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Environmental Studies - Introduction

An Update on Major Environmental Issues, and an Introduction to Environmental Science and Sustainability

Course outcome

- Discuss the role of Environmental Science, its multidisciplinary nature in conservation of global environment.
- Describe the natural resources, utility and the role of ecosystems in maintaining planetary cycles.
- Discuss types, sources, and prevention and control measures of pollution.
- Discuss laws, acts and policies related to environmental protection in India.
- Describe types, mitigation and management techniques of disaster.

References

- Benny Joseph, Environmental Studies, Tata McGraw-Hill Publishing Company Ltd., New Delhi (2008).
- *Student guide*: Environment Reader for Universities, based on UGC syllabus published by Centre for Science and Environment, (2017)
- Mohan kanda, Disaster Management in India evolution of institutional arrangements & operational strategies. (2017)

Definition : It deals with every aspect that affects a living organism. It is essentially a Multidisciplinary approach that bring about an appreciation of our natural world and human impact on its integrity.

- Objectives
- Importance

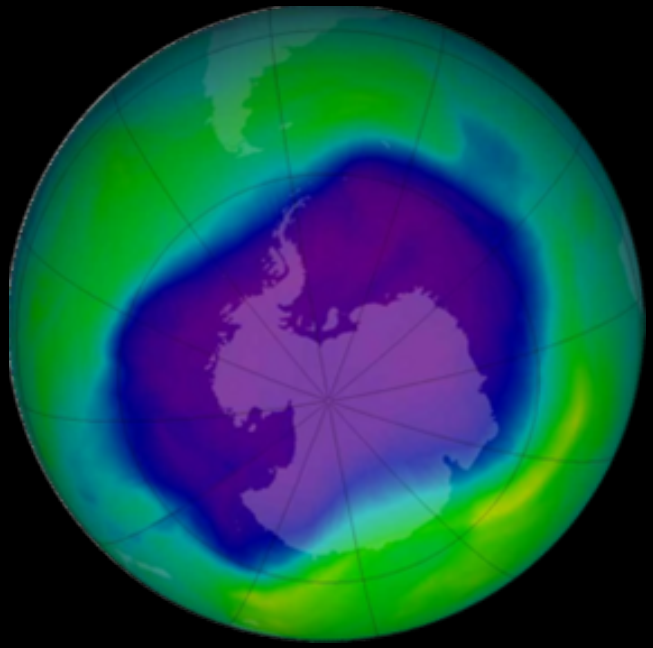
Significance of Environmental Studies

- Inculcating attitude and values towards understanding interdependence of nature, man and work towards sustainable development.
- Conservation of energy and fast depleting natural resources.
- Imparting knowledge about waste management, treatment and disposal.
- Develop social responsibility towards environment protection.

Major Environmental Issues

- Ozone Layer Depletion
- Resource Depletion
- Pollution
- Extinction
- Global Warming

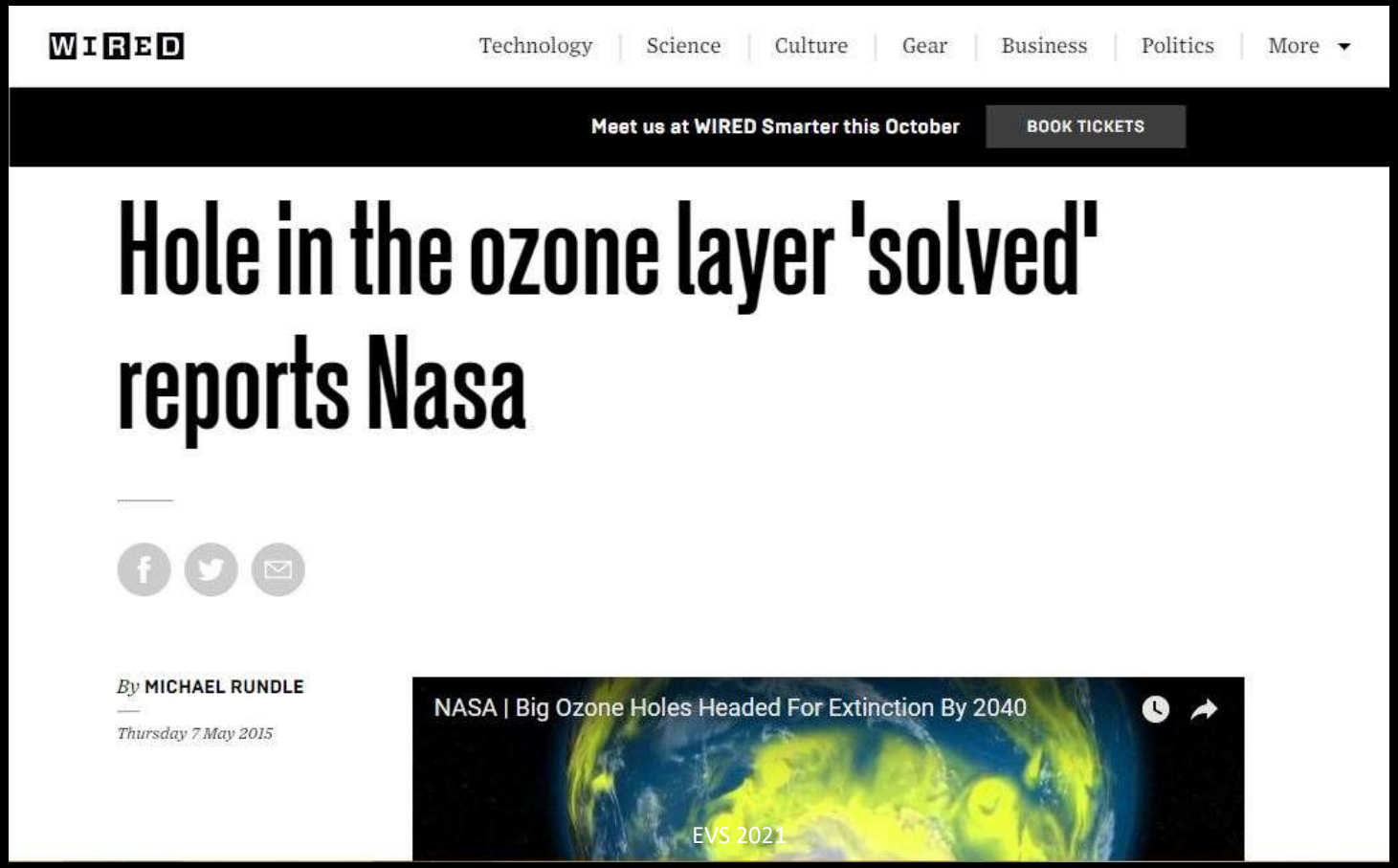
Ozone Layer Depletion



Source: wikimedia

- Explain the significance of Ozone in the atmosphere and what the ozone hole is. Ozone is a gas in the stratosphere which converts the incoming UV radiation from the sun into infrared rays by what is known as the **ozone-oxygen cycle** (https://en.wikipedia.org/wiki/Ozone–oxygen_cycle). In the above diagram, the blue part is the "ozone hole" over the Antarctic. It is the part of the stratosphere where the concentration of Ozone is very low.

Ozone Layer Depletion- Solved!



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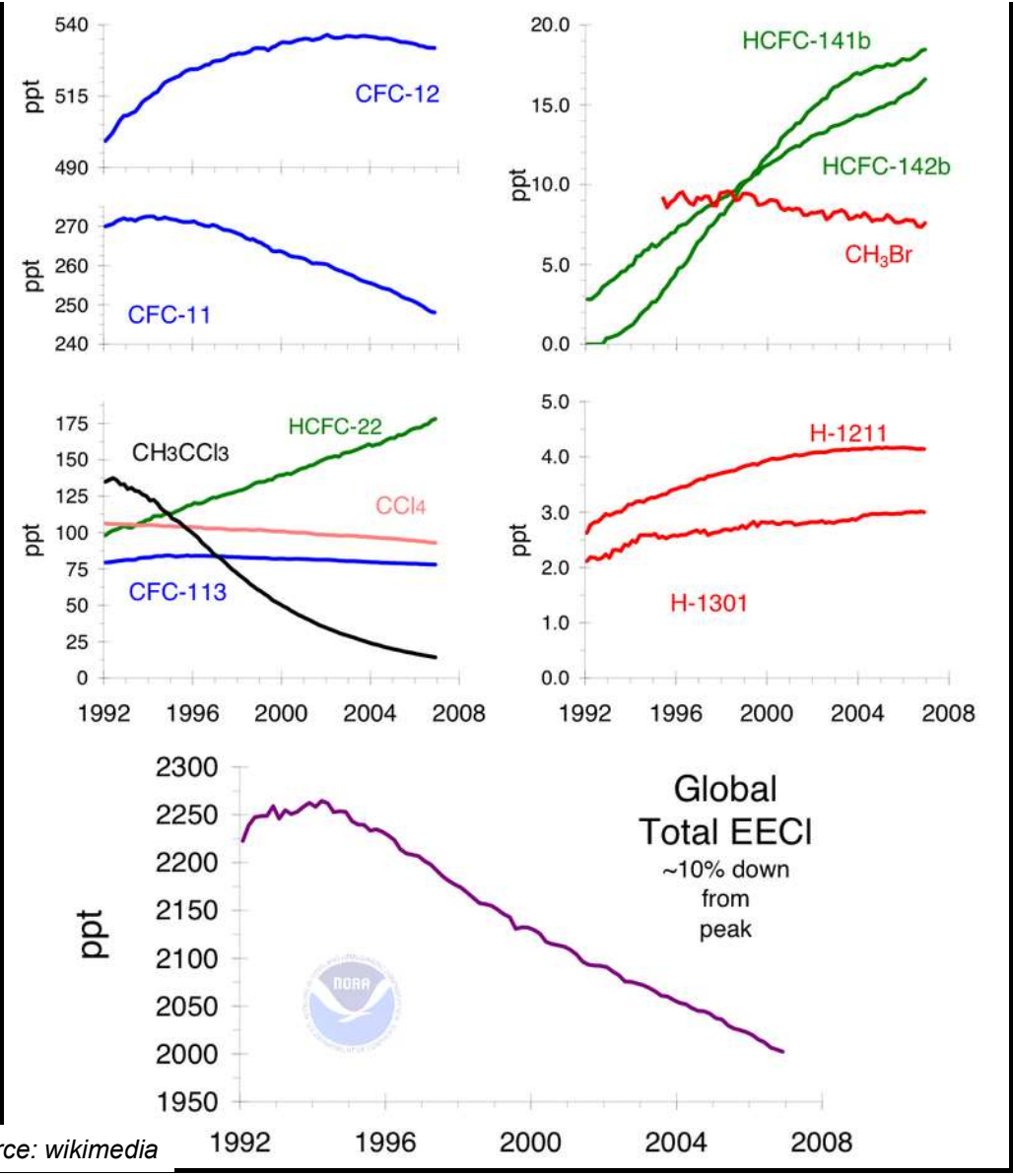
Hole in the ozone layer 'solved' reports Nasa

By MICHAEL RUNDLE

Thursday 7 May 2015

- It is very important to explain here that the Ozone hole is no longer an issue. It is a problem we have successfully solved by imposing a worldwide ban on CFC and other Ozone Depleting substances via the Montreal Protocol (1987). Since then, the concentration of such substances in the atmosphere have stabilized or are decreasing and are soon expected to disappear. The “Ozone hole” is expected to close by 2040.

Trends of various Ozone-depleting gases like HCFC,CFC, Bromomethane, carbon tetrachloride



Source: wikimedia

- These are the trends of the ozone-depleting gases in the atmosphere. Only a few gases like HCFCs are on the rise but are expected to be phased out by 2030. Other slight rises are due to weak regulation in East Asian countries and are expected to go down as well as those countries become more developed and impose regulations more stringently. Overall, Ozone hole issue has been declared as resolved. The only reason one should discuss this problem now is to understand how the entire planet came together to solve this very complex problem. These lessons can be used to solve other, much pressing, environmental issues.

- Citation for the HCFC claim: http://www.eia.gov/oiaf/1605/ggrpt/documentation/pdf/0638(2005).pdf

Major Environmental Issues

~~Ozone layer Depletion~~

Resource Depletion

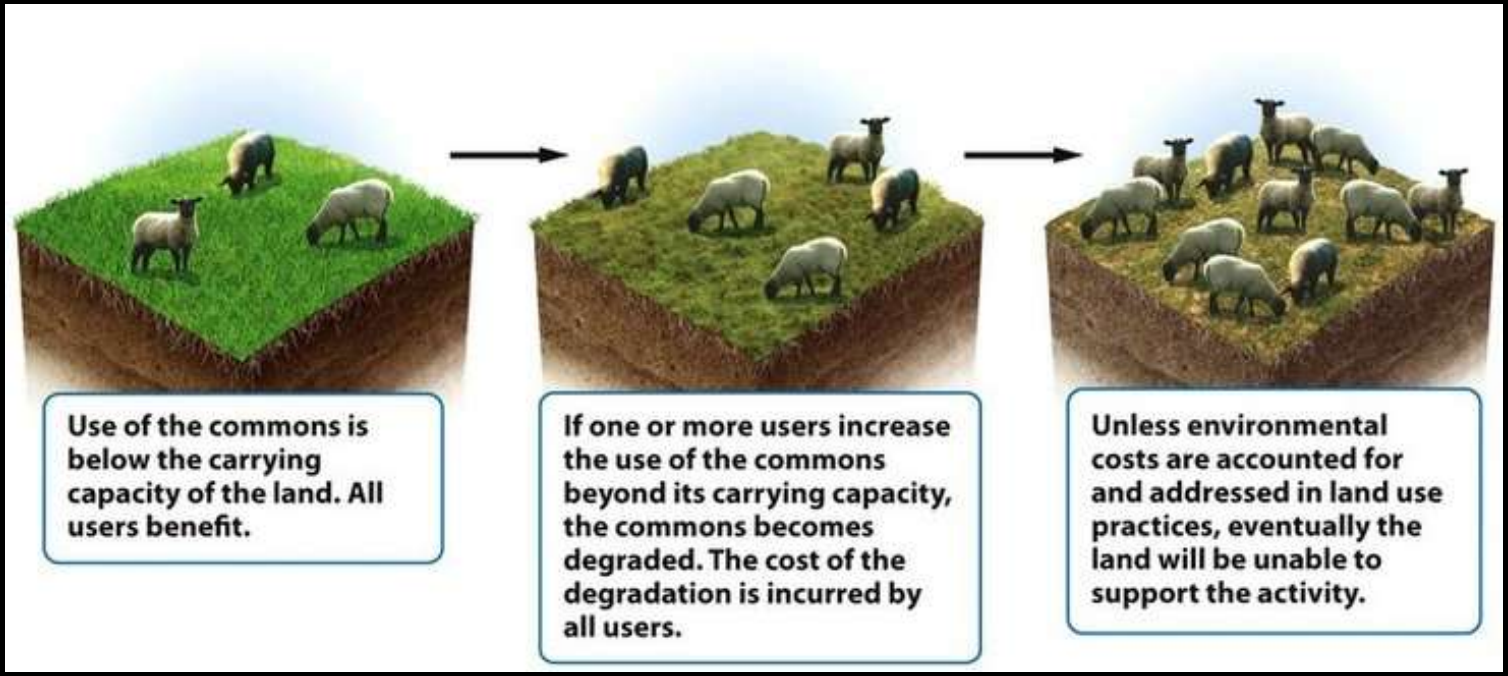
Pollution

Extinction

Global Warming

- It is important here to highlight that tragedy of commons is a serious issue that very few people understand, but actually encapsulates many environmental problems. Also, many environmental problems, like tragedy of the commons, cannot be solved. They can only be managed.

Resource Depletion
Tragedy of the Commons

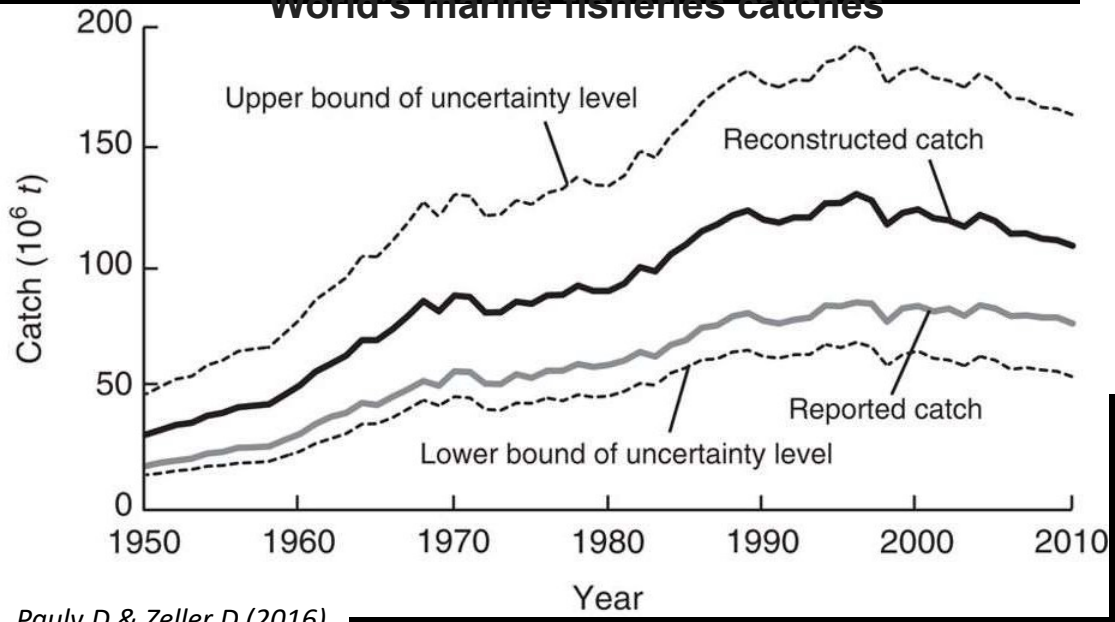


Source: NTU

“Tragedy of the commons” is a term that was first used to explain how the exploitation of common grazing lands by farmers in Great Britain and Ireland. It is a situation where on a jointly owned resource like grazing land, river, air, roads etc. (otherwise called commons), individuals acting independently based on their own self interest will cause harm to the resource and to the benefit of all the users from that resource. In the short run, the individuals acting on their self interest will benefit by shifting the burden of maintenance of the commons on the other parties, but eventually everyone will suffer from the degradation of that resource. Hence the word tragedy is used.

Examples of Tragedy of the Commons

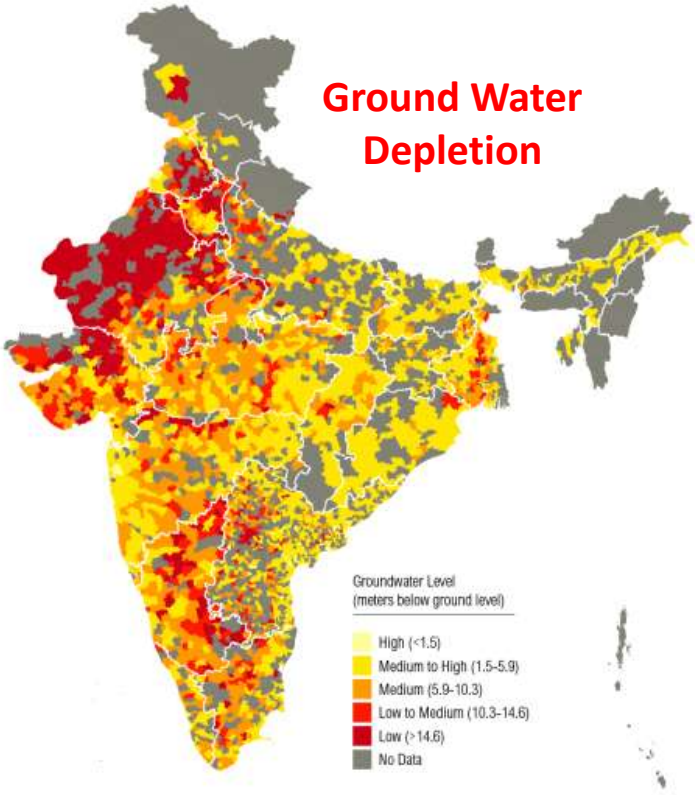
Overfishing



Pauly D & Zeller D (2016)

54% of India's Ground-water Wells Are Decreasing

Ground Water Depletion



www.indiawatertool.in

WORLD RESOURCES INSTITUTE

Ground water is a tragedy of the commons issue because underground water is a commons property. Individuals extract water from their borewells but the underground aquifer is common to all. If one extracts heavily, it affects the supply of others. The graphic on the right shows this tragedy happening in India as of today.

Overfishing is commons problem because though fish stocks are a renewable resource, they are common to all fisherman and are renewable only if they can breed in the same numbers as they are being extracted. If some fishermen over extract fish, the other fishermen have a lesser fish stock to fish, straining the overall population of fish. As a result, each subsequent population of fish will be smaller than the previous causing a “tragedy” for all. In the short run, some fishermen who exploit are benefited but in the long run everyone suffers as their catch decreases. In the graph you can see the global fishing catch declining, heralding the tragedy of this commons.

Citation for the overfishing graph: Pauly, Daniel, and Dirk Zeller. "Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining." *Nature communications* 7 (2016): 10244.

Solutions?

- Government Intervention?
- Privatization?
- Local Management?
- Is there a technological solution?

There is no definite solution

- Will government intervention work for all cases of this problem? How will government reinforce a single policy for each such commons (they can be quiet far apart and isolated from populated areas. They can also be very different from one another). Also, how will the govt. tackle the power disparity in each commons (one of the farmers can be much richer than the others, or could be of a higher or more influential caste) which can affect how policing works (they can influence the policing mechanisms through bribes or other such mechanisms)

- Will privatization always work? Will the private owner be considerate of all necessities of all the farmers, if that means his/her profits might be less? Will they stay neutral to the power/influence imbalance in that locality?

- Will local management always work? Here again you will have problems as listed for government intervention.

- There is also no technology that can definitively solve this problem. This is an environmental issue with no definite solution and in many cases, no solution at all. This is a type of problem which, in many cases, cannot be solved-only managed.

Nobel Prizes and Laureates

Prize in Economic Sc ‹ 2009 ›

- ▸ About the Prize in Economic Sciences 2009
- ▾ Elinor Ostrom
  - Facts
  - Biographical
  - Prize Lecture
  - Prize Presentation
  - Interview
  - Diploma
  - Photo Gallery
  - Other Resources
- ▸ Oliver E. Williamson

All Prizes in Economic Sciences
All Nobel Prizes in 2009

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2009
Elinor Ostrom, Oliver E. Williamson

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Elinor Ostrom - Facts

Photo: U. Montan

Elinor Ostrom

Born: 7 August 1933, Los Angeles, CA, USA

Died: 12 June 2012, Bloomington, IN, USA

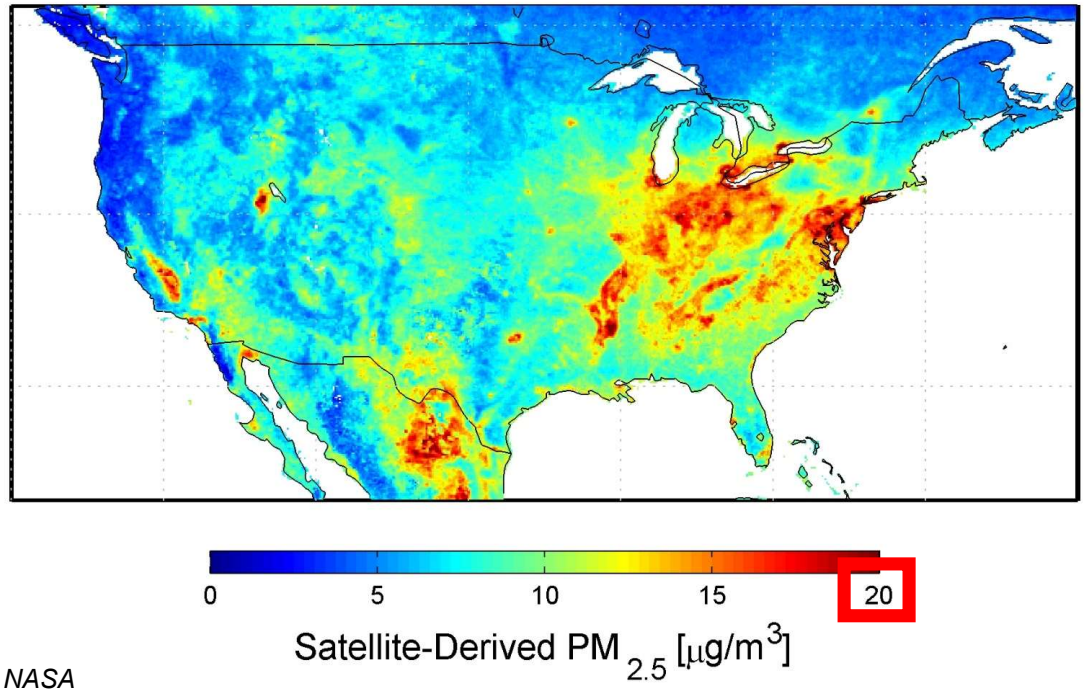
Affiliation at the time of the award: Indiana University, Bloomington, IN, USA, Arizona State University, Tempe, AZ, USA

Prize motivation: "for her analysis of economic governance, especially the commons"

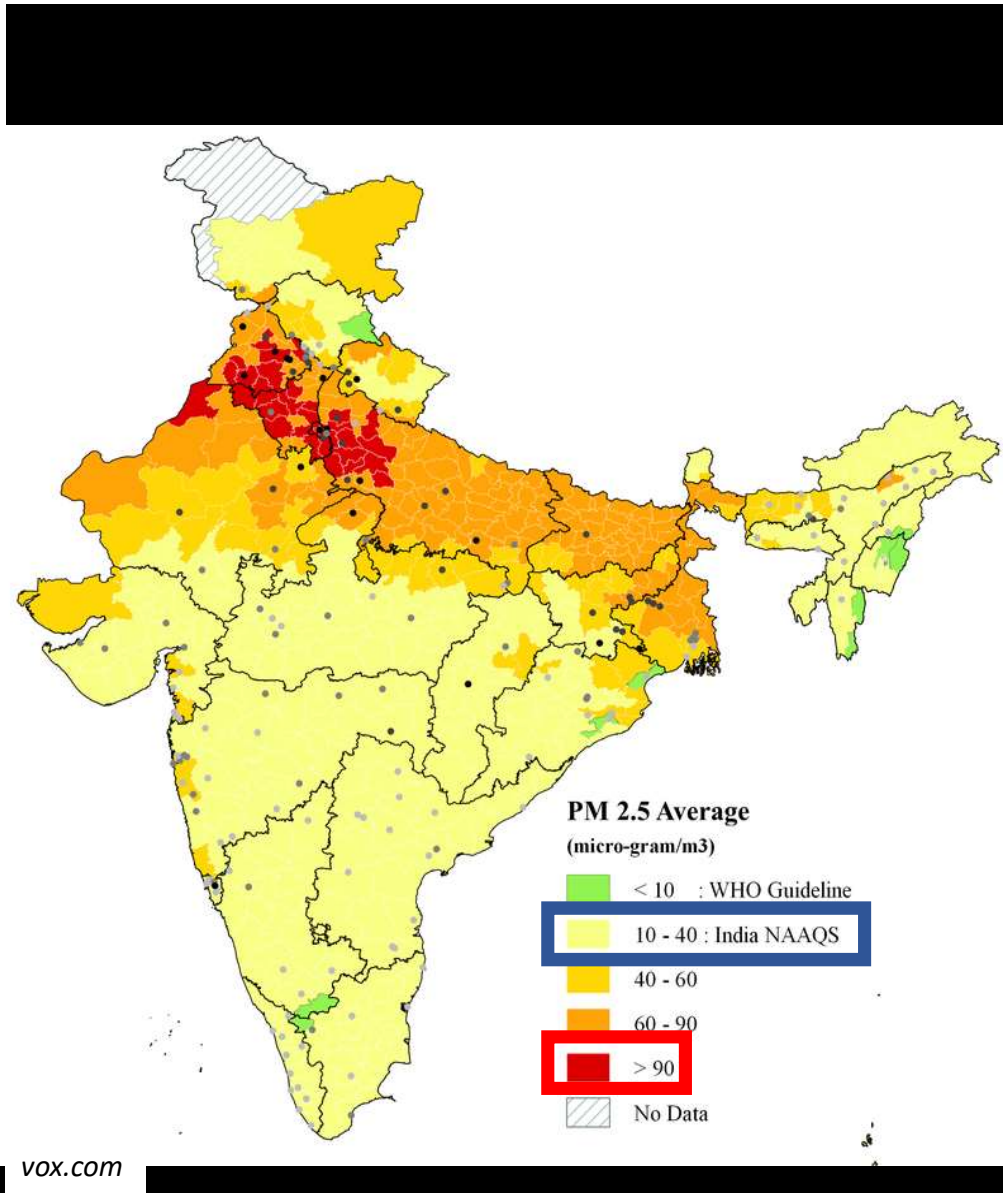
Field: economic governance

Contribution: Challenged the conventional wisdom by demonstrating how local property can be successfully managed by local commons without any regulation by central authorities or privatization.

Elinor Ostrom is the first woman to win the Nobel Prize in Economics. She won it for her work that showed for the first time that the local commons can be successfully managed by locals without any regulation by government or privatization. Till her work was seen, it was assumed that only the latter two options existed for solving this problem.



NASA

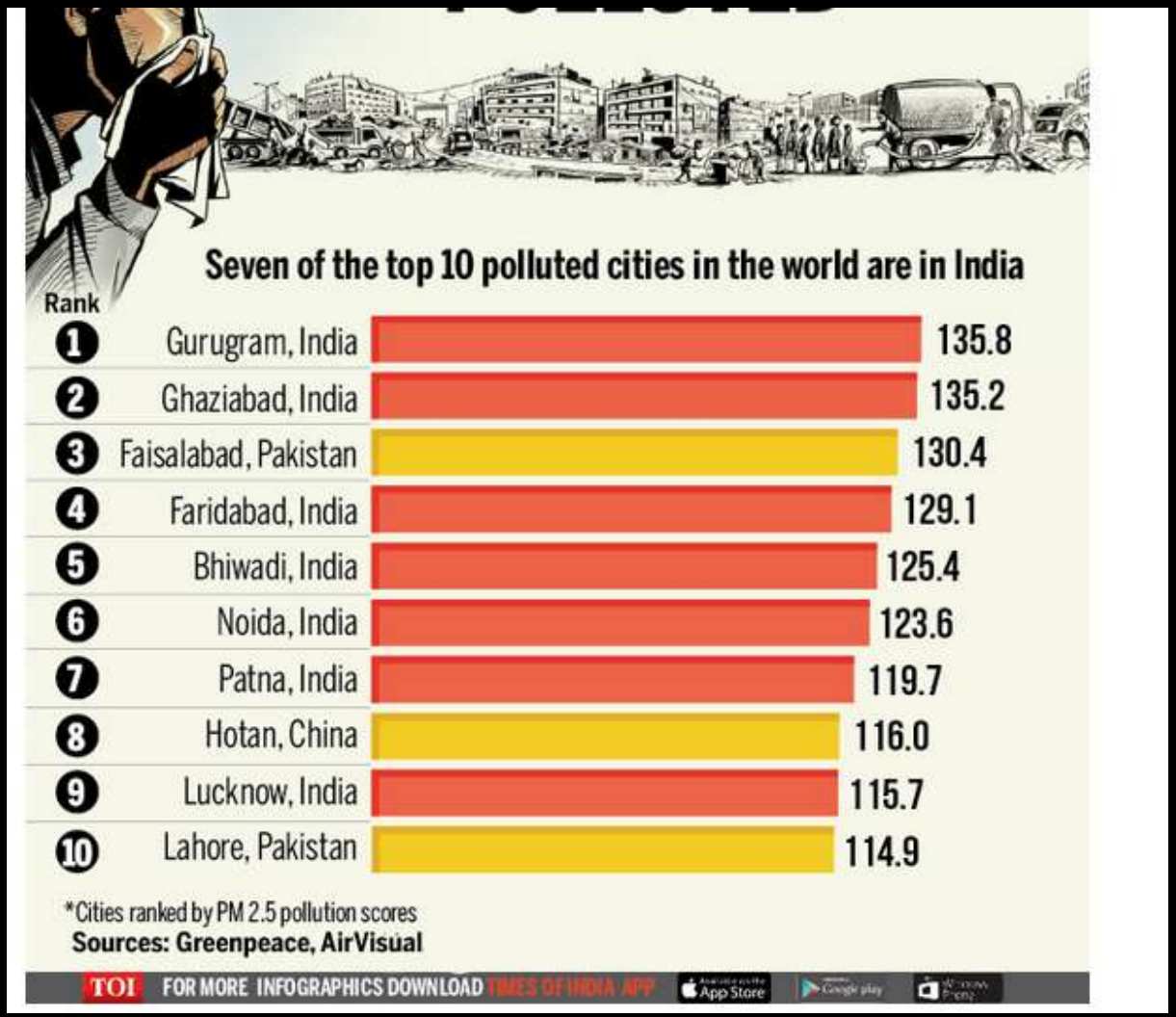


vox.com

Pollution

- Pollution is a serious problem in India. To give an example of how bad it is, take the case of Air Pollution. On the left is a map of the United States's PM 2.5 (considered one of the most serious pollutant for human respiratory health) concentration in the atmosphere. US follows the WHO guidelines which says that up to 10 ug/m3 is safe, after which it is can be detrimental. The scale in the US map reflects this with 10 ug/m3 designated as green. The highest that scale goes to is 20ug/m3. If the PM2.5 goes to this level, they usually announce health advisory and generally discourage people from going out of their houses.

- The India map on the right shows the conc. of the same PM 2.5 in the country in the same units. India follows the NAAQS (National Ambient Air Quality Standards) which is a standard it formed itself. As you can observe, the NAAQS limit is 4 times above WHO limits. And even with these exaggerated limits, many parts of the country to do not satisfy it. If at 20 ug/m3, the US announces health advisories, what is the condition of respiratory health of people in India? We will get back to this graph in the later chapter on pollution to understand why we have such lax standards. Please refer to pg 131 in book (environmental reader for universities) for more details.


Seven of the top 10 polluted cities in the world are in India
Rank
1 Gurugram, India 135.8
2 Ghaziabad, India 135.2
3 Faisalabad, Pakistan 130.4
4 Faridabad, India 129.1
5 Bhiwadi, India 125.4
6 Noida, India 123.6
7 Patna, India 119.7
8 Hotan, China 116.0
9 Lucknow, India 115.7
10 Lahore, Pakistan 114.9
*Cities ranked by PM 2.5 pollution scores
Sources: Greenpeace, AirVisual
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Cutting Through India's Smog

By THE EDITORIAL BOARD FEB. 23, 2015

Proof of the grave air pollution problem confronting India is seen not just in the suffocating smog that on many days crowds out the sun in New Delhi, the world's most polluted city. It can be measured as well in the fact that the country has the world's highest death rate from chronic respiratory diseases, which kill an estimated 1.5 million Indians every year. A 2014 World Health Organization report concluded of the 20 most polluted cities in the world, India has 13.

New Delhi Tsering Topgyal/Associated Press

After years of denial and indifference, ordinary Indians appear to be waking up to the dangers of relying on some of the dirtiest energy sources on the planet, including coal, diesel oil and burning garbage, to sustain economic growth and an exploding population. Yet the government has failed to address with any urgency what is

nytimes.com

It is of no surprise then that we have one of the highest death rate related to chronic respiratory issues. And of the 20 most polluted cities in the world, we are home to 13. As shown in this article from New York Times.

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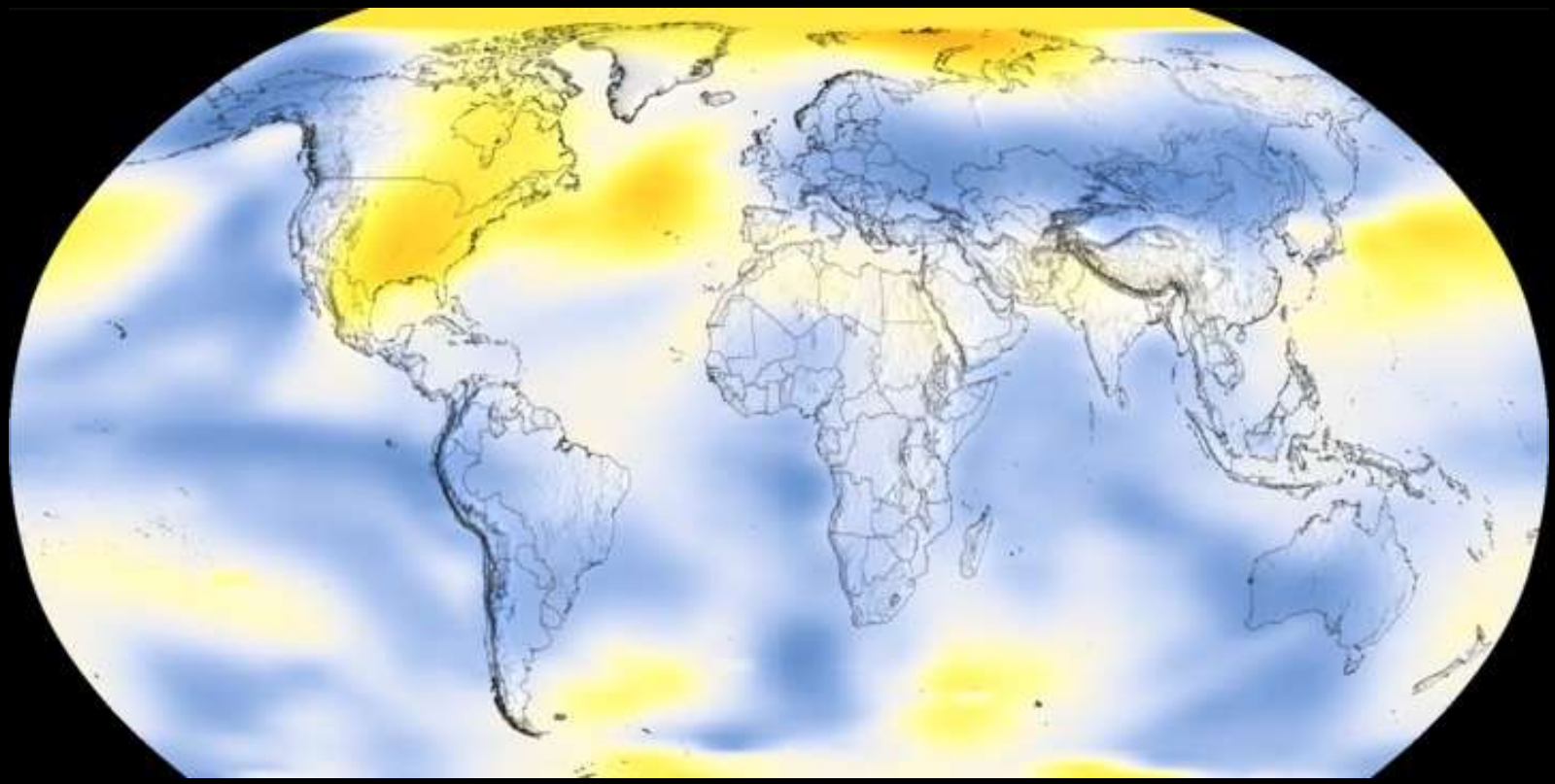
Extinction

- Though we know extinction is happening, what is surprising is the rate at which it is happening. It is so fast that scientists now think that the 6th mass extinction has begun. In many instances, we are losing species faster than we are discovering them.

Global Warming

1956

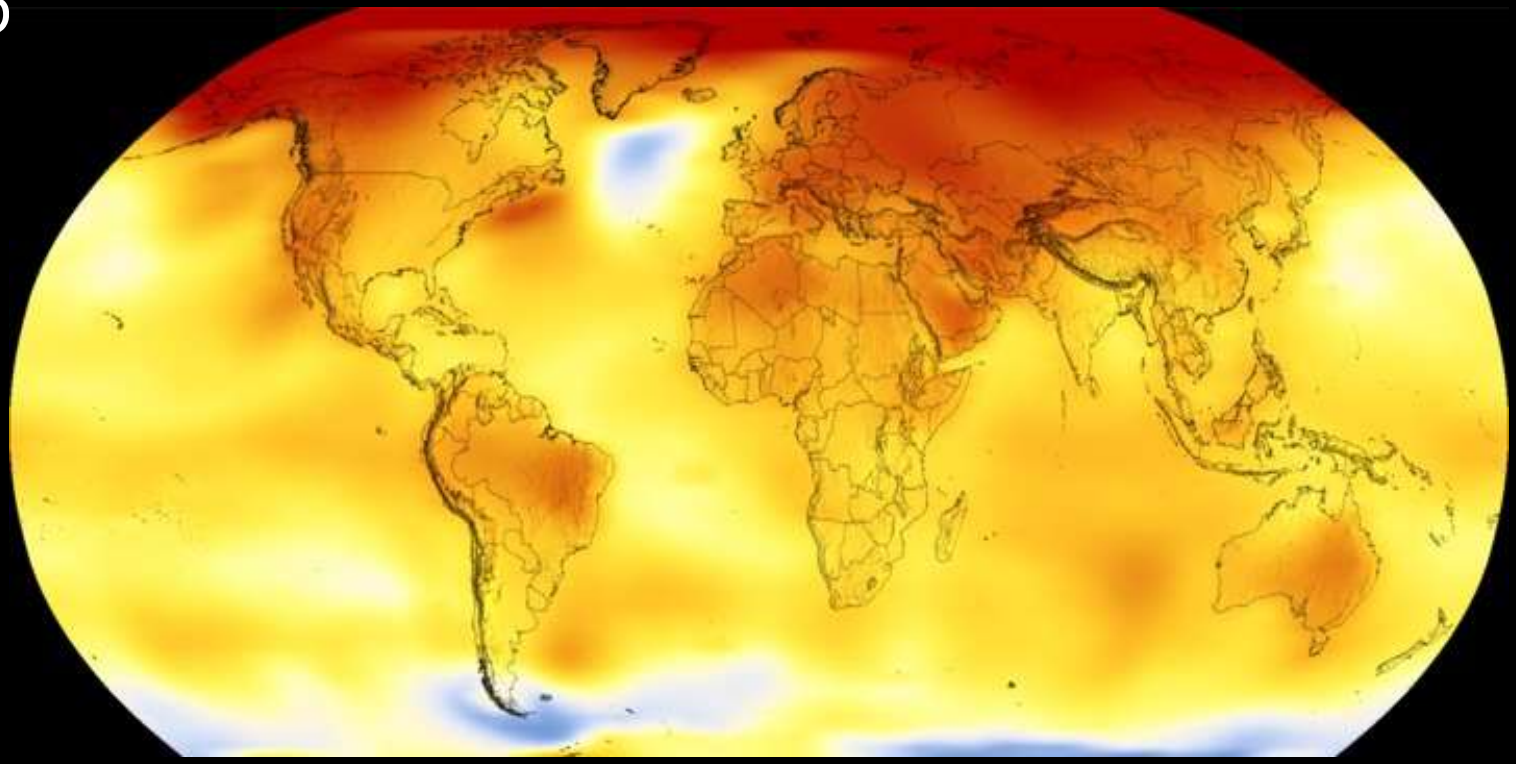


Temperature Difference (Fahrenheit)

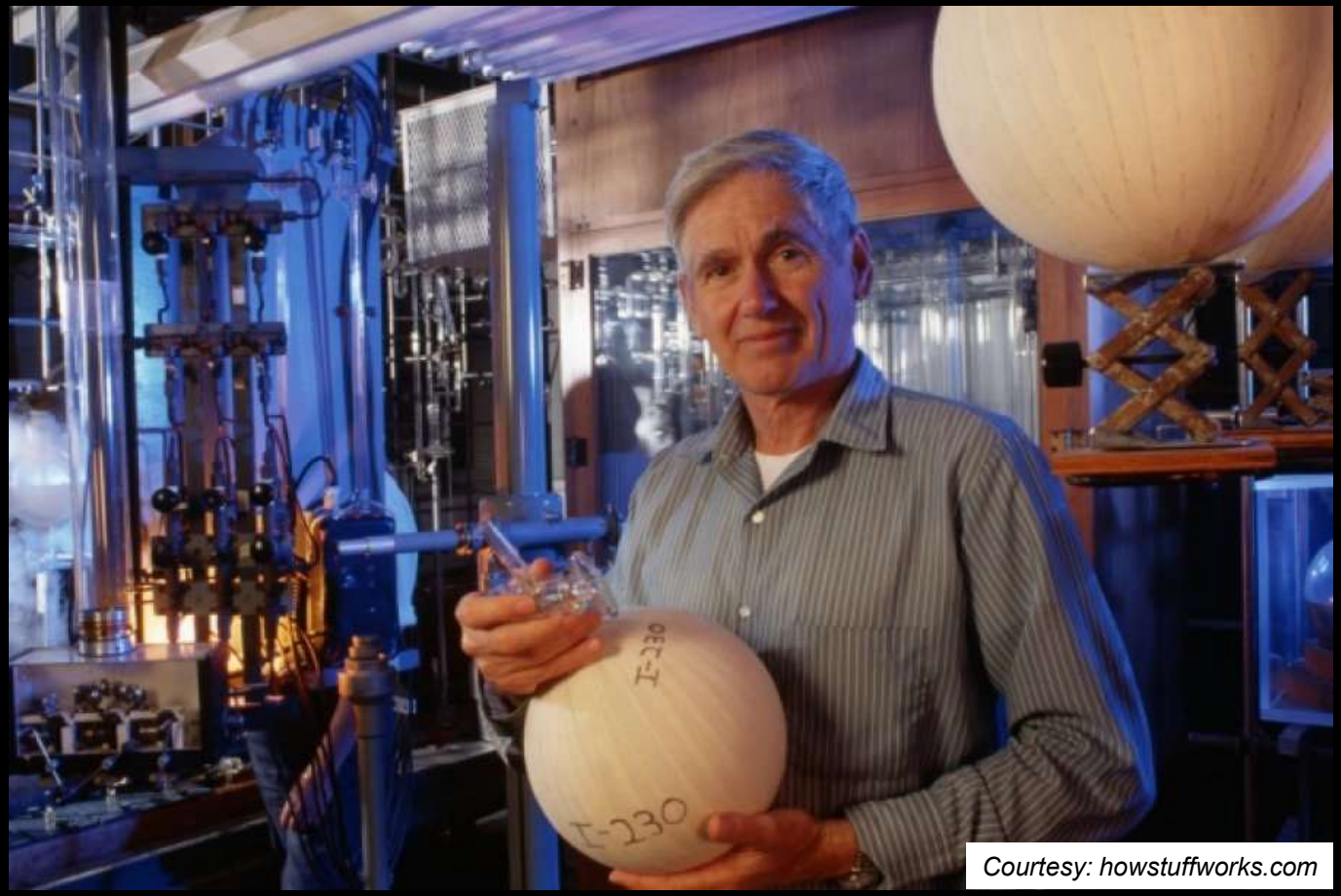
Data source: NASA/GISS

Credit: NASA Scientific Visualization Studio

2016



Data source: NASA/GISS
Credit: NASA Scientific Visualization Studio



Courtesy: howstuffworks.com

Charles David Keeling

- To understand about global warming and its relation with the carbondioxide concentration in atmosphere, it is important to look at the work of Charles David Keeling. He was a geochemist who built the first instrument to take precise measurements of CO2 in the atmosphere and took preliminary readings from Mauna Loa in Hawaii. Before his work, the CO2 measurements in the atmosphere varied quiet a bit and were wholly unreliable. Mauna Loa was chosen as the first test site because it is away from the mainland US and as winds come from the ocean to the mainland, the readings he would get would not contaminated by local influence such as cars and industries. He would truly get the average conc. of CO2 in the atmosphere.

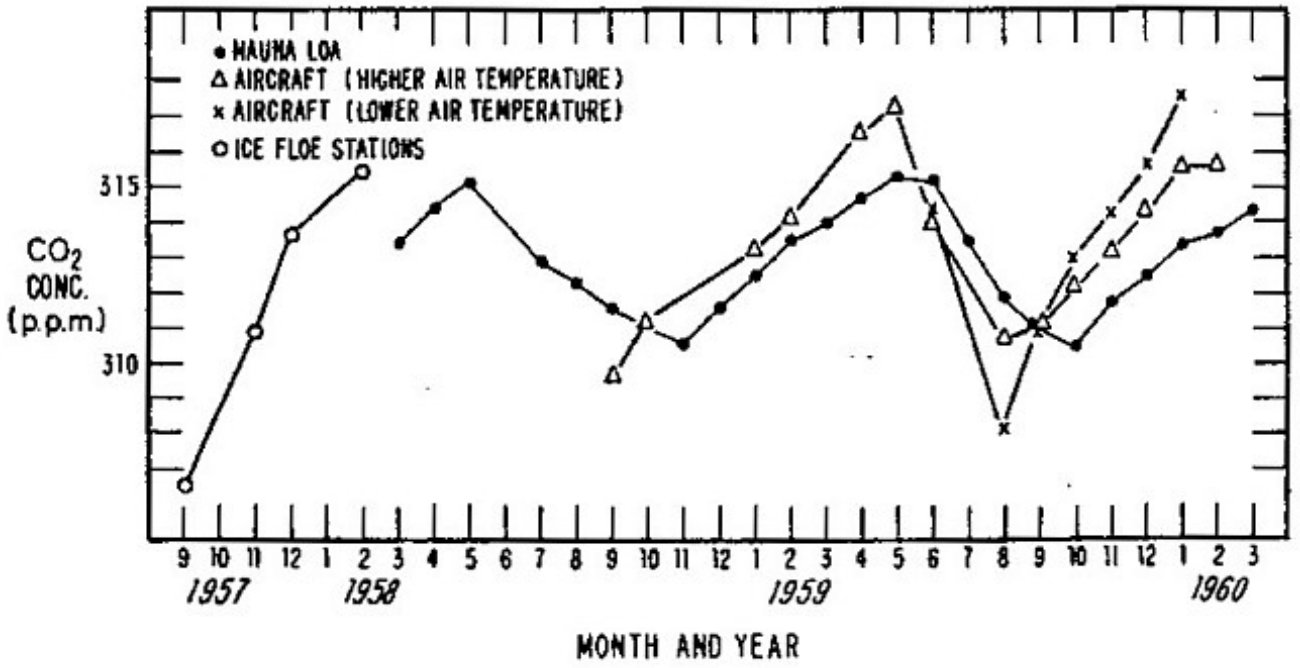
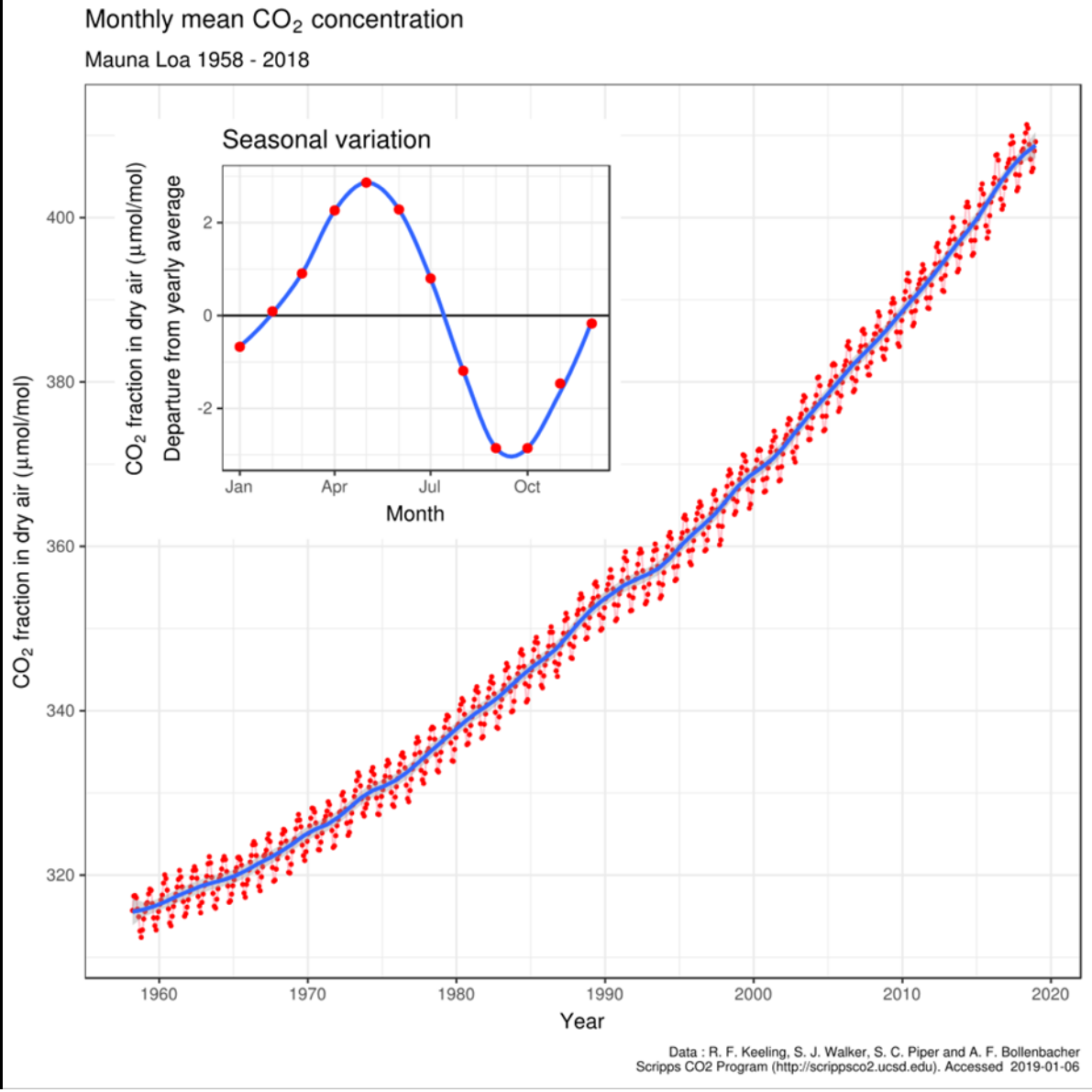


Fig. 1. Variation in concentration of atmospheric carbon dioxide in the Northern Hemisphere.

Tellus XII (1960), 2

He took readings from 1957 to 1960. He also sent copies of his instruments to ice floe station in the South Pole and high and low altitude aircrafts. The graph is the result of his measurements. It has **three** major breakthroughs. **First**, that the CO2 conc. in the atmosphere is not a constant. It varies according to season. In the spring and summer seasons, trees grow leaves in the northern hemisphere which reduces the amount of CO2 in the atmosphere. In fall and winter seasons, these trees shed leaves and also lose their CO2, which causes a rise of CO2 in the atmosphere. **Second** breakthrough was that if you were draw a trend line through this graph, you would see a slight uptick. He roughly calculated this uptick is at the same rate of fossil fuel emissions in the world. **Third,** though the rate is the same, the total estimated quantity of CO2 increase in the atmosphere is not the same as the amount emitted in the atmosphere by fossil fuels. He conjectured that some of it was being absorbed by natural systems like forests and oceans (and hence not all of it was being absorbed back by earth systems).

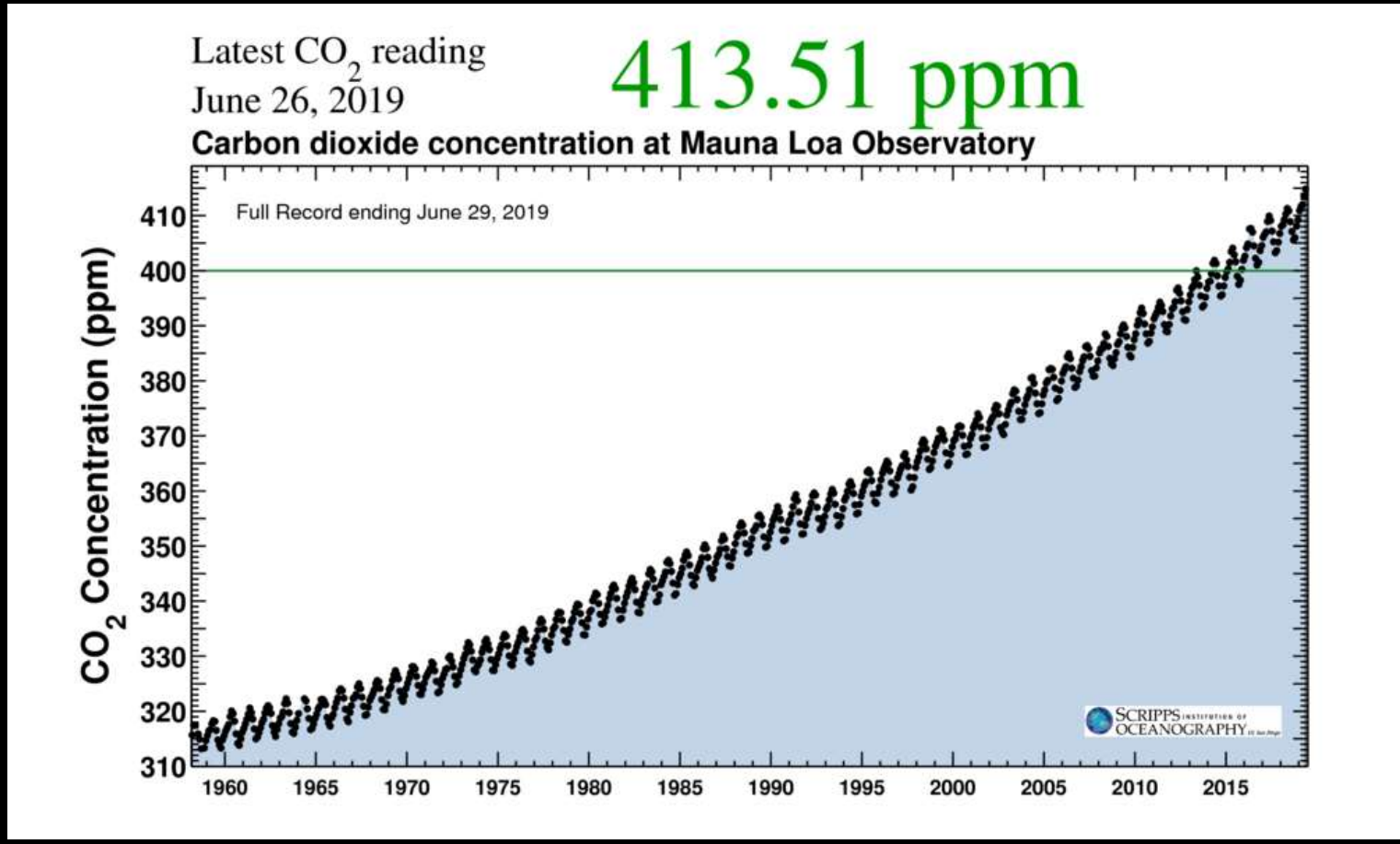
The Keeling Curve



10/1/2022

Though some of his results were controversial at that time, his measurements gained enough support to secure funds and set up a permanent observatory in Mauna Loa. The graph above is the result of this effort. Though somewhat vaguely present in his 1960 graph, this one shows a clear uptick in the CO_2 conc. and an increase of roughly 100ppm of CO_2 in the atmosphere since 1957. Mauna Loa is now the worlds longest continuous CO_2 measuring station. In commemoration of his efforts, this curve is now called “The Keeling curve”. It has been heralded as one of the most influential scientific works of our time.

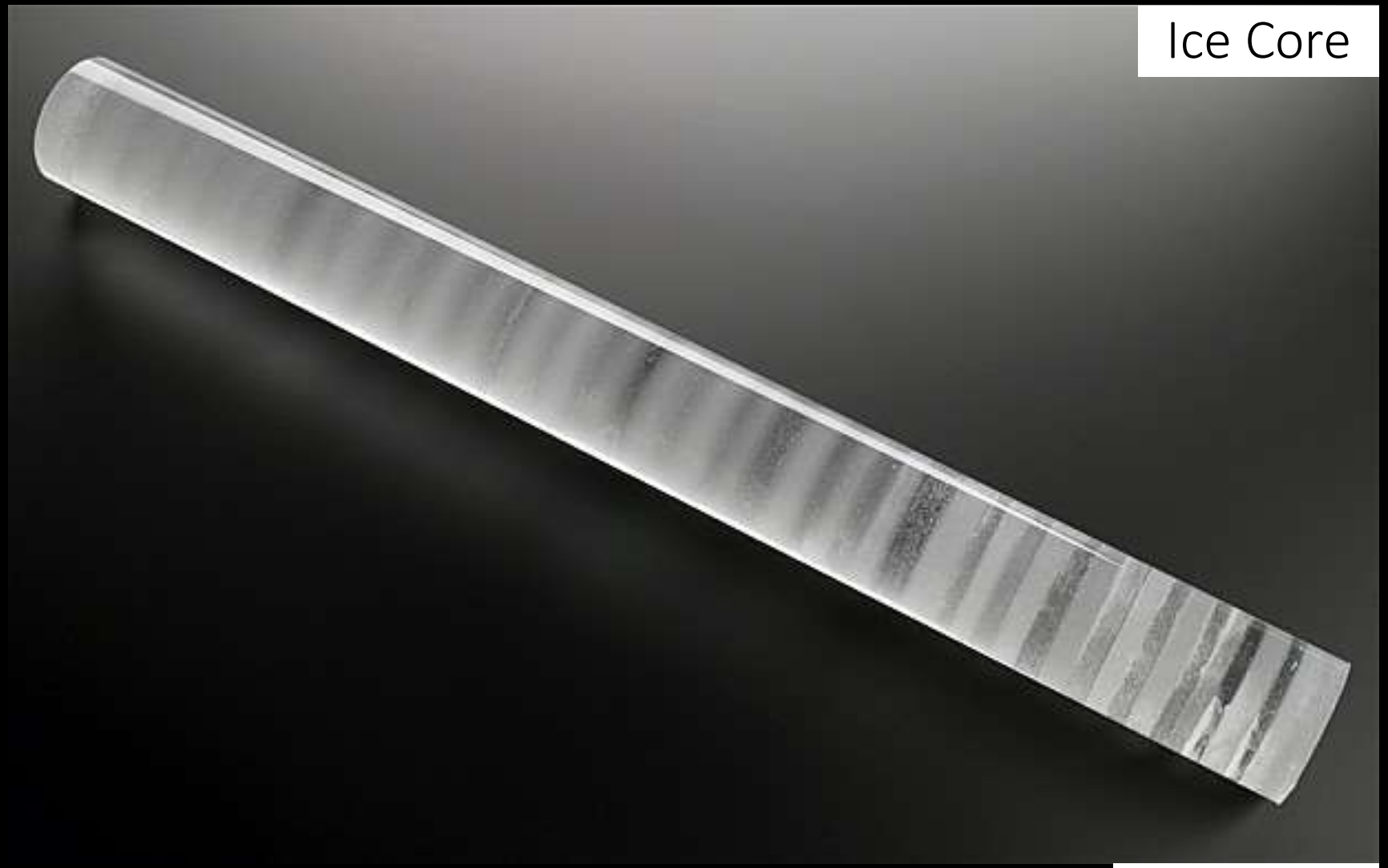
So what?



The Keeling Curve

This is the latest reading of CO_2 conc. in the atmosphere. It is important to ask why this value should be taken seriously. So what if the value of CO_2 conc. in atmosphere is 413.51ppm. So what if it is roughly 100ppm more than the first measurement in 1957. That does not mean anything without proper context. For this, one needs to look at ice core data.

Ice Core



Courtesy: The Telegraph

Ice cores look like this. They are cylindrical blocks of ice dug out of from permafrost. Permafrost as the name suggests is permanent frost. In certain places in the world, like the poles, when snow forms in the winter, it never melts. When this snow forms, it traps small air pockets within itself, and as snow forms every winter every year, each year forms a layer of ice over the last years ice deposit. If one were to dig vertically into these layers and extract the air pockets from each layer of ice, you would get a temporal scale of atmospheric composition of the planet. You can use this composition to decipher the amount of CO2 in the atmosphere and also the ambient temperature of the planet in that year.

Ice Core Drilling

Courtesy: Frontier Scientists

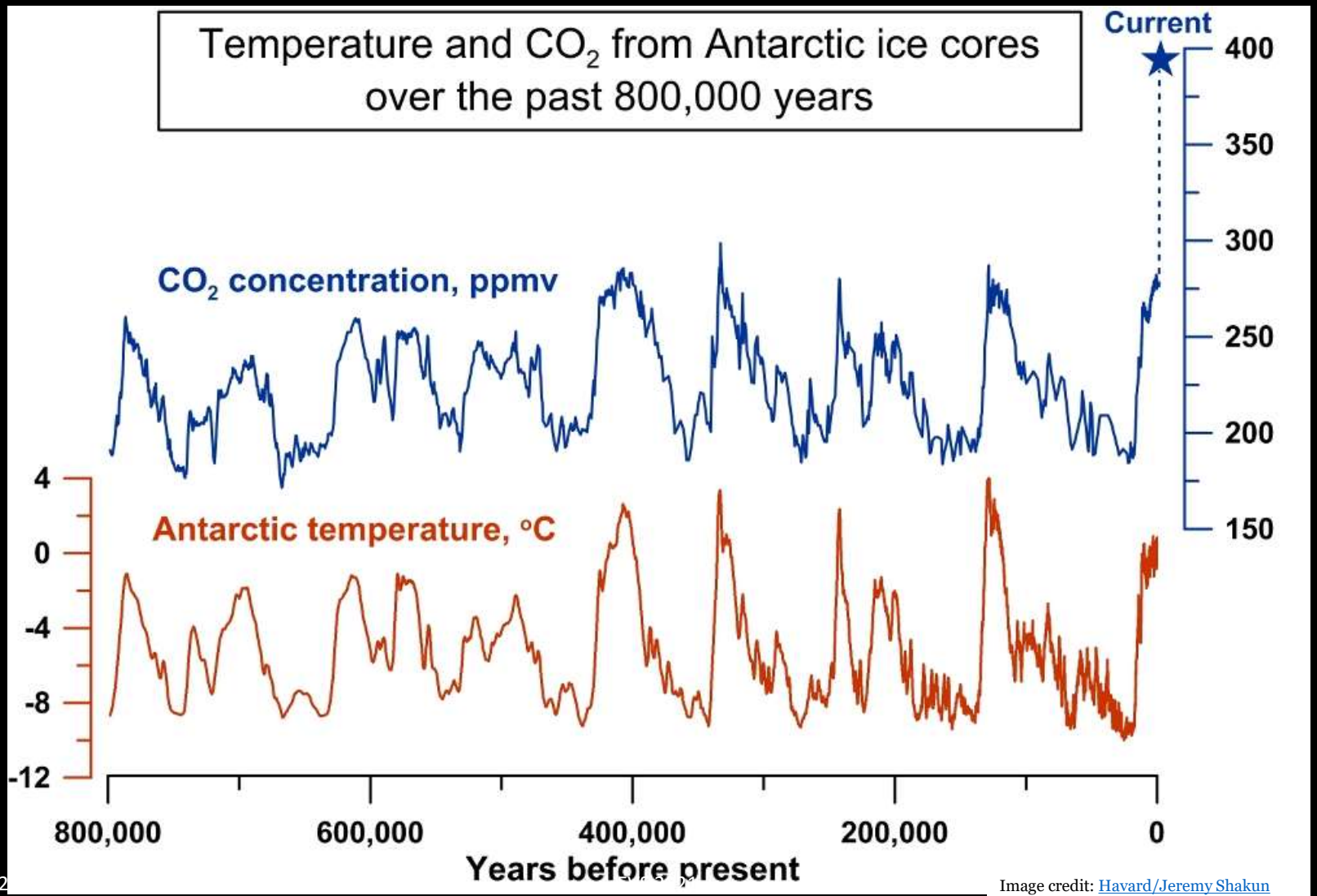
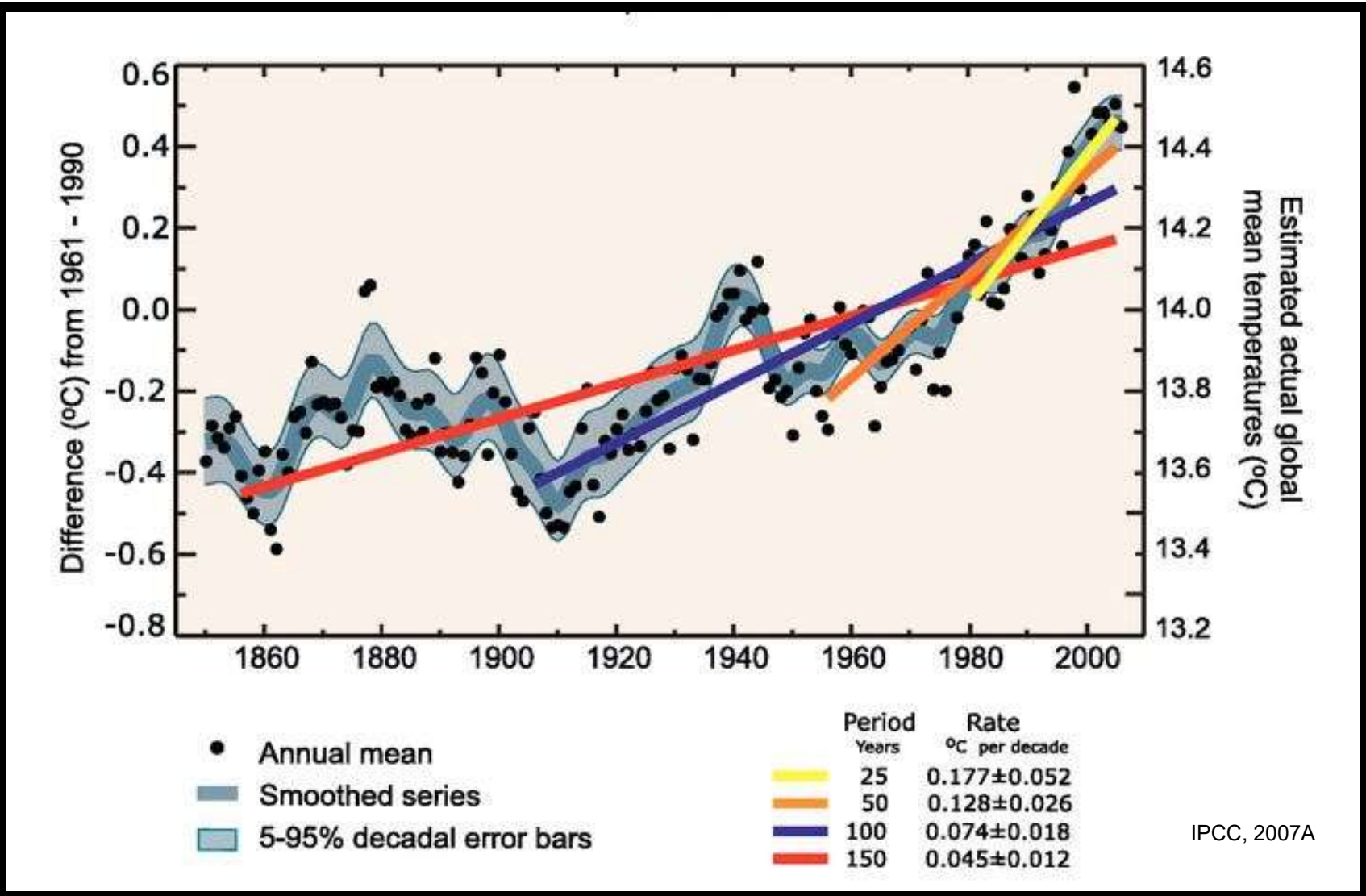


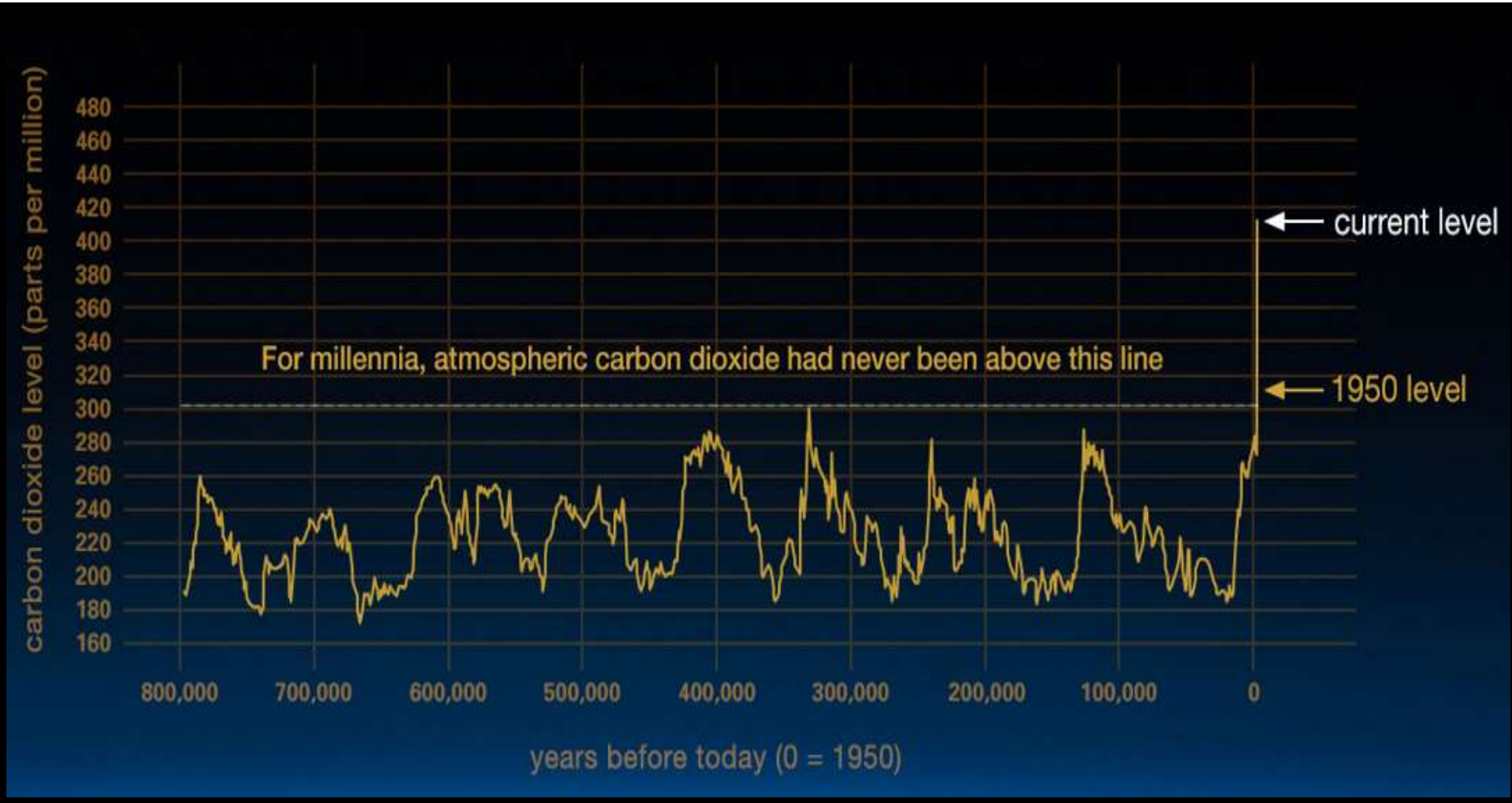
Image credit: Havard/Jeremy Shakun

Scientists have been able to reconstruct earth's CO_2 and avg. Antarctic temperature history for the past 800,000 years through ice cores data. In this graph, each trough represents an ice age. In the last 800,000 years, we have seen 7 ice ages. As is evident from this graph, Earth is presently coming out of an ice age. As is also clear from the graph, temperature and CO_2 are strongly correlated (the relationship between them though, is not linear). This is where the concern is raised. If CO_2 and temp are correlated, and if every time CO_2 has increased in the atmosphere, the Earth has warmed enough to come out of an ice age, what will the current amount of CO_2 do to the present climate. As is clear from the graph, earth has never seen so much CO_2 in the atmosphere in its past 800000 year history. This excess CO_2 is clearly a cause of major concern and is entirely due to man made reasons. There is nothing natural about this CO_2 conc. in the atmosphere.


Difference (°C) from 1961 - 1990
Estimated actual global mean temperatures (°C)
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
14.6
14.4
14.2
14.0
13.8
13.6
13.4
13.2
1860
1880
1900
1920
1940
1960
1980
2000
Annual mean
Smoothed series
5-95% decadal error bars
Period
Years
Rate
°C per decade
25
0.177±0.052
50
0.128±0.026
100
0.074±0.018
150
0.045±0.012

IPCC, 2007A

This problem is further made worse by the fact that the rate of change of CO_2, as shown in the graph has accelerated despite our efforts to curtail it in the last couple of decades. This shows that all the measures we have taken till date to tackle this issue have been woefully inadequate.



This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO_2 has increased since the Industrial Revolution. (Credit: Luthi, D., et al., 2008; Etheridge, D.M., et al. 2010; Vostok ice core data/J.R. Petit et al.; NOAA Mauna Loa CO_2 record.)

Evidences

1.Shrinking ice sheets : The Greenland and Antarctic ice sheets have decreased in mass. Data from NASA's Gravity Recovery and Climate Experiment show Greenland lost an average of 286 billion tons of ice per year between 1993 and 2016, while Antarctica lost about 127 billion tons of ice per year during the same time period.

2.Declining Arctic sea ice : Both the extent and thickness of Arctic sea ice has declined rapidly over the last several decades. (Image: Visualization of the 2012 Arctic sea ice minimum, the lowest on record)

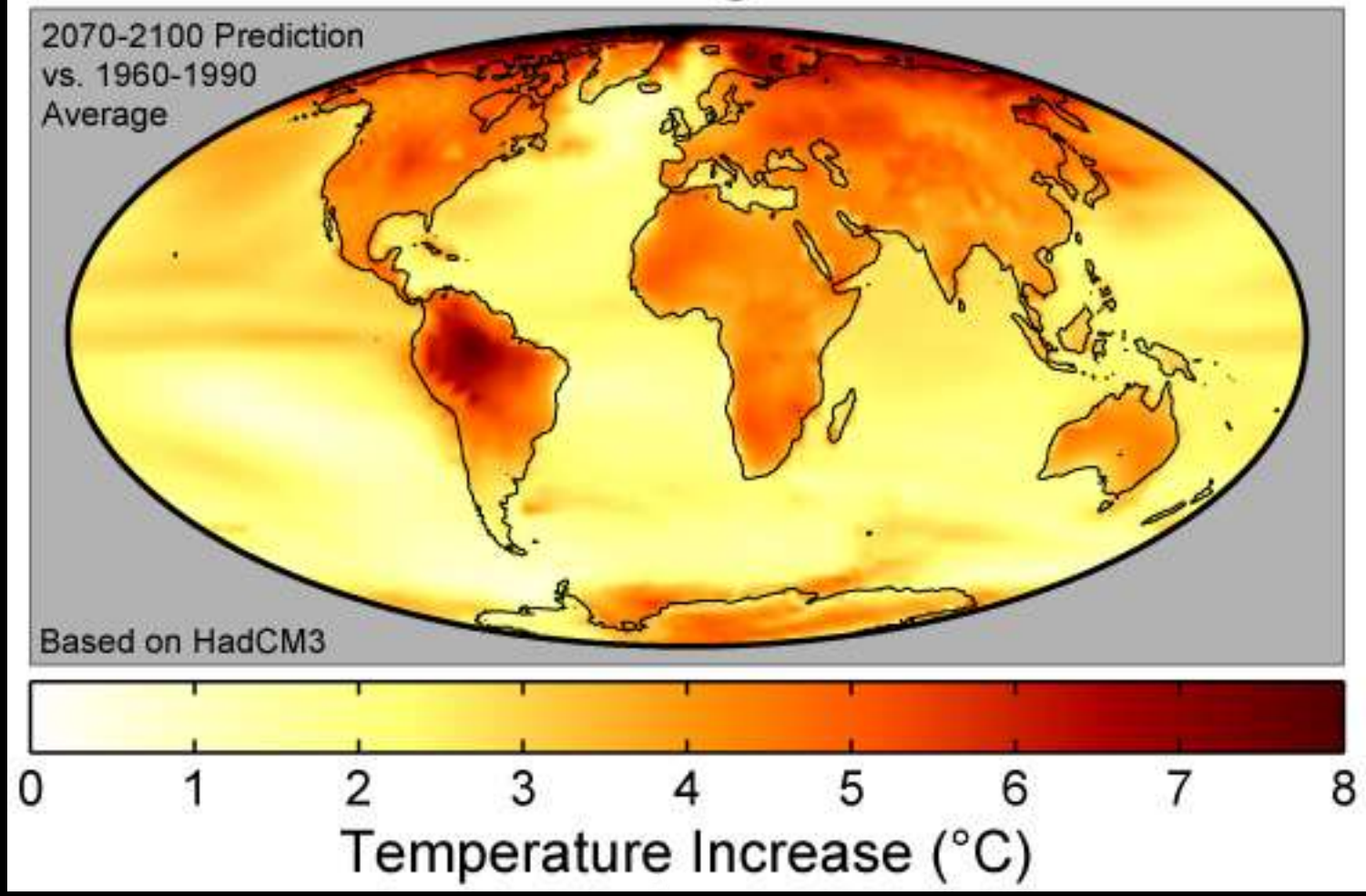
Source: UCAR centre for science education

3.Extreme events : The number of record high temperature events in the United States has been increasing, while the number of record low temperature events has been decreasing, since 1950. The U.S. has also witnessed increasing numbers of intense rainfall events.

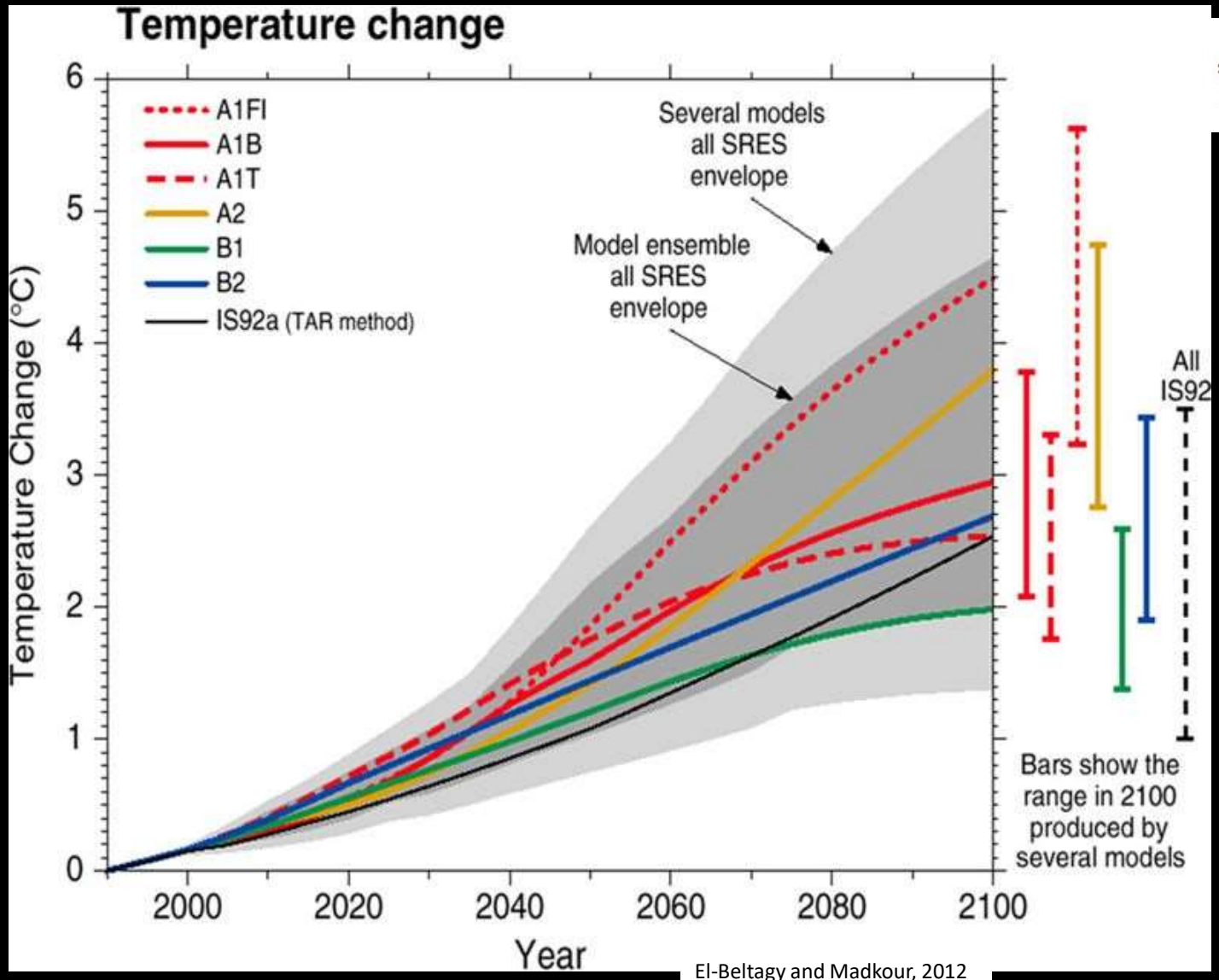
4.Ocean acidification : Since the beginning of the Industrial Revolution, the acidity of surface ocean waters has increased by about 30 percent. This increase is the result of humans emitting more carbon dioxide into the atmosphere and hence more being absorbed into the oceans. The amount of carbon dioxide absorbed by the upper layer of the oceans is increasing by about 2 billion tons per year.

Source: UCAR centre for science education

Global Warming Predictions



Another layer of complexity to this problem comes when you take this data and try to predict what is going to happen in the future. Because Earth is a **non-linear dynamical system**, it is hard to anticipate how the future of climate is going to look.



El-Beltagy and Madkour, 2012

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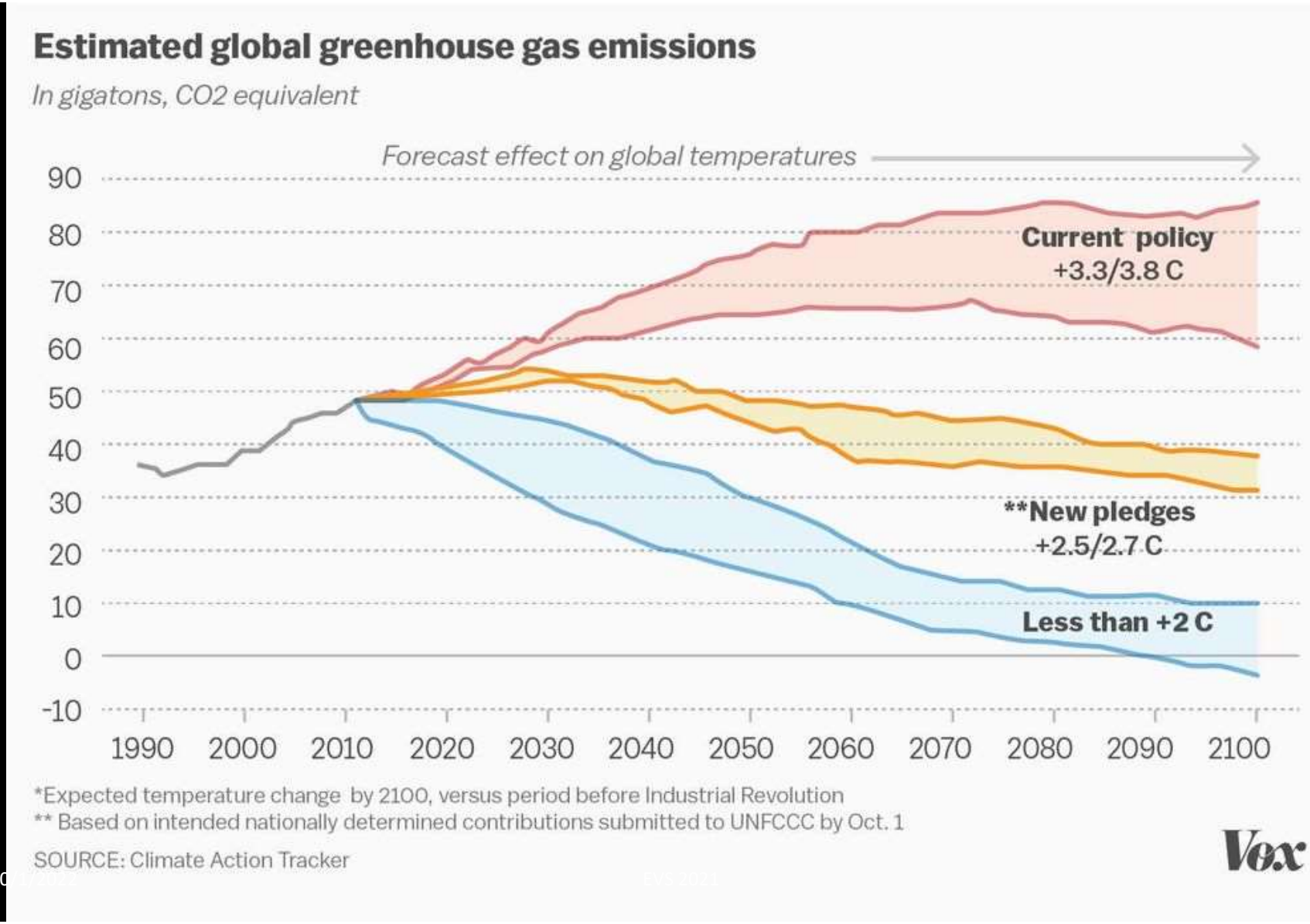
Temperature change under different scenarios

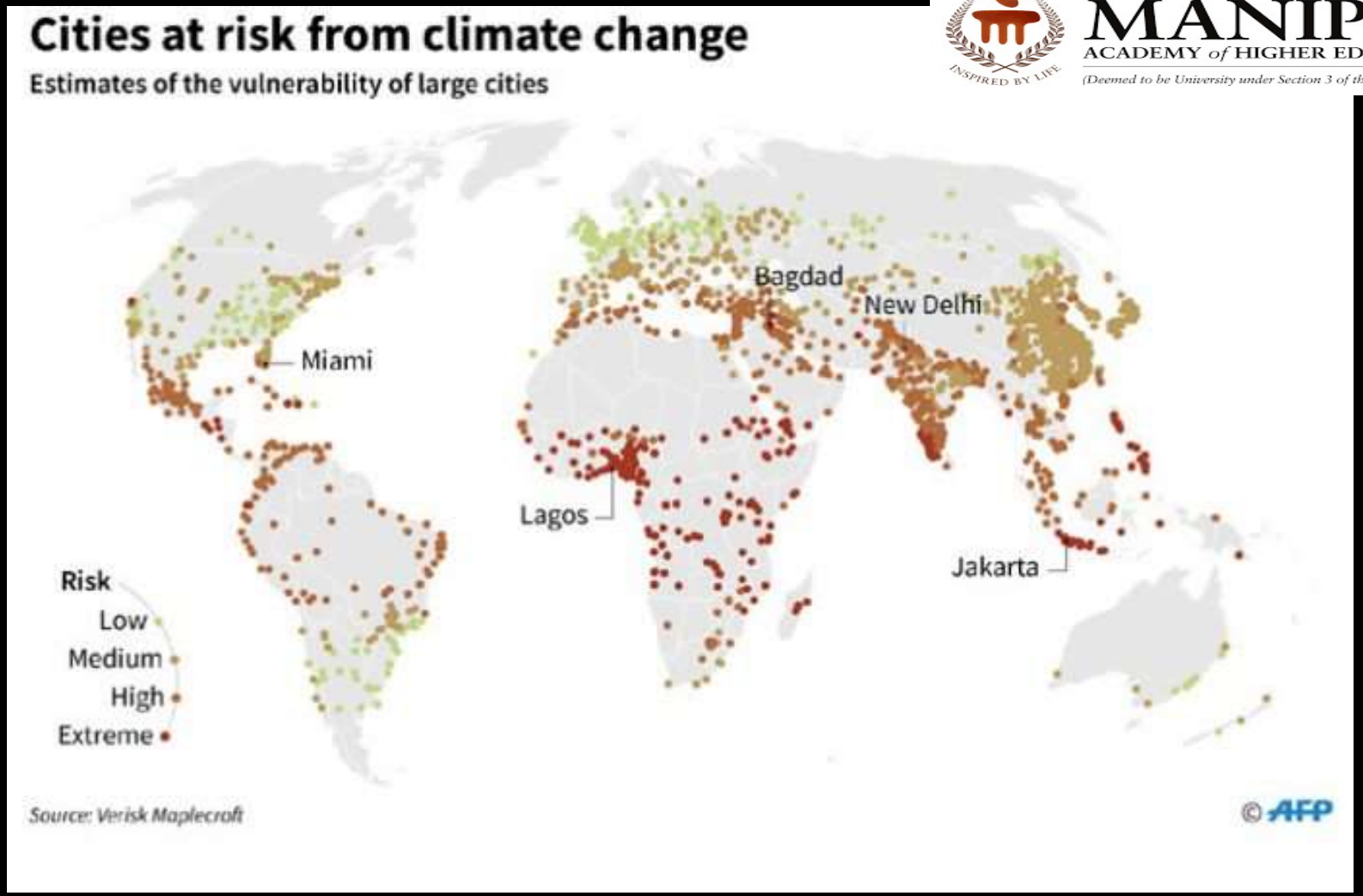
This is a graph of temperature change in the year 2100 under different scenarios. Each line represents a different model which takes into different, but equally valid assumptions about how the temperature of planet will rise. As you can see, the variation is quite large. It ranges from about 1.5 C to about 6 C which, is quiet a large difference. 6 C change will mean evacuation of many coastal areas and islands around the world. 1.5 C change will mean slight but manageable sea level rise. Both those extreme scenarios require diametrically opposite policy interventions.

Image Credit: Friendsofe

COP21 or otherwise known as the Paris Climate Agreement, signed in 2015, has the ambitious goal of keeping global temperature rise by 2100 to below 2 C with aspirations to keep it below 1.5 C. These goals are nearly unattainable keeping in mind the projections seen in previous slide.


Estimated global greenhouse gas emissions
In gigatons, CO2 equivalent
Forecast effect on global temperatures
90
80
70
60
50
40
30
20
10
0
-10
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Current policy
+3.3/3.8 C
**New pledges
+2.5/2.7 C
Less than +2 C
*Expected temperature change by 2100, versus period before Industrial Revolution
** Based on intended nationally determined contributions submitted to UNFCCC by Oct. 1
SOURCE: Climate Action Tracker
Vox

This graph highlights this issue. Even with the current policies, we are realistically looking at about 4 C rise, which is catastrophic. Some new proposed environmental policies are expected to bring this down to 2.5-2.7 C but nothing close to the 2 C or 1.5 C COP21 goals.


Cities at risk from climate change
Estimates of the vulnerability of large cities
Miami
Bagdad
New Delhi
Lagos
Jakarta
Risk
Low
Medium
High
Extreme
Source: Verisk Maplecroft
© AFP

India and other developing countries will disproportionately suffer from the consequences of the failure of such policies.

Sustainable Development

Sustainable Development (SD)

"Development that meets the needs of the present without compromising the ability of future generation to meet their own needs"

1987 report of the World Commission on Environment and Development (WCED).

What is Sustainable about Development?

- What is development?
- How do you measure sustainability in the current paradigm of development?
- Is your definition of sustainability in line with environmental sustainability?

- To understand the term sustainable development truly, it is first important to understand what we mean by development and also sustainability. And then see if these two definitions are in line with each other.

What is development?

Definition of Development:

Gross Domestic Product (GDP)

"GDP measures the monetary value of final goods and services—that is, those that are bought by the final user—produced in a country in a given period of time"- IMF

Measurement of throughput of natural resources

- In our world, development is primarily defined by GDP. Lesser developed economies have lower GDP. Developed economies have higher GDP. Therefore, for development to happen GDP must rise. But, GDP is actually a measure of how much natural resources are consumed. So resource consumption must increase for development to happen.

Challenges to Sustainable Development

- Rising income inequality (Economical Kuznets curve)
- Environmental degradation (Environmental Kuznets curve)

Economical Kuznets curve : Refers to relating growth and income redistribution.

Environmental Kuznets curve : Refers to relating growth and environment.

How to measure sustainability?

- For the case of development- Sustainable growth
- For the case of the environment- Environmental sustainability
- Environmental sustainability requires that we don't consume non renewable resources. In such a scenario, GDP should be close to zero.

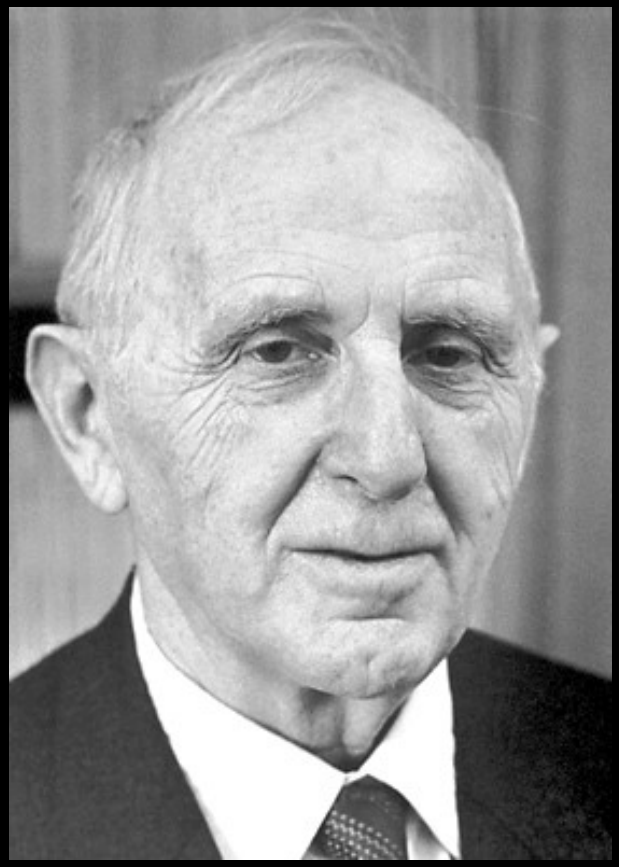
Sustainable Growth ≠ Environmental Sustainability

- Therefore, for development to happen at a regular pace, we need a “sustainable” **GDP** growth. But this means that we are increasing our resource consumption at a regular pace.

- Environmental sustainability requires that we don’t consume non-renewable resources since any consumption of such resources will reduce the environment as an entity.

- Therefore, sustainable growth and environmental sustainability necessarily cannot be the same thing.

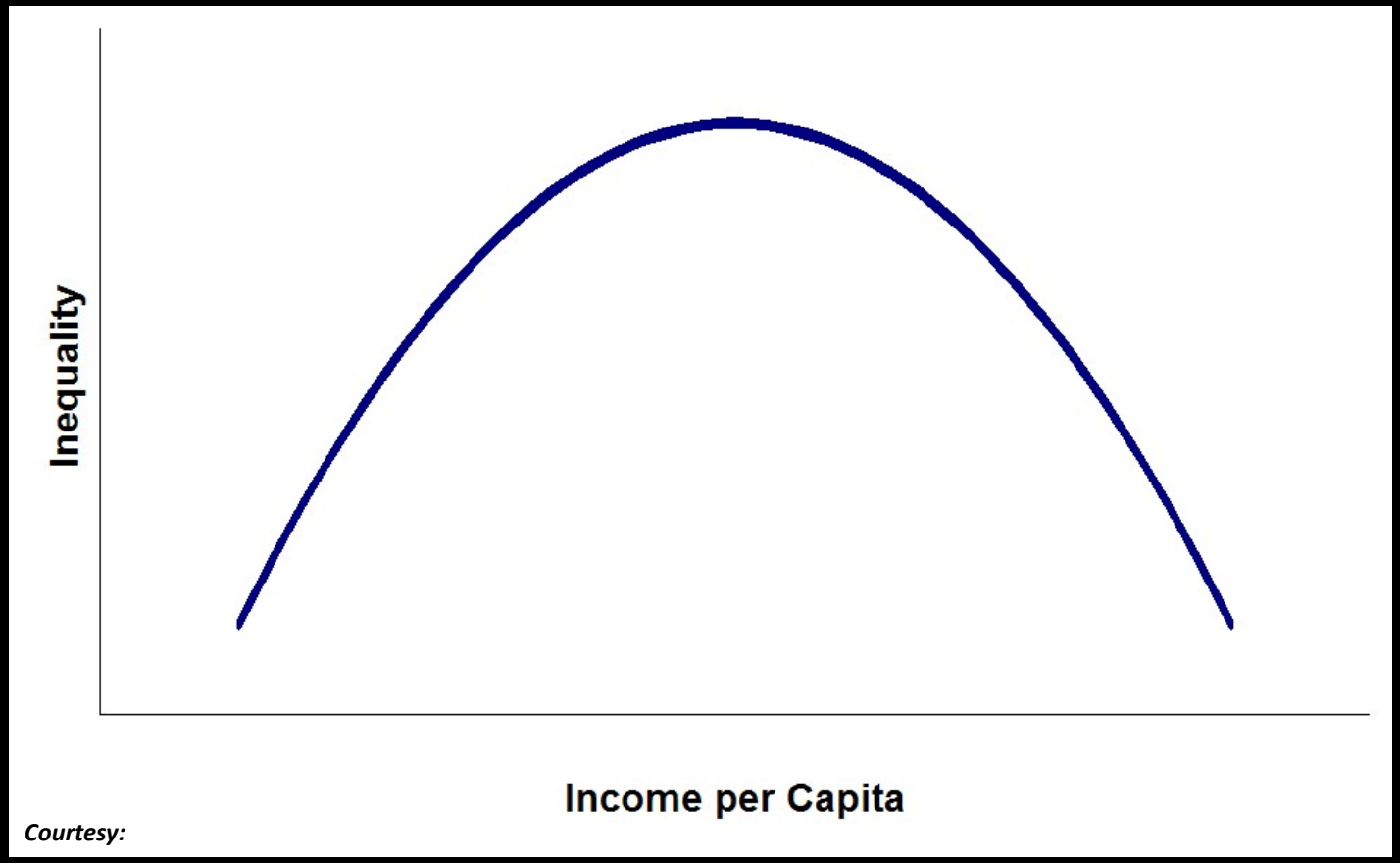
Why do we use GDP as a metric for overall improvement in human life?



Simon Kuznets

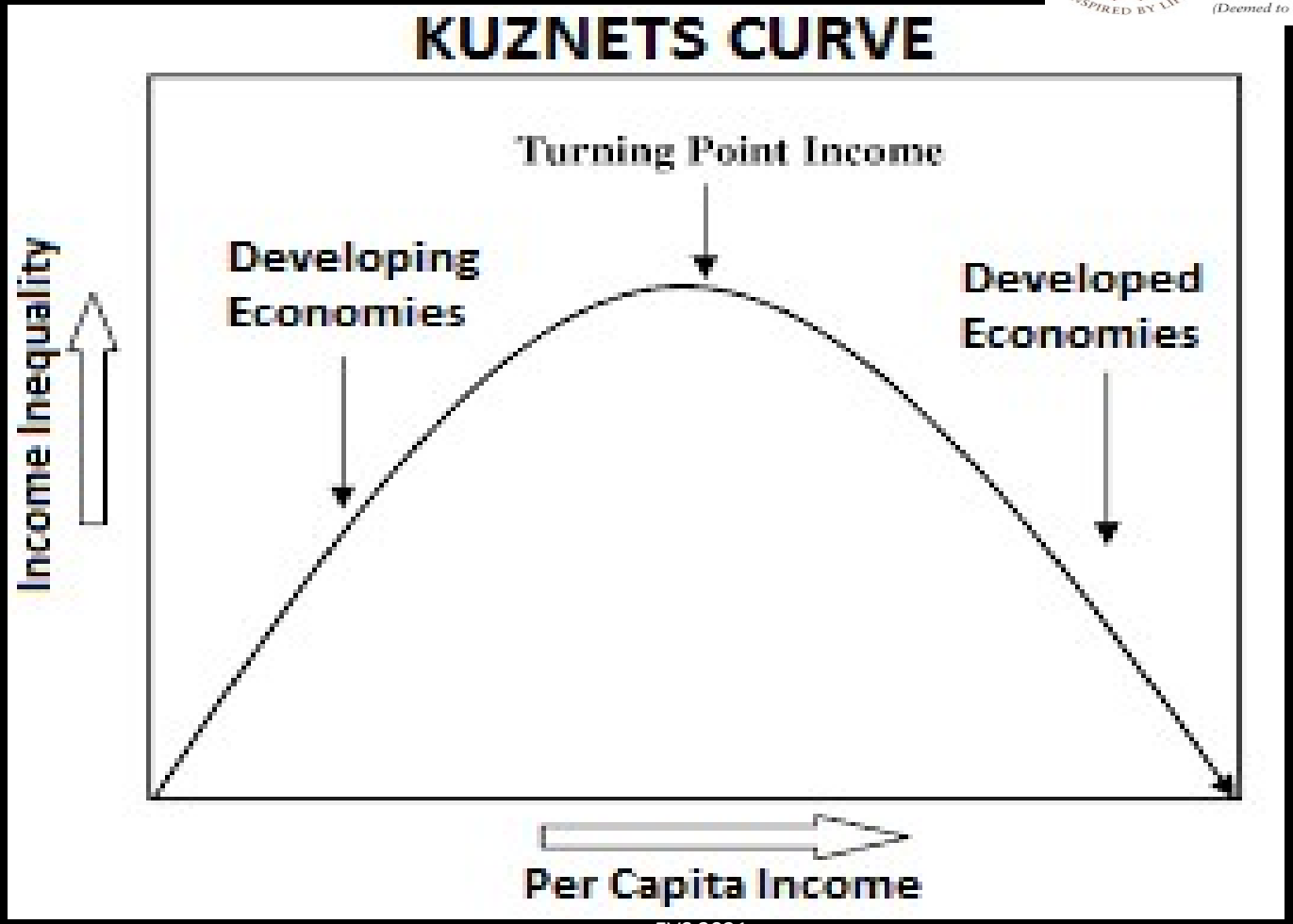
Simon Kuznets was the first person to introduce the concept of GDP to understand year on year development rate of a country and quantify it. Before his time, industrial growth of was only measured in indirect terms and was very vague. This lead to serious issues in framing proper economic policies. The great US depression of 1929 is a good example of the problems caused by this vague understanding. He was also the first person to collect data for the US and some European countries to calculate their GDPs.

Kuznets Curve

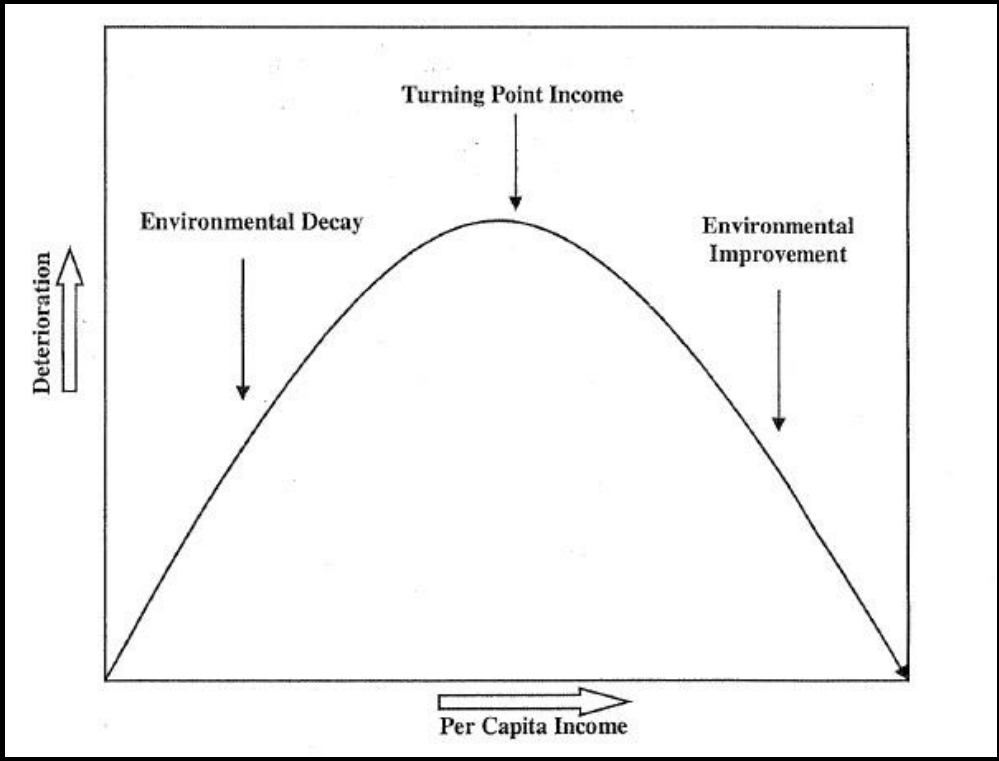


Courtesy:

While he was collecting this data, he observed that as the income per capita increases, so does the income inequality of the country, but only up to a certain point. Any subsequent increase in the income per capita then decreases Inequality. He did not comment on how this happens or why it happens. Just that it happens. He even said that this conclusion was "*"Perilously close to pure guesswork"* as the data he was working with was very limited. But, nonetheless, it became very popular especially for many underdeveloped/developing economies. The policy for removing income inequality was now simple. Just focus on GDP (Income per capita as an aggregate will be GDP). As long as the GDP rose, inequality would rise but at some point come down on its own. Take the case of the western economies. They are on the right hand side of this curve and their income inequality is low. India is somewhere near the top left side of the curve and our inequality is high. Intuitively, this graph makes sense.


KUZNETS CURVE
Turning Point Income
Developing Economies
Developed Economies
Income Inequality
Per Capita Income

Environmental Kuznets Curve (EKC)



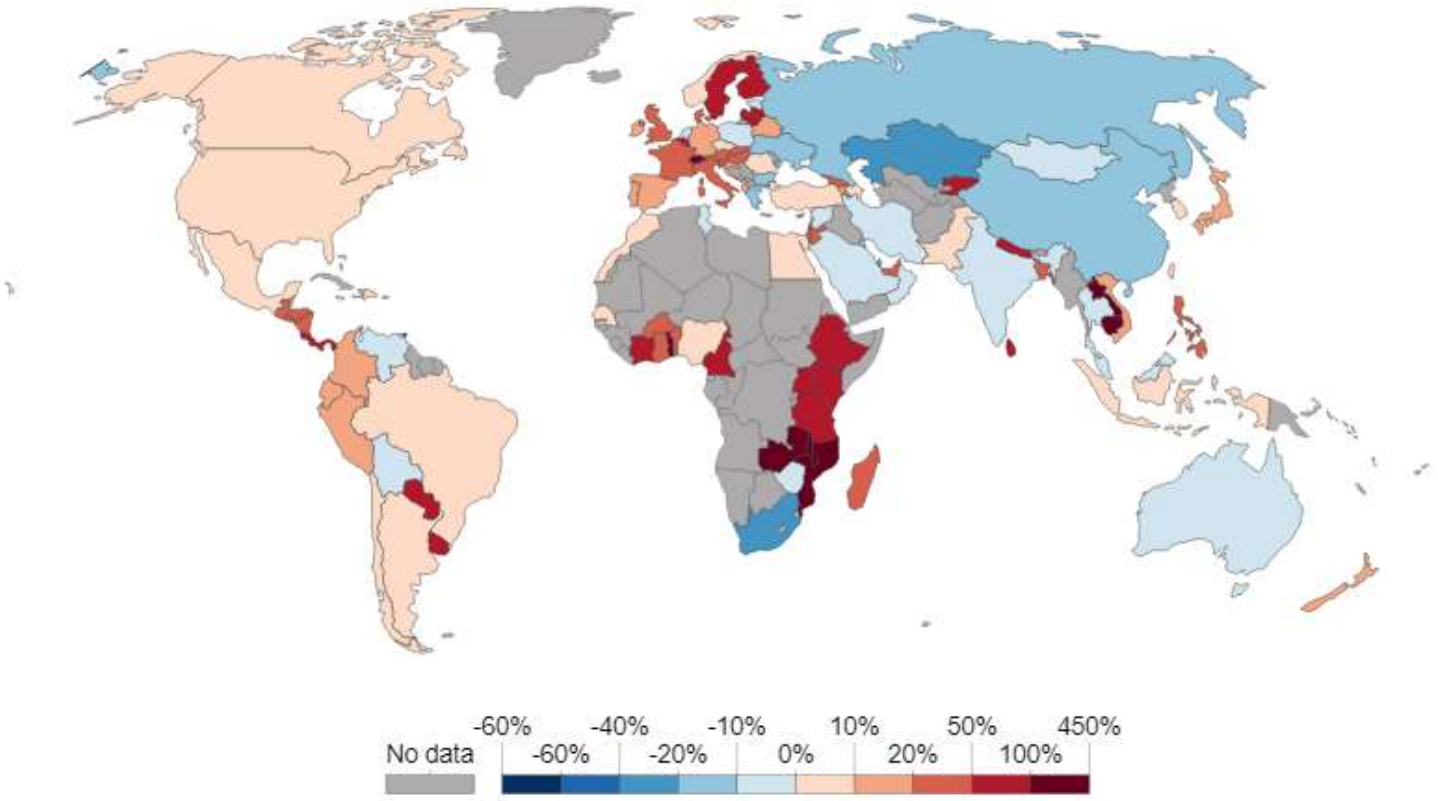
Courtesy: perc.org

- This understanding got carried forward to the environment as well. As a country is developing, it will consume resources at a rate which will cause environmental decay, but after a certain point, environmental decay will come to a halt and will start to improve. Again, if you take the case of Europe and India, it makes intuitive sense. Europe is rich enough to spend some of its income on protection of their environment. India is not quite there yet and is seeing destruction of its environment. Many developing countries are doing worse. This is an amazing insight for a policy maker or the government. With this and the previous graph combined, what it means for them is that if they focus just on growing the GDP, though in the short term inequality and environmental destruction will rise, in the long run both of those major issues will be resolved ***automatically***.

CO_2 emissions in imported goods as a share of domestic emissions, 2014

Share of carbon dioxide (CO_2) emissions embedded in trade, measured as emissions exported or imported as the percentage of domestic production emissions. Positive values (red) represent net importers of CO_2 (i.e. "20%" would mean a country imported emissions equivalent to 20% of its domestic emissions). Negative values (blue) represent net exporters of CO_2.

Our World in Data



Source: Peters et al. (2012 updated); Global Carbon Project

OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/ • CC BY-SA

But lets stop to think about how the EKC actually works. Take the case of Europe. Europe is very sensitive to its environment and have very stringent rules for its protection. But does that mean they have low carbon footprints? No! On the contrary it has one of the highest per capita CO2 emissions of the world. It manages to have a clean environment by shifting the onerous of doing polluting jobs to other countries and importing the products from them. This allows them to be clean while also causing environmental degradation. This is clearly not a sustainable way to reduce environmental degradation in the world as countries like India and China also “develop”. The EKC is right if you take countries in isolation but very wrong when taken for the whole world. There is therefore a need to move to better policies to reduce environmental degradation and actually develop sustainably.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(Deemed to be University under Section 3 of the UGC Act, 1956)

Thank you