

Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

Economics of Climate Change

Nelson Mark

(University of Notre Dame)

Hesburgh Lecture Detroit Club

May 8, 2023

Effects of
Climate
Change

Climate
Science in
Brief

Kaya Identity

Climate
Science
Approach

Economic
Approach

Policy Options

Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

Effects of
Climate
Change

Climate
Science in
Brief

Kaya Identity

Climate
Science
Approach

Economic
Approach

Policy Options

NOAA Headlines



National Oceanic and Atmospheric
Administration
U.S. Department of Commerce

Search NOAA sites



Home / News & Features

U.S. sweltered through third-hottest summer on record

August 2022 saw remarkable heat, historic flash floods

Focus areas: Satellites, Climate Topics: monthly climate report , severe weather , heat , flooding

Share: [t](#) [f](#) [e](#) [b](#)

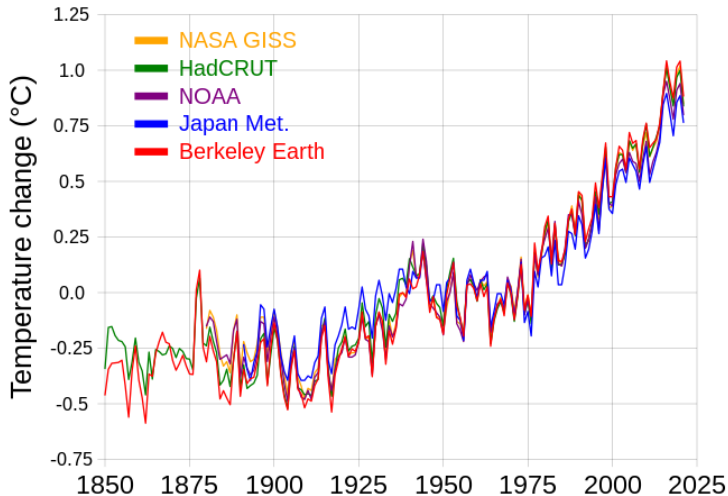
September 9, 2022



Photo of flood damage at Mud Canyon Road in Death Valley National Park, California, from August 2022. On August 5, 2022, the park received 1.70 inches of rain — an all-time 24-hour rainfall record for the area. (National Park Service)

Global Average Temperature

Global average temperature change



Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

Effects of
Climate
Change

Climate
Science in
Brief

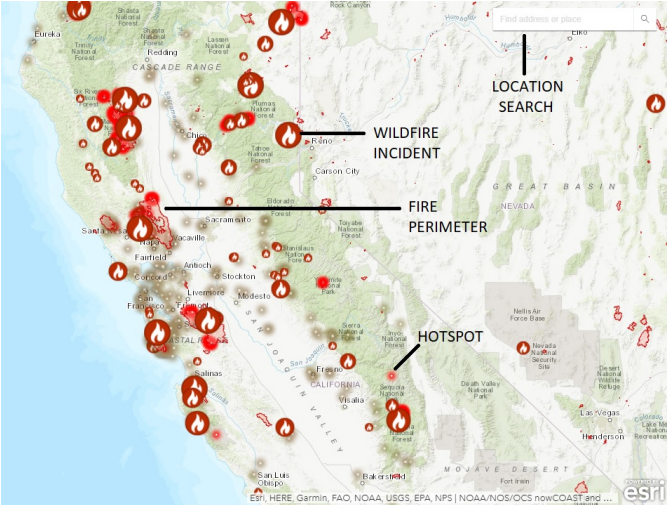
Kaya Identity

Climate
Science
Approach

Economic
Approach

Policy Options

California Wildfires



Wildfires

Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

Effects of
Climate
Change

Climate
Science in
Brief

Kaya Identity

Climate
Science
Approach

Economic
Approach

Policy Options



And Floods

Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

Effects of
Climate
Change

Climate
Science in
Brief

Kaya Identity

Climate
Science
Approach

Economic
Approach

Policy Options



Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

NOAA Sea Level Rise Map

<https://coast.noaa.gov/digitalcoast/tools/slr.html>

Effects of
Climate
Change

Climate
Science in
Brief

Kaya Identity

Climate
Science
Approach

Economic
Approach

Policy Options

Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

Effects of
Climate
Change

Climate
Science in
Brief

Kaya Identity

Climate
Science
Approach

Economic
Approach

Policy Options

Floods in Pakistan



Water Stress in India

Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

Effects of
Climate
Change

Climate
Science in
Brief

Kaya Identity

Climate
Science
Approach

Economic
Approach

Policy Options



Drought in China

Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

Effects of
Climate
Change

Climate
Science in
Brief

Kaya Identity

Climate
Science
Approach

Economic
Approach

Policy Options



Drought in China

Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

Effects of
Climate
Change

Climate
Science in
Brief

Kaya Identity

Climate
Science
Approach

Economic
Approach

Policy Options



Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

Effects of
Climate
Change

Climate
Science in
Brief

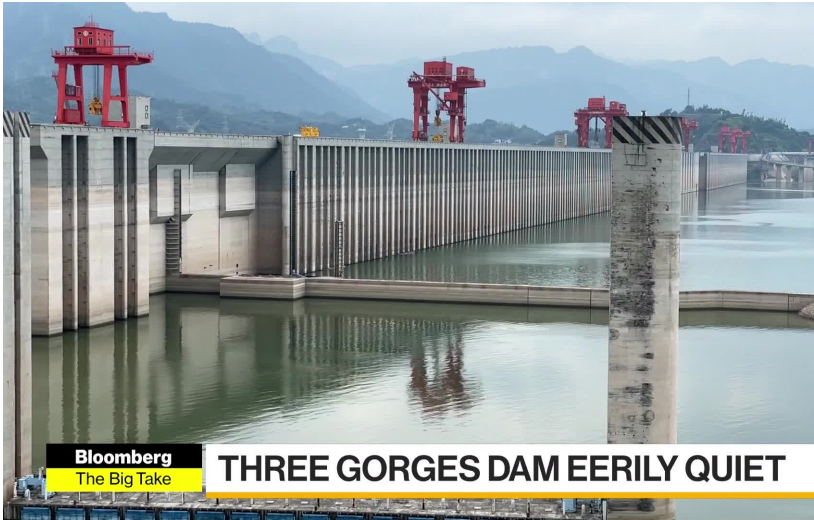
Kaya Identity

Climate
Science
Approach

Economic
Approach

Policy Options

Interrupts Hydroelectric Generation



Bloomberg
The Big Take

THREE GORGES DAM EERILY QUIET

Glacier Loss

Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

Effects of
Climate
Change

Climate
Science in
Brief

Kaya Identity

Climate
Science
Approach

Economic
Approach

Policy Options



Incidence is Uneven

Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

Effects of
Climate
Change

Climate
Science in
Brief

Kaya Identity

Climate
Science
Approach

Economic
Approach

Policy Options

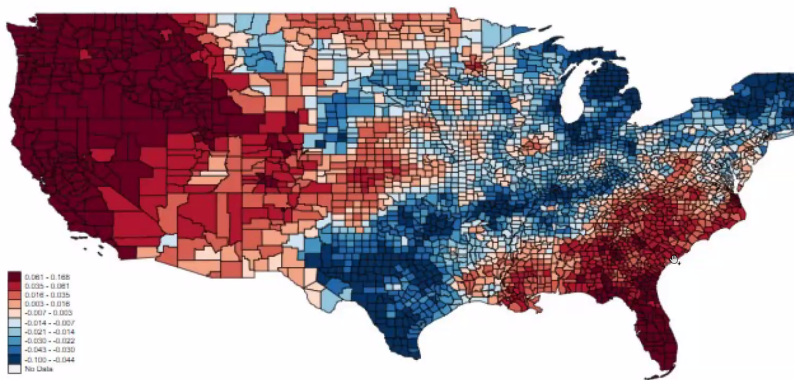
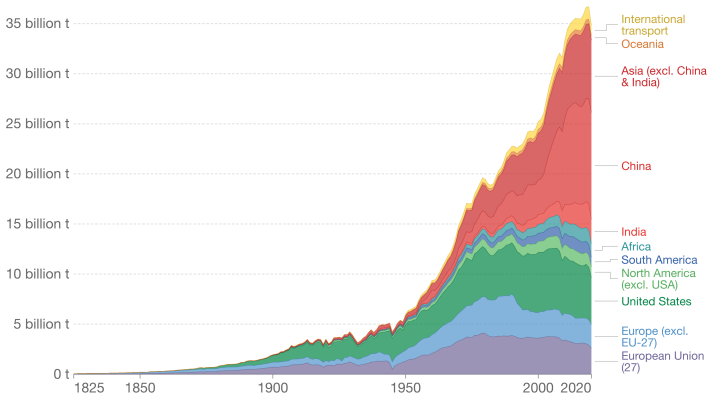


Figure plots the change in average daily temperature at the county level in each (2000-2015)

Emissions by Region

Annual CO₂ emissions from fossil fuels, by world region

Our World
in Data



Source: Global Carbon Project

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

Note: This measures CO₂ emissions from fossil fuels and cement production only – land use change is not included. 'Statistical differences' (included in the GCP dataset) are not included here.

The Holy Father Says Pay Attention!

Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

Effects of
Climate
Change

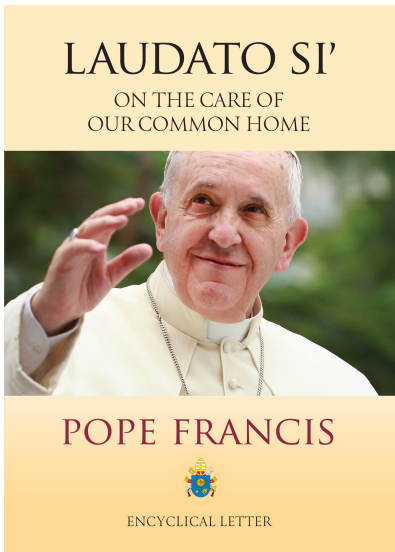
Climate
Science in
Brief

Kaya Identity

Climate
Science
Approach

Economic
Approach

Policy Options



Some People Do

- Property insurers
- Mortgage lenders
- Central banks (the Fed, the European Central Bank)
- World Bank, IMF
- Portfolios heavy in fossil fuel assets

Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

Effects of
Climate
Change

Climate
Science in
Brief

Kaya Identity

Climate
Science
Approach

Economic
Approach

Policy Options

Greenhouse Effect

- Discovered by Fourier in 1824. Demonstrated in lab by John Tyndell in 1859, Eunice Foote 1856.
- Solar energy hits earth. 30 percent reflected back into space. 70 percent absorbed by GHG molecules, which get excited and emit energy. Atmospheric GHGs traps energy on the planet.
- Equilibrium occurs when energy in = energy out.
- Climate sensitivity: warming induced by doubling atmospheric CO₂. Estimated likely range 1.5°C to 4.5°C—a lot of uncertainty.
- ICE 22 mpg, drive 11,500 miles. You emit 4.6 tons CO₂.

Three Major Greenhouse Gases

- 1 CO₂ is no. 1 main GHG. Produced by burning fossil fuels, solid waste, trees and other biological materials. Stays 300 to 1000 years (approximately forever).
- 2 Methane CH₄ (natural gas). Burped up by cows, decay of landfill organic waste. Sequestered in the tundra. 1 ton CH₄ = 84 tons CO₂. Stays about a decade.
- 3 Nitrous oxide N₂O. Burning fossil fuels, solid waste, runoff from farms treated with nitrogen fertilizers. 1 ton N₂O = 298 tons CO₂. Stays 100 years.

Carbon Sinks

- **Land:** plants, trees, forests. May increase initially, but reduced nutrient and water availability, will cause decline.
- **Ocean:** Organisms in the ocean absorb CO_2 . Acidification increases with CO_2 , limiting ability to absorb.
- **Permafrost** stores methane. Is released from peat, wetlands, thawing permafrost. Hydrate stores– large quantities of methane trapped under the oceans under high pressure. Ocean warming can destabilize and release methane.

Kaya Identity: Emission Reduction Levers

- M are CO₂ emissions, P population, E energy use, and Y GDP.

$$\begin{aligned} M &= M \\ &= P \underbrace{\left(\frac{Y}{P}\right)}_{\text{GDP per capita}} \underbrace{\left(\frac{E}{Y}\right)}_{\text{Energy intensity}} \underbrace{\left(\frac{M}{E}\right)}_{\text{Carbon Intensity}} \end{aligned}$$

- Warming occurs with a lag
- To stop warming, need zero-net emissions.

What Climate Scientists Do

- Run computationally intensive and complicated climate models.
- Generate scenerios called Shared Socioeconomic Pathways (SSP's).
- 46 Authored Paper



Contents lists available at ScienceDirect

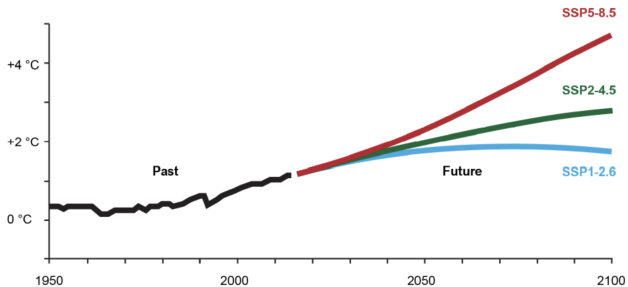
Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview

Keywan Riahi^{a,*}, Detlef P. van Vuuren^b, Elmar Kriegler^c, Jae Edmonds^d, Brian C. O'Neill^e, Shinichiro Fujimori^f, Nico Bauer^g, Katherine Calvin^h, Rob Dellinkⁱ, Oliver Fricko^a, Wolfgang Lutz^a, Alexander Popp^g, Jesus Crespo Cuaresma^a, Samir KC^{h,ij}, Marian Leimbach^k, Leiwen Jiang^g, Tom Kram^b, Shilpa Rao^a, Johannes Emmerling^{l,j}, Kristie Ebi^h, Tomoko Hasegawa^g, Petr Havlik^k, Florian Humpenöder^c, Lara Aleluia Da Silva^{l,j}, Steve Smith^g, Elke Stehfest^b, Valentina Bosetti^{h,j,j}, Jiyong Eom^{d,m}, David Germaat^b, Toshihiko Masui^g, Joeri Rogelj^h, Jessica Strefler^c, Laurent Drouet^{l,j}, Volker Krey^g, Gunnar Luderer^c, Mathijs Harmsen^b, Kiyoshi Takahashi^l, Lavinia Baumstark^l, Jonathan C. Doelman^g, Mikiko Kainuma^l, Zbigniew Klimont^g, Giacomo Marangoni^{l,j}, Hermann Lotze-Campen^{c,p}, Michael Obersteiner^q, Andrzej Tabeau^r, Massimo Tavoni^{l,d,o}

Global Surface Temperature Change



On the 2^o threshold (tipping point). Paris Agreement's 2100 target.

Economists Assess and Model Costs and Benefits

Comparatively, economic research is like a cottage industry

- What does catastrophe mean (in terms of dollars)?
- What are the economic costs of climate change?
- What are the costs of abatement and adaptations?
- What is optimal policy? Integrated Assessment Models (IAMs). Relative to climate models, simple and understandable.

Economic Damages

- Crop yields
- Wealth destruction and hits to income from extreme weather events.
- Health, labor productivity, labor supply, and human capital accumulation reductions from temperature stress

International Macroeconomic Evidence

- Conventional wisdom: Dell, Jones and Olken. Higher temperature reduces per capita GDP of poor (hot) countries. Uncertain if there is an effect on rich (cool) countries.
- New evidence: Berg, Curtis, and Mark. Higher temperatures reduces per capita GDP of rich countries. Many poor countries GDP seems to surge.

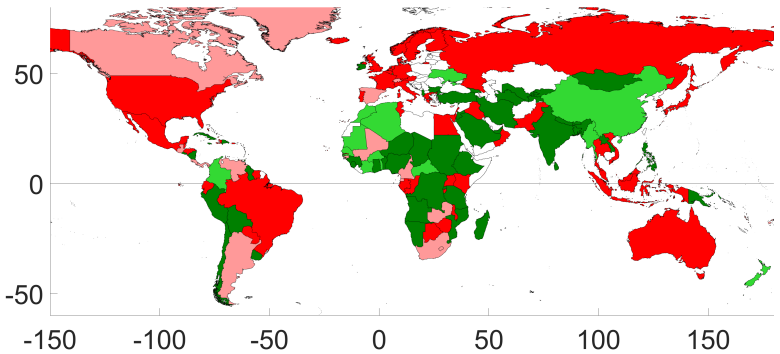
Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

- Effects of
Climate
Change
- Climate
Science in
Brief
- Kaya Identity
- Climate
Science
Approach
- Economic
Approach
- Policy Options

GDP 5 years after temperature shock

Green: slower growing, poorer, less educated, more authoritarian



Climate Externality: Special Problem

- My emission of CO₂ is a special type of pollution. Costs borne by 8bn people of the world.
- **Free Rider** problem. Why should I pay to abate?
 - Benefit accrues to 8 bn other people
 - Benefit accrues to future generations
- The market will not solve this problem.

Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

Effects of
Climate
Change

Climate
Science in
Brief

Kaya Identity

Climate
Science
Approach

Economic
Approach

Policy Options

the Social Cost of Carbon

- William Nordhaus invented climate change economics by doing this in early 1990s.
- DICE (The Dynamic Integrated Climate-Economy model). Nordhaus adapts the **neoclassical growth model** to include a carbon module and a damage function.
- The SCC is **present value** of future damage caused by additional one-ton emission. Requires ton of assumptions.
- Many estimates are in the \$100-\$250 2010 USD range.

Economic Solutions

- The Pigouvian Tax: A.C. Pigou (1877-1959) English Economist at Cambridge.
 - Set the tax equal to the SCC everyone who emits (pollutes). Rebate the proceeds to people.
 - Typical vehicle, \$100 per ton tax raises gas by \$0.88 per gallon.
 - Drive less, get more fuel efficient car (maybe EV).
 - Emissions reduced.
 - You get the money back at end of year.

Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

Effects of
Climate
Change

Climate
Science in
Brief

Kaya Identity

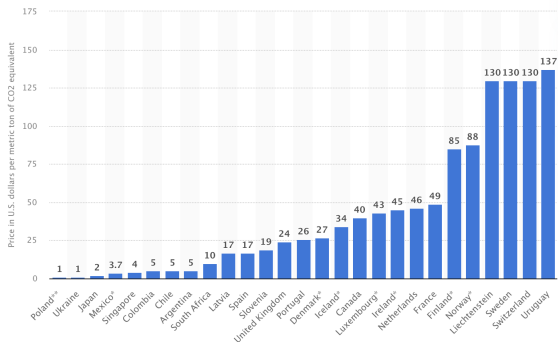
Climate
Science
Approach

Economic
Approach

Policy Options

Carbon Taxes around the World

Carbon tax rates worldwide as of April 1, 2022, by country
(in U.S. dollars per metric ton of CO₂-equivalent)



[Additional Information](#)

© Statista 2022

[Show source](#)

Emission Quantity Restrictions

- Cap and Trade
 - Several US states (CA, DE, ME, MD, MA, NH, NJ, RI, NY, VT)
 - Canadian provinces (BC, Nova Scotia)
 - European Union

Effectiveness of Abatement Policies

- 25% of carbon emissions covered by carbon taxes or trading systems but emissions keep rising.
 - Many fossil fuel subsidies in place
- Carbon offsets can be accounting loopholes
- Carbon taxes have worked better than trading systems
 - Taxes tend to be national whereas ETS are local/regional, plus firms prefer and lobby for ETS

What to do?

- Policy can only be effective when there is strong majority public sentiment.
- Nations form a climate club
- Adapt to a hotter world

Nelson Mark
(University of
Notre Dame)

Hesburgh
Lecture
Detroit Club

Effects of
Climate
Change

Climate
Science in
Brief

Kaya Identity

Climate
Science
Approach

Economic
Approach

Policy Options