



**Climate Change Consolidated:  
A Manual of Everything Regarding Climate Change,  
In A Certain Degree of Detail**

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## Abstract

This manual aims to comprehensively discuss the topic of climate change. Climate is defined as the long term weather patterns of a region. It is decided by the Sun, and the super spheres of Earth: atmosphere, hydrosphere, cryosphere, lithosphere, and biosphere. Changes occurring in these spheres have large effects on the climate. These effects are known as climate change. Natural climate change happens due to natural processes and cycles, over long time scales. Anthropogenic, or manmade climate change is occurring now over a short timeframe, primarily due to the emissions of greenhouse gases generated by manmade infrastructure. These emissions affect the spheres, changing the climate. This change has an adverse effect on human food security, water security, health, infrastructure, and biodiversity. This triggers feedback loops which worsen the problem and weaken processes designed to regulate the climate. An important aspect to consider is environmental law, which is how humans legally deal with the environment. This is studied through case studies of India and the state of Maharashtra. Finally, solutions to climate change are in terms of mitigation and adaptation. Mitigation includes efforts which aim to resolve climate change in the future through various plans and technologies. Adaptation means modifications and improvements to be made in order to deal with the effects of climate change that are already at the door. By exploring this issue in depth, this manual aims to be a repository for all basic important information on climate and climate change.

*Keywords:* Climate, Climate Change, Earth, The Sun, The Atmosphere, Environmental Law, Environmental Solutions

## Chapter 1: What Are We Doing Here?

Climate change, and the various ways in which it presents itself, is the most pressing problem that humanity faces. As the saying goes, knowing the problem is half the solution. Unfortunately, where climate change is concerned, knowing the problem is a problem in and of itself. The intricacies, causes, effects, systems, perspectives, of climate change, are too many to count. One cannot understand much about this issue unless one conducts a (somewhat) deep dive into the subject.

That is where we begin, dear reader. Through the course of this manual, we aim to understand the basic facets of climate change, the science behind it, the effects it causes, the areas it affects, and how the affected communities can/will/hope to deal with it. We will learn what climate exactly is, how it works as a detailed system on planet Earth, what climate *change* is, and what are the impacts it leaves (on the landscape and on living beings). The latter half of this manual will focus on the anthropocentric response to climate change: what is environmental law, how that affects the climate (with a case study of India and Maharashtra), and working/proposed solutions to this problem. This should provide a basic, comprehensive understanding of climate change.

All that said, to put it bluntly, this manual aims to:

1. Understand the current climate crisis,
2. Understand the Earth's climate system and climate science,
3. Understand the role of human activities in altering the Earth's climate,
4. Learn about impacts of climate change, and
5. Familiarise with potential climate solutions.

So now let us actually start working on this large amount of understanding and learning.



## Chapter 2: What is Climate?

The climate of a region is something that affects everyone in said region. Many practices, traditions, cultures, are built on it. Earth is a dynamic planet, the climate of a region is one of the few reliable factors on it that does not change on a whim.

So what is climate? This is something you probably know. It's not the most complicated concept, and school does a decent job of teaching that. Regardless, let us revisit it. Britannica defines climate as the “conditions of the atmosphere at a particular location over a long period of time,” only a short period of time alluding to the weather (Gentili et al., 2025). A simpler explanation of this would be that climate is the average weather of a region. It is “the long-term weather pattern of an area” (Brown, 2025). We will take a closer look at the elements establishing the climate of a region soon. The climate of a region differs from the weather by large timescales. Weather may change every minute, but the climate of a region is finalised over months/years/thousands of years/millions of years of observation (World Meteorological Organisation, 2025a). One can choose their own range of time to define a climate.

Naturally, there exist classifications of climate. A common system is Köppen classification. In this, climate is mainly of five types (with many subcategories): Tropical, Dry, Mild, Continental, and Polar (Tyson, 2025). With the added considerations of many factors, Köppen classification is done in types A, B, C, D, E, and H (with more subcategories, as aforementioned) (Arnfield, 2025). This can be seen in Fig. 1. To not overcomplicate matters, we will not be diving deeper in this classification.

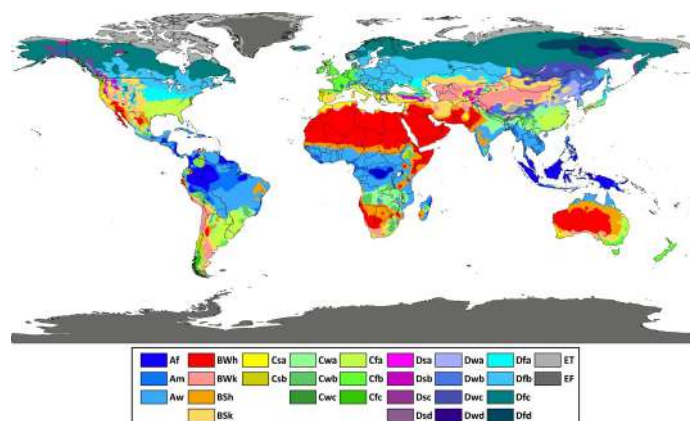


Fig. 1: Köppen Climate Classification (Arnfield, 2025)

## Chapter 3: The Pale Blue Dot

### 3.1 Earth

Earth is the third planet in the solar system. It has a diameter of 12760 km (fifth largest) and sits at an average distance of 150 million km from the Sun (Barnett, 2025). Technically speaking, climate is not a phenomena that just exists on Earth. It is present in some manner on all planets and moons. Mercury and Venus are hot, Mars is dry, Uranus is cold, Neptune, Saturn, and Jupiter are all highly dynamic while being cold, and so on (Raynor, 2023). But indeed, for us humans, the only climate that matters is that of Earth.



Fig. 2: Earth (Carlowicz, 2018)

Earth's climate is like a sloppily made mix-fruit smoothie in a blender. Some parts have distinct tastes, others have a blend, and all are influenced by many things, including a big body in the sky.

We briefly glanced at the ‘tastes’ (climates) in the previous section. Now, dear reader, let us get to the more science-y, fun part: what influences that climate. The Sun is the big body in the sky, acting like an engine and driving weather and climate. It has a massive influence on the planet. The atmosphere crucially keeps everything on Earth and forces interactions between spheres. The icy parts of the planet (cryosphere), alongside the ocean, typically act as a cooling system. Finally, the biosphere and lithosphere house many distinct elements, each contributing its own part to the climate. The following sections will dive deeper into these dynamic systems, as well as the scientific explanations behind them.

### 3.2 Sol

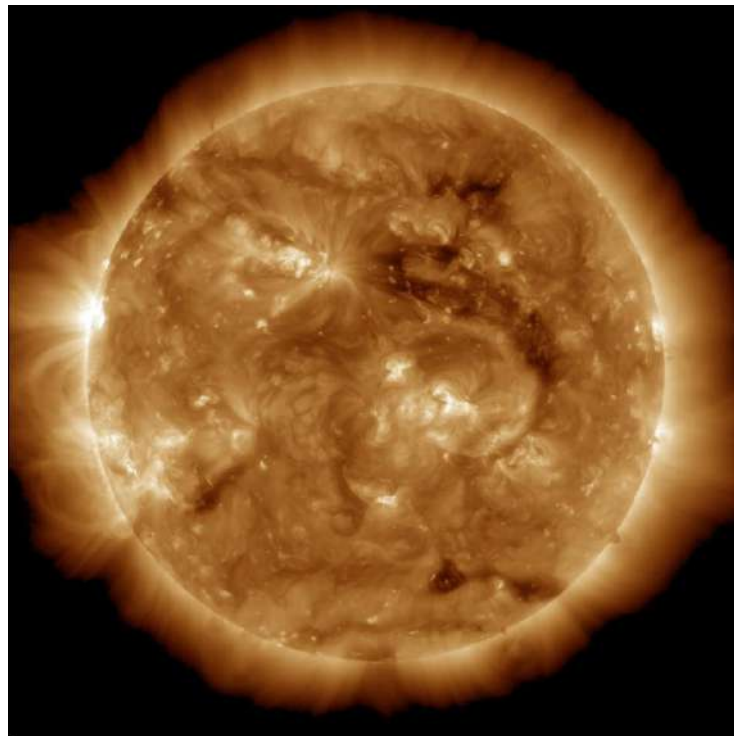


Fig. 3: The Sun (JPL, 2014)

The influence of the Sun is a complex story. The Sun very kindly sends Earth 44 quadrillion watts of energy every moment, in the energy flux of light and heat (NASA, n.d.), forming the Earth-Sun energy budget. This energy budget is responsible for a large chunk of the natural happenings, as it is the most direct and abundant source of heat. From being crucial in setting the temperature of an area to influencing wind patterns, the energy budget is what makes the planet work. With the various systems that we will discuss in the upcoming chapters, we'll see how this energy budget is distributed over the planet and how it affects the climate.

Temperature is one of the main factors in climate. To understand temperature on Earth, we must see how that temperature is set on Earth. For this, we must know what a blackbody is. In physics, a blackbody is an object that “absorbs all radiant energy falling on it” (The Editors, 2025a). The energy absorbed (in the form of heat) decides the temperature. To understand how why Earth’s temperature is what it is, we assume Earth to be a perfect blackbody (in reality, it is not a ‘perfect’ blackbody). Therefore, we can now apply the Stefan-Boltzmann Law for blackbodies and calculate the suggested average temperatures caused only due to the Sun’s influence.

$$T = \left( \frac{F}{\sigma} \right)^{\frac{1}{4}}$$

T = Temperature

F = Energy Flux

$\sigma$  = Stefan’s constant =  $5.67 \times 10^{-8} \text{ W/m}^2\text{k}^4$

In fact, if we assume all planets to be blackbodies, we can calculate the average temperatures for those too. Refer Table 1 and Figure 4 to see the difference between observed and calculated temperatures of the planets.

Planet	Distance from Sun in $10^6$ km	Solar Energy Flux Watts/m <sup>2</sup>	Obs. Surface Temp.		Calc. Surface Temp.	
			K	C	K	C
Mercury	58	2290	440	166.85	448.294185375494	175.144185375494
Venus	108	660	730	456.85	328.465846771053	55.315846771053
Earth	150	342	287	13.85	278.683182726842	5.53318272684202
Mars	228	148	218	-55.15	226.031862759039	-47.118137240961
Jupiter	778.5	50.5	166	-107.15	172.753589432597	-100.396410567403
Saturn	1430	14.9	143	-130.15	127.321223217133	-145.828776782867
Uranus	2870	3.71	76	-197.15	89.9389292136028	-183.211070786397
Neptune	4500	1.51	72	-201.15	71.8370470965947	-201.312952903405

Table 1 (Class Assignments)

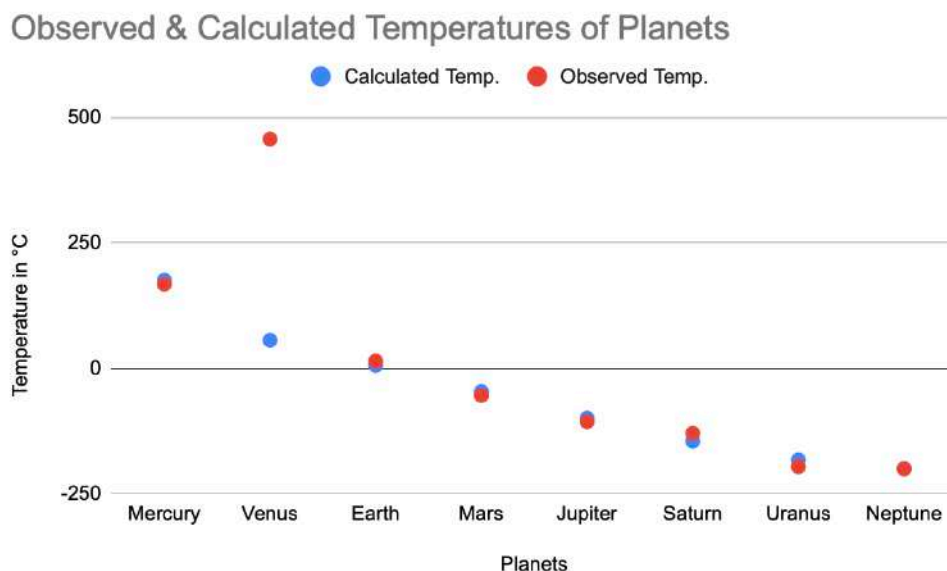


Fig. 4 (Class Assignments)

From this, the influence of the Sun on the temperatures of planets is clear (Venus is a rather weird case which we will touch upon later). The marginal differences between observed and calculated temperatures is due to the influence of atmospheres (see Appendix Pt. 3).

By conducting a separate experiment (see Appendix pt. 1), we model the Earth as a perfect blackbody with and without an atmosphere. Through this experiment, it is clear that the marginal difference between observed and calculated temperatures is due to the presence of our wonderful atmosphere.

Another manner in which the Sun affects Earth is with certain parameters regarding how the Earth is positioned with respect to the Sun. These parameters are eccentricity (shape of orbit), obliquity, and longitudinal vernal equinox. Obliquity is the axial tilt of the planet and is primarily responsible for the seasons on our planet. It determines how directly light from the Sun hits Earth, hence deciding how warm or cold the planet is at that time. These parameters build up the Milankovitch Cycle (see Fig. 5 & Appendix pt. 2), which is how the Earth is positioned with respect to the Sun over a period of 1,00,000 years (NASA Science, 2020). In this cycle, Earth receives different amounts of energy, something which has driven natural climate change in the past (we'll discuss that in a bit). Hence, we can conclude that the Sun is primarily responsible for the climate.

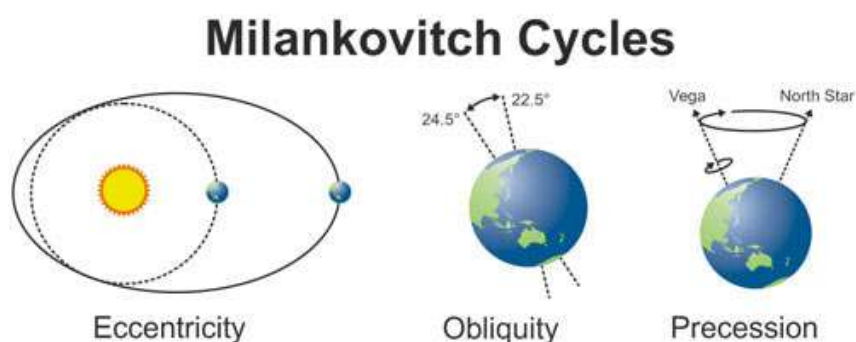


Fig. 5: Milankovitch Cycles (Rossett, n.d.)

### 3.3 The Big Invisible Dome

The atmosphere refers to “the gas and aerosol envelope that extends from the ocean, land, and ice-covered surface of a planet outward into space” (Pielke, 2025). It extends upwards from land for 100 km on average, after which it is extremely thin. It is responsible for being the air we breathe, for winds, for hosting clouds, tornadoes, cyclones, and more, and it is also responsible for forcing spheres (biosphere, hydrosphere, lithosphere, etc.) to interact with each other and exchange energy in the form of heat.

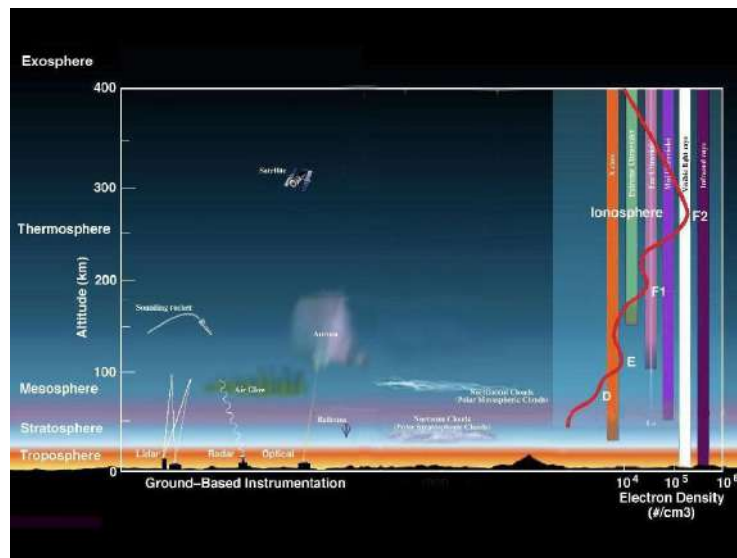


Fig. 6: Layers of the Atmosphere (Buis, 2024a)

The layers of the atmosphere begin on land with the troposphere, then stratosphere, mesosphere, thermosphere, and exosphere (which is the edge of outer space) (Buis, 2024). While the troposphere is only around 12 km tall (Fig. 6), it houses 99% of water vapour and other aerosols, with most weather activity happening in this layer (Buis, 2024).

The composition of the atmosphere is extremely important for understanding air quality as well as climate change. Air in the atmosphere is a mixture of many gases (Fig. 7). It is majorly nitrogen (78%), alongside oxygen (20%). The remainder (2%) is made up mostly of carbon dioxide and the minute amount left is trace gases such as argon, neon, helium, and more (Buis, 2024b). Due to the properties of these gases, their amounts play a huge role in regulating temperature, and consequently, weather and climate.

Let us spend some more time on this, and discuss the greenhouse effect. Earth, in the solar system, is located in an area known as the Goldilocks Zone. The Goldilocks Zone is wherein, due to

proximity to the Sun, it is neither too hot nor too cold. This is key in maintaining life-sustaining temperatures on Earth. Gases such as carbon dioxide, methane, water vapour, etc. are known as greenhouse gases, as they trap heat and help maintain a certain temperature. This is the Greenhouse Effect. These two features of Earth are why life exists.

Unfortunately, this can go horribly wrong, as is the case with Venus. Venus suffers from a runaway greenhouse effect, wherein an overabundance of greenhouse gases (GHGs) forces the planet to trap more and more heat. This why there is such a large difference in the calculated and observed temperatures of Venus (see Fig. 4). the global warming phenomenon, which we'll discuss later, is because of the same reason. Too many GHGs in the atmosphere are trapping too much heat, causing the planet to warm up. But we'll get to that too, dear reader.

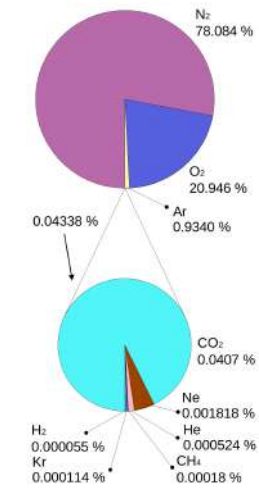


Fig. 7: Composition of the Atmosphere, (Buis, 2024b)

The atmosphere houses another system that helps regulate temperatures: clouds. Why clouds? Well, their white colour supports the Albedo Effect (see Appendix pt. 4). Albedo refers to “the amount of energy reflected by a surface” (see Fig. 8) (University Corporation for Atmospheric Research, 2025a). We know that light from the Sun brings heat and energy to Earth. Clouds (as well as other reflective surfaces like icy/snowy areas and oceans) directly reflect this light into space, not allowing heat to be transferred into the atmosphere. This phenomenon is crucial to cooling the planet. The higher up a cloud is (like cumulus or altostratus clouds), the more it contributes to the Albedo Effect. Funnily enough, a runaway Albedo Effect is also possible and has happened in the past with ‘Snowball Earth’ occurring during a period of ice ages.

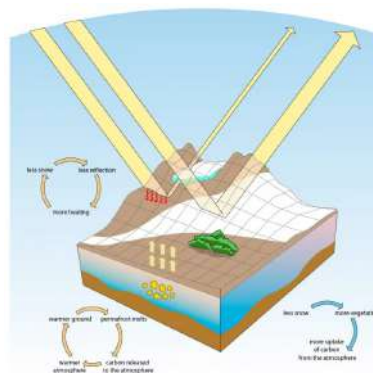


Fig. 8: Albedo Effect (Norwegian Polar Institute, n.d.)

Winds are also pivotal to the climate. Winds not only distribute temperature, but also moisture, ocean currents, and dust (Turgeon & Morse, 2024). Wind patterns influence monsoons, rains, tornadoes, hurricanes, and cyclones (Turgeon & Morse, 2024). All this means that wind has a huge impact on weather and therefore, on climate. Changes in wind patterns have a profound effect on many systems on Earth.

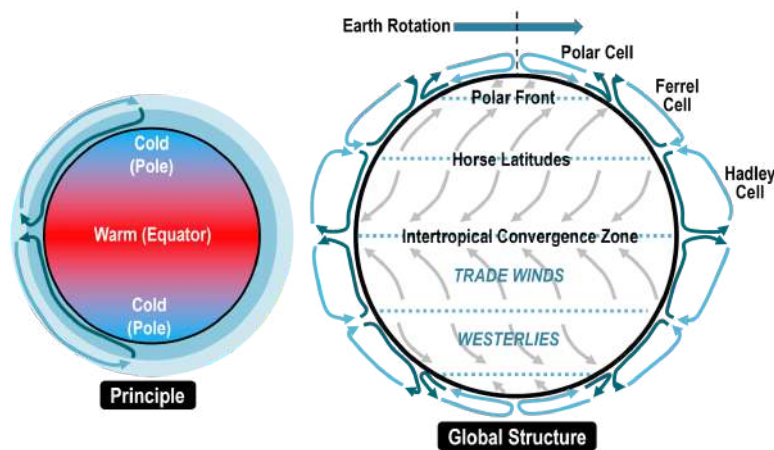


Fig. 9: Global Wind Patterns (Rodrigue, 2025)

All these features of the atmosphere showcase its importance and effect on climate.

### 3.4 Waterworld

One of the first things taught to children in geography is that Earth is 70% water. This includes oceans, rivers, lakes, groundwater, aquifers, wells, etc. This is the Hydrosphere, the “total amount of water on a planet” (Rutledge et al., 2023). While usually used with reference to liquid water, the definition technically extends to gas and ice, meaning that water vapour, clouds, fog, as well as the Cryosphere (discussed later) is included in the Hydrosphere.

When we discuss the Hydrosphere and climate, the main player is the water cycle (Fig. 10). While the detailed water cycle is quite complicated, the simple version is a cyclic process of evaporation, condensation, and precipitation (National Oceanic Atmospheric Administration, 2025). This movement of water is what decides the amount of moisture in the air and the precipitation a region gets, hence influencing the climate of that region. Water also has a certain albedo, which along the natural properties of water, helps cool areas.

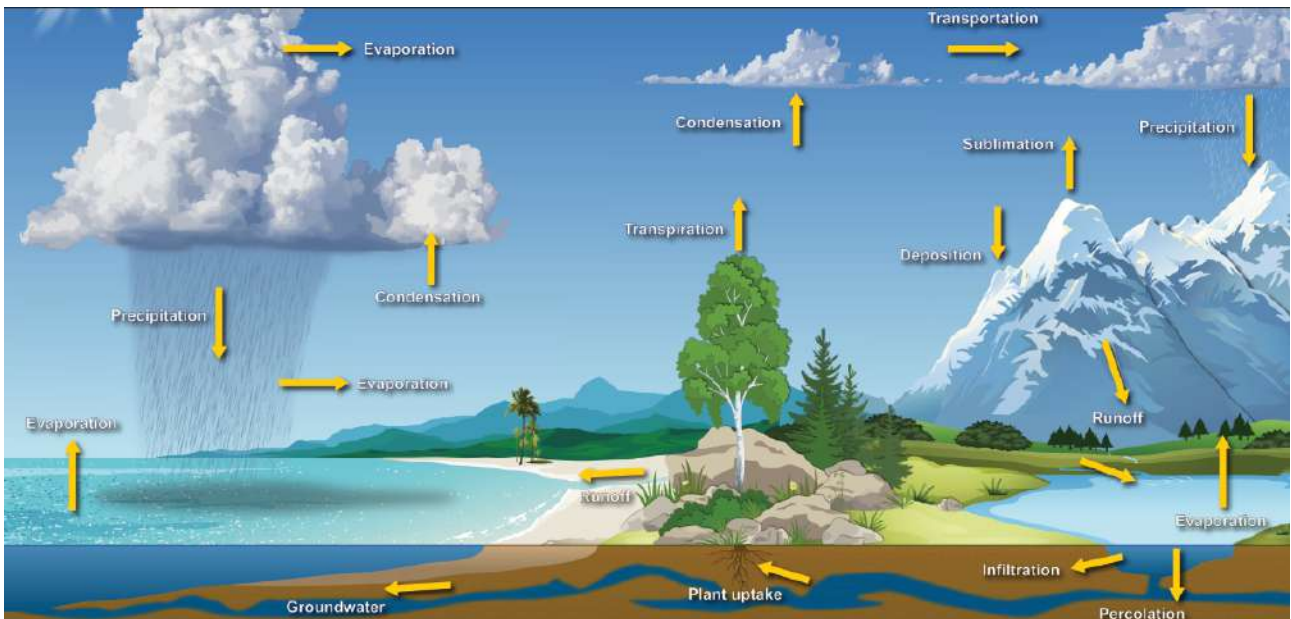


Fig. 10: Detailed Water Cycle (National Oceanic Atmospheric Administration, 2025)

### 3.5 Ice, Ice, Baby

The Cryosphere (Fig. 11) is one of the more subtle aspects influencing climate. With Antarctica and the Arctic being majority stakeholders, the:

Cryosphere includes the components of the Earth System at and below the land and ocean surface that are frozen, including snow cover, glaciers, ice sheets, ice shelves, icebergs, sea ice, lake ice, river ice, permafrost, and seasonally frozen ground, and solid precipitation (World Meteorological Organisation, 2025b).

It can also be referred to as the frozen part of the hydrosphere. So how does it influence climate?

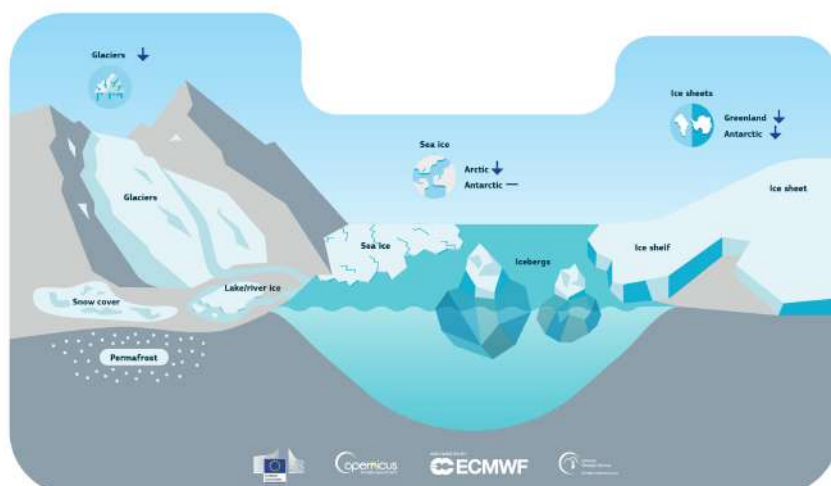


Fig. 11: The Cryosphere (Copernicus, 2024)

As explained by the National Snow and Ice Data Center (2025), temperature control comes into play. The massive albedo of ice is partially responsible for preventing overheating. The natural cooling effect of ice and snow also regulates temperature.

Moisture transfers between frozen water and the atmosphere influence cloud cover formation, precipitation, and atmospheric circulation. Water composition, such as fresh meltwater flowing into a salty ocean, strongly affects ocean circulation. These back-and-forth exchanges influence long-term trends in climate and regional weather patterns (National Snow and Ice Data Center, 2025).

The Center also explains that as ice and snowmelt occurs, it also acts as a source of freshwater for many regions, hence determining whether that region is dry or not.

### 3.6 Breaking Ground

The Lithosphere is the “rigid, rocky outer layer of Earth, consisting of the crust and the solid outermost layer of the upper mantle” (The Editors, 2025b). All land, i.e. plains, hills, mountains, deserts, valleys, etc. alongside underground elements such as tectonic plates, are included in the lithosphere (Fig. 12). With water covering 70%, the land makes up 30% of Earth. The simple existence of landforms plays a role in deciding the climate of a region.

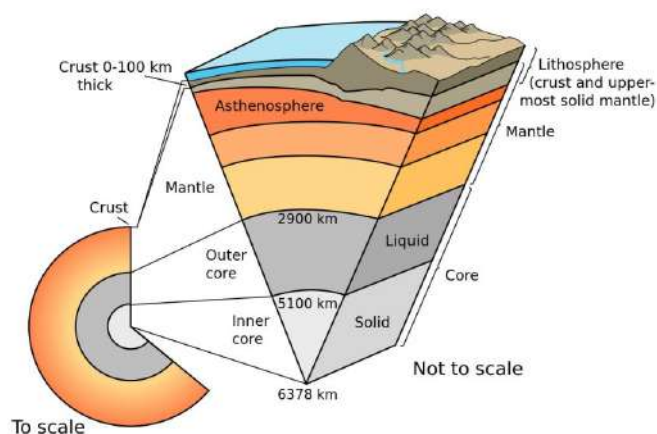


Fig. 12: Layers of the Earth (Evers, 2023)

Interactions of the lithosphere with other spheres influence temperatures greatly, in turn influencing precipitation and moisture levels (Evers, 2023). This is a very visible, obvious effect of this sphere. The invisible effect comes in the form of tectonic activity. “The most well-known feature associated

with Earth's lithosphere is tectonic activity. Tectonic activity describes the interaction of the huge slabs of lithosphere called tectonic plates" (Evers, 2023). The movement and interactions between tectonic plates influences uplift (increase in vertical elevation of land), atmospheric circulation, and the water cycle (Hay, 1996). Tectonic activity also generates mountains (orogeny), earthquakes, volcanic eruptions, tsunamis, and geothermal energy, all of which can have a massive influence on the climate and can even alter it permanently (Evers, 2023).

### **3.7 Life**

The last major factor influencing climate on Earth is life, i.e. the Biosphere. It includes all life in the lithosphere, atmosphere, hydrosphere, and cryosphere. For a figure, just take a look around you. From massive trees to microscopic algae, all components of the biosphere affect the climate in some way, big or small. Even you, dear reader. As explained by the University Corporation for Atmospheric Research (2025b):

Living organisms comprising Earth's biosphere affect Earth's climate system. They can change the chemical makeup of the atmosphere by, for example, absorbing carbon dioxide through photosynthesis as plants and algae do, and by adding chemicals to the atmosphere from pollution as humans do. Life also alters Earth's surface, changing the colours of the landscape as more plants are grown or harvested, for example. The changes affect the albedo, or brightness, of Earth's surface and influence the overall climate system.

The list of ways in which the biosphere affects climate is long and detailed, with many living beings contributing in different ways. This list cannot be covered here, but the above explanation covers the main ways.

To sum it up, climate change is affected by all the super spheres of Earth as well as the Sun. The Sun decides the energy budget of the planet and sends it to Earth in the form of light and heat, setting the average temperature of the planet. The atmosphere houses important characteristics of the planet, while its composition and wind patterns determine temperatures of regions in conjunction with the Greenhouse and Albedo Effects. The Hydrosphere and Cryosphere are pivotal in moving water through the layers of Earth, cooling the planet while deciding moisture levels of areas. The subtly active features of the lithosphere as well the trillions of living cells on the planet change compositions of the atmosphere, interact with spheres, and affect temperatures, all ending with some impact on the climate.

## Chapter 4: So What is Climate *Change*?

### 4.1 Climate Change & Feedback Loops

As the name suggests, climate change is when the climate changes. By definition, “Climate change is a long-term change in the average weather patterns that have come to define Earth’s local, regional and global climates” (Velev, 2024). This can happen for a variety of reasons, natural and manmade. Even a slight change in climate can have many consequences.

Typically, climate change begins with a few random occurrences. These triggers something known as feedback loops. Feedback loops are, in essence, cyclic chain reactions. One event triggers another, and another, and another, eventually either amplifying or diminishing the primary event. When these events amplify each other cyclically, it is known as a positive feedback loop, and if the events diminish each other cyclically, it is known as a negative feedback loop. Typically, a negative feedback loop reduces and eventually stops change, acting as a regulator, while a positive one accelerates it and produces instability (Robinson, 2021).

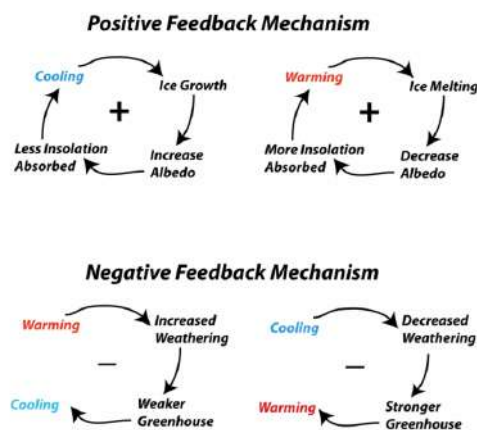


Fig. 13: Feedback Loops (Bice, n.d.)

As ice melts, Earth’s albedo reduces, making it warmer. Hence, more ice melts, further reducing albedo, further increasing the temperature, and so on. In contrast, increase in ice formation increases albedo, reducing temperatures and facilitating more ice formation. Both of these examples are those of positive feedback loops, as each event is amplifying the next. An example of a negative feedback

loop is that an increase in temperature induces more cloud formation, increasing albedo and actually causing cooling. Feedback loops are extremely important players in climate change.

## 4.2 Natural Climate Change

To clear any misconceptions, climate change does occur naturally. The Earth has had a rocky and tumultuous past in terms of temperature. We know this because of ice cores. Recall that the presence of carbon and other GHGs in the atmosphere are essential in determining the climate and temperature. The lack thereof implies lower temperatures. On a supporting note, as snow falls, it traps air bubbles between layers of snow. Well, over centuries, as snowfall happened in winter in Antarctica, the deposited snow preserved centuries of data on what the composition of the atmosphere was in the form of air bubbles trapped between layers of snow. The deeper you go in this layers, the more centuries of information you uncover. This information is gathered through ice cores harvested in Antarctica. Fig. 14 shows carbon abundance in the atmosphere over centuries as seen in the Vostok Ice Core.

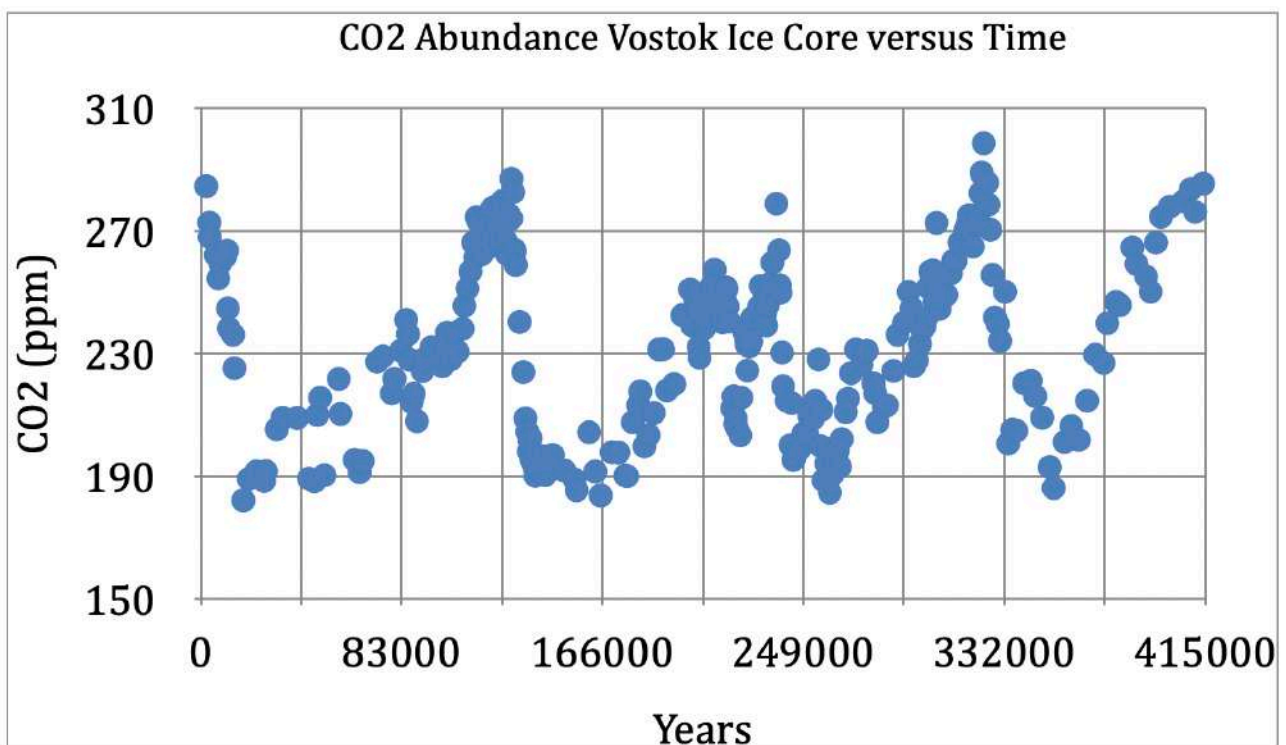


Fig. 14 (Class Notes)

This variation in carbon abundance tells us that the temperatures on Earth experienced massive fluctuations over centuries as carbon abundance changed due to events such as volcanic eruptions and fires. Changes in the super spheres which trigger feedback loops are the causes of natural

climate change. The past 11,700 years are known as the holocene epoch, a period after the last ice-age (or Snowball Earth or glacial epoch), wherein the temperatures have been reasonably stable, allowing for humans to develop, grow, and settle (Waggoner, 1996). Thankfully, an ice age won't be affecting us humans, as it is unlikely to occur soon. We have something worse coming.

### **4.3 Anthropogenic Climate Change**

Human beings evolved into existence around 3,15,000 years ago somewhere in Africa (Tuttle, 2025). For the longest time after this, while their settlements expanded and popped up across the world, they really were not a problem—just another dominant species on Earth. That took a turn with the second industrial revolution, the one which began in the mid-1900s in Europe, North America, and Japan, slowly expanding across the planet (The Editors, 2025c). The second industrial revolution has had a massive impact on Earth, with more and more metals and minerals being used in production, and large amounts of byproducts and emissions coming out of the process.

Emissions. That is the key word. All this jazz, industrialisation, development, transportation, etc. all this doesn't grow on trees. You need a lot, a lot, of energy for such progress. Humanity got this energy from fossil fuels. Fuels such as coal, oil, natural gas, are considered 'fossil' fuels as they are formed from the remains of dead biological matter from millions of years ago (Denchak, 2022). Thing is, all biological matter has the core component of carbon. When you utilise fossil fuels (which naturally contain carbon), you burn them, and in that process, you release carbon (Denchak, 2022). Same thing happens when you cut/burn a tree. Or use a car. Or produce electricity. Produce anything, really. Or cook on a bonfire. Pretty much most human activity facilitates the release of not just carbon (in the form of carbon dioxide), but other GHGs such as methane, water vapour, and more. These GHGs are being released from where they were sequestered (be that in fossil fuels or even soil) through human activity. The graph in Fig. 15 shows how much carbon levels in the atmosphere have increased since the second industrial period. To give a sense of scale, the fluctuations over 4,15,000 years (as seen in Fig. 14) had a maximum amount of carbon as 298.7 ppm, while as of 2025, the current carbon abundance sits at 423 ppm (see Appendix pt. 5 for more information).

This does not go unnoticed by climate. Recall from the biosphere section that life typically affects the climate because of what it emits. Usually, this is kept in check via natural processes and cycles.

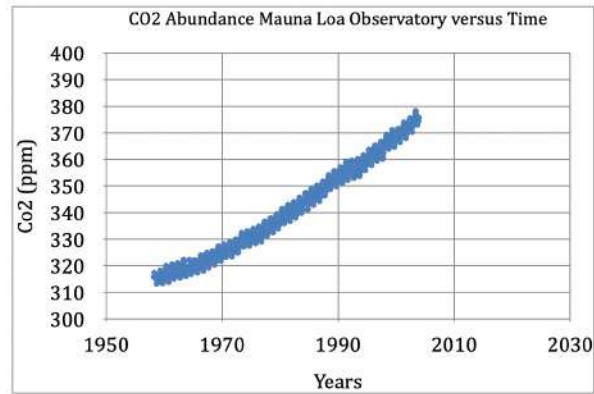


Fig. 15: Carbon Abundance (Class notes)

However, humanity is emitting in quantities that natural processes cannot keep up. We are producing GHGs too fast (Fig. 15). This overabundance of GHGs means that more heat is being absorbed by the planet, leading to the phenomenon of Global Warming. NASA defines global warming as “the long-term heating of Earth’s surface observed since the pre-industrial period (between 1850 and 1900) due to human activities, primarily fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth’s atmosphere” (Fig. 16) (Velev, 2024). Global warming is where man-made, or “anthropogenic” climate change begins. This climate change has little to no influence by nature, it is purely due to human activity.

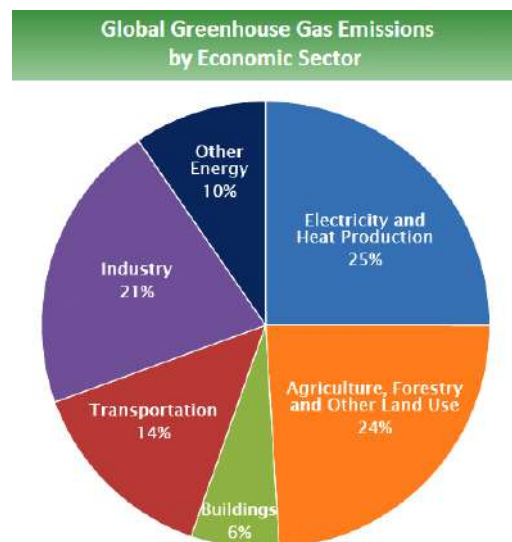


Fig. 16: (Ahmed & Sharma, 2018)

Global warming is just where it begins. Thankfully, humanity cannot affect the Sun (at least, not yet), but it does massively affect the super spheres of our planet. Massive GHG emissions wreaks havoc in the atmosphere, raising average temperatures. These raised temperatures melt ice, decreasing the albedo effect and raising sea levels. Raised temperatures also mean more water

evaporation, and with water vapour being a GHG itself, this acts as a positive feedback loop. With huge mining operations and agricultural activities, carbon sequestered in the land is released, furthering global warming. Urbanisation also changes the way land distributes heat and moisture. Finally, the destruction brought upon the biosphere for resources (mostly in the form of deforestation), is a huge blow to the natural regulatory processes of the planet, letting phenomena like global warming run unchecked. These activities often trigger the chaotic positive feedback loops and weaken the regulatory negative feedback loops. This change becomes irreversible when positive feedback loops reach “tipping points,” i.e. “critical thresholds beyond which a system reorganises, often abruptly and/or irreversibly” (OECD, 2022).

So while natural climate change does exist, what is happening globally right now is purely due to humans. This is called Anthropogenic Climate Change, and it is bad. Really bad. In the next chapter, we will take a closer look at the impacts this climate change will have on our systems as humans.

## Chapter 5: It Hits. Hard.

### 5.1 The Basics

This message unfortunately has to be repeated but the impacts of climate change are also too many and sometimes too subtle to count. For ease of communication and understanding, this manual will split the effects into four categories: food security, water security, human health and infrastructure, and biodiversity loss. Through these categories, ultimately we should cover all the main manners in which human life, as well as general life, is affected. These impacts serve as a reminder of what all is at stake if climate change is allowed to continue and take hold. All these categories, wherever and whenever affected, pose a deadly threat to the community of that region and time.

The important threat to current systems posed by climate change is through incidents known as Extreme Weather Events. “An extreme weather event is rare at a particular place and time of year, with unusual characteristics in terms of magnitude, location, timing, or extent” (World Meteorological Organisation, 2025c). These events occur more and more frequently, wrecking the



Fig. 17: Extreme Weather Events (Geneva Environment Network, 2025)

systems of a region and posing a threat to the way of life (Fig. 17).

## 5.2 What's for Dinner?

Remember the Holocene? This period of calm temperatures is what allowed humanity to settle.

“The relatively stable Holocene climate enabled the development of farming and a forty-fold increase in human numbers by 2,000 BP” (Murphy, 2007). The climate provided by the holocene is the single reason behind why humanity could stabilise (due to the development of agriculture in this calm time), and this stability is what gave humans the time to develop and innovate. This innovation kept accelerating, eventually causing the industrial revolutions.

Agriculture means stability for humans. Having a (mostly) reliable source of food is what our society is built on. Even today, most farming is reliant on the stable temperatures of the Holocene Epoch. With the climate changing, this period of climate stability draws to a close, putting the most important, foundational system of mankind in jeopardy. Agriculture is a fragile system, prone to many threats. As the super spheres of Earth change, agriculture is affected in many ways. The details in Fig. 18 elaborate the impacts of climate change on food security with examples.

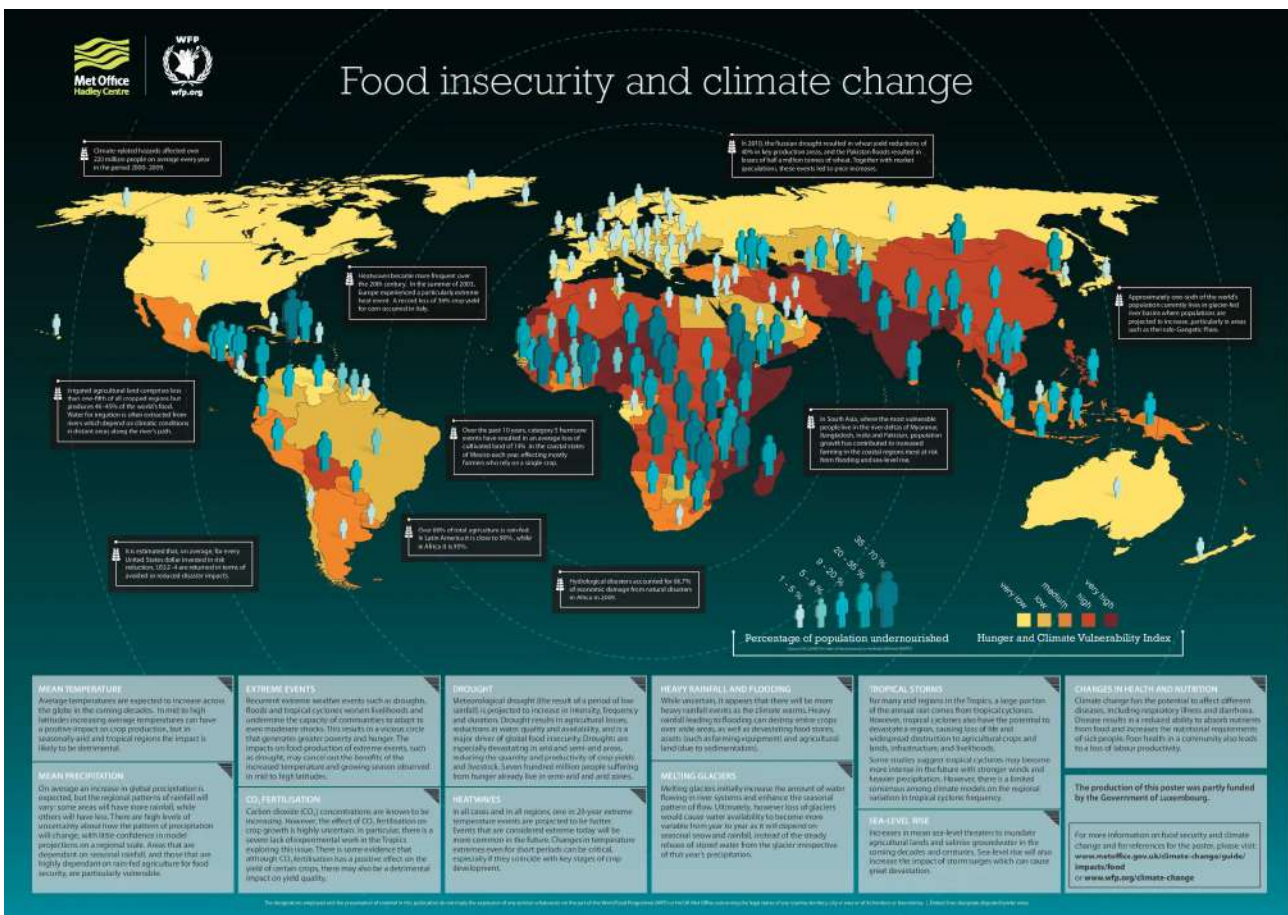


Fig. 18: Food Insecurity & Climate Change (Villarama, 2021)

Changes in the atmosphere and increased fluctuations of temperature are disastrous. Many crops require certain temperatures to grow. For example, temperatures of more than 32° C and 36° C means that the crops of wheat and rice respectively, will die (Tamil Nadu Agricultural University, 2016). These temperature fluctuations also mean unreliable rains. Depending on how a positive feedback loop kicks in within a region, drought, as well as excessive rainfall and storms, are likely with climate change—both of which kill crops. The Hydrosphere also comes into play here: flooding or receding of waters, alongside the above effects, can make or break harvests. Changes in this sphere are deadly for crops. Climate change also affects quality of soil, further destabilising agriculture. These spheres are changing across the planet, putting global agriculture at risk.

### **5.3 No Waterworld?**

Water is one of the essential needs for survival. On a survival basis, we need water for drinking. On a basic basis, we need it for cleaning, cooking, agriculture, and animal husbandry. Aside from this so many other systems on the planet use water for a variety of purposes, primarily in the industrial sector.

It is so important that the United Nations calls the climate crisis primarily a water crisis (United Nations Water, n.d.). The UN goes on to say “Extreme weather events are making water more scarce, more unpredictable, more polluted or all three. These impacts throughout the water cycle threaten sustainable development, biodiversity, and people’s access to water and sanitation” (United Nations Water, n.d.). Rising sea levels and flood contaminate land resources. Meltwater from glaciers, ice sheets, and snow fields further hasten this volatility. On the other hand, the lack of water increases droughts and makes a region hotter, making it more prone to fires. Climate change affects the water cycle, worsening all this aforementioned mess and setting off more feedback loops. The most important resource as required by the entire planet is jeopardised with climate change.

### **5.4 Many, Many Doctor’s Visits**

Now the topic arrives to the human body. Climate change, and the accompanying extreme weather events, can be quite dangerous to human health. The human body has evolved to survive certain types of climate, and changing weather patterns obviously affect this.

The World Health Organisation (2024) explains this in detail. The first thing that comes to mind is increases in illnesses and fatalities as a direct result of extreme weather events. Increasing temperatures and irregular precipitation strengthen and spread air, water, and food borne diseases. Mental health issues are also affected and worsened. “Furthermore, climate change is undermining many of the social determinants for good health, such as livelihoods, equality and access to health care and social support structures” (World Health Organisation, 2024). This can be disproportionately felt by minorities such as women, children, elderly, ethnic minorities, etc. WHO data indicates that 3.6 billion people (especially in Africa and Asia) currently live in areas particularly susceptible to climate change.

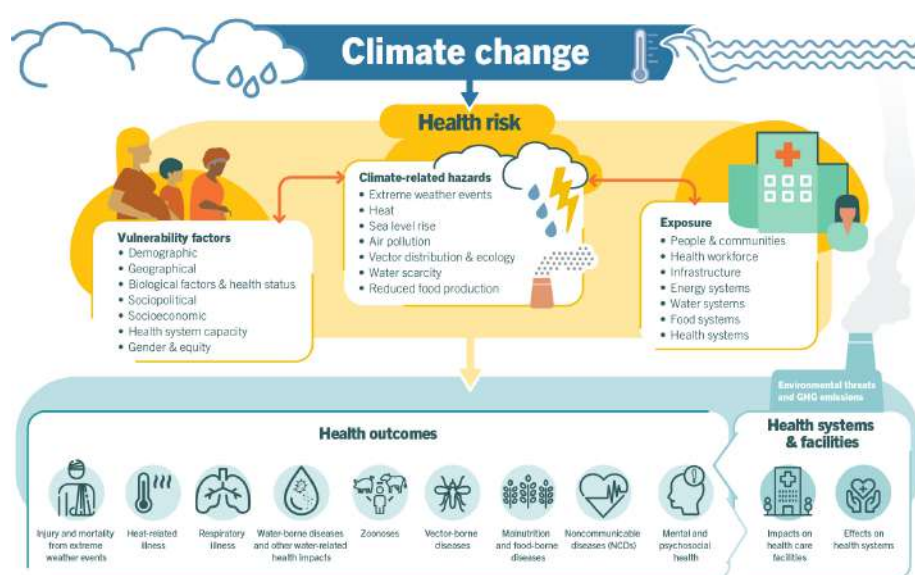


Fig. 19: Effects of Climate Change on Health (World Health Organisation, 2024)

WHO continues, elaborating on how aside from the direct effects, climate change also affects human health indirectly. As environmental determinants deteriorate, our ability to prevent things harmful to health degrades, making diseases unpredictable. It decreases the availability of to care for those affected, as it affects the global health workforce and infrastructure. Lastly, climate change also stifles access to elements that make people healthier, such as clean water and uncontaminated food. See Fig. 19 for more details.

The other purely human element affected by climate change is infrastructure. Infrastructure is also designed to deal with a certain climate. The United Nations Development Programme (2025) explains as follows:

As it changes and extreme weather events increase in frequency, infrastructure also lingers unsupported. rising temperatures, shifting patterns of rainfall, more frequent and intense extreme weather, and rising sea levels – will affect all types of infrastructure from energy and transport to water, waste, and telecommunications.

These direct effects on the body and human creations are happening now, and are in their own way, a kind of feedback loop.

## **5.5 Where All The Greenery At?**

As the super spheres of Earth change, the species living in these spheres are affected. Similar to humans, these beings have evolved to live in their respective spheres with a certain climate and temperature. While certain species are less sensitive to changes in climate and temperature, all are affected to some degree. “The term biodiversity (from “biological diversity”) refers to the variety of life on Earth at all its levels, from genes to ecosystems, and can encompass the evolutionary, ecological, and cultural processes that sustain life,” states the American Museum of Natural History (n.d.). It is also used to refer to the living organisms within a given area (The Wise Apple, 2025).

Climate change has altered marine, terrestrial, and freshwater ecosystems around the world. It has caused the loss of local species, increased diseases, and driven mass mortality of plants and animals, resulting in the first climate-driven extinctions (United Nations, n.d.).

Of course, extreme weather events come into play. Wildlife is affected by such events just like humans are, with losses in habitats, spread of disease, collapse of systems (ecosystems in this case). This is especially concerning for forest and ocean biodiversity, as lifeforms in these habitats (particularly oceanic) are susceptible to slight changes in temperature. Losses in these spheres deteriorate the planet’s natural processes of regulating climate and sequestering GHGs, hence kicking off positive feedback loops (United Nations, n.d.). For example, even a 1.5° C change kills 70% to 90% corals globally (United Nations, n.d.). When the health of ecosystems is affected, so are humans. As ecosystem services such as food and medicine deteriorate, human health and lifestyle is affected as well (United Nations, n.d.).

All life on Earth is connected to some degree, in a delicate complex web-like ecosystem. As climate change hits and a few links break, the entire system may collapse. Any ecology lecture can tell you

that, dear reader. Humanity is a part of this system, hence we will be affected too. It is imperative for solutions to be sought for the same.

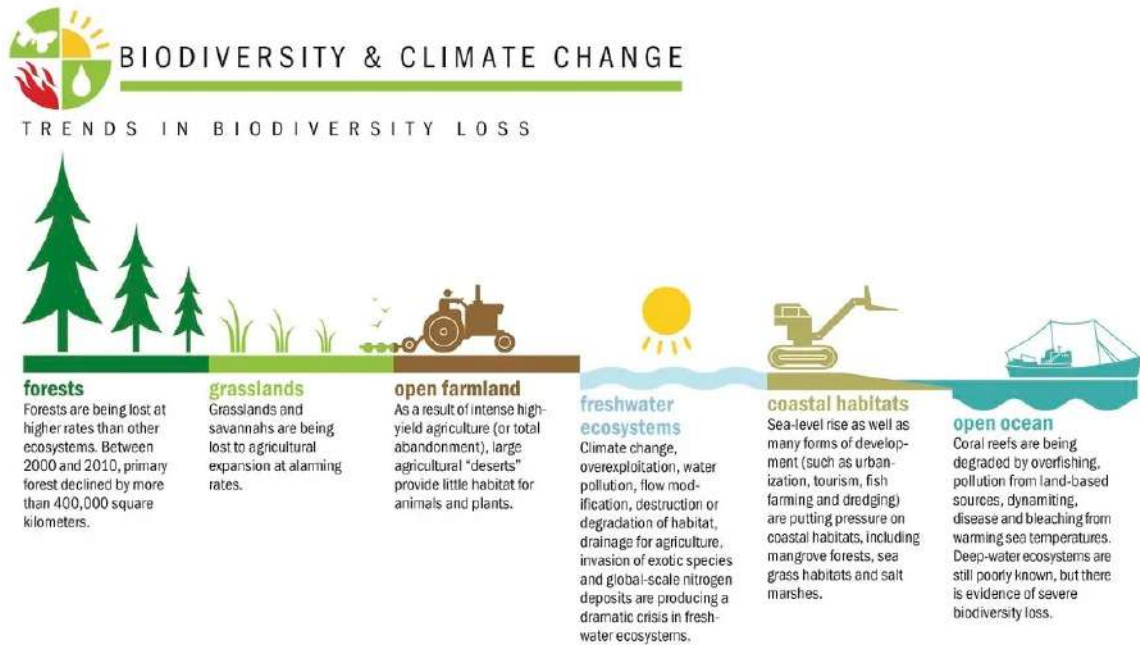


Fig. 20: Biodiversity Loss Trends (Guest Blog Posts, 2023)

## Chapter 6: I'll See You In Court

### 6.1 Why Does It Matter?

Environmental law refers to “principles, policies, directives, and regulations enacted and enforced by local, national, or international entities to regulate human treatment of the nonhuman world” (Campbell-Mohn & Cheever, 2025). It is a “collective term encompassing aspects of law that focus on protecting the natural environment, human health, and natural resources” (American Public University, 2023). Essentially, it refers to how humans legally should deal with the environment. Like regular law, environmental laws differ nation to nation/state to state/region to region, so environmental practices are mostly not global, although certain trends are. Environmental law works on the principles of precaution, prevention, “polluter pays,” integration, public participation, and the promotion of sustainable development (Campbell-Mohn & Cheever, 2025). The details of environmental law are many, and deep, but we will take a quick look at why it is important, as well as a case study about India and the Indian state of Maharashtra.

The American Public University (2023) explains it in detail. Environmental law addresses many of the factors affecting climate change, primarily emissions. It sets limits, guidelines, and goals for emissions, hopefully ensuring that the environment is protected as much as possible. By setting rules around emissions, GHGs are delimited, helping stop climate change. Environmental law sets boundaries for protecting biodiversity, helping reinstate regulatory processes and negative feedback loops. Naturally, entities which violate these laws, harming the environment and climate, are held liable and are charged accordingly (whether criminal or not is dependent on the exact law). It sets goals for sustainable development and renewable energy generation, further lessening emissions and protecting the environment. Environmental public policy is also pivotal in involving the public, giving it a voice, and ensuring that it is educated and aware. The strictness and detail of such laws can go a long way in protecting the environment and dealing with climate change.

### 6.2 Bharat

Indian environmental law is a unique situation. It has to deal with the demands of a developing nation, while ensuring that India's massive population (and landmass) is healthy and protected against environmental issues. India is a big country, with many unique land features: forests,

mountains, water bodies, and a lot of biodiversity. All of this has to be protected, while making sure that the needs of a growing economy and people are met. Economic needs are usually placed above environmental, as there are few who place votes on the basis of environment. India also has a diverse population with many cultures and religions. These cultures and religions have to be respected (freedom of practicing personal religion is an article in the Indian constitution that supersedes protection of the environment), regardless of what that may entail for the environment. This often means that the environment is damaged, emissions are made, losses in biodiversity occur, as development, economic prosperity, and religion/culture is given priority.

That said, India does what it can. To avoid the hassle of votes in the first place, the country often joins international treaties which protect the environment. Unfortunately, several landmark laws and acts for the environment were passed in the wake of a national disaster/calamity, but at least now such laws exist. For example, the Environmental Protection Act (1986) is widely considered to be a response to the Bhopal Gas Tragedy of 1984. This law is the umbrella law for the environment in India, providing many important guidelines, especially regarding pollution and emissions. The Wildlife Conservation Act (1972) as well as the Forest Conservation Act (1980) are India's first line of defence against practices harming wildlife and forests respectively. The Environmental Impact Assessment Report for factories is a necessary test all emitting industries must go through in order to maintain pollution and emission regulations. The Essar Oil Case, Alembic Pharma Judgement, Research Foundation Case, Andhra Pradesh Pollution Control Board (AP PCB) Case, Vellore Citizens Case, etc. all played pivotal roles in reshaping and improving Indian Environmental Law by adding important features and practices. As technology progresses and renewable/sustainable energy and practices become more and more competitive, laws are also made to augment such practices. In a country with as much climate responsibility as India, with its sheer size and population, environmental law is essential for regulating climatic aspects such as emissions and biodiversity protection with the higher goal of slowing and preventing climate change.

### **6.3 Maharashtra, A Bharat Case Study**

Here's what makes Maharashtra important. It is the second most populated state in the country, and is the financial and commercial hub of India with a GDP of \$390 billion (Unacademy, 2025). It is also known for its industries. All this means that it has a lot of emissions, and a big effect on the climate. In order to deal with climate change, the state came up with the Maharashtra State Action

Plan for Climate Change. The plan primarily addresses agriculture, water resources, health, ecosystems, energy and infrastructure, as well as land development and land use (The Energy and Resources Institute, 2014). The key question here is, does this plan make sense? It is actually a worthwhile step in environmental policy and does it help climate change and help in the fight against it? The short answer is yes. After the analyses of multiple popular news channels, the primary issues related to climate seen were food security, water security, biodiversity losses, and extreme weather events, all of which are discussed to some degree in the Action Plan (see Appendix pt. 7 for more details). This section was to show how environmental policy works regarding challenges, region by region.

Now that we have covered Environmental Laws and Public Policy, let us move on to the final chapter: solutions.

## Chapter 7: The Answers

JPL (2023) states:

Responding to climate change involves two possible approaches: reducing and stabilising the levels of heat-trapping greenhouse gases in the atmosphere (“mitigation”) and adapting to the climate change already in the pipeline (“adaptation”).

The single root cause of climate change is emissions. Make emissions net zero, and the issue is solved for the future. Of course we also need to deal with its current form, but for the moment let’s focus on the future.

Manmade emissions are primarily due to electricity/heat generation, industries, and transportation. The short answer of making net emissions zero is firstly to electrify industries and transportation as much as possible (which alone would do a lot for the climate), and then making the source of all electricity clean (i.e. renewable) (Clark, 2025). Not only does electrification make everything more energy efficient (meaning much less primary energy is required), using renewables/nuclear also almost entirely cuts out the need for primary energy, starting us off from secondary energy (Fig. 21).

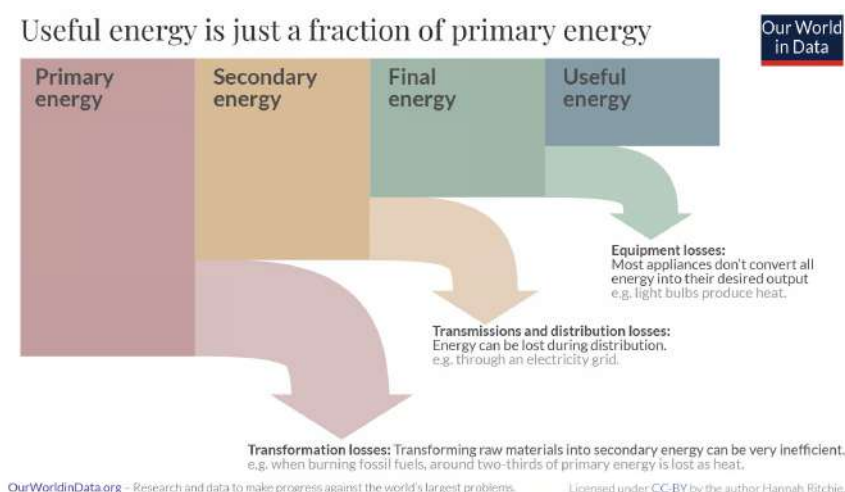


Fig. 21: Primary to Useful Energy (Ritchie, 2022)

While a small chunk of industries still require fossil fuels due to their energy density which cannot be compensated for by technology, that can be covered by methods such as carbon capture. The end result remains the same: net zero emissions (not “zero” emissions period).

This is a process. A plan, as given by the Natural Resources Defense Council’s Jeff Turrentine (2022) consists of ending reliance on fossil fuels by using renewable sources (thereby making everything more energy efficient), developing sustainable buildings and transportation (electric transportation is already around 90% efficient, while traditional combustion engines are around 11% to 45%), and more. “Some solutions are big and will require billions in investment. Some are small and free. All are achievable,” Jeff writes. He continues, including sustainable agriculture and better forest management (both of which act as “carbon sinks”) into the plan, and focusing on sustainable solutions for it all. The importance of more and more green areas, trees, and plants, cannot be stressed enough.

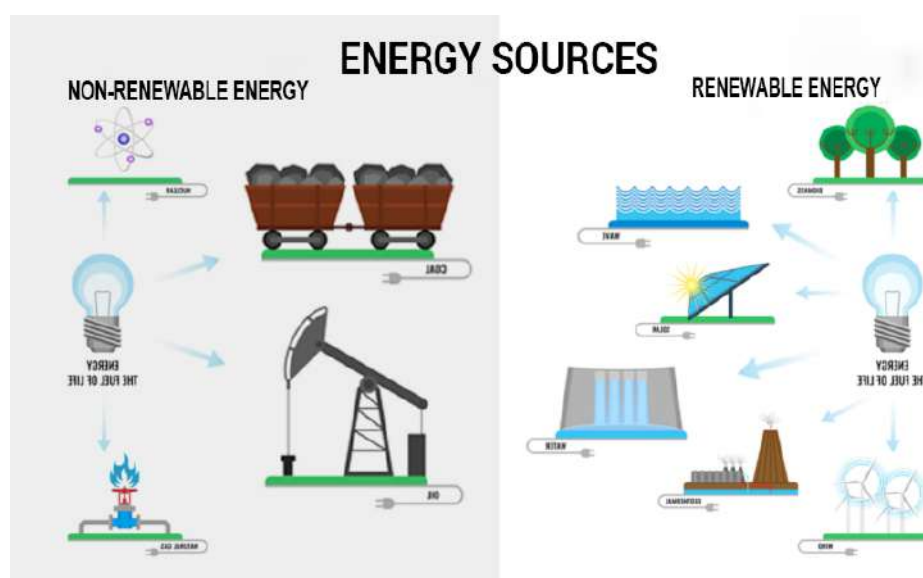


Fig. 22: Energy Sources (Basics, 2025)

Through scalable (and widely available) practices which are not many investment cycles away, industries can be decarbonised and made sustainable. Jeff writes that all of this needs to be augmented by ever-innovating technological solutions, which not only present new ideas and answers, but keep making existing solutions (such as solar panels and whatnot) better, cheaper, and more efficient. Making all this possible also requires support on the political end, something that only the people of the world can do by holding governments accountable and pushing for environment-friendly practices (Clark, 2025). This resolves the “mitigation” part, going one step further to end the problem for future generations entirely. As technology improves, it makes renewable energy and electrification more competitive, making this plan an extremely lucrative investment, that is actually possible (see Appendix pt. 6 for a detailed example).

Now we get to the present. Adaptation. How to deal with the effects of climate change that are already here. “Adaptation refers to a wide range of measures to reduce vulnerability to climate change impacts, from planting crop varieties that are more resistant to drought to enhancing climate information and early warning systems to building stronger defences against floods,” states a page on the United Nations Development Plan (2024). There are many practices such as the above which come under adaptation. This is necessary as certain effects of climate change are inevitable and are already here. There exists no way around them, the only way through is to deal with it.

## Chapter 8: The End

Recall the aims of this manual:

1. Understand the current climate crisis,
2. Understand the Earth's climate system and climate science,
3. Understand the role of human activities in altering the Earth's climate,
4. Learn about impacts of climate change,
5. Familiarise with potential climate solutions.

By stating and explaining the various systems determining climate, we fulfilled the first and second aim. Climate is the long term weather pattern of a region. We examined the Sun, atmosphere, hydrosphere, cryosphere, lithosphere, and biosphere, carefully investigating what all these super spheres contribute to the climate. This manual also explained natural and manmade climate change. We briefly learnt about human history and what enables us to hold the power of changing climate. We saw that the Greenhouse Gas emissions which have come primarily through the industrial revolutions are primarily responsible for anthropogenic climate change. Then, we examined the impacts of climate change on crucial aspects of human life, and which individual events affect what. This manual dove into what environmental law is and what role it serves, with short case studies studying India and the Indian state of Maharashtra. Finally, the manual familiarised us with mitigation and adaptation, the future and current plans of dealing with and solving climate change. Thus, we fulfil our objectives.

This manual comprehensively sums up the climate crisis. Through understanding what climate is, what affects it, what climate change is, natural and anthropogenic climate change, its impacts, environmental law and its importance, and ending on what the solutions to climate change are, this manual is a repository to find all important information regarding the climate crisis in some degree of detail. All these topic have the capacity to dive deeper and explore further, something that future papers can accomplish. All these facets of climate and climate change have several facets that one can research more about.

The climate crisis is serious, no doubt. However, as humans, we persevere. We are well aware of climate change, and we know what its root causes are. We solve one problem, then the next, then

the next, so on till we get to keep our home (the way it is, not some dystopia). There do exist solutions to climate change, and on paper, they are quite straightforward. The problem, as always, is implementation. These solutions need to be applied whenever and wherever possible, and the governments need to be pushed to implement policies which support these solutions. All the methods discussed above are not just nice suggestions, they are tangible solutions with the capacity and hope of preserving the trillions of life forms on Earth (Fig. 23). The ball is now in our, the people's, court.



Fig. 23: Earth from the Apollo Spacecraft (NASA, 2017)

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## Appendix

This appendix contains extra information which is more numerical in nature regarding several concepts discussed in the manual.

1. [The Solar System & Accompanying Observations on The Stefan-Boltzmann & Inverse Square Laws](#)
2. [Parameters of Earth & Orbit: Eccentricity, Obliquity & Long. Vernal Equinox For the Years 2025, -10,000, 10,000 & 40,000](#)
3. [The Sun & Energy Budgets: Energy Budgets for Earth & Mars With Models for Multiple Layers of Atmosphere](#)
4. [Models of The Atmosphere: MODTRAN IR Light in the Atmosphere Models As Affected by Methane, Carbon Dioxide & Clouds](#)
5. [Anthropogenic CO<sub>2</sub> versus Natural CO<sub>2</sub> Variability, The Vostok Ice Core & Mauna Loa Observatory](#)
6. [Electricity Consumption & Correlation to Resources Used for Power Generation](#)
7. [Learn more in short about Maharashtra's climate and the Action Plan here.](#)