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NOTE AND COMMENT

# Climate policy beyond ideological trenches

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## Abstract

The climate crisis demands urgent and effective policy interventions, yet the discourse remains mired in ideological polarization. On one side, some argue that reducing consumption is the primary solution to the climate crisis, while others emphasize that technological innovation is the only viable option. We argue that a convergence of perspectives is needed and propose using the ecological footprint metric as a framework for evaluating the environmental impacts of different policies. The metric, expressed as a fraction with consumption in the numerator and efficiency in resource use in the denominator, allows for an equitable evaluation of the outcomes of policies that focus on either reducing consumption or improving efficiency. Through simulations, we analyze the ecological footprint outcomes of various scenarios—Business-As-Usual, Tech World, Consumption Reduction, and Smart Sustainability. We show that trade-offs between consumption and efficiency are hardly avoidable, and policies that address both aspects—such as those outlined in the Smart Sustainability scenario—are more likely to reverse the growing trend of global ecological footprints. While sharp and unexpected disruptions—such as major epidemics causing abrupt declines in consumption or breakthrough innovations dramatically improving efficiency—could in theory shift these dynamics, bridging ideological divides remains the most prudent approach for crafting policies that can effectively address the climate crisis and ensure a sustainable future.


**Keywords** Climate change · Degrowth · Equity · Growth · Human footprint · Scenarios · Sustainable development

## The great divide

In November 2024, the UN Climate Change Conference (UNFCCC COP) convened for the 29th time since 1995. Thousands of attendees filled the halls of COP29 in Baku, Azerbaijan, to assess progress and strategize on the ongoing implementation of the Paris Agreement. However, it is likely that several external observers echoed Greta Thunberg's sentiment toward the COP's deliberations, dismissing them as mere "blah blah blah" (2022). This statement, made outside of COP26 in Glasgow, has come to symbolize the contemporary debate around alternative solutions to climate change—not only within the context of the COP meetings, but more broadly as well.

At first glance, the divergence in discussions about climate action seems rooted in the immediacy of action required. Within the confines of the COPs, the emphasis is on multilateral diplomacy—a naturally lengthy process. Meanwhile, voices from outside the negotiation rooms are generally clamoring for swift, decisive action. However, a deeper dive into these discourses reveals that the split is not merely about urgency. It is also about contrasting political

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narratives that stem from different ideological traditions. On one side, narratives influenced by Malthusian theories (Malthus 1798) argue that unchecked population growth and resource consumption will inevitably lead to environmental degradation and societal collapse. Proponents of this view, often aligned with modern neo-Malthusianism (Meadows et al. 1972), stress the need to reduce human population (Ehrlich and Holdren 1971) or consumption (Hickel et al. 2021) to prevent ecological disaster and mitigate climate change. On the other side, critics emphasize technological innovation as the key to overcoming resource limitations (e.g., Lomborg 2001; McCabe 1998). They argue that technological advances have historically defied Malthusian predictions, allowing societies to increase efficiency and productivity, often through breakthroughs in agriculture, energy, and manufacturing (e.g., Evenson and Gollin 2003). These critics often invoke works like Julian Simon's *The Ultimate Resource* (1981), which argues that human ingenuity and innovation will always outpace resource constraints, ensuring continued growth without the need for drastic reductions in consumption.

## Addressing the divide through the lens of the ecological footprint

These environmental narratives drive distinct policy directions, leading to the question: are these differing views fundamentally incompatible, or is there a way to reconcile them for the sake of sustainability? While we do not aim to fully reconcile these perspectives here, we posit that fixing the climate crisis requires some convergence between these two opposing perspectives, for reasons that are best understood by examining the human ecological footprint metric (EF), which depicts humanity's impact on the environment (Barrett et al. 2020):

$$EF = Ny/a,$$

where $N$ signifies the number of consumers (humans), $y$ represents per capita resource consumption by humans, and $a$ denotes efficiency in resource conversion to goods and services and associated environmental repercussions.

As a fraction, modifying humanity's ecological footprint can arise from reducing the numerator (population and/or per capita consumption) or elevating the denominator (enhancing resource utilization efficiency). Presently, only China has ventured to address $N$ politically, with its one-child policy, yielding varied outcomes (Wang et al. 2016). While it did reduce population growth, the policy faced significant criticisms for its social and demographic repercussions, leading to an aging population, gender imbalances, and human rights concerns. Globally, the prevalent view is that enhanced economic growth and superior education, particularly for women, will naturally reduce fertility rates (Lutz and Samir 2011). This stems from the observation that countries with higher educational and economic opportunities for women often experience reduced birth rates. However, projections based on current trends suggest only a moderate potential for significant shifts in global population patterns throughout the twenty-first century (Bradshaw and Brook 2014). Many factors can shape these projections: governmental policies related to family planning and welfare, societal shifts in attitudes toward family size and child-rearing, economic fluctuations affecting living standards, and unexpected global events like pandemics or major geopolitical shifts (Kirk 1996). Beyond this century, the trajectory becomes even more uncertain. The breadth of projections spans from sharp population growth, stabilization, and even moderate declines, reflecting the vast unpredictability of long-term population dynamics (Basten et al. 2013).

Given the profound unpredictability in population dynamics, coupled with the moral and practical challenges exemplified by China's one-child approach, policy measures specifically targeting $N$ reduction are not gaining widespread traction on the global political agenda, despite occasional calls for implementation of voluntary family planning in countries with rapid demographic growth (Ezeh et al. 2012). Indeed, in much discussions outside the COPs the emphasis is on economic degrowth, a "planned reduction of energy and resource use designed to bring the economy back into balance with the living world in a way that reduces inequality and improves human well-being" (Hickel 2021). Simply put, degrowth concentrates on moderating per capita consumption, the $y$ term in the human footprint equation, primarily in the developed world and among the more affluent social classes. In contrast, across much of the political mainstream, the predominant discourse revolves around adopting innovative green technologies, fostering a circular economy, and advancing nature-centric solutions. This includes financial assistance to the developing world, ensuring widespread green technological adoption, effectively targeting an enhancement of resource use, the $a$ in the footprint equation.

While the COP24 in Paris managed to rally nations around collective climate targets, the pathways to achieve them remains a more contentious arena (Garcia et al. 2022). This is not surprising: political alternation, characterized by varied viewpoints, is intrinsic to modern democracies and a consistent pattern in international relations (Lundell 2011). But the backdrop against which these debates occur is increasingly concerning. We are operating within a realm defined by the pressing nature of our environmental challenges and the finite nature of our planet's resources (Richardson et al. 2022). In this setting, the urgency for effective and immediate policies is more pressing than ever, yet conflicting interests and expectations can significantly delay meaningful action.

## Simulating the ecological footprint across UN scenarios

One approach to fostering rational dialogue and bridging seemingly irreconcilable viewpoints is through the development of scenarios. These scenarios allow for the exploration of potential environmental outcomes resulting from different policy choices (e.g., Ribeiro et al. 2022; Rounsevell et al. 2006). When combined with joint examination of outcomes and collaboration with concerned stakeholders in a co-knowledge creation process, they can significantly enhance understanding and drive better decision-making (Garcia et al. 2020, 2022).

Here, we developed four ecological footprint scenarios to explore plausible end-of-century outcomes based on varying trajectories. Demographic elements were sourced from the *World Prospects Report* (United Nations 2017, 2022), while financial data and greenhouse gas emissions were drawn from *Our World in Data*. Our scenarios, inspired by United Nations Development Programme (UNDP)-targeted scenarios (Aplizar and Bovarnick 2013), are as follows: Business-As-Usual (BAU), assuming a doubling of the population, moderate increases in per capita consumption due to regional inequality, and only incremental improvements in resource and energy efficiency; Tech World (TW), with a 20% population increase, strong economic growth doubling consumption, and a doubling of efficiency through significant green technology investments; Consumer Reduction (CR), sharing the demographic assumptions of Tech World, but with only small increases in consumption and efficiency due to modest green tech investments; and Smart Sustainability (SS), assuming moderate reductions in consumption and substantial gains in efficiency, alongside a 20% population growth. These scenarios track human population ($N$), consumption ($y$), and efficiency ($a$), with baseline values derived from published sources, expressed in billions of people ($N$), thousands of dollars per capita ($y$), and thousands of dollars per ton of $CO_2$ (for details on the scenarios, parameters, and simulations see supplementary material and supplementary table). The ecological footprint is thus expressed as a ratio of total consumption (dollars spent) to efficiency ($CO_2$ emissions per unit of consumption), capturing the relationship between resource use and environmental impact.

Our simulations of the twenty first century trajectory of the human footprint under the Business-As-Usual (BAU) scenario anticipate that the human impact on the planet, characterized with our ecological footprint metric, could more than double, increasing from an estimated 37 units of impact to 86 units (Fig. 1). This scenario calculates

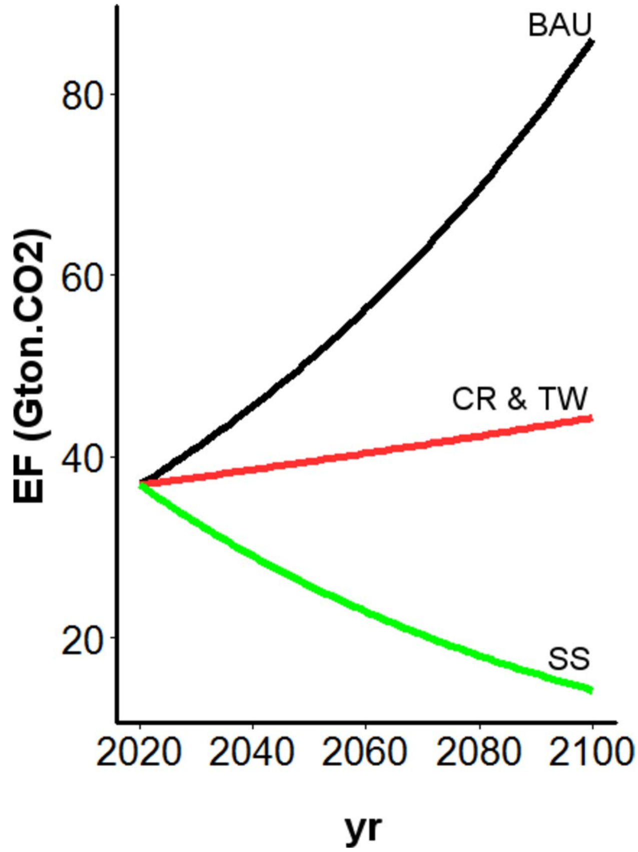


**Fig. 1** Simulated human ecological footprint throughout the twenty-first century. The ecological footprint varies in response to four UN scenarios: BAU “Business-as-Usual”; TW “Tech World”; CR “Consumption Reduction”; and SS “Smart Sustainability”. See supplementary materials for details on the underlying data, methods, and assumptions

a significant rise in per capita consumption—partially restrained by regional wealth disparities—alongside gradual improvements in resource and energy efficiency, and a population surge to 16 billion by 2100, doubling from 2020 levels.

In contrast, technological advancements, denoted by the $a$ in the human footprint equation, and the political engagements within the COPs could offer some scope for optimism. In the UN's 'Tech World' (TW) scenario, heavy investment in green technology yields better energy and resource efficiency. Yet, this is offset by economic growth and rising per capita consumption, alongside a moderate population increase to 9.6 billion by 2100, up 20% from 2020. This scenario calculates a 20% increase in the human footprint by the century's end (Fig. 1). The 'Consumption Reduction' (CR) scenario mirrors the 'Tech World' in demographic trends, but posits only minor increases in consumption and efficiency improvements, thus leading to a similar footprint trajectory by 2100 (Fig. 1).

While both TW and CR scenarios present reductions in the human footprint relative to BAU, the 'Smart Sustainability' (SS) scenario is the only one that offers a turning point (Fig. 1). This scenario acts on both the numerator and the denominator of the human footprint equation. It calculates a decreasing footprint to 14 units by 2100, combining moderate consumption cuts—more viable as developing economies grow and emphasize sustainability—with major efficiency gains. This is the sole scenario that, in our simulations, not only halts but reverses the ecological footprint growth.

Our simulations, like any, are influenced by underlying assumptions and specific parameterizations. While the assumptions are guided by the narratives accompanying the UN scenarios, the parameterizations are necessarily approximative. For example, in the Tech World (TW) scenario, we assume a doubling of efficiency in energy and resource use. However, while technology may advance beyond these assumptions, there are physical limits to how much 'reuse' and 'recycling' can improve efficiency. To explore alternative pathways for stabilizing the ecological footprint, we analyzed adjustments in key value parameters—one at a time—across the different developmental scenarios (Fig. 2). Take the Business-as Usual (BAU) scenario: with per capita consumption ($y$) and resource use efficiency ($\alpha$) evolving as anticipated, the population level ($N$) required to maintain

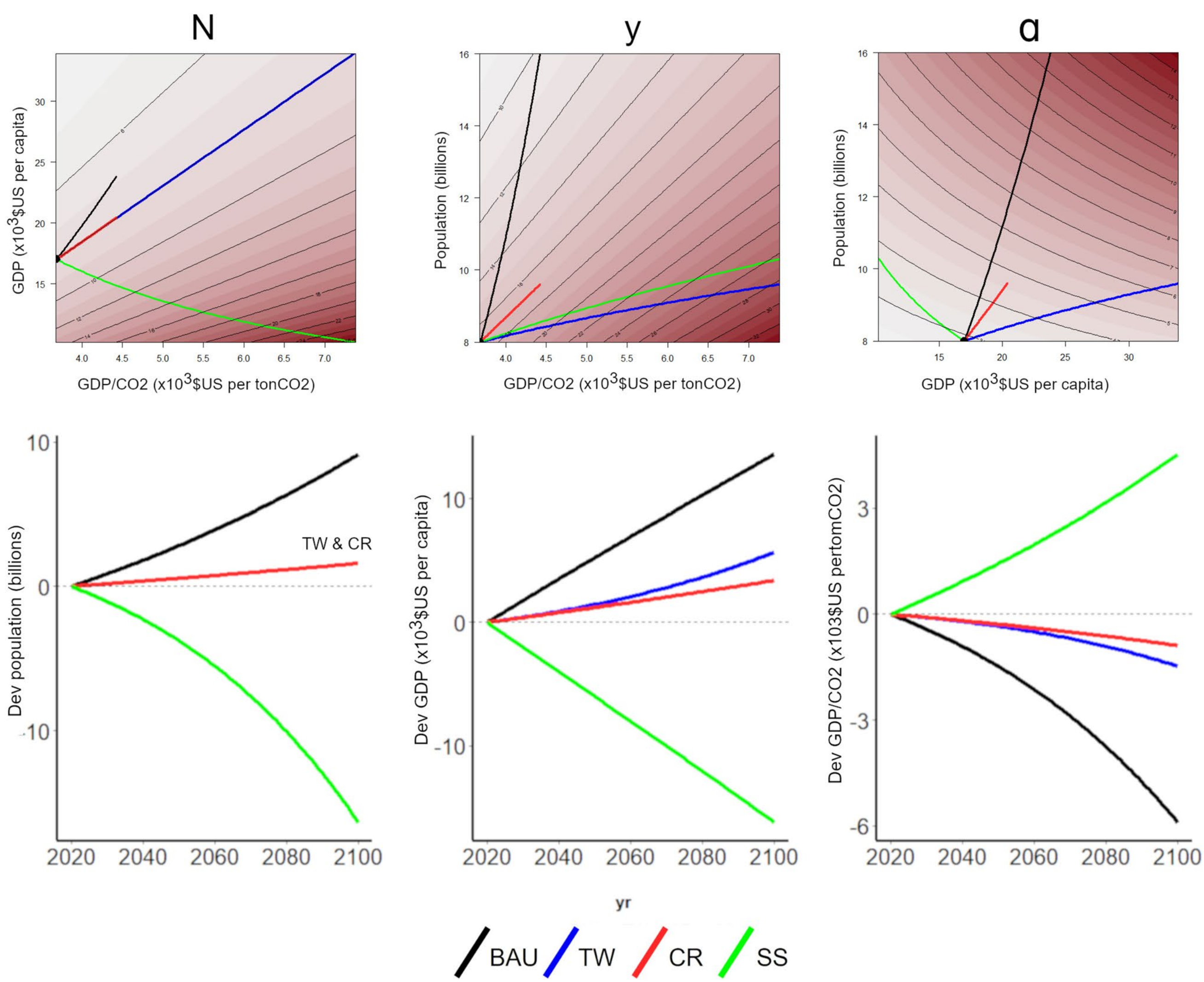


**Fig. 2** Pathways to stabilize the human ecological footprint. The upper charts depict future development trajectories with two parameters held constant, and showing the required values for the third parameter to maintain the ecological impact at 2020 levels by 2100: EF(2100) = EF(2020) (represented by the isolines). The lower charts reveal the absolute deviations of each parameter within each development scenario from its "stability value," as shown in the respective upper chart. "$N$" denotes human population, "$y$" consumption level, and "$a$" efficiency in resource use. BAU indicates the "Business-As-Usual" scenario, TW stands for "Tech World," CR for "Consumption Reduction," and SS signifies "Smart Sustainability"

the ecological footprint in 2100 at 2020 levels is estimated at 6.8 billion (Fig. 2). However, BAU anticipates a population of 16 billion—far exceeding this balance (lower chart in Fig. 2). To align the ecological footprint with 2020 levels, per capita consumption should be \$10.2 thousand by 2100, but BAU calculates it to be much higher by \$13.6 thousand. This means that for the footprint to stabilize, efficiency would need to increase to \$10.3 thousand per ton of $CO_2$ emitted, well above BAU's calculated \$4.4 thousand. Conversely, in the Smart Sustainability (SS) scenario, the projected population of 10.3 billion by 2100 is much lower than what would be required for stability, assuming other factors evolve as anticipated. Per capita consumption is calculated at \$16.2 thousand, well below the \$26.4 thousand required for footprint stability. The anticipated efficiency at \$7.37 thousand per ton of CO2 is substantially higher than the \$2.8 thousand needed to maintain a 2100 footprint similar to that of 2020.

## The need for pluralism and pragmatism

Our simulations are not intended as forecasts, nor do they provide precise estimates of future pathways. Given the inherent uncertainty surrounding future trajectories and key parameters in the ecological footprint metric, such precision is unattainable. However, while the simulations illustrate the trade-offs in political choices affecting the behavior of consumption, population, and efficiency, they also reveal the difficulties of achieving human footprint stability under current trends, highlighting the need for policy interventions that address all components of the ecological footprint equation. In other words, the scenario analysis highlights the imperative to not only improve efficiency in resource use, but also actively reduce the numerator in the ecological footprint equation, which represents consumption. Without this, breaking the current link between economic growth and environmental degradation, including climate change, remains a formidable challenge (Figge and Thorpe 2023).

However, reducing consumption—whether by decreasing the number of consumers, their per capita consumption, or both—has consequences beyond resource usage. A drastic cutback in consumption could reduce demand—unless counterbalanced by substantial public investment—potentially decelerating technological innovation (Weinberger et al. 2017), and impacting the efficiency factor $\alpha$ in the ecological footprint equation. Additionally, if access to emerging technologies ($\alpha$) remains uneven—concentrated primarily in the hands of affluent, energy-rich, or industrial powerhouses—this disparity could disproportionately affect the Global South, exacerbating regional population growths (Coccia 2014), increasing global $N$, and further complicating efforts toward global sustainability. These complexities reveal that focusing exclusively on one component of the ecological footprint equation—whether by reducing consumption or increasing technological efficiency—as is often the case in polarized ideological narratives, is unlikely to be effective.

Current sustainable development policies remain heavily centered on the concept of green growth (Hickel and Kallis 2020), which focuses primarily on improving technological efficiency ($\alpha$) while insufficiently addressing the need to reduce population ($N$) or consumption levels ($y$). Traditional economic models, such as the neoclassical Solow–Swan growth model (Solow 1988), have long assumed continuous, exponential growth. Romer's (1990) endogenous growth model, which incorporates human capital, and Nordhaus' (2019) DICE model, which accounts for natural resources and climate impacts, still largely adhere to this framework of perpetual growth. Some economists have called for a shift away from these linear growth models toward a framework that respects the planet's ecological limits (Raworth 2017). However, evidence suggests that current policies remain closely associated with conventional economic targets and have not reversed the global trend of rising ecological footprints. In some cases, environmentally high-performing countries appear to achieve their success by outsourcing their environmental impacts to other regions (Moinuddin and Olsen 2024).

Paradoxically, the alternative policy focused solely on Consumption Reduction, without significant investment in research, development, and innovation, would likely fall short of achieving the technological advancements needed to improve efficiency and sustain global well-being. This could lead to a vicious cycle where insufficient economic welfare fosters social instability, which in turn causes political instability, curtails investment, stifles innovation, and ultimately exacerbates the ecological footprint. Without innovation-driven improvements in resource efficiency, efforts to reduce the ecological footprint would hinge primarily on reducing global population or per capita consumption—ambitious targets that are unlikely to be achieved under normal, Business-As-Usual conditions.

While sharp and unexpected disruptions—such as major epidemics causing abrupt declines in consumption or breakthrough innovations dramatically improving efficiency—could in theory shift these dynamics, a pragmatic "no regrets" approach (Paterson et al. 2008), which balances technological innovation with mindful consumption, and fair distribution, remains the more prudent strategy. Only through such an integrated strategy can we find a sustainable way forward, steering clear of the environmental crisis threatening our collective future.

## Key takeaways

1. **Balanced policy interventions are essential**: Achieving human footprint stability requires addressing both consumption (the numerator) and technological efficiency (the denominator) in the ecological footprint equation. Focusing exclusively on one component, as often occurs in polarized narratives, is unlikely to be effective in curbing environmental degradation and climate change.
2. **Reducing consumption alone is insufficient**: A policy centered solely on reducing consumption, without substantial investment in technological innovation, risks triggering a cycle of social and political instability. This approach would stifle innovation and fail to improve efficiency, making it difficult to sustain global well-being and reduce the ecological footprint.
3. **A "no regrets" approach is needed**: The best path forward is a pragmatic strategy that balances technological innovation, mindful consumption, and equitable distribution. This pluralistic approach would offer the most sustainable and feasible way forward for mitigating the environmental crisis and addressing the growing ecological footprint.

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## Declarations

**Conflict of interest** The authors have no conflicts of interests/competing interests to declare.



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