whose industrial era is still young and vibrant, such as in African and generally -the global south, so that they avoid mistakes that more advanced civilizations made in the past.

## 2. LITERATURE REVIEW

### 2.1 The Historical Development of Man and Technology

The history of man over the past 500 years can be generally demarcated into the Neolithic Age, the Iron Age, the Industrial revolution (Age of Knowledge Explosion), and the Computer Age or the Age of Artificial Intelligence (Scarre and Fagan, 2016). During the Neolithic period, man's way of life was simplistic, with an economy mainly consisting of hunting and gathering with small-scale primitive subsistence farming (Ibid, 2016). Before BC2000, communities in many parts of the world except for the Middle East were primarily hunter-gatherers (Muhanna, 2017). Agriculture had not yet taken significant ground and settlement infrastructure was basically made up of small grass-thatched houses made out of mud (Arlt and Daviau, 2009). In the progress of time, populations grew and another Age of Industrial Revolution was born (Clark, 2014). Sources indicate that, it started in Britain during the 1700s following the explosion of knowledge in science and technology (Xu, David, and Kim, 2018; Clark, 2014). With the invention of a

powered engine, it was now possible to harvest raw materials in larger quantities (Xu *et al.*, 2018). Countries across Europe and overseas began to industrialize and with it came urbanization (Rymarczyk, 2020). Industrialized centers attracted vast populations which applied pressure on settlement (Ibid, 2020). Rymarczyk, further narrates that, due to urbanization, people needed constant water and food supply, shelter, education and health facilities, recreation and waste management systems.

From the foregoing, it seems like the industrial revolution is undeniably one of the most important transition of man's development and appears to make the greatest impact on environmental degradation. This is because it came with mass deforestation, draining of marshes, emission of toxic fumes, and discharge of effluence (Rymarczyk, 2020). All these resulted in the erosion of green spaces, the loss of biodiversity, drying up of surface water bodies, lowering of the water table, and pollution in all its forms (Rashid, Irum, Malik, Ashraf, Rongqiong, Liu, Ullah, Ali and Yousaf, 2018; Jorgenson, 2003). The industrial age has also seen another advancement in the development of man called the Computer Age. This heightened use of machine technology in almost all economic sectors has truncated another pressing demand for energy (Rymarczyk, 2020). Today, the world is a global village and several matters faced by diverse communities are shared (Muhanna, 2017; Mazlish, 2001). The correlation between economic growth and environmental degradation seems to puzzle even the elite of elites. Communities that are lagging behind (development-wise) ought to strengthen their economies, but at the same time preserve their ecological print for posterity.

## **2.2 Climate Change**

According to Harvey (2018), climate change is the significant change in the overall pattern of weather defying the long-term pre-existing or natural conditions. When climate changes, it takes time to detect, later on to ascertain. Climate prevails over a long time and rarely changes. Suffice to note that, geological evidence shows that climate has been changing from one epoch to another (Singer, 2006). The reasons for such changes are still being researched. Nevertheless, it is assumed that the modern human race (*homo sapiens*) and their associated technology have been on the face of the earth for less than 20, 000 years, and that in this duration climate change seems to have taken rapid shifts (Labat, Godd ris, Probst and Guyot, 2004). More robust assessment tools to unearth the way climate was changing in the epochs of prehistoric times ought to be done to establish whether our contribution to the predicament is significant or not. Even if it were so, climate change itself is merely a function of a malfunctioning ecosystem attempting to balance itself. If something is happening to the eco-system, then something is happening to the natural resources (Held and Soden, 2006). This indicates that, there is careless manipulation of both the living and non-living environment. Such things could have happened in the past, perhaps as a function of natural terrestrial or extra-terrestrial catastrophe. However, in man's history, the age of industry has its fair share of contributing to the predicament. In the meantime, it is phronesis to act prudently and create a preventive strategy against future calamity. The first step is to understand the dynamics involved. Therefore, it is the aim of the study to surface the crucibles that are critical for building such understanding. Historical exegesis of how human civilization once mishandled can disturb natural ecology has been used to establish such knowledge.

## **2.3 Ecological Footprint**

The earth is a unit mass found in the dynamic complex of nature governed by universal laws. It is made up of an environment that functions by a symbiotic balance of living and non-living organisms. Ecology can basically be described as the interaction between the living and non-living environment as well as the sub-interaction of the non-living environment and living environments within themselves to create balance of nature and continuity (Rees, 2018). Ecology

is a system that constitutes habitat and symbiotic relationships among organisms. Its footprint spans across the entire earth. The earth-atmosphere system is sustained by a complex network of interaction between what happens on the surface of the earth and what prevails in the atmosphere (Held, and Soden, 2006). For instance, if vegetative cover is significantly eroded, then river catchment is lost and the rate of evapotranspiration is significantly reduced (Labat, *et al.*, 2004). This in turn reduces the amount of rainfall received in a particular catchment. If such a situation is extrapolated across a broader space, then it significantly transforms the average conditions for smooth interaction in the earth-atmosphere system. Such global ramifications are due to erosion of the ecological footprint -which can simply be defined as the removal of original/natural resources of the earth.

The world is on a trajectory to find means of striking a balance to cope with the 'poverty-environmental degradation' trap. The most significant strides are seen in the advancement and implementation of the SDGs (UN-Habitat, 2019). This new trajectory has given birth to fresh concepts and methods in the field of planning, such as regional integration, inclusivity, mixed land-use, green building, garden city, and 'city within a city' (UN-Habitat, 2022). Therefore, planners have restructured the concept of planning to suit the growing need of preserving ecology. And so, land use planning has taken another shape to ensure that there is mixture of both natural and built environment (Dovey, Shafique, Van Ostrum and Chatterjee, 2021; UN-Habitat, 2022). It is the endeavour of this study to reveal the conflict between urbanization and ecology preservation.

## **2.4 Development and Climate Change**

Development refers to change of something, in this context, improvement or progress (Klasen, 2018). Man's development implies advancement in the modus operandi to create capacity for meeting all of a population's basic needs (Ibid, 2018). This definition rests upon the bedrock of optimal and balance of population. Optimal population refers to the sufficiency of a population to maximize its natural resource for their benefit, while balanced population refers to the ability of natural resources to sufficiently furnish the population size (Yumashev, Ślusarczyk, Kondrashev, and Mikhaylov, 2020; Rabie, 2013). While the ratio between the size of population versus the resource base is critical, it is the ability of the population to access basic needs of life that really matters. This involves the transformation of raw materials into products and services and avail them to the mass of the people (Yumashev *et al.*, 2020; Klasen, 2018). The process of converting of raw materials into finished goods often requires industry. The larger the population, the higher the demand and the consequently the large the industries. If production is deficient, then goods and services become scarce which leads to inflation. Therefore, a healthy Gross Domestic Product (GDP) is key for the development of a country (Klasen, 2018).

Also, the mass of the people should have access to these resources which would translate into favourable Human Development Index (HDI) -another index of development. The index refers to income per capita or the amount of money that an individual in a country will have to spend for an entire year if all the resources of the country were equally distributed (Ibid, 2018). This entails that, healthy economies inherently have individuals within a population sustaining enough buying power to decently meet all their basic needs and more (Chibuye, 2014). Nonetheless, economic growth must not override resource repletion and waste management. Otherwise, a collapsed economy alongside a contaminated environment produces compromise in the quality of life. The two evils can organically work together to degrade human life by brewing depravity, poverty, sickness and disease, hunger and starvation, and even death. For civilizations that have continued on the trajectory of economic development negating environmental concerns, the ravages of climate change have come with unforgiving consequences.

## **2.5 Climate Change and its Ramifications on Quality of Life**

Climate change has a telling impact upon the quality of both human and non-human life. The most obvious effects of climate change are witnessed in extreme weather, heat waves, tropical storms, torrential rains, floods, droughts, increased glaciation, and global warming (Bartke, Forster, Githiri, Jering, Kago, Schlimmer, and Sietchiping, 2021). These outcomes of climate change have both direct or immediate repercussions as well as indirect and long-range repercussions. These things impact the quality of human life on earth. Quality of human life can be defined as the measure of access by a person to basic needs (Chibuye, 2014). The most basic of such needs is safety and security, food and nutrition, fresh water and air, health and descent shelter (UN-Habitat, 2018). Therefore, it always remains crucial to provide an environment that sustains the provision of these things. Hidden from the radar of economists and most developers are the far-reaching damages caused by climate change. For example, climate change can cause heat waves that result in tropical storms leading to death (Pieterse, 2010). Meanwhile, the ripple effects of tropical storm or a tsunami are the floods that sweep across houses causing water pollution and consequently water-borne diseases (Nchito, 2007). Also, the torn down infrastructure sometimes leaves irreparable damage which bites into the economy, while the loss of lives leaves emotional scars (Vlek and Steg, 2007). The problem of climate change is that, it changes the average weather patterns to something that humanity and many life forms are not accustomed to. Although we may perceive it to be a simple matter, the underlying reality is that, what really enables any organism to exist is its host (environment) (Ndebele-Murisa, Mubaya, Pretorius, Mamombe, Ipinge, Nchito, Mfuno, Siame, and Mwalukanga, 2020).

## **3. METHODOLOGY**

### **3.1 Research Design and Approach**

The study is a desk analysis that surveyed data from a relatively large number of places in the world. Since the study sought to cover a wider geography, the desk analysis was more ideal (Bostley, 2019). The study recollected data from remote sensing surveys done by the Forest Resource Assessment (FRA) (FRA, 2020 RSS), which relied on photointerpretation of a global sample of high-resolution imagery through a worldwide network of national experts. The surveys involved the use of modern remote sensing tools and methods. The study approach was a mixed method, that is both quantitative and qualitative because it involved data that was both stringed and numeric in nature (Tesfaye, 2018). Quantitatively, the study recollected large quantities of geospatial images, and therefore relied on the count of hexagonal pixels obtained from Landsat and Sentinel Mosaics. The recollected geospatial images were captured and measured by surveyors from the National Research Council (NRC) and the areal cover of ecology and trends in climate change was recorded year after year. Data, recollected from assessment reports on forest cover by the FRA was analysed using statistical testing. At the same time, qualitatively, the study explored data recollected from field surveys done by the FRA via interviews of indigenous people in several countries across the globe.

### **3.2 Sampling Technique**

The sample is drawn from a population of spaces mapped out from global grid of equal area hexagons documented by the FRA. A stratified random sampling technique was used by the agency to conduct the survey and reduce uncertainty of the forest area change estimates. The technique was based on eighty (80) strata derived using a combination of twenty (20) Global Ecological Zones for categories of change in the cover of trees. The map under assessment shows in total about 430 000 remote sensing samples of hexagons covering 40 hectares and centroid

spreading across 1 hectare from all over the world. On the other hand, qualitatively, purposive sampling was used by the FRA to select indigenous people across several countries in order to solicit data through interviews. The countries were selected based on evident disproportionate removal of forest cover or widespread built environment. Apart from these, the study also samples timeline analysis graphs and images from the NRC showing global trends in the change of climate. The graphs were purposively selected based on the climatic index they were projecting and its significant contribution to the nature of climate and ecology. For instance, temperature, land, ocean, air, and vegetation sinks were part of the variables. Therefore, their trends were probed on global scale in order to study the complexion climate and ecology in the progress of time.

### **3.3 Data Collection Instrument**

The data was collected from the Global Forest Resource Assessment report prepared by the FRA from the early 1900s upto the year 2020. The assessment was done from data collected using remote sensing and survey. The FRA and National Research Council (NRC) conducted remote sensing through the Collect Online Earth Platform, and Google Earth alongside Bing Maps to collect auxiliary data. Other Geospatial more modern tools with improved data entry, data visualization, review and analysis functions were also used. Such advanced geospatial analysis data collection tools were used to collect data especially from countries where forest information was limited or not available. The surveys were done via interview of local residents who were familiar with the geography of the selected countries spread across the globe. Also, the views of the people from the interview surveys and pictures were recollected and from the reports from selected countries.

### **3.4 Data Analysis**

The study analysed data from the global assessment reports on change of global forest cover over the years using a One paired Two Sample Mean t-Test at Pearson correlation 0.458, 1 tailed at 8 degrees of freedom. The other data was interpreted from graphs showing trends of climate change over the years extrapolated from the global data assessment of temperature, forests, land and water. These were compiled by the NRC using the Open Floris Collect Earth software tool to visually interpret about 213 000 sample plots. The Collect Earth tool was also used in the analysis of data to access and display high resolution images from Google Earth and Bing Maps. The assessment tool also generates grids through Google Earth Engine, that allows ready access to Landsat and Modis image archives.

## **4. FINDINGS OF THE STUDY AND DISCUSSION**

### **4.1 Pre-Historic Times and Climate Change 800, 000 years ago: The Ice Age**

It is important to recognize that climate change is not a recent phenomenon. In the past epochs, the earth has undergone various phases of climate change. One of the most recent traceable epochs of climate change is the Miocene epoch within which is encapsulated in the Ice Age (Rashid *et al.*, 2018). During this epoch when modern human life had not yet evolved, the earth underwent climate change when global temperatures dropped below the 'normal' average. Temperatures drastically dropped all across the world and this phenomenon resulted in the freezing of almost all parts of the earth ending most life forms (Rashid *et al.*, 2018). One theory explaining this was the striking of a meteorite into the earth causing ecological disturbance (Rashid *et al.*, 2018; Rees, 2018). The other theory, advanced by some geological studies

postulate that, the earth naturally undergoes periodic rise and fall in global temperatures (Rees, 2018).

The graph in figure 1 shows the trend of temperature during the Ice Age. One important observation made by the NRC on climate change during Ice Age and the post-modern climate change is the vast difference in temperature variation between them. During the Ice Age period after BC800 000 to around BC100 000, CO<sub>2</sub> and temperature levels in the atmosphere underwent cycles of change every 100 000 years. Each 100 000 years division saw a rise and decline in temperature levels systematically. As the carbon levels rose, so did the temperature and the vice versa. The cyclical pattern shows a system of balance in the climatic patterns separated by a 200 000 years interval. For instance, CO<sub>2</sub> levels rise only upto a maximum threshold of 300 parts per billion (ppb) during the entire ice age period and this was the time when temperatures also rose to a maximum threshold average increase of about +4°C. However, after the Ice Age period, CO<sub>2</sub> alongside temperature in the atmosphere have been increasing. As at 2010, the amount of CO<sub>2</sub> in the atmosphere over 390ppb varying from the maximum overage of the Ice Age by a staggering 90ppb. Compounded to this accumulation of extra carbon dioxide in the atmosphere is the further addition of other heat retaining gases (CFCs) in the atmosphere such as Methane (CH<sub>4</sub>) and Nitrous Oxide (N<sub>2</sub>O), which together with carbon dioxide are accelerating the rise in global temperature levels.

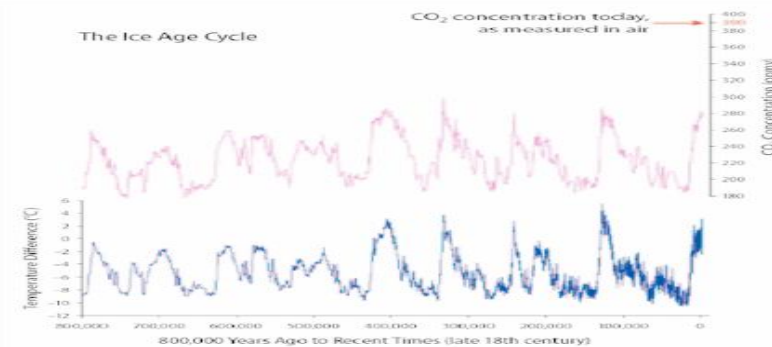


Figure 1. Climate Change during the Ice Age  
Source: National Research Council, 2010d

## 4.2 Important Dispensations of Human Civilization over the Past Five Centuries

From pre-historic times, human civilization has seen the development of technology from the simple to the complex. The human economy has advanced from hunting and gathering to agriculture, from agriculture to iron-working, and from Iron-working to the period of knowledge explosion which ushered in the industrial revolution in the 1700s. Invention during the industrial revolution gave way to the computer age or the age of artificial intelligence (AI). This series of indelible advancement in human civilization is shown in table 1.



Table 1. Historic times and human civilization after the ice age

<i>S/N</i>	<i>Years of Invention</i>	<i>Age (Dispensation)</i>	<i>Time-line (Period)</i>	<i>Human Development (Civilization)</i>
<i>1</i>	> BC10000	Prehistoric	> 10, 000	Hunting & Gathering
<i>2</i>	BC10000s	Neolithic	10, 000 – 2, 000	Agriculture & Settlement
<i>3</i>	BC2000s	Iron Age	2, 000 – 500	Technology
<i>4</i>	AD1700s	Industrial Revolution	500 – 200	Manufacturing & Urbanization
<i>5</i>	AD1900s	Computer Age	200 - date	Artificial Intelligence

Source: Adapted by Author, 2022

These dispensations of human civilization have not gone without impacting the trends of global climatic shift. It may be true that the natural tendency of the earth is to undergo changes in weather patterns after a certain period. However, the rate at which the changes are happening in recent times is alarming. The phenomenon also reveals a seeming correlation between human civilization and climate change.

### 4.3 Climate Change in recent times

Findings show the pillars upon which human survival and advancement is premised upon in order to project like-hood of ecological depletion, thus, unveil the future of climate change. Findings also reveal that humanity is grappling with a dichotomy of population change and poverty across the globe. These are matters that have grave ramifications upon ecological preservation (UN-Habitat, 2022; Giddings, Hopwood and O'Brien, 2002). The two matters are also significantly part of the motivation behind human technological advancement and the quest to develop. As a matter of fact, the two are among the Sustainable Development Goals (SDGs). Findings also show that, in an attempt to attain such goals, the global community is contending with a complex situation whereby, development naturally demands supply from the ecology, while the ecology also demands replenishment. Failure to reconcile the two is likely to breakdown ecological stamina and unleash all the dangers of climate change. Therefore, the concept of sustainable development becomes handy but also complicated at the same time. In order to understand the potential of population change in the matters of climate change, the section that follows maps out populations change across the world. This is to give light into the situation obtaining in the world about how much needs to be addressed to aid the status quo for most parts of the world.

#### 4.4 Population Change and the Trajectory of Ecological Degradation/Climate Change

The world map in figure 2 shows the population change across the world in the period between 1990-2013.

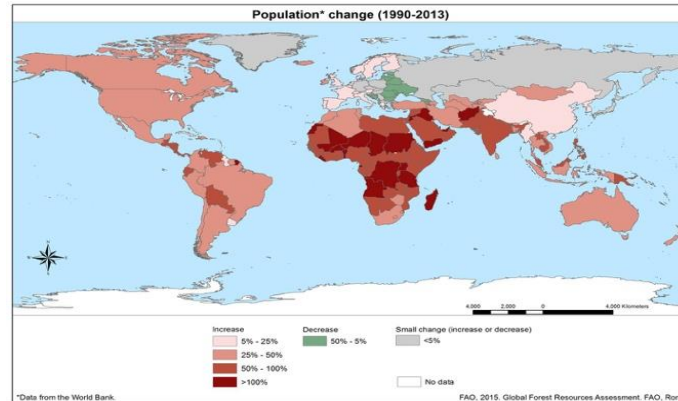


Figure 2. Mapping of Population Change around the world  
Source: FAO Assessment Report, 2015

According to map evidence, much of the world falls in the category of between 25 to >100 percent increase in population and only less than 25 percent have minimal, zero, or negative growth. This shows the recent historical trajectory of world population dynamics. Populations are generally expanding and this is increasing the pressure on development agenda for many nations. Extremely few (<5 percent) countries which are located in the Scandinavian world are the ones that have attained an impressive global trajectory with a promising future for decreased pressure upon natural ecology. If the majority are still striving with efforts to reach zero or negative increase in population, then the challenge of population pressure upon the ecological footprint continues. This in turn culminates in ripple concerns over the climate change issues. All the parts of the world with increase in population are mapping out areas of potential ecological degradation. And unless measures are put in place, the world still risks chances losing the ecological footprint.

#### 4.5 Poverty and the trajectory of Ecological Degradation/Climate Change

As mentioned earlier, in section 4.3, the other factor motivating ecological erosion is the relentless quest to alleviate poverty across the world. Poverty is a social-economic ill in human society and it is one of the main issues being addressed by global communities. Findings show that, this zest to make as many people access basic social and economic needs has a telling impact on the environment because the obvious instruments are industry and technology. However, these engines of mass production escalate the consumption of natural resources and serve to accelerate the rate of ecological degradation and climate change. As at 2015, the prevalence of poverty in the world according to FAO is shown in the figure 3. As shown in the findings, literally the entire global south including parts of Central Africa, Central America, India and the islands of East Indies, except for Australia is still ravaged by poverty and this state of affairs calls for more implementation of developmental plans. If there are still traces of large portions of land ravaged by poverty, then there is still greater potential for developers to deplete the ecology.

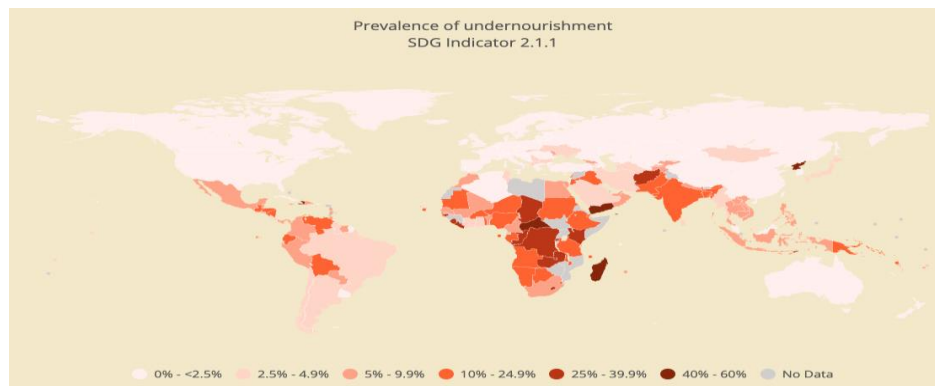


Figure 3. Mapping of Poverty across the globe

Source: FAO Assessment Report, 2015 <https://nap.nationalacademies.org/read/14673/chapter/2#3>

It is the exploitation of natural resource which further robs it of the natural elements needed to support healthy conditions on the planet. And if this potential for further exploitation exists, then the future of climate change is still in limbo. Today, there are not so many ways of alleviating poverty except through developmental agendas that resort to depletion of natural resource. Strides are being initiated to develop ways of combating poverty with minimal damage to the ecology. Nonetheless, such strides are still insufficient to reach the mass number of people who still need to be salvaged from the shackles of poverty especially in Africa.

#### 4.6 Extent of Climate Change over the past three centuries

Findings of the study have also shown that, the reality of climate change has been radically observed in the past three centuries beginning from the late 1800s to the year 2000. During this period, there has been a phenomenal rise in global land and ocean temperatures. Temperature indices on both the land and continental plains have shown a rise such as never been recorded since pre-historic times. The sharp rise in temperature levels shows a net rise of a +6 score within only a space of approximately three centuries. The figure 4 shows the trends in the sharp rise of temperature within the 200 plus years.

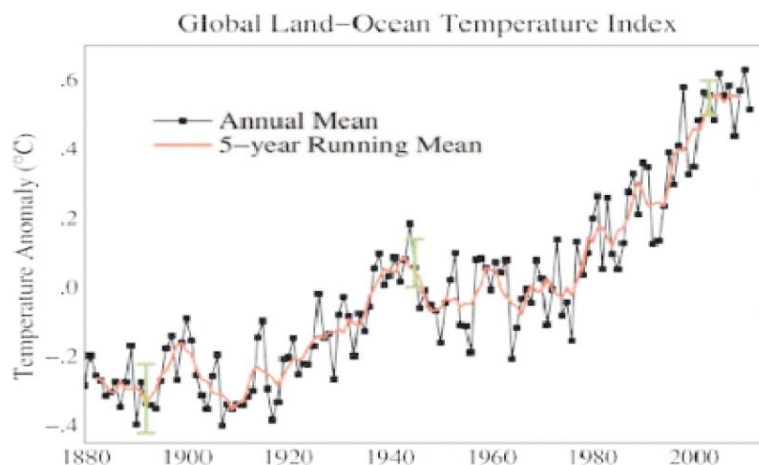


Figure 4. Rise in Global Temperatures in the past three centuries

Source: <https://nap.nationalacademies.org/read/14673/chapter/2#3>

There is still more evidence of global climate change in the world today. For instance, the past two centuries have seen a rise in the atmospheric concentration of Carbon Dioxide (CO<sub>2</sub>).

According to the earth system research, there has been a sharp and steady rise in the concentration of carbon dioxide in the earth's atmosphere. This means that, CO<sub>2</sub> has continued to increase steadily in the atmosphere since the 1960s as shown in the figure 5.

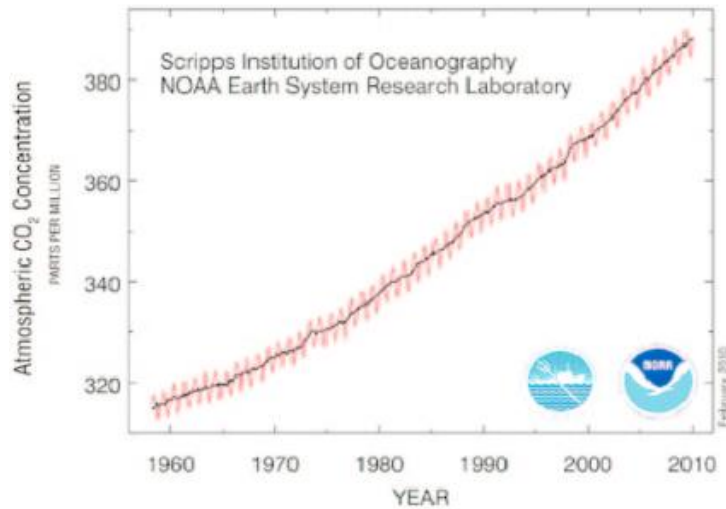


Figure 5. Rise in Atmospheric CO<sub>2</sub> Concentration in the world  
Source: National Research Council, 2011a

It is not only the rise in CO<sub>2</sub> concentration in the atmosphere but, findings also show that alongside are two other Chlorofluorocarbon gases that have also sharply risen. These are Methane (CH<sub>4</sub>) and Nitrous Oxide (N<sub>2</sub>O) which, just like CO<sub>2</sub> are gases with High Heat Retention Capacity (HHRC). The diagram in figure 6 shows the trend of the three gases on the atmosphere for the past 2000 years.

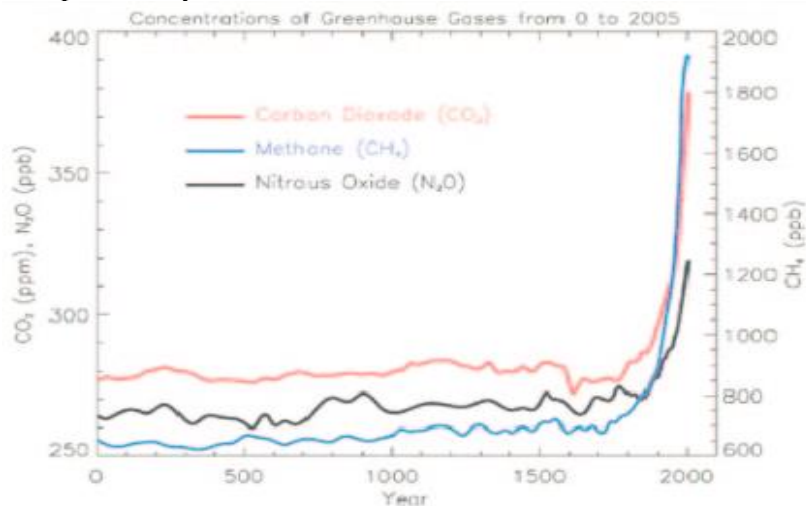


Figure 6. Sharp rise in Atmospheric CO<sub>2</sub> CH<sub>4</sub>, and N<sub>2</sub>O Concentration in the world from the late 1800s.  
Source: National Research Council, 2011a

According to the figure 6, it is clear that during the past 2000 years in the period from 0AD upto the 1800s, the concentration of the three gases -CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O was relatively the same. Findings show that, there was no significant rise according to research. The lab tests reveal that, within the period from 0AD to 1800AD, on average CO<sub>2</sub> only had a concentration range variation of about 15parts per million (ppm), CH<sub>4</sub> had a concentration range variation of only about

250ppb, while N<sub>2</sub>O had a concentration range variation of only about 15ppb. However, the graph shows that immediately after the late 1800s, all three gases shot up to levels never seen before. For example, CO<sub>2</sub> shot up from its normal average of 280ppm in the year 1880 to a staggering 380ppm in the year 2000, N<sub>2</sub>O shot up from 270ppb in 1880 to about 320ppb in the year 2000, meanwhile CH<sub>4</sub> shot up from an average of 800ppb in 1880 to a whopping 1950ppm in the year 2000.

It is the margin of variation in concentration of the gases that is alarming. For example, CO<sub>2</sub> concentration in the atmosphere stayed the same from 1800 years at an average of only 280ppm while in the last 200 years it has risen to a maximum average of 380ppm. Also, the variation between the 1800 years and last 200 years is disproportionately insurmountable. For instance, there was minimal range of only 15ppm in the 1800 period but this changed in the last 200 year to become a range of 100ppm. This produced a net surplus of about 75ppm of atmospheric CO<sub>2</sub> concentration within the last 200s year of the past 2000 years. The same goes for N<sub>2</sub>O whose range was also 15ppb within the 1800 years dispensation, but later suddenly shot up to a range of 50ppm, producing a net surplus of 35ppm of N<sub>2</sub>O concentration in the atmosphere during the last 200 years. CH<sub>4</sub> equally became more abundant in the atmosphere. From the range of 250ppb during the 1800 years to a phenomenal 1,150ppb range variation in the last 200 years, producing a net surplus of about 900ppbs of CH<sub>4</sub> concentration in the atmosphere.

This insurmountable increase in concentration of the three gases in the atmosphere in the past 200 years in comparison to the 1800 years before clearly indicates an abnormality that seems to have transpired after the late 1800s. It is also interesting to note that this period which marks the sharp rise in CFC gas concentration coincides with age of industrial revolution. The industrial revolution in Europe began on the late 1700s and by the late 1800s, various factories had spread across most European countries and CFC gas emission had started skyrocketing. As industry and urbanization gained momentum in human society, so did CFC gas emission. Therefore, there is a correlation between human development and climate change embedded in the mutual relationship between industry and increased concentration of CFC gases into the atmosphere. The consumption of fossil fuel with its concomitant release of CFC gases is largely influenced by the general change in land-use. With the change in land use from simplistic Neolithic (agrarian) rural communities to the more complex industrial urban communities, there has been a general depletion of the two most significant components of the eco-system -land and water.

Research has shown that within the past 200 years, land and water resources have drastically reduced. This has compounded the problem of CFC emission thus expediting climate change. The figure 7 shows a summary diagram of how factors combine to produce an atmosphere of increased CFC gas concentration. According to the findings, the use of fossil fuels to run industry has significantly changed the use of land and water. This means that fossil fuel consumption due to industry has reduced land and ocean sinks. This in turn has resulted in proliferated rise in CFC concentration in the atmosphere predisposing the earth to global warming and climate change.

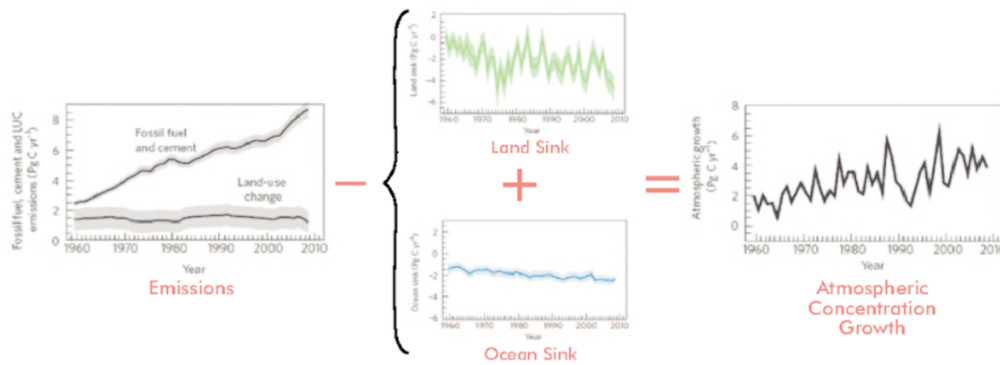


Figure 7. Interplay of industry and land-use change in CFC gas atmospheric concentration  
Source: National Research Council, 2011a

#### 4.7 The Correlation between Human Development and Climate Change

Findings of the study have established that there is a correlation between human development and climate change. Human development has dictated the pace of land use change and led to increased emission of greenhouse gases. Primarily change of land-use in the past 200 years has been characterized by the establishment of industries and the spread of urbanization. Compounding this land-use changes is the continued rapid growth of human population cross most parts of the world. The meaning of such population growth in the dynamics of climate change is that, industry will continue releasing of greenhouse gases and temperatures are likely to continue rising (Harvey, 2018). The double flanked problem is that, industry and urbanization consume massive amounts of natural resources in terms of land, water and forest, while at the same time emitting greenhouse gases. This means that ecological erosion and pollution are happening at phenomenal rates around the globe at phenomenal (Ibid, 2018).

Another critical component of the ecology has been introduced in the mix of land and oceanic degradation -forest cover. This is yet another aspect of the ecology that has been significantly impacted by human development. Again, both industry and urbanization has grossly reduced forest cover across the world. Today, there is nothing exploited by industry more than forests. Many sectors of the economy demand timber, and so, the lumbering industry has received more attention than several others. The challenge in the industry is that trees are not only exploited to produce manufactured goods in industries but are also indiscriminately cut down for clearance to establish industrial plants or even settlement as well as shifting cultivation (Cudworth, 2005). This makes forest cover one of the most threatened aspects of the ecology. The global trend across history shows that brown spaces are not only draining marshes but swallowing up forest cover.

The world map today shows how the built environment is encroaching green spaces and overtaking vegetative cover. Although urban planning seems to be taking sustainable planning concepts to include green spaces, this kind of integrated planning has largely been ignored in the past 200 years by many communities in the world (UN-Habitat, 2020; Mori and Christodoulou, 2012). This is especially common in the global south where unplanned or informal settlements are rife. It is an international urban challenge which the UN seeks to address in this 21<sup>st</sup> century but so far has recorded minimal success (UN-Habitat, 2022). Despite efforts to transform planning into a means of establishing smart cities to incorporate greening, brown development continues to override in many cases. For example, shopping malls in urban centres have for some time removed vegetation and paved vast spaces depriving land sinks and vegetative cover. There are now new approaches and concepts in planning that seek to address such issues. The figure 8 shows how brown spaces are predominant the green spaces.

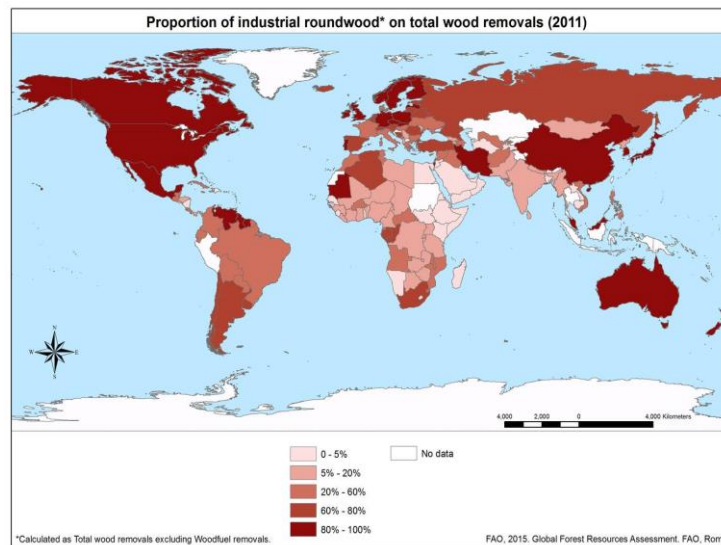


Figure 8. Spaces of brown development and degrees of potential for deforestation  
 Source: FAO Assessment Report, 2015

All the spaces mapped out with brown are areas of high deforestation due to peak industrialization. Those are spaces most vulnerable to desertification. Nevertheless, they are also communities that have taken matters of forest management more seriously than the spaces mapped-out in brighter colours. It also seems that the communities that are less developed have more forest cover compared to that are developed. Perhaps the developed countries depleted their forests in a bid to attain development. And this becomes the trap thesis of poverty. If development will come to the global south and poverty should be eradicated, then deforestation must rise to a certain threshold. And yet with deforestation also comes climate change and other ecological ramifications.

#### 4.8 A Timeline Ratio of Natural Vegetative Spatial cover against Brown Spaces

In order to comprehend the gravity of the ecological transformation across the globe, it is imperative to consider the ratio of forest cover relative to how much cover is removed within a certain period. Such an analysis provides insight into the trends of how deforestation has reduced forest cover in the progress of time. Finding of the study are shown in the table 2 indicating the trend of global forest cover and how it has been depleting over time.

Table 2. Global Ecological Deficit through a Timeline Ratio of Vegetative Cover against its removal

<i>Year</i>	<i>Global Cover (Billion Hectares)</i>	<i>Forest Net Forest Change</i>	<i>Global Annual Change</i>	<i>Net Global Brown Spaces</i>	<i>Ecological Deficit</i>
1948	4.0	-	Not Reported	Unclear	Unclear
1953	3.8	<b>-0.2</b>	Not Reported	Increased	Yes
1958	4.4	<b>+1.4</b>	Not Reported	Decreased	No
1963	4.1	<b>-0.3</b>	Not Reported	Increased	Yes
1988	3.6	<b>-0.5</b>	Not Reported	Increased	Yes
1990	3.4	<b>-9.9</b>	Not Reported	Increased	Yes
1995	3.4	<b>-11.3</b>	Not Reported	Increased	Yes
2000	3.8	<b>-9.4</b>	-0.18	Increased	Yes
2005	3.8	<b>0</b>	-0.11	Increased	Yes
2010	4.0	<b>+0.2</b>	-0.08	Decreased	No
2015	3.99	<b>-0.01</b>	-0.08	Increased	Yes

Source: FAO Assessment Reports

For the most part, the period from the year 1948 to 2015 has seen a sustained erosion of vegetation across the globe. The direct inference of this is generally ecological deficit. Approximately, out of the 10 dispensations observed, 80% of them showed ecological deficit and only 20% showed surplus. This significant (80%) difference in ecological deficit indicates that, the world is consuming more of vegetation than it is replating or replenishing. A typical example is about countries on the African continent which are now exploiting forests at an increasing rate. According to the Forest Assessment Report (2005), in Africa, overall progress towards sustainable forest management in the continent appears to have been limited during the last fifteen years. There are some indications that net loss of forest area has slowed down and that area of forest designated for conservation of biological diversity has increased slightly. However, the continued, rapid loss of forest area – the largest of any region during this 15-year period – is particularly disconcerting. This is a similar story for even other parts of the global south such as India, South America and some parts of the Middle East.

#### 4.8.1 Net Loss of Global Forest Cover over a 67-year period (1948 to 2015)

There has been a net loss of forest cover between the year 1948 to 2015. This net loss is as a result of rate at which forest cover has been eroded and seemingly replaced worldwide. The trends reveal a pattern of fluctuation in removal and replacement of forest cover. However, according to the findings of the study from an assessment of past records, the final correlation yields a negative t-Statistic value of -0.185 which indicates an overall net loss. The table 3 shows the findings after running a One-tailed, paired Two-Sample Means t-Test which yielded a significant result. Findings were that the p-value was 0.429 which was less than the Pearson correlation of 0.458. Also, the t Statistic (-0.185) is less than the t Critical (1.860) at one tail. Therefore, from the foregoing, the result shows a negative correlation indicating a global net loss of forest cover in the period between 1948 and 2015.



Table 3. A Paired Two Sample Means t-Test of forest cover from the year 1948-2015

t-Test: Paired Two Sample for Means	Forest Cover Billion Hectares	Forest Cover Billion Hectares
<i>Period of change (years)</i>	<i>before</i>	<i>after</i>
1948 - 1953	4	3.8
1953 - 1958	3.8	4.4
1958 - 1963	4.4	4.1
1963 - 1988	4.1	3.6
1988 - 1990	3.6	3.4
1990 - 1995	3.4	3.4
1995 - 2000	3.4	3.8
2000 - 2005	3.8	3.8
2005 - 2010	3.8	4
2010 - 2015	4	3.99
Mean	3.81111111	3.83222222
Variance	0.10611111	0.10959444
Observations	9	9
Pearson Correlation	0.4576021	
Hypothesized Mean Difference	0	
df	8	
t Stat	-0.1851479	
P(T<=t) one-tail	0.42886044	
t Critical one-tail	1.85954804	

Source: Generated by Author, 2022

Therefore, from the foregoing, the Null Hypothesis ( $H_0$ ) which states that there is no net loss of vegetation over built environment in the world between the year 1948 to 2015 is rejected, while the Alternative Hypothesis ( $H_1$ ) which states that there is a global net loss on forest cover over built environment between the year 1948 to 2015 is accepted. As a matter of consequence, it is important to note that, such a significant net loss ought to be checked, lest the trend continues and the global loss of vegetation cover increases exponentially with the passage of time. And if such be the case, the ramifications of ecological imbalance will ravage the planet at dangerous levels.

#### 4.9 The Ecological ramifications of Climate Change

The ecological implications of climate change can be seen in the drastic change of average temperature. Findings reveal that temperatures in the stratosphere have been dropping, while temperatures in the troposphere have been rising above the normal average. The figure 9 shows the cooling trends in the stratosphere and the warming trends in the troposphere in the period between 1960 to 2010. This means that those temperatures in the upper part of the atmosphere are significantly dropping below the normal. Meanwhile, temperatures in the lower part of the atmosphere with which we mostly interact are rising to disproportionate levels. The rise of temperature in the troposphere has led to the predicament called global warming. Generally, all eco-systems on earth directly interact with the troposphere. Infact, the earth-atmosphere system basically comprises the land, water, vegetation and all the weather elements of the troposphere. Therefore, a rise in temperature affects all the aspects of ecology.

An analysis of the collective impact of different factors in the earth-atmosphere system shows a net effect of human activity as being the largest contributor to global warming. The study established that there are some factors that influence of cooling and warming of the atmosphere.

Among these factors include the emission of greenhouse gases, depletion of ozone, availability of water vapor, surface reflexivity, particle and cloud reflexivity. According to the findings, greenhouse gases emitted largely through human activity (industry and urbanization) is the greatest contributor to global warming. The gases which mainly include CO<sub>2</sub>, N<sub>2</sub>O, and CH<sub>4</sub> have high HRC, and therefore trap heat in the atmosphere. These gases can stay within the atmosphere for a span of between 10 to 30 years and continue to absorb and contain heat for as long as they are present.

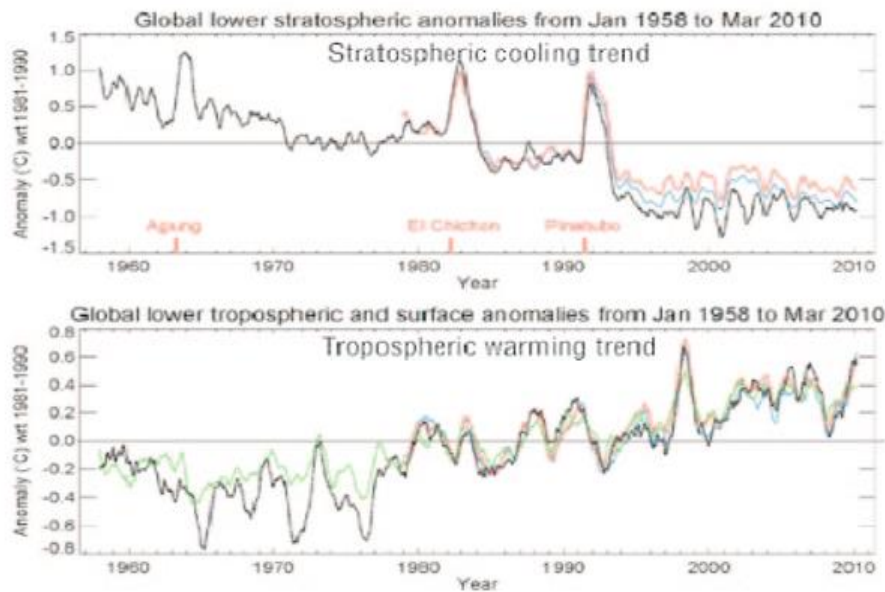


Figure 9. Cooling and Warming trends in the Atmosphere  
Source: National Research Council, 2011a

Apart from the three CFCs aforementioned, other gases such as Carbon Monoxide (CO) and Sulphur Dioxide (SO<sub>2</sub>) which are continuously released from mines and manufacturing industries are largely responsible for the depletion of ozone (O<sub>3</sub>). These gases tend to split O<sub>3</sub> by extracting an oxide (O) from it so that it becomes oxygen (O<sub>2</sub>). The findings show that depletion of O<sub>3</sub> is creating increased warming and decreased cooling conditions due to increased penetration of Ultra-Violet Radiation (UVR) and other thermal energy waves into the atmosphere. Water vapor content has also reduced as temperatures rise further. Surface reflexivity has been affected by two factors with counteracting effects. For instance, land-use that is now mainly characterized by urban built environment has greatly increases reflexivity, thereby raising temperatures. At the same time, soot from carbon which collects on snowflakes reduces reflexivity and generally create warmer conditions in the atmosphere. The figure 10 shows a summary of the interplay of natural and human influence upon the balance of the earth-atmosphere system. The figure shows how human beings are altering the natural course of atmospheric temperature equilibrium.

Given a collection of all the factors at play in the earth-atmosphere system, there interaction has ultimately led to an energy net gain from both natural influences and human activity. Most importantly human activity has transcended its impact on global warming against natural factors on a scale of 1: 2.5. This significant difference in the ratio to which human activity is far exceeding natural influence in global warming places the catastrophe of climate change solely upon human beings. The greatest contributor to the earth-atmospheric ecological imbalance is greenhouse gas emission and these are a direct by-product of industry and urbanization.

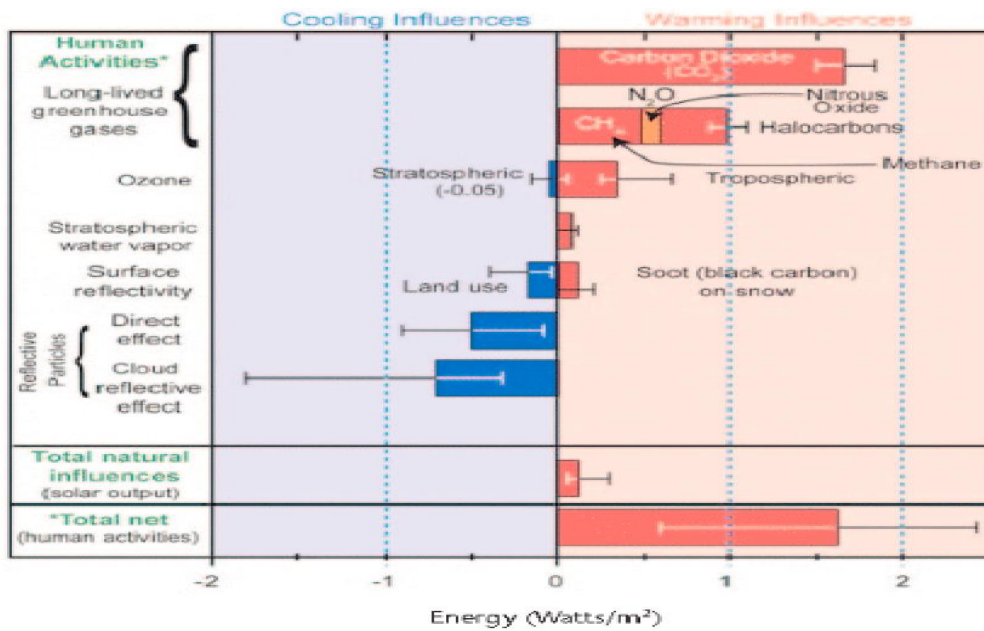


Figure 10. Interaction of natural and human Influence on the average temperature of the atmosphere  
 Source: National Research Council: 2010d

Apart from the atmospheric part of the earth-atmosphere system, climate change has also adversely affected the earth part of the system. In this way, the land, water and vegetation resources have been altered in composition and functionality. For instance, sources indicate that oceanic potential Hydrogen (pH) has been dropping insurmountably. According to the studies, between the years 1989 to 2007 the oceanic pH within the depth of about 0-30 meters have dropped from an average of 8.12 down to about 8.08. This poses a danger not only to aquatic but terrestrial life as well. Lower pH entails decreased alkaline conditions and increased acidity, a predicament with high chances of further repercussions on other parts of the environment and biodiversity. Apart from the decrease in pH, the quantity of seaweed has also been increasing following the rise of CO<sub>2</sub> content in the atmosphere. For instance, studies show that the consumption of CO<sub>2</sub> by seaweed between the year 1989 to 2007 has increased from a volume of 330 units to about 360 units, giving a net excess of 30 units. This scenario is depicted in the figure 11 showing how seaweed is steadily increasing alongside CO<sub>2</sub> and how the oceanic pH is also decreasing.

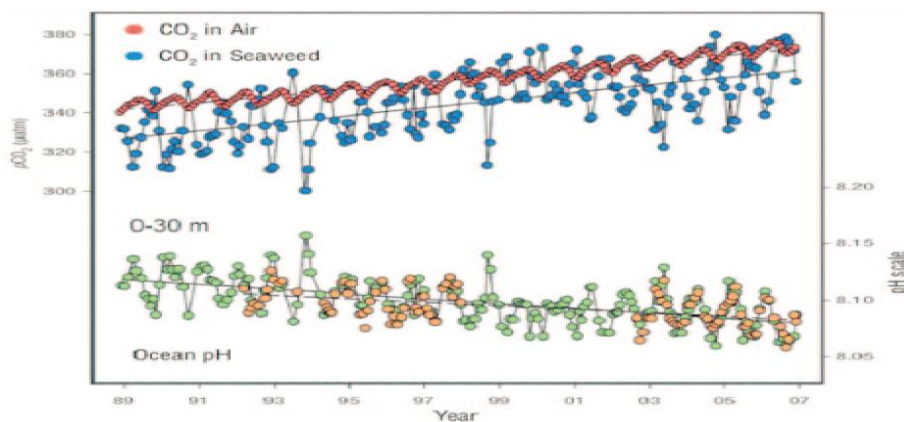


Figure 11. Escalating seaweed alongside CO<sub>2</sub> and the dropping of oceanic pH  
 Source: National Research Council: 2010d

The increase in seaweed following increased volume of CO<sub>2</sub> means that invasive species are multiplying at an alarming rate threatening natural species. This entails that aquatic life is endangered and so are other aspects of vegetation and animal life that survive on aquatic creatures. This challenge rallies alongside acidity of the water bodies that pose a threat to life in any of its form that survives at an average pH. The general shift in ecological composition of different ecosystems is also fast changing biodiversity. Findings also reveal that, subtle shifts in gaseous composition, pH levels and temperature degrees are resigning the ecological footprint. The predicament is recreating natural habitation into something unfamiliar to the existing biodiversity. The current natural environment being suited to the excising conditions are likely to experience a struggle to adapt to the new changes in ecological construction. This will entail that other species may emerge that are better suited for the new conditions and this leads to the development and evolution of foreign/invasive species. It may not be so clear as to what the foreign species adapted to the new ecology can do but at least some studies have revealed that most of such species are invasive and terribly harmful to the current species. A typical example if the black beetle found the Californian forests which has ravaged the vegetation there to the brink of extinction. The beetle literally feeds on entire branches removing chlorophyll and sucking the life out the plants. The photo in figure 12 shows how the black beetle has ravaged a forest in California -USA.



Figure 12. How the invasive Black Beetle has ravaged a forest in California  
Source: National Research Council: 2010d

In Africa, Zambia in particular, number of invasive species have evolved apart for the Kafue weed such as water hyacinth. These weeds have mainly been a source of the destruction of crops in the areas where they have appeared. They have made agriculture almost impossible in the areas where the Kafue River passes. Other invasive species in Zambia include the Mimosa Pigra plant from South America, which is ravaging wildlife especially in the area around the Kafue flats.

#### **4.10 Social-Economic Ramifications of Climate Change**

Climate change has phenomenal impact upon human life. The unprecedented shifts in weather patterns have produced catastrophe such as floods and outbreak of disease in several parts of the world. Global warming has not only raised the sea levels but created conditions favorable for certain fleas to survive. Various microbes harmful to human health such as the bacteria and viruses like the Chaleo Vibrio (Cholera Virus) has in modern history ravaged Europe, Asia and Africa (Ndebele-Murisa *et al.*, 2020). Although Europe and Asia contained the situation in the early 1900s, Africa and India seemed to have failed for the most part to contain it. The predicament seems to affect the two localities on earth perhaps due to the abundance of informal settlements or slums in urban areas. It is these spaces of urban blight where bacteria and viruses that cause water bone diseases are commonly found. This is probably due to their unsanitary

conditions. And so, the challenge of informal settlement becomes top priority in forwarding the urban agenda on several international forums. In the most recent years, during the period between 2020-2022, a strange virus called Corona Virus -19 (COVID) emerged and enveloped most countries with cooler climatic conditions. It was viewed by the WHO that the virus flourishes best in temperate regions where temperatures were relatively quite low. Nonetheless, it is interesting to note that the same virus as well as its hybrid still spread to countries in the tropics (mostly found in Africa) and infected large populations as well (Chigbu and Onyebueke, 2021). This is indicative that temperatures in Africa during the cold season have dropped below the normal. Throughout the world, millions of people lost their lives at a rate never experienced before since the last outbreak of small pox. Perhaps, COVID-19 was the first tip of the iceberg showing us the fate a future whose ecology is completely distorted.

Overall, we can also say that climate change has a cost implication upon the lives of people. The economic implication is created by the loss of human resource, infrastructure breakdown, and the disruption of trade and commerce. The COVID -19 pandemic literally halted the peak performance of business. Many people lost employment during the 2020-2021 lockdown (Chigbu and Onyebueke, 2021). Generally, the laws of supply and demand were grossly disturbed and this was typically seen in the agriculture sector in United States of America, where gallons and gallons of milk was disposed-off into canals as refuse due to lack of demand. The world was clearly headed for an economic meltdown similar to that of 2008.

## 5. CONCLUSIONS

It can be concluded that the advancement of human so-called civilization through history from prehistoric times throughout the ages, beginning from the Neolithic, Iron, Technology, Industry, and Artificial Intelligence are forerunners of quantum ecological transformation. Prehistoric times have shown a more natural and normal curve of ecological cycles. Neolithic times show a normal trend in the climatic and ecological structure of the earth-atmosphere system. The iron age ushered in increased productivity and more structured settlement of human communities, but still did not have significant impact in altering natural ecology. Agriculture was the mainstay that consumed forest and iron-working expedited this. However, this was not at rates as phenomenal as in the latter period. Arguably, the industrial revolution was an era of man's history that seems to have contributed the greatest deal to ecological disturbance and climate change. The late 19<sup>th</sup> century began to realize the higher levels of CFCs in the atmosphere and later on other ecological factors were affected. The chain reaction was upset in the late 1800s and other parts of the ecosystem such as water and land reacted to the atmospheric restructuring. All these changes inevitably began to impact biodiversity in terms of flora and fauna both in terrestrial and aquatic domains. The industrial revolution has spread across the globe and its ecological ramifications have followed it concomitantly. The industrial revolution has also precipitated the birth of further technological advancement called artificial intelligence. This is the current trend of human achievement and is dictating the pace of productivity and economic development.

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