The Impacts of Climate Change and Climate Policies in Japan

Japan Climate Working Group[1]

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Abstract

We synthesize scientific evidence on climate change with an emphasis on observational and statistical evidence rather than climate model simulations. Avoiding duplication with the U.S. Climate Working Group (CWG) report[2],, we focus on Japan-specific aspects. We find no evidence from Japan that contradicts the CWG report. Observations and statistics for Japan do not show any long-term increase in the intensity or frequency of natural disasters. Although the Government of Japan plans to invest hundreds of trillions of yen to achieve net-zero emissions by 2050, the expected reduction in global mean temperature would be at most 0.006 °C, and the reduction in heavy rainfall intensity would be at most 0.04%. Overall, Japan's net-zero policy does not appear to pass a cost–benefit test.

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[1] Members:

Satoshi Matsuda, Shizuoka University
Yoshihiro Muronaka, Professional Engineer Office
Taishi Suigyama, Research Director, The Canon Institute for Global Studies
Hiroshi Tanaka, Professor Emeritus, University of Tsukuba
Tadashi Watanabe, Professor Emeritus, The University of Tokyo
Ryuzo Yamamoto, Professor Emeritus, Tokoha University

[2] Climate Working Group (2025) A Critical Review of Impacts of Greenhouse Gas Emissions on the U.S. Climate, United States Department of Energy July 23. https://www.energy.gov/sites/default/files/2025-07/DOE_Critical_Review_of_Impacts_of_GHG_Emissions_on_the_US_Climate_July_2025.pdf

Contents

1. No evidence of typhoon intensification

Figure 1 shows typhoon counts: the annual number formed, the number approaching Japan's main islands, and the number making landfall. Thick lines denote five-year centered moving averages. None of the series exhibits a long-term increasing trend.

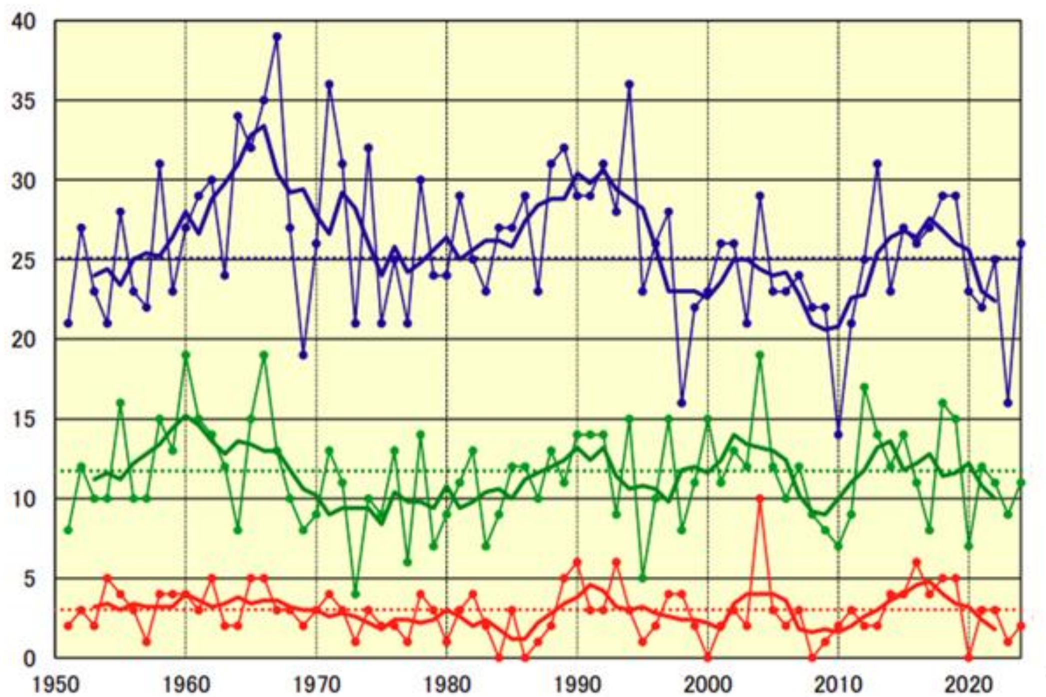

Figure 1. Long-term changes in typhoon counts. Data: Japan Meteorological Agency (JMA). From top to bottom: typhoons formed (blue), approaches to the Japanese mainland (green), and landfalls in Japan(red). The thin and thick lines represent annual and five-year running means, respectively. Source: https://www.data.jma.go.jp/yoho/typhoon/statistics/index.html

Figure 2 shows the number of typhoons classified by JMA as "Strong" or higher, defined as maximum sustained wind speeds ≥ 33 m s^{-1}. The number of typhoons in this category has not increased.

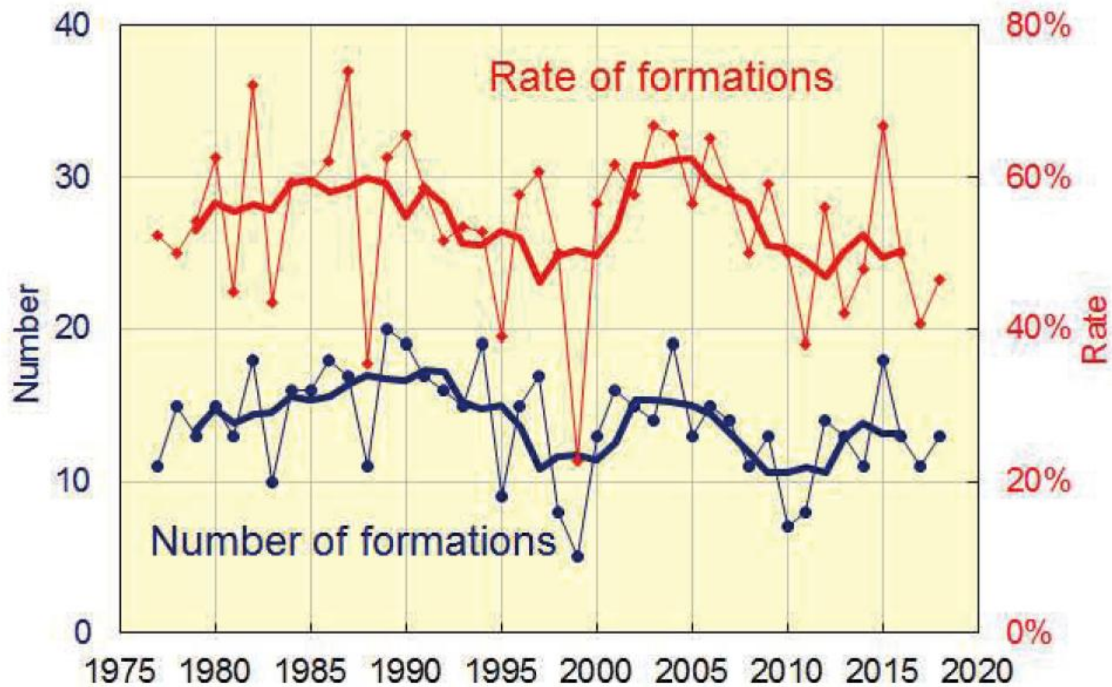

Figure 2. Numbers of typhoons classified as "strong" or higher (≥ 33 m s^{-1}, blue) and their proportion of the total (red). Thin lines indicate annual values, while thick lines show five-year running means. Source: JMA https://www.jma.go.jp/jma/en/NMHS/ccmr/ccmr2018.pdf

Table 1 ranks historical typhoons by the lowest central pressure at landfall at the time of landfall in Japan, used here as a proxy for intensity.

The ranking contains many events up to 1971—three in the 1950s and three in the 1960s—whereas relatively few events appear thereafter, with only one each in 1991, 1993, and 2022. The 2022 event (Typhoon No. 14, 2022) ranks fifth and was indeed strong; however, this was the first typhoon to enter the ranking since 1993.

Many other datasets exist regarding typhoon frequency and intensity, but none shows evidence of intensification in the observational record.

Table 1. Ranking of typhoons by lowest central pressure at landfall (1951–2023). Data: JMA. Source: https://www.data.jma.go.jp/typhoon/statistics/ranking/air_pressure.html

Rank	Typhoon No.	Central Pressure at Landfall (hPa)	Date & Time of Landfall	Landfall Location
1	6118*2	925	Shortly after 09:00 on 16 Sep 1961	West of Cape Muroto, Kochi Prefecture

Rank	Typhoon No.	Central Pressure at Landfall (hPa)	Date & Time of Landfall	Landfall Location
2	5915*[3]	929	Around 18:00 on 26 Sep 1959	West of Cape Shionomisaki, Wakayama Prefecture
3	9313	930	Just before 16:00 on 3 Sep 1993	Southern Satsuma Peninsula, Kagoshima Prefecture
4	5115	935	Around 19:00 on 14 Oct 1951	Near Kushikino City, Kagoshima Prefecture
5	2214	940	Around 19:00 on 18 Sep 2022	Near Kagoshima City, Kagoshima Prefecture
6 (tie)	9119	940	Shortly after 16:00 on 27 Sep 1991	South of Sasebo City, Nagasaki Prefecture
6 (tie)	7123	940	Around 23:30 on 29 Aug 1971	Osumi Peninsula, Kagoshima Prefecture
6 (tie)	6523	940	Around 08:00 on 10 Sep 1965	Near Aki City, Kochi Prefecture
6 (tie)	6420	940	Around 17:00 on 24 Sep 1964	Near Cape Sata, Kagoshima Prefecture
6 (tie)	5522	940	Around 22:00 on 29 Sep 1955	Satsuma Peninsula, Kagoshima Prefecture

2. Precipitation exhibits multidecadal variability

A July 12, 2023 Nikkei Newspaper article reported that, within Japan, the number of heavy-rain events with three-hour totals ≥130 mm in July had increased by a factor of about 3.8 from 1976 to 2020. Such reports are common but generally rely on data beginning in 1976. Figure 3 is one example: it plots the nationwide annual total of station-days with daily precipitation ≥300 mm across roughly 1,300 Automated Meteorological Data Acquisition System (AMeDAS) stations.

However, an important caveat accompanies this figure: “For intense rainfall such as daily precipitation ≥300 mm, the frequency has increased to about twice that around 1980, and global warming may be contributing to increases in the frequency and intensity of such heavy rainfall. Nevertheless, because extreme heavy rainfall events are rare and the AMeDAS observation record is relatively short, more data will be needed to robustly detect long-term trends. (emphasis added by the author)"

To understand this caveat, consider Figure 4 (annual precipitation anomaly, Japan average) from the same report. Interannual variability is large: compared with the climatological mean of roughly 1,700 mm, some years exceed the mean by 300 mm while others fall short by 400 mm. Longer-term tendencies also shift: while a post-1976 subset shows an increasing tendency, the 1950s were also very wet—comparable to the 2010s. Hence, claims of "intensifying heavy rainfall" often reflect short-window sampling; long records show no sustained increase in nationwide precipitation totals.

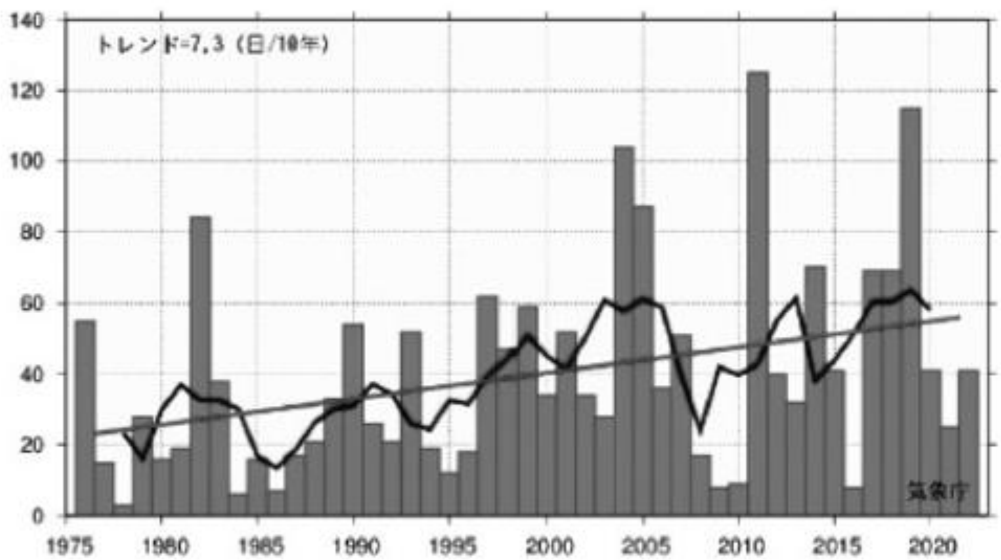

Figure 3. Annual number of station-days with daily precipitation ≥ 300 mm. Bars: annual totals across ~1,300 AMeDAS stations. Line: five-year centered moving average. Slanted straight line: linear regression (=7.3 day/decade). Note: This figure does not represent a long-term trend. Source: JMA, Climate Change Monitoring Report 2022. https://www.data.jma.go.jp/cpdinfo/monitor/index.html

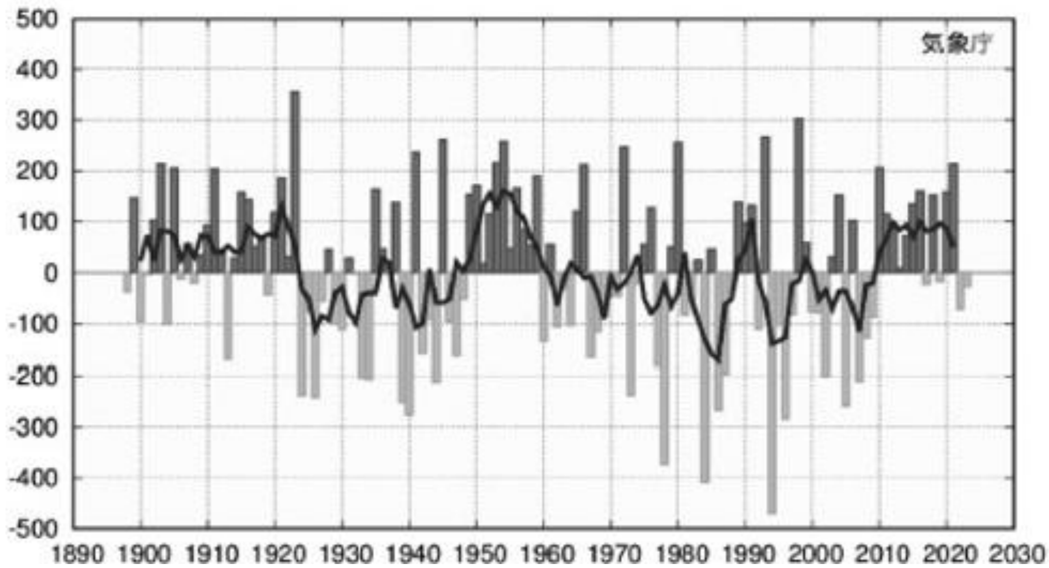

Figure 4. Annual precipitation anomaly (Japan average). Baseline: 1991–2020 thirty-year mean. Bars: average anomaly across 51 domestic stations; positive (negative) bars indicate above- (below-) baseline precipitation. Line: five-year moving average of the anomaly. Source: JMA, Climate Change Monitoring Report 2022. https://www.data.jma.go.jp/cpdinfo/monitor/index.html

3. Urban warming exceeds the background global-warming

Figure 5 compares annual mean temperatures in Tokyo, Osaka, and Nagoya with the mean of 15 stations that JMA considers relatively less affected by urbanization. Over a century, the trends are approximately +3.2 °C (Tokyo), +2.8 °C (Osaka), and +2.6 °C (Nagoya). Even the 15-station average is not free of urban influences—this is explicitly noted in the JMA report—yet these data are commonly used by government agencies and the media to characterize the pace of warming in Japan (about +1.25 °C per 100 years). By contrast, Junsei Kondo's estimate, after correcting for urbanization, yields about 0.89 °C per century for Japan (Figure 6).

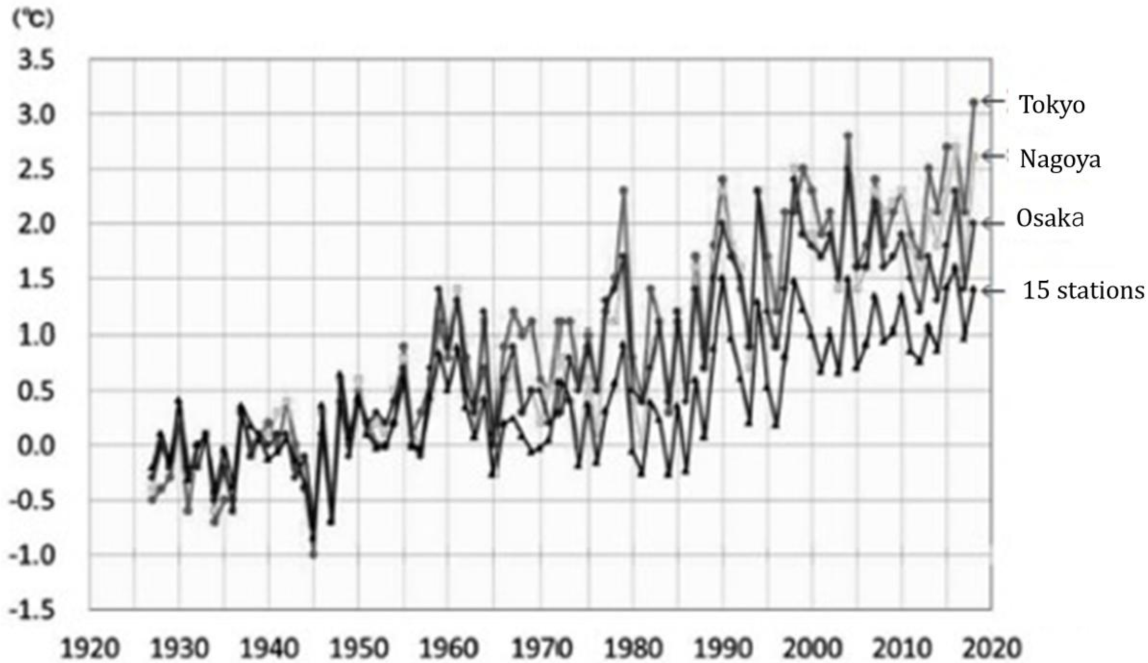

Figure 5. Impact of urbanization on annual mean temperature. Annual means for Tokyo, Nagoya, and Osaka compared with the average of 15 stations judged to be relatively less affected by urbanization. For comparability of warming, data are shifted such that the 1927–1956 average is zero. Source: JMA, Climate Change Monitoring Report 2018.
https://www.data.jma.go.jp/cpdinfo/monitor/2018/pdf/ccmr2018_all.pdf

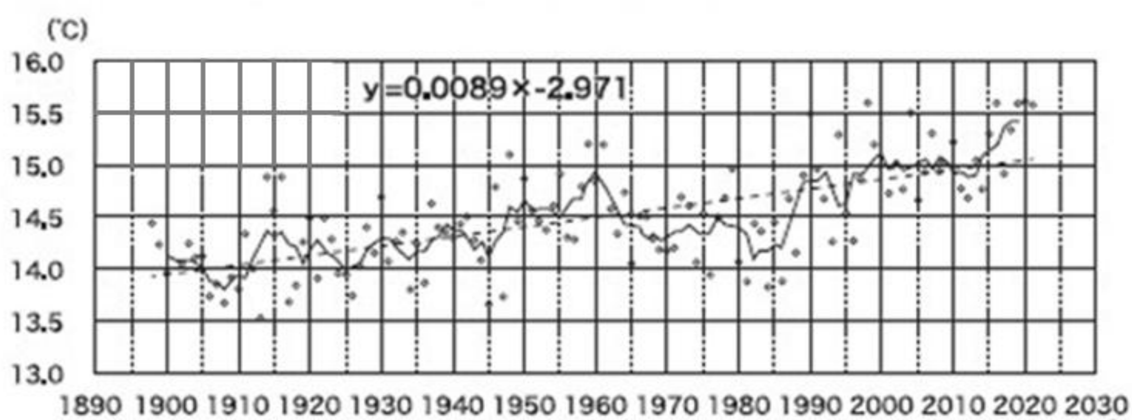

Figure 6. Urbanization-corrected estimate of national warming in Japan. Average across 28 stations. Circles denote annual mean temperatures; dashed line is the regression; solid line is the five-year moving average. Source: Junsei Kondo. Global Warming in Japan: Reanalysis 2022, Junsei Kondo Homepage. https://www.asahi-net.or.jp/~rk7j-kndu/kenkyu/ke225.html

4. Cold-related mortality exceeds heat-related mortality by a factor of 30 in Tokyo

According to Gasparrini et al. (2015), the relationship between daily mean temperature and mortality risk in Tokyo is as follows (Figure 7). Bars show the annual distribution of the number of deaths (right axis). The curve shows the relative mortality risk (RR; left axis), which is minimum at about 26 °C; mortality risk rises on both the colder and hotter sides. RR is expressed relative to the minimum-mortality temperature (RR = 1.0 at 26 °C).

Three points follow. (i) The temperature with minimum RR in Tokyo is high, around 26 °C. (ii) Most deaths (86%) occur on days colder than this threshold. (iii) Although RR is elevated on days hotter than 26 °C, the number of deaths occurring on those days accounts for a small fraction (14%) of the total.

In Figure 7, the area between the curve and the horizontal dashed line RR = 1.0 corresponds to the excess mortality attributable to heat or cold. Using these data, the study estimates annual excess mortality shares in total deaths: 9.81% for cold versus 0.32% for heat—implying roughly 30 times more deaths attributable to cold than to heat in Tokyo. This suggests that past warming in Tokyo (Figure 5) may have reduced overall mortality risk.

Higher cold-season mortality is thought to be driven by respiratory and circulatory diseases.

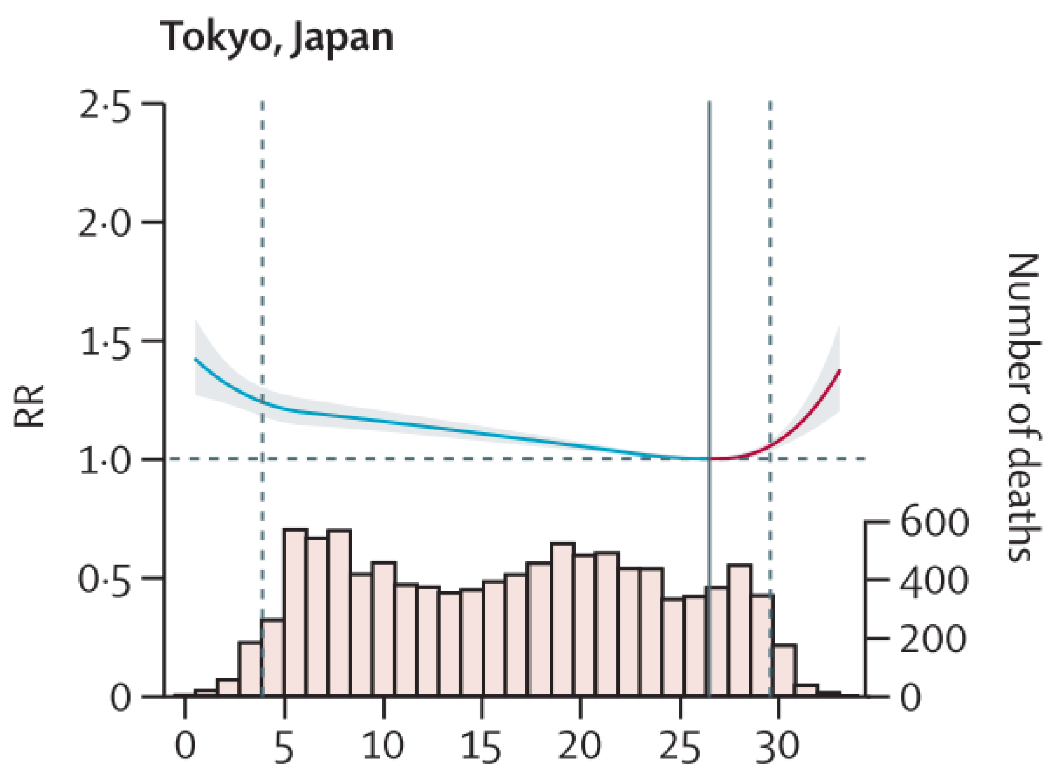

Figure 7. Tokyo: distribution of the number of deaths by daily mean temperature (bars, right axis) and relative mortality risk RR (curve, left axis). Source: Gasparrini et al. (2015).[3]

5. Tokyo's annual minimum temperature has risen by 6 °C

Urbanization tends to affect minimum temperatures more strongly than means. Figure 8 shows long-term changes in the annual minimum temperature at Otemachi, Tokyo: the solid line indicates the long-term trend, while the dashed line indicates the trend in the occurrence of extreme cold events with return periods of several decades (both are guides to the eye). The annual minimum rose from about −7 °C around 1880 to about −1 °C around 2000, an increase of roughly 6 °C (about 5 °C per 100 years), clearly larger than the rise in annual mean temperature (~3 °C). This likely contributed to reduced mortality in Tokyo.

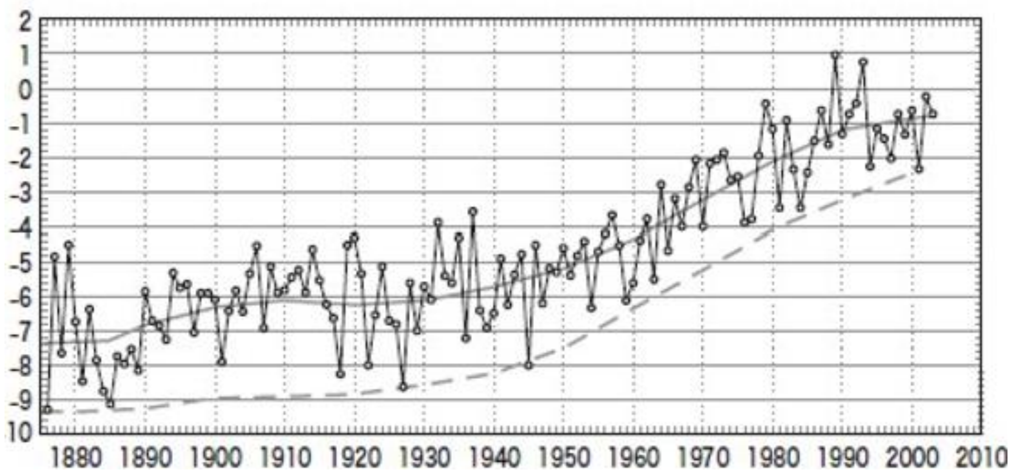

Figure 8. The annual minimum temperature at Otemachi, Tokyo (°C). Source: Junsei Kondo, "K240. Seeking the Correct Warming Rate… 8. Urbanization and Radiative Cooling," website. Source: https://www.asahi-net.or.jp/~rk7j-kndu/kisho/kisho08.html

6. Land subsidence and sea-level changes due to natural variability have been large

Rapid land subsidence has been observed in various parts of Japan (Figure 9), driven by factors such as groundwater extraction for industrial use and reduced sediment supply from rivers due to dam construction. In Kōtō Ward, Tokyo, subsidence reached about 4 m over 50 years—producing what is effectively an anthropogenic rise in relative sea level.

[3] Gasparrini, A., Guo, Y., Hashizume, M., Lavigne, E., Zanobetti, A., Schwartz, J., Tobias, A., Tong, S., Rocklöv, J., Forsberg, B., Leone, M., De Sario, M., Bell, M. L., Guo, Y.-L. L., Wu, C., Kan, H., Yi, S.-M., de Sousa Zanotti Stagliorio Coelho, M., Saldiva, P. H. N., … Armstrong, B. (2015). Mortality risk attributable to high and low ambient temperature: a multicountry observational study (D1199, trans.). *The Lancet*, *386*(9991), 369–375. https://doi.org/10.1016/S0140-6736(14)62114-0

Countermeasures include levees and pumped-drainage systems that evacuate water from inhabited areas to rivers.

Japan also experiences frequent "effective" sea-level changes due to natural variability, notably coseismic land-level changes. During the 2011 Great East Japan Earthquake, parts of the Miyagi coastline subsided by nearly 1 m—an effective sea-level rise occurring almost instantaneously. By contrast, the 1923 Great Kantō Earthquake uplifted land by more than 1 m along parts of the Bōsō Peninsula and the Kanagawa coast near Tokyo.

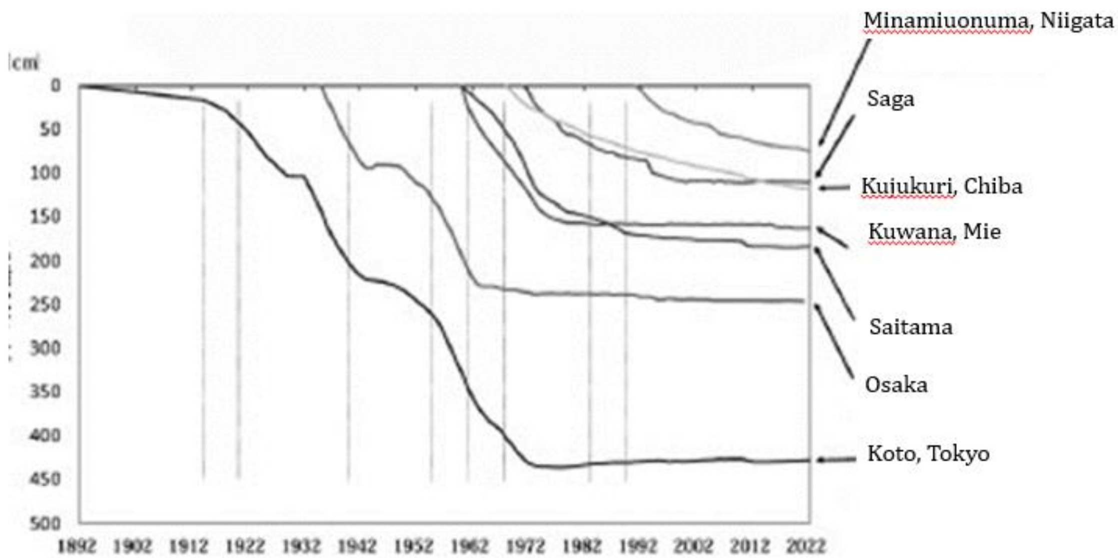

Figure 9. Land subsidence at selected locations in Japan (vertical axis: cumulative subsidence, cm). Source: Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan, "Current status of groundwater conservation and land subsidence." Source: https://www.mlit.go.jp/mizukokudo/mizsei/mizukokudo_mizsei_tk1_000063.html

7. Fatalities from natural disasters have declined substantially

Figure 10 shows that in Japan the number of deaths from water-related disasters has declined substantially over time. Note that the vertical axis is in log scale. Economic damages have also shown a downward tendency—despite the very large increase in asset values accompanying economic growth. Both achievements owe to public infrastructure development such as levees.

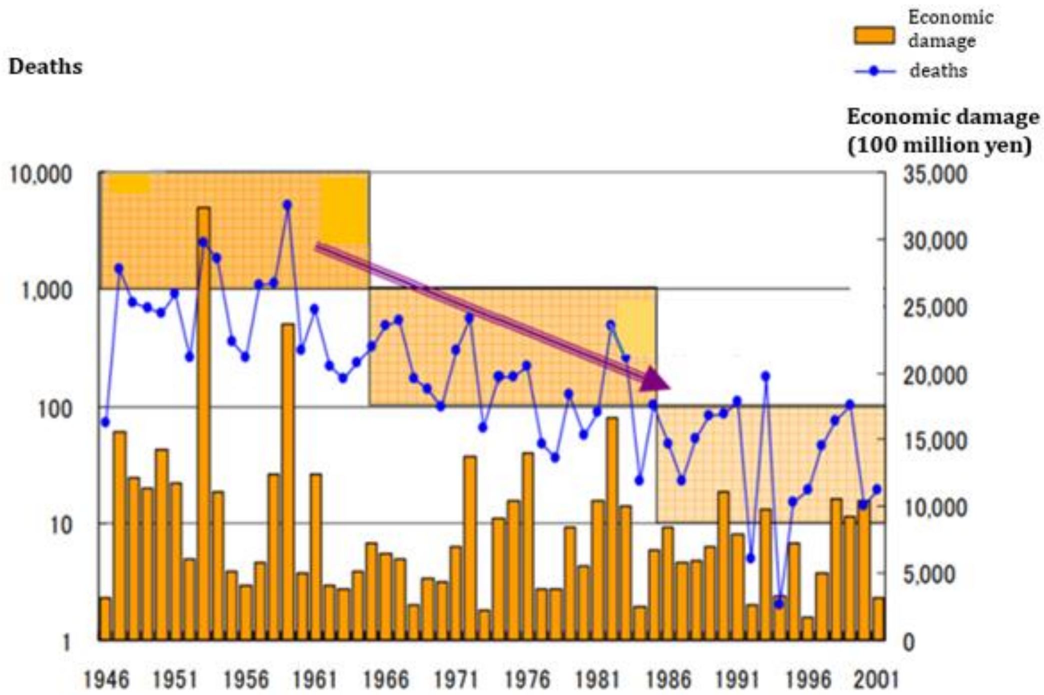

Figure 10. Trends in deaths and economic damages from water-related disasters in Japan. Deaths are mostly related to water, but they include landslides and volcanic disasters. Annual water-disaster damages are expressed in real terms (FY1995 prices). Source: MLIT (Japan). http://www.cbr.mlit.go.jp/shinmaru/101_hitsuyou/3.pdf

8. The decline in CO_2 emissions due to deindustrialization

Since 2013, Japan's CO_2 emissions have been trending downward. Figure 11 provides a factor decomposition. In the industrial sector, the 2013–2023 reduction (−23.3%) breaks down as follows: 73% from a decline in economic activity (①, −17.0%), 18% from a lower-carbon energy mix (②, −4.2%), and 9% from improved energy efficiency (③, −2.1%). Thus, factors possibly attributable to climate policy (②+③) account for only 27% of the reduction.

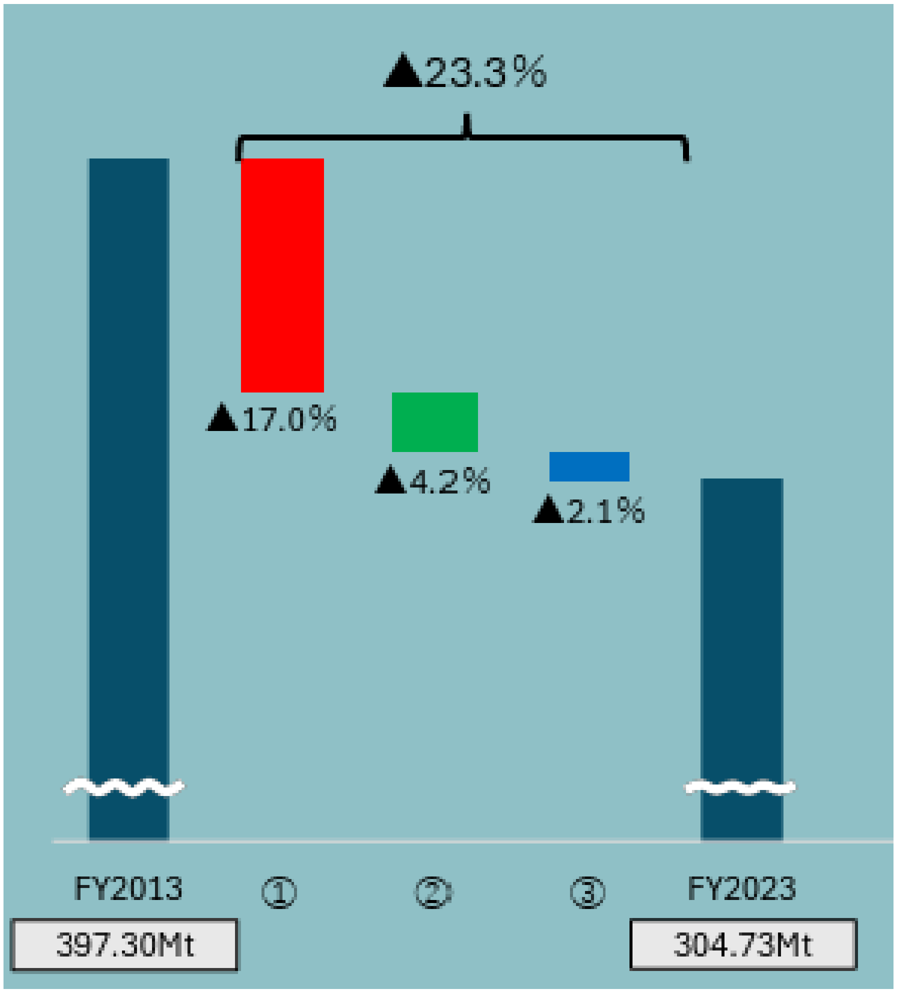

Figure 11. Decomposition of Japan's Industrial CO_2 emissions reductions (Fiscal Year 2013–2023). ① decline in economic activity; ② lower-carbon energy mix; ③ improved energy efficiency. Source: Keidanren Carbon Neutral Action Plan, April 2, 2024, Keidanren. https://www.keidanren.or.jp/policy/2023/072_honbun.pdf

9. The cost of the 2030 climate target is already 5% of GDP

The Government of Japan is advancing a Green Transformation Plan with the target of net zero emissions by 2050[4]. According to the plan, Japan spurs innovation in decarbonization technologies and mobilizes public and private investment of 150 trillion yen over ten years (≈15 trillion yen per year, roughly 3% of GDP) through regulations and subsidies. The

[4]The Basic Policy for the Realization of GX - A roadmap for the next 10 years, February 2023, Cabinet Office (Japan) https://www.cas.go.jp/jp/seisaku/gx_jikkou_kaigi/pdf/kihon_en.pdf

government argues that this policy achieves “green growth”, meaning economic growth boosted by decarbonization technology development.

Planned items include large-scale deployment of renewable energy (≈31 trillion yen or more), hydrogen and ammonia production and use (≈7 trillion yen or more), and carbon capture and storage (CCS; ≈4 trillion yen or more). However, they all are substantially more expensive than existing technologies.

As an interim target, which has been pledged as a Nationally Determined Contribution (NDC) under the Paris Agreement, Japan commits to a 46% reduction in GHG emissions by 2030 relative to 2013.

However, an estimate (Figure 12) suggests that achieving this target would entail an annual GDP loss of about 30 trillion yen in 2030 (≈5% of GDP). Although investment in decarbonization technologies and reduced fossil-fuel imports would raise GDP, these gains would be more than offset by higher energy bills that depress final consumption and by a deterioration in international industrial competitiveness that reduces exports and raises imports. Thus, this analysis shows that the governmental slogan of “green growth” is untenable.

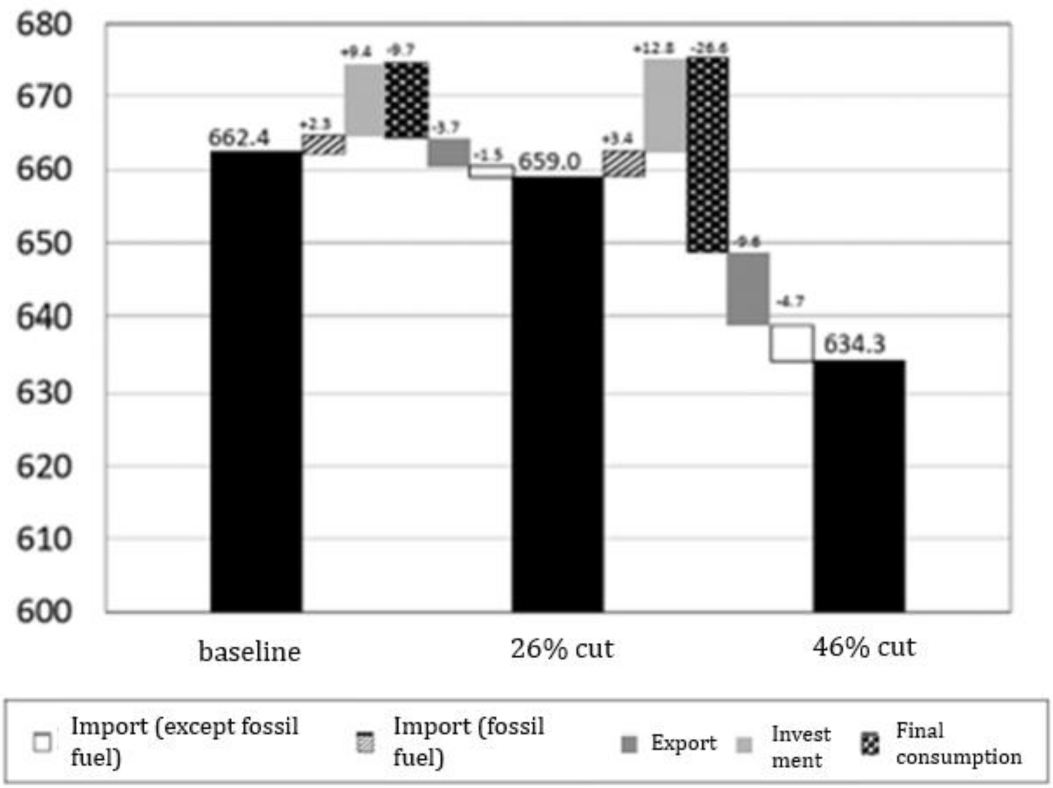

Figure 12. GDP loss associated with achieving the numerical target in 2030 (trillion yen). Bars from left: baseline, 26% reduction case, 46% reduction case. Source: Akimoto, K., et al. (2023) [5].

10. Net Zero fails cost-effectiveness test

How much would Japan's 2050 net-zero target reduce global temperature and heavy rainfall? We make a back-of-the-envelope calculation using rounded numbers: (i) 1 trillion tons CO_2 ≈ 0.5 °C of warming (Transient Climate Response to cumulative carbon Emissions, TCRE of IPCC); (ii) 1 °C of warming ≈ 6% increase in precipitation (Clausius–Clapeyron relationship); (iii) Japan's current CO_2 emissions ≈ 1 billion tons per year.

Under (i), each 1 trillion tons of cumulative CO_2 raises global temperature by about 0.5 °C (Figure 13); The latest IPCC report estimates this at ~0.45 °C. Taking 0.5 °C for simplicity, Japan's annual emissions of ~1 billion tons (i.e., one-thousandth of a trillion tons) correspond to ~0.0005 °C per year. From 2025 to 2050, if emissions stayed constant, this would add ~0.0125 °C. If emissions decline linearly to zero by 2050, cumulative emissions would be half that rectangle—so the temperature effect is roughly half: ~0.006 °C (Figure 14). Applying (ii) gives a rainfall reduction of ~0.04%, meaning that even a 1,000 mm heavy-rain event would shrink by only ~0.4 mm.

These calculations rely on the TCRE relationship of IPCC and Clausius–Clapeyron relationship, both of which likely overestimate the magnitude of the effects. Thus, even with CO_2 reduced to zero by 2050, Japan's contribution would have virtually no effect on temperature or heavy rainfall—both because the underlying temperature and heavy rainfall trends are modest and because Japan's share of global emissions is only about 3%.

[5] Akimoto, Keigo and Takashi Homma(2023), Analyses on Economic Impacts of the Nationally Determined Contributions and Carbon Border Adjustment Mechanisms for 2030, Economic and Social Research Institute (ESRI).
https://www.esri.cao.go.jp/jp/esri/archive/bun/bun206/bun206c.pdf

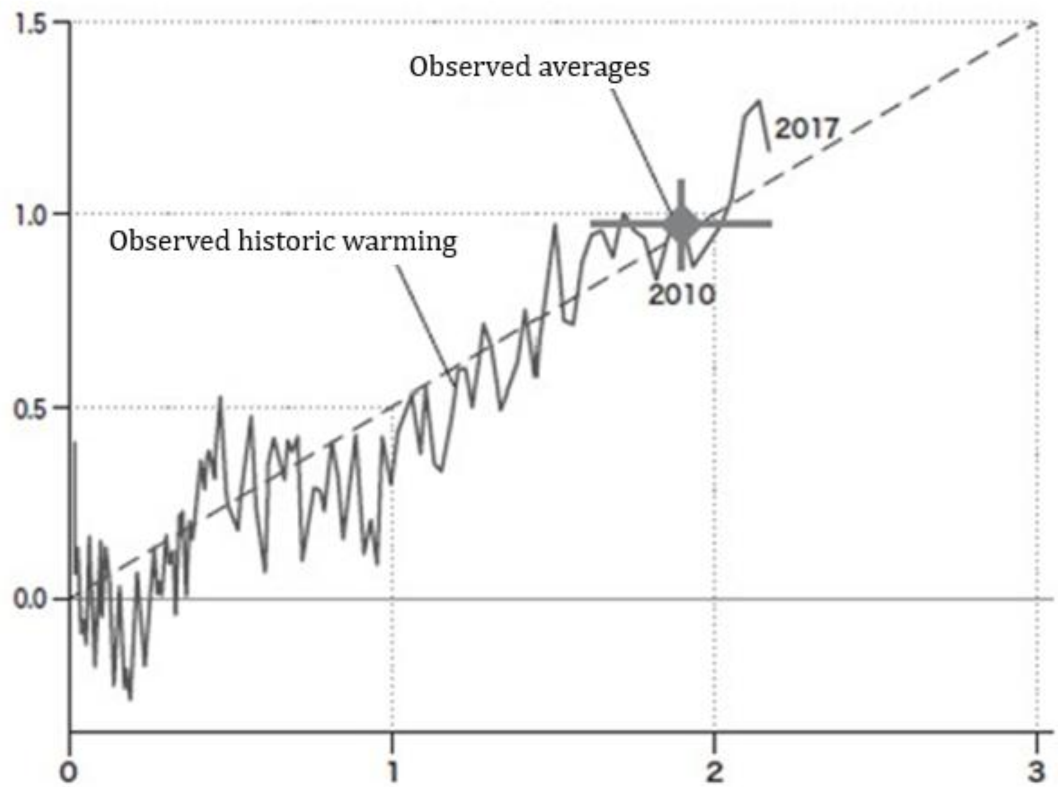

Figure 13. Relationship between cumulative CO_2 emissions and global warming (TCRE). Horizontal axis: cumulative CO_2 emissions since 1876 (trillion tons CO_2). Vertical axis: global mean temperature increase since 1850–1900 (°C). Source: Global Warming of 1.5°C, IPCC, Fig. 2-3.
https://www.ipcc.ch/sr15/chapter/chapter-2/2-2/2-2-2/2-2-2-1/figure-2-3/

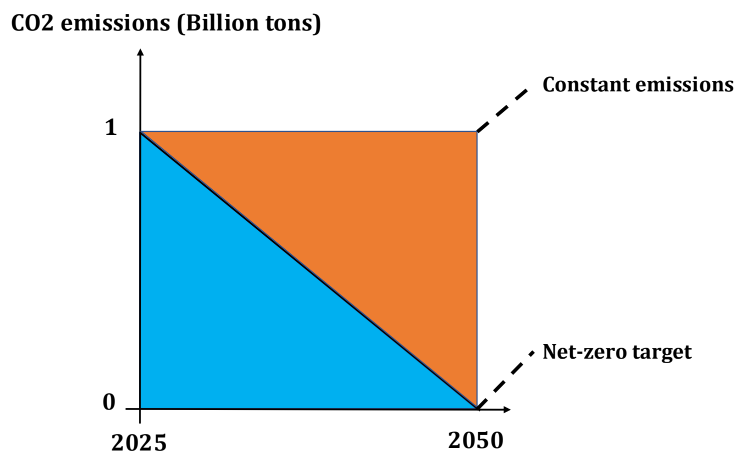

Figure 14. Schematic of Japan's cumulative CO_2 emissions. A constant-emissions baseline (rectangle) is contrasted with a net-zero pathway (blue triangle). The red triangle represents the integral difference between the two paths—i.e., avoided cumulative emissions relative to the baseline.