

Climate Change Chartbook

Bob Agnew

raagnew1@gmail.com

raagnew.com

December 2022

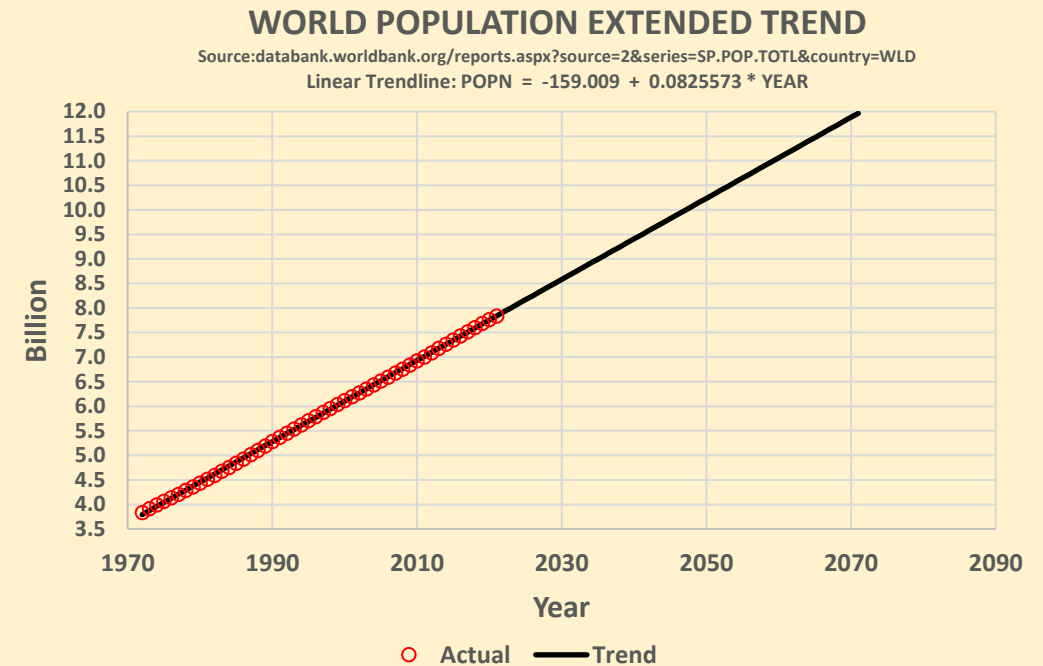
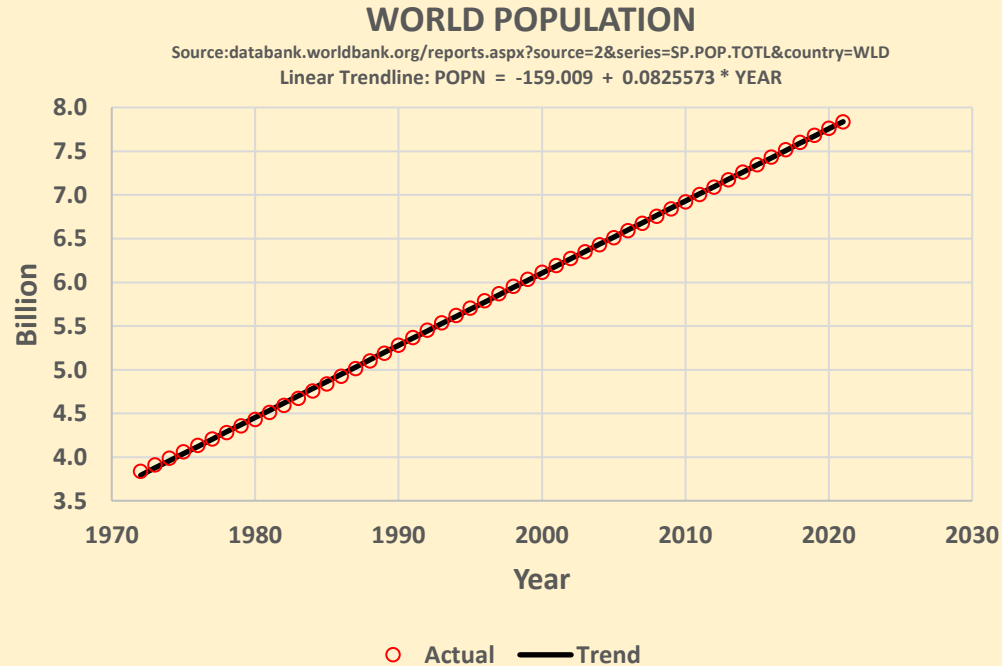
Thesis

Global mean temperature is rising relentlessly in tandem with atmospheric carbon dioxide. We must accelerate the world energy transition from fossil fuels to renewables.

Approach

- **Simple trendlines estimated over last 50 years (1972-2021)**
 - Global Population
 - Global Real GDP (2015 US\$, Overall and Per Capita)
 - Global Atmospheric Carbon Dioxide Concentration (PPM)
 - Global Temperature Anomaly (Degrees Celsius, Relative to 1951-1980 Baseline)
- **Trendlines extended over next 50 years (2022-2071)**
 - Global population, growing linearly, will rise to 12 billion, a lot of people
 - Global real GDP, growing exponentially at about 3%, will rise to \$412 trillion
 - Global real GDP per capita will rise from \$11,057 in 2021 to \$34,394 in 2071
 - *But*, global CO2 will rise from 416 PPM in 2021 to 571 PPM in 2071
 - *And*, global temperature anomaly will rise another 1 degree Celsius
- **Charts illustrate our quandary**

Population grows linearly, from 8 to 12 billion

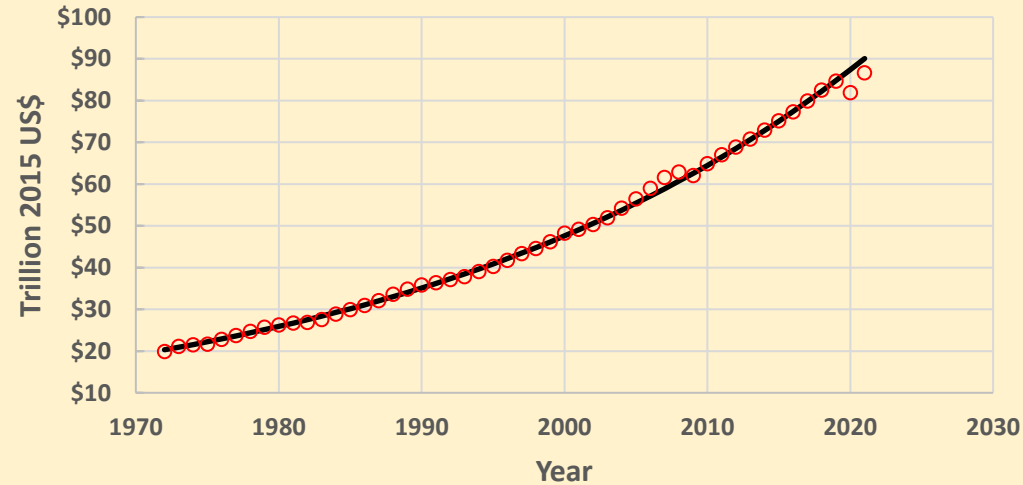


Population has the potential to grow exponentially. However, yearly percentage growth rates have steadily decreased since 1972, resulting in approximate linear growth. Nevertheless, this linear growth trajectory still yields a significantly larger population by 2071, all of whom will want a better life.

Real GDP grows exponentially, at about 3% pa

WORLD REAL GDP

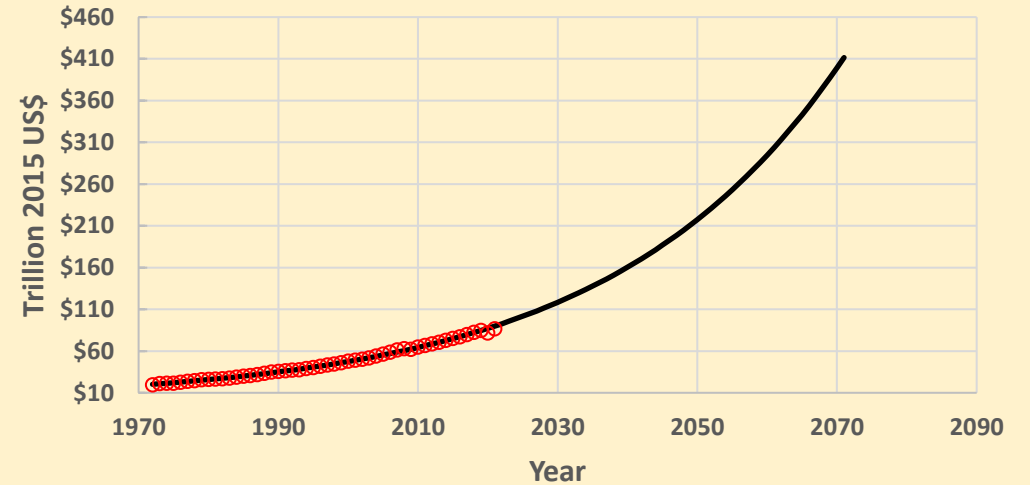
Source: databank.worldbank.org/reports.aspx?source=2&series=NY.GDP.MKTP.KD&country=WLD
Exponential Trendline: $GDP = \text{EXP}(-56.9140 + 0.0303882 * \text{YEAR})$



○ Actual — Trend

WORLD REAL GDP EXTENDED TREND

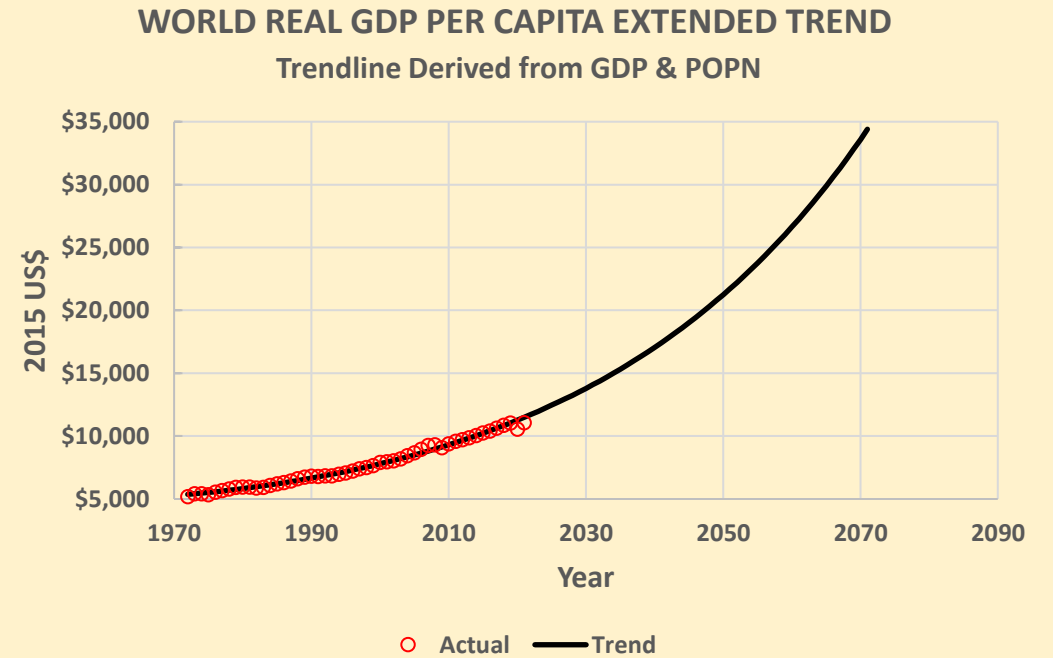
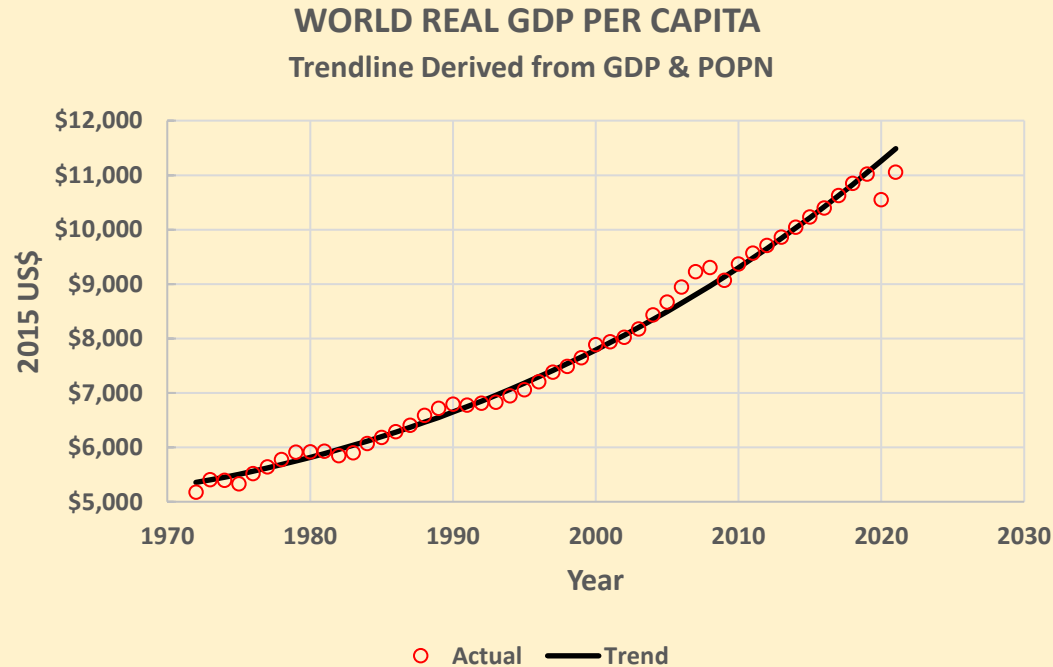
Source: databank.worldbank.org/reports.aspx?source=2&series=NY.GDP.MKTP.KD&country=WLD
Exponential Trendline: $GDP = \text{EXP}(-56.9140 + 0.0303882 * \text{YEAR})$



○ Actual — Trend

Notwithstanding various economic cycles, including the recent pandemic, world real GDP has followed a remarkably consistent exponential growth path since 1972, largely driven by fossil fuels. However, extension of this trajectory to 2071 is highly questionable in view of environmental impacts.

Real GDP per capita grows nicely, despite significant population increase



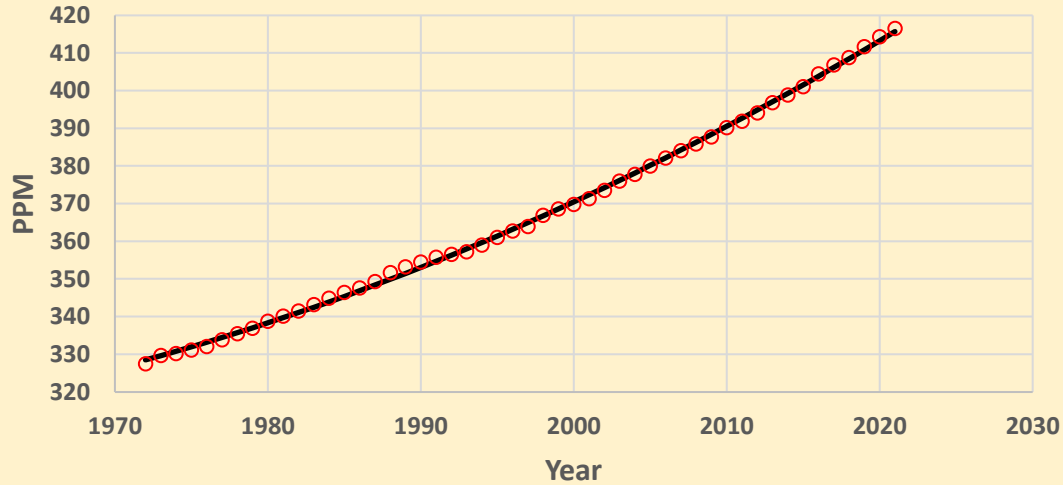
This would be great without major environmental degradation! Once again, extension of this trajectory is highly questionable. We need to find a way to uplift the world population without poisoning the atmosphere.

Unfortunately, CO2 increases significantly

GLOBAL ATMOSPHERIC CO2 CONCENTRATION

Source: gml.noaa.gov/ccgg/trends/data.html

Parabolic Trendline: $CO_2 = 50044.9 - 51.5466 * YEAR + 0.0133547 * YEAR^2$

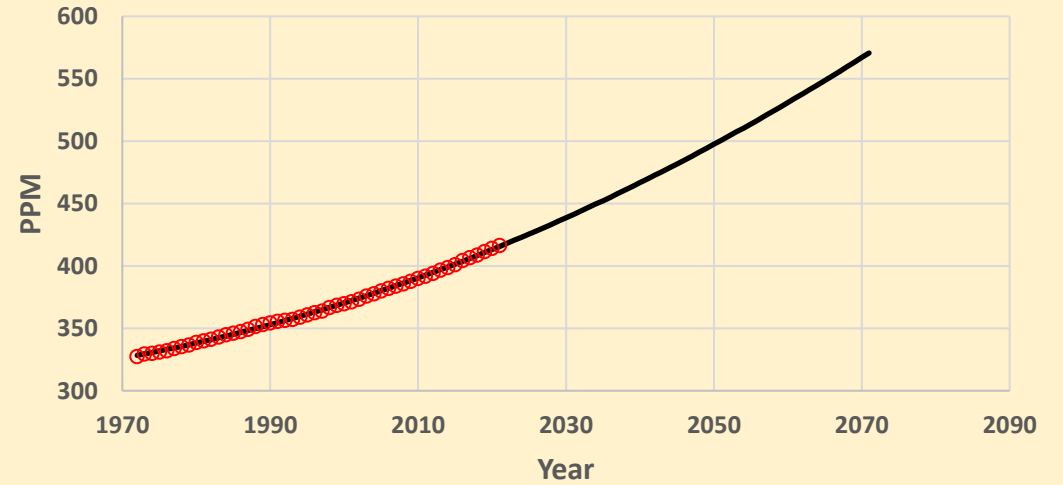


○ Actual — Trend

GLOBAL CO2 CONCENTRATION EXTENDED TREND

Source: gml.noaa.gov/ccgg/trends/data.html

Parabolic Trendline: $CO_2 = 50044.9 - 51.5466 * YEAR + 0.0133547 * YEAR^2$



○ Actual — Trend

Causal relationships between economic output, carbon emissions, atmospheric greenhouse gas concentrations, and global warming are complex and nonlinear, but they are no longer in doubt. We are already in uncharted territory. Business as usual will make matters worse.

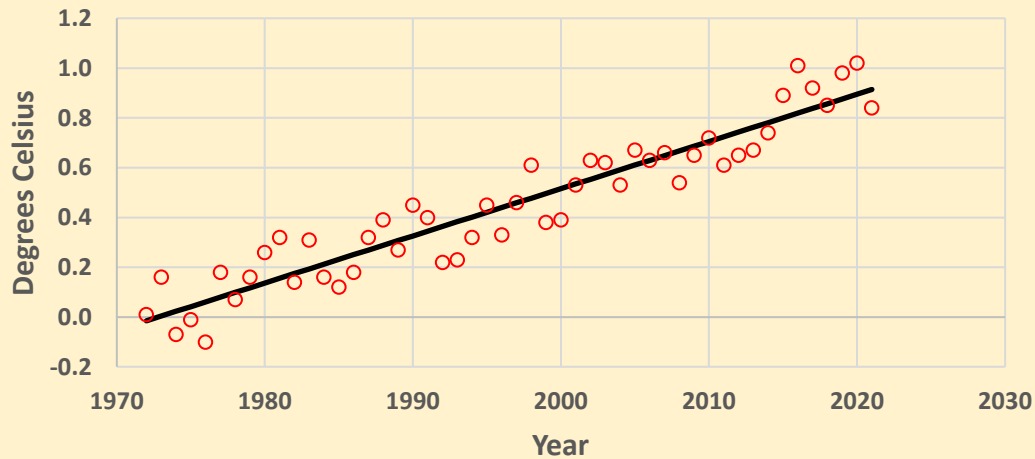
Moreover, temperature increases by 1 degree

GLOBAL TEMPERATURE ANOMALY

Relative to 1951-1980 Baseline

Source: climate.nasa.gov/vital-signs/global-temperature

Linear Trendline: $TEMP = -37.392 + 0.0189534 * YEAR$



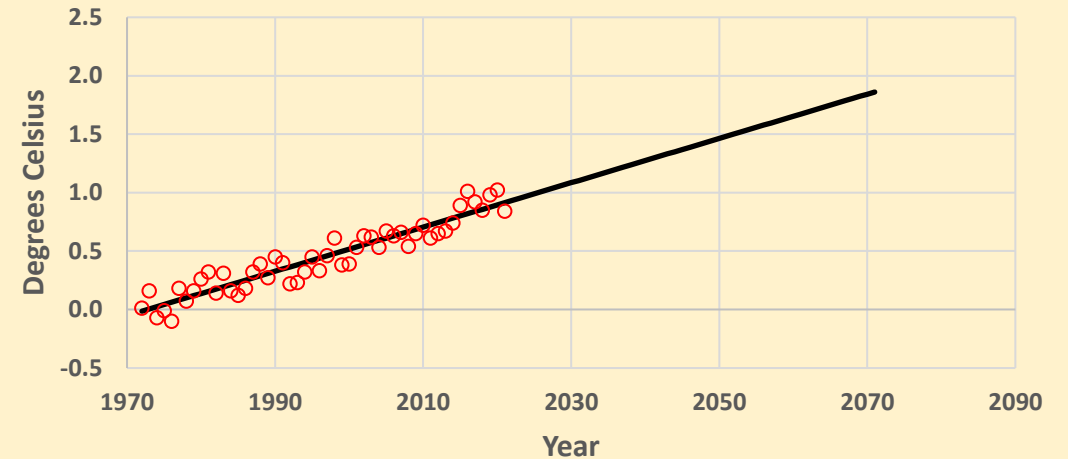
○ Actual — Trend

GLOBAL TEMP ANOMALY EXTENDED TREND

Relative to 1951-1980 Baseline

Source: climate.nasa.gov/vital-signs/global-temperature

Linear Trendline: $TEMP = -37.392 + 0.0189534 * YEAR$



○ Actual — Trend

Given everything we're experiencing now (global melt, floods, superstorms, droughts, vast wildfires, extreme temperatures, wildlife extinctions), another 1 degree is unacceptable. We would exceed the "pre-industrial" benchmark by more than 2 degrees. Feedback loops, like permafrost methane release, could accelerate global warming further.

Conclusion

- **We can't allow another 1 degree, or worse, of global warming**
- **We must accelerate the transition from fossil fuels to renewables**
- **We must tax bad stuff (fossil fuels, carbon emissions) and fund good stuff (renewables, technological innovation)**
- **We must cap, and ultimately reverse, atmospheric CO2 concentration**
- **We must stabilize the Earth's population, which is already too large**
- **We must develop the global economy within Nature's limits**
- **We are environmental stewards for our descendants**
- **The future of the planet is in our hands**
- **Time is of the essence**