

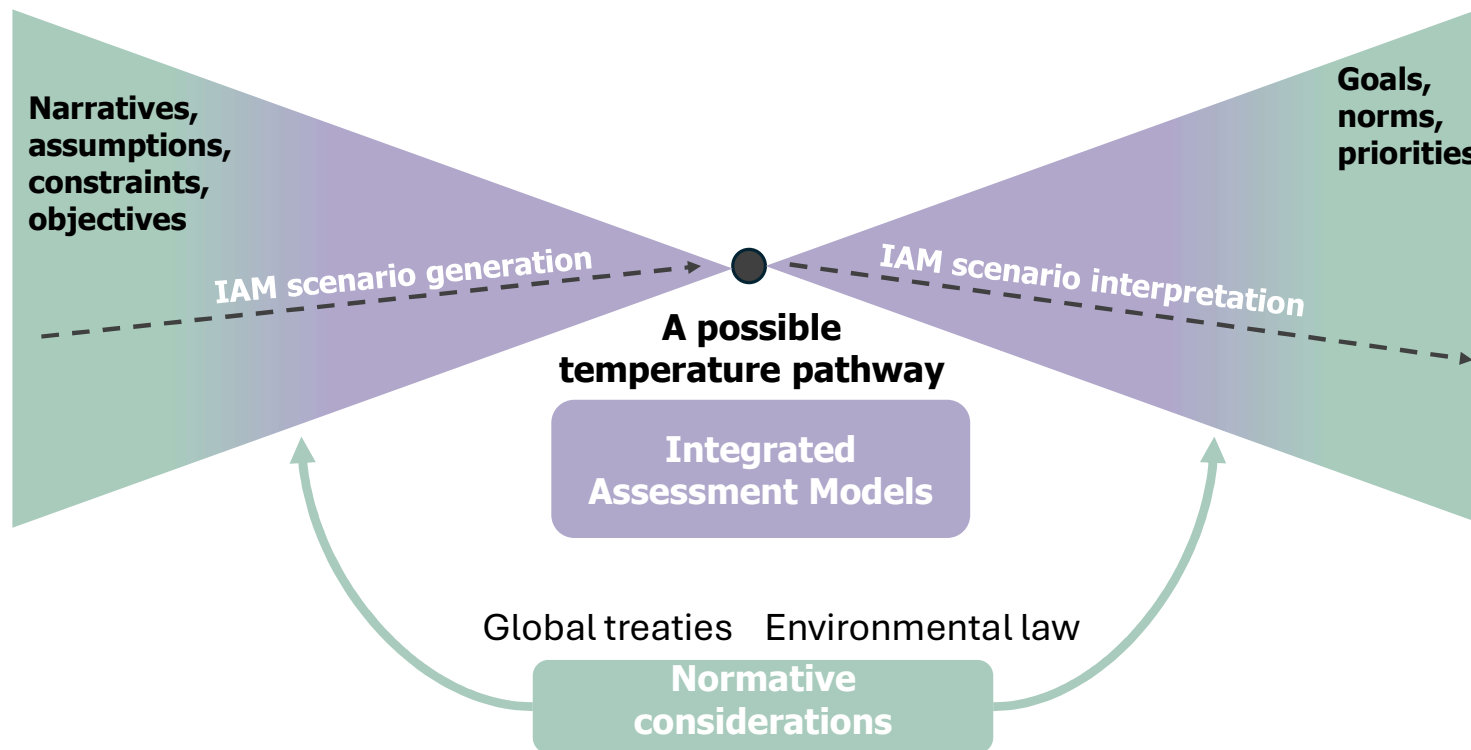
Normative considerations in the models and actions for improvement

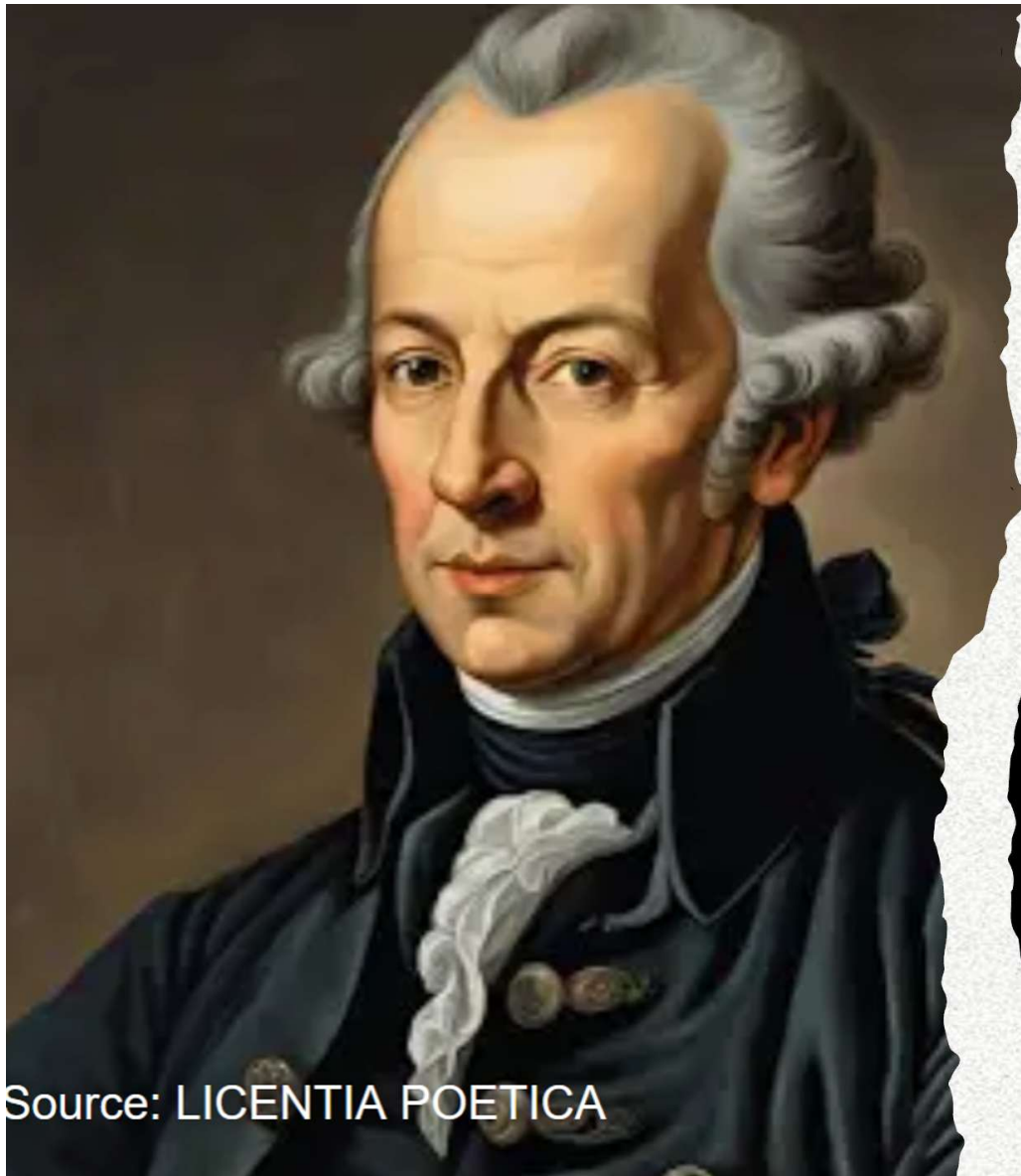
DAY 3

PRISMA summer school

Presentation by Elina Brutschin (IIASA)

Normative considerations in integrated assessment modelling





Source: LICENTIA POETICA

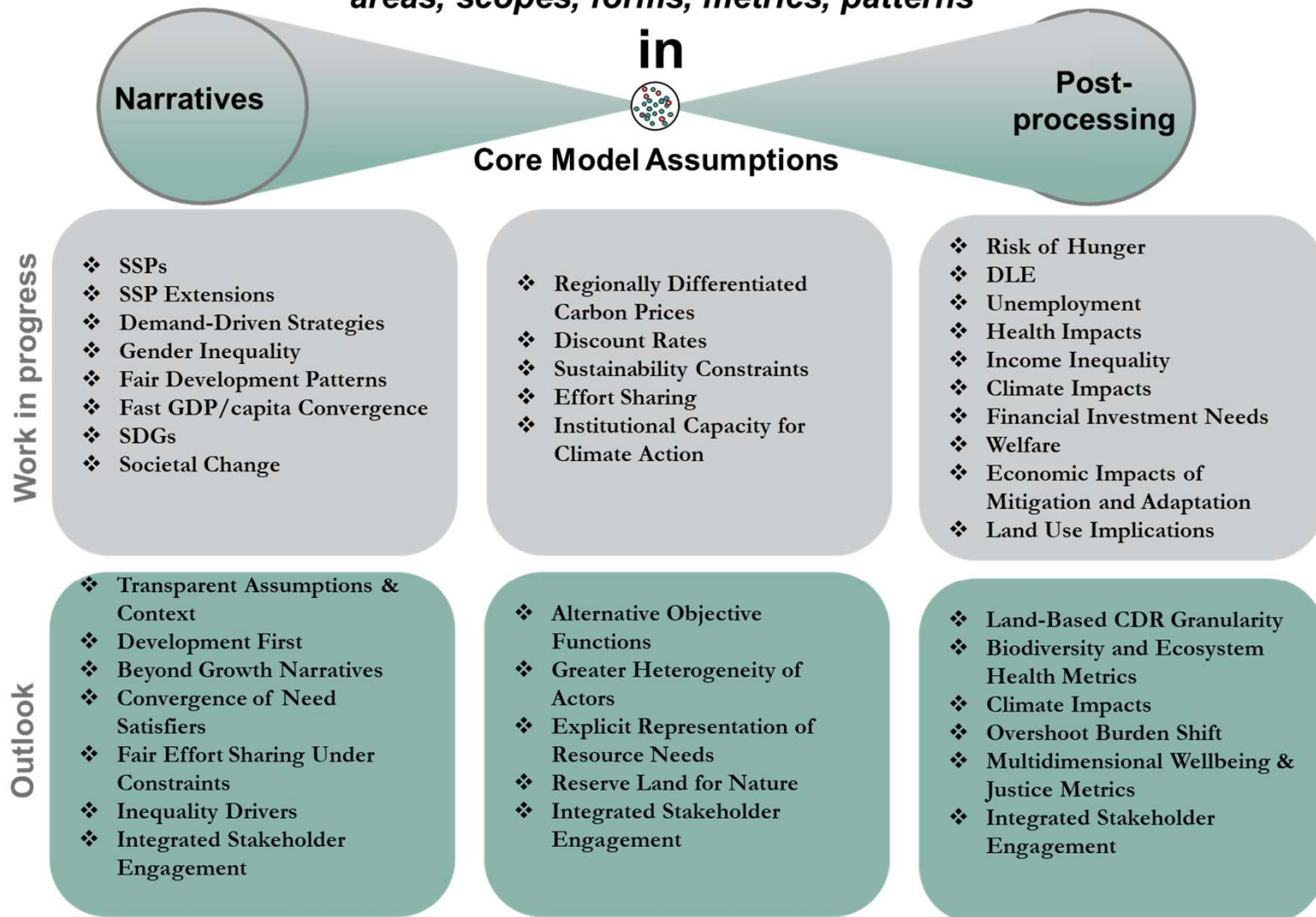
What is a possible future?

“The idea that something which has hitherto been unsuccessful will therefore never be successful does not justify anyone in abandoning even a pragmatic or technical aim. This applies even more to moral aims, which, so long as it is not demonstrably impossible to fulfil them, amount to duties.”

Immanuel Kant, *On the Common Saying: “This May Be True in Theory, but It Does Not Apply in Practice”* (1793)

Justice Considerations

areas, scopes, forms, metrics, patterns



Narratives (Examples)

Ways to develop scenario narratives

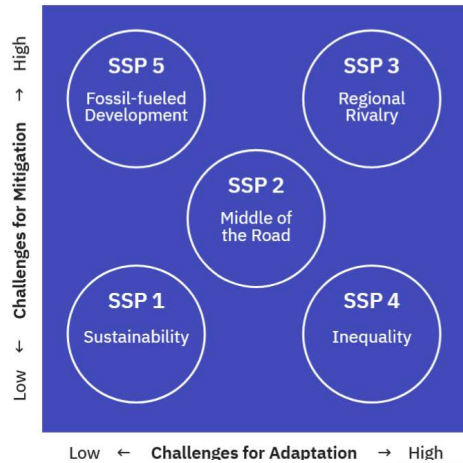
TABLE 1 | Comparison of Scenario Methods Regarding Their Saliency, Credibility, and Legitimacy, Based on Definitions in Ref 5

Scenario Storyline Method	Saliency (Relevance for Decision Makers' Needs)	Credibility (Scientific Adequacy of the Methods and Evidence)	Legitimacy (Unbiased Incorporation of Divergent Values)
Exploratory	<i>Medium.</i> Compromised when the focus has low policy relevance	<i>Medium.</i> The most applied method, described in a vast body of research	<i>Low-Medium.</i> Strongly dependent on the beliefs of the scenario analysts involved
Normative	<i>High.</i> A focus on specific desired futures	<i>Low-Medium.</i> Difficult to address uncertainties in trajectories toward the desired future	<i>Low-Medium.</i> Strongly dependent on the visions of the scenario analysts involved.
Business-as-usual	<i>High.</i> Usually directly policy relevant and based on extrapolation	<i>Low.</i> Based on current processes without alternatives and uncertain developments	<i>Medium-High.</i> Based on current values and beliefs
Participatory	<i>High.</i> Shaped by relevant stakeholders	<i>Low-Medium.</i> Limited by the lack of stakeholder mental models and internal consistency	<i>Medium-High.</i> Stakeholders consulted, but dependent on those individuals
Probabilistic	<i>Low-Medium.</i> Increases complexity leading to communication difficulties	<i>High.</i> Based on formal representation of uncertainty	<i>Low-Medium.</i> May be affected by communication issues due to complexity
Scaling methods	<i>High.</i> Increasing the spatial and thematic resolution enhances the relevance to local stakeholders	<i>Low-High.</i> Depends on whether scaling introduces new process information or is simply a graphical representation	<i>Low-Medium.</i> Depends on stakeholder acceptance of methods

The low, medium high classification reflects the opinions of the authors; the scenario storyline methods given in this table are not necessarily mutually exclusive, but follow the structure of the discussion above.

Rounsevell, M., & Metzger, M. J. (2010). Developing qualitative scenario storylines for environmental change assessment. *Wiley Interdisciplinary Reviews: Climate Change*, 1, 606–619. <https://doi.org/10.1002/wcc.63>

Socio-economic Development



SSP 2: Middle of the road

- This future poses **moderate challenges to mitigation** and **moderate challenges to adaptation**
- Population growth stabilizes toward the end of the century
- Current social, economic, and technological trends continue
- Global and national institutions make slow progress toward achieving sustainable development goals

Taken from:
<https://climatescenarios.org/primer/>



SSP 1: Sustainability - Taking the green road

- This future poses **low challenges to mitigation** and **low challenges to adaptation**
- Global population peaks mid-century
- Emphasis on human well-being
- Environmentally friendly technologies and renewable energy
- Strong and flexible institutions on global, regional, and national level



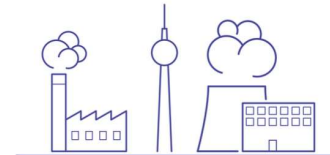
SSP 4: Inequality - A road divided

- This future poses **low challenges to mitigation** and **high challenges to adaptation**
- Population growth stabilizes toward the end of the century
- Growing divide between globally-connected, well educated society and fragmented lower income societies
- Unrest and conflict becomes more common
- Global, regional, and national institutions are ineffective



SSP 3: Regional rivalry - A rocky road

- This future poses **high challenges to mitigation** and **high challenges to adaptation**
- Population growth continues with high growth in developing countries
- Emphasis on national issues due to regional conflicts and nationalism
- Economical development is slow and fossil fuel dependent
- Weak global institutions and little international trade



SSP 5: Fossil-fueled development - Taking the highway

- This future poses **high challenges to mitigation** and **low challenges to adaptation**
- Global population peaks mid-century
- Emphasis on economic growth and technological progress
- Global adoption of resource and energy intensive lifestyles
- Lack of environmental awareness

Low Energy Demand Scenario

Core reading:

Grubler, A., Wilson, C., Bento, N., Boza-Kiss, B., Krey, V., McCollum, D., Rao, N., Riahi, K., Rogelj, J., De Stercke, S., Cullen, J., Frank, S., Fricko, O., Guo, F., Gidden, M., Havlik, P., Huppmann, D., Kieseewetter, G., Rafaj, P., Schöpp, W., ... Pachauri, S. (2018). A low energy demand scenario for meeting the 1.5 °C target and sustainable development goals without negative emission technologies. *Nature Energy*, 3(6), 517–525. <https://doi.org/10.1038/s41560-018-0172-6>

Sector	Key Assumptions	Efficiency/Impact
Thermal Comfort	- Global convergence to 30 m²/capita residential floor space (Global North average)	- Energy per m ² improves via best practices in new builds (South) and retrofits (North)
Consumer Goods	- Device ownership increases: +80% (North); ~3x (South)	- Significant efficiency gains per device- Multifunctional smart devices save up to 100x power
Smart Integration	- Devices become interconnected and smart	- Enables demand response, load management, and system integration
Mobility	- >100% increase in mobility (passenger-km) in Global South- Moderate growth in Global North	- Major drop in energy intensity via electrification and shared mobility models
Food Supply	- Global food supply grows by 1/3 to support +20% population and eliminate malnutrition	- Diets shift toward healthier, more diverse patterns- Average intake: 3130 kcal/day

Economic Narratives in SDP Scenarios

(Based on GDP per capita growth modifications)

Core readings:

Soergel, B., Rauner, S., Daioglou, V., Weindl, I., Mastrucci, A., Carrer, F., Kikstra, J., Ambrósio, G., Aguiar, A. P. D., Baumstark, L., Bodirsky, B. L., Bos, A., Dietrich, J. P., Dirnaichner, A., Doelman, J. C., Hasse, R., Hernandez, A., Hoppe, J., Humpenöder, F., Iacobuță, G. I., ... Kriegler, E. (2024). Multiple pathways towards sustainable development goals and climate targets. *Environmental Research Letters*, 19(12). <https://doi.org/10.1088/1748-9326/ad2e84>

Min, J., Soergel, B., Kikstra, J. S., Koch, J., & van Ruijven, B. (2024). Income and inequality pathways consistent with eradicating poverty. *Environmental Research Letters*, 19(11), 114041. <https://doi.org/10.1088/1748-9326/ad2543>

Scenario	Narrative	GDP Growth Assumptions
SDP-EI (<i>Economic Innovation</i>)	Innovation-driven economy with high growth across all regions	Low- and middle-income countries get up to +15% growth boost . Growth enhancement declines with rising GDP/cap. No changes for high-income countries.
SDP-MC (<i>Moderate Convergence</i>)	Service-driven economy with moderate growth in developed countries	High-income countries: growth rate reduced by up to 50% (U.S.-level GDP/cap and above). Lower reductions for others. Phased in by 2030.
SDP-RC (<i>Reduced Consumption</i>)	Society-driven, post-growth in developed regions	High-income countries transition to zero growth (midpoint at \$30,000 PPP2005). Gradual phase-in to 2030. No changes for low-income countries.

Core model Assumptions

Reserving land for nature

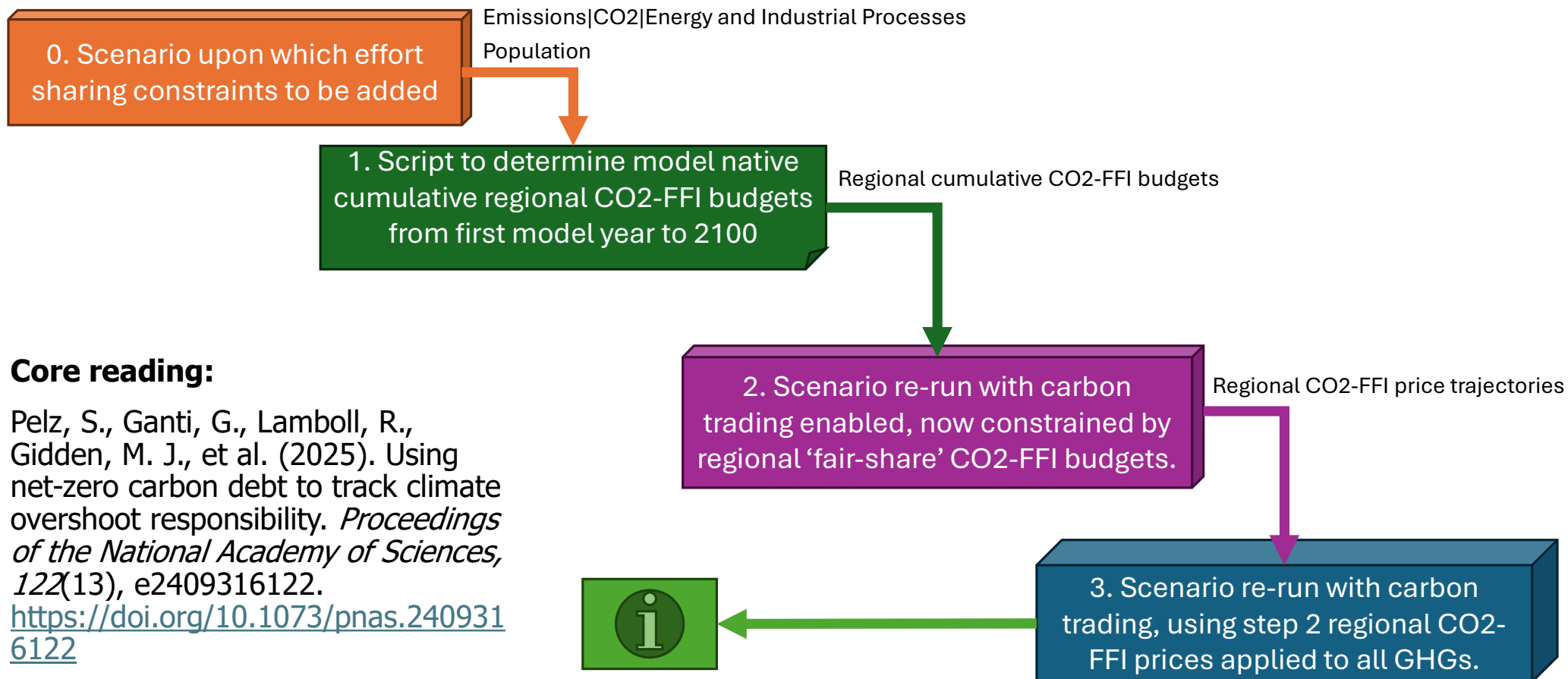
Core reading:

Frank, S., Gusti, M., Havlík, P., Lauri, P., DiFulvio, F., Forsell, N., Hasegawa, T., Krisztin, T., Palazzo, A., & Valin, H. (2021). Land-based climate change mitigation potentials within the agenda for sustainable development.

Environmental Research Letters, 16(2), 024006.
<https://doi.org/10.1088/1748-9326/abd6f1>

- Climate scenarios aiming for 1.5°C warming limit anticipate biomass demand for bioenergy between 100–260 EJ/year by 2050.
- Biomass use beyond 170 EJ/year may conflict with biodiversity conservation goals.
- Stricter protections (e.g., protecting one-third of global land) could reduce sustainable biomass potential to about 130 EJ/year by 2050

Effort Sharing implementation directly in a model



Core reading:

Pelz, S., Ganti, G., Lamboll, R., Gidden, M. J., et al. (2025). Using net-zero carbon debt to track climate overshoot responsibility. *Proceedings of the National Academy of Sciences*, 122(13), e2409316122.

<https://doi.org/10.1073/pnas.2409316122>

Adjusting the discount rate

Core reading:

Emmerling, J., Drouet, L., van der Wijst, K.-I., van Vuuren, D., Bosetti, V., & Tavoni, M. (2019). The role of the discount rate for emission pathways and negative emissions.

Environmental Research Letters, 14(10), 104008.
<https://doi.org/10.1088/1748-9326/ab3cc9>

•Discount rate significantly shapes emission reduction strategies:

It affects when net-zero emissions are reached, the size of carbon budget overshoot, and carbon price trajectories.

•Lower discount rates lead to stronger climate action:

Reducing the discount rate from 5% to 2% doubles the current carbon price and cuts carbon budget overshoot by more than half, reducing reliance on negative emissions by ~300 GtCO₂ over the century.

Philosophers versus Economists

Core reading:

Nesje, F., Drupp, M. A.,
Freeman, M. C., & Groom, B.
(2023). Philosophers and
economists agree on climate
policy paths but for different
reasons. *Nature Climate
Change*, 13(515–522).
<https://doi.org/10.1038/s41558-023-01623-3>

- This study compares economists' and philosophers' views on the SDR and finds **broad agreement**, with both groups favoring a **real SDR around 2%**.
- Economists focus on technical aspects like uncertainty and environmental scarcity, while philosophers prioritize ethical concerns such as the rights of future generations and present-day duties beyond consequentialism.

Modifying the objective function

Core reading:

Żebrowski, P., Dieckmann, U., Brännström, Å., Franklin, O., & Rovenskaya, E. (2022). Sharing the burdens of climate mitigation and adaptation: Incorporating fairness perspectives into policy optimization models. *Sustainability*, 14(7), 3737.

<https://doi.org/10.3390/su14073737>

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- Most IAMs focus on **maximizing total global utility**, not the impacts on regional utilities
- A **social welfare function** within IAMs maps individual utilities into a **social ranking** of outcomes. With **different utility aggregation methods**, this ranking can reflect different perceptions of fairness.

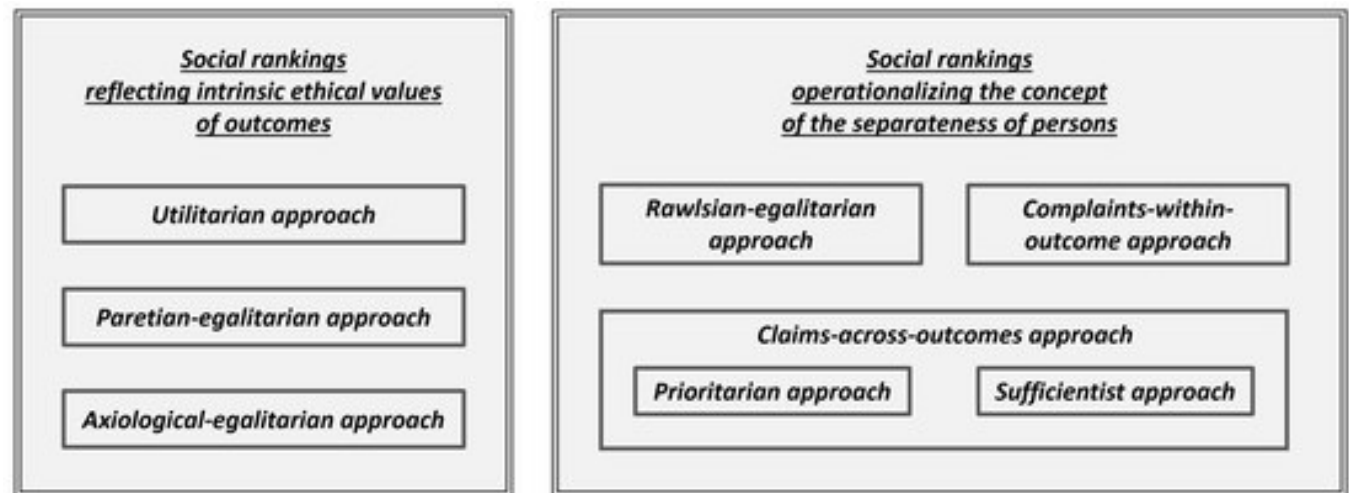
Modifying the objective function

Core reading:

Żebrowski, P., Dieckmann, U., Brännström, Å., Franklin, O., & Rovenskaya, E. (2022). Sharing the burdens of climate mitigation and adaptation: Incorporating fairness perspectives into policy optimization models.

Sustainability, 14(7), 3737.

<https://doi.org/10.3390/su14073737>



The idea of the **separateness of agents** means that when we assess the impacts of climate policies, we must give equal importance to the well-being of every individual involved. Furthermore, the final decision or policy outcome should be understandable and justifiable to each person from their own point of view. This respects everyone as a distinct decision-maker with their own perspective and interests.

Post-processing tools

Health impacts

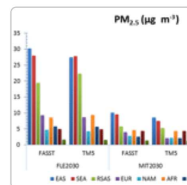
<https://doi.org/10.5194/acp-18-16173-2018>
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Research article | 

TM5-FASST: a global atmospheric
 source–receptor model for rapid impact
 analysis of emission changes on air
 quality and short-lived climate
 pollutants

Rita Van Dingenen , Frank Dentener, Monica Crippa, Joana Leitao, Elina Marmer, Shilpa Rao,
 Efisio Solazzo, and Luana Valentini

13 Nov 2018

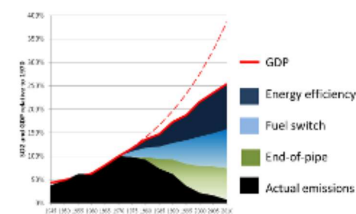


GAINS Online

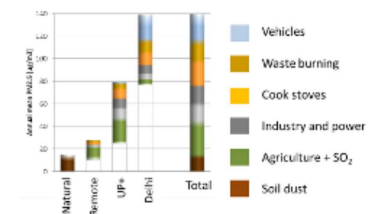
Greenhouse Gas - Air Pollution Interactions and Synergies

Reveal win-win policy interventions with GAINS-online

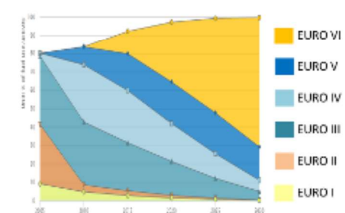
Factors leading to the decline of SO₂ in Europe
 1945–2010



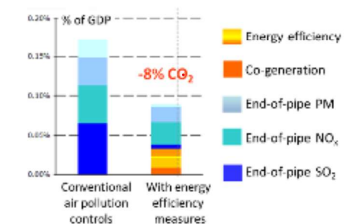
Sources of ambient PM_{2.5} in Delhi
 2009



Emission controls for trucks
 Current legislation scenario, Poland, 2005–2030



Costs for reducing premature deaths from PM_{2.5}
 in China



Decent Living Gaps

Core reading:

Kikstra, J. S., Daiglou, V., Min, J., Sferra, F., Soergel, B., Kriegler, E., Lee, H., Mastrucci, A., Pachauri, S., & Rao, N. (2025). Closing decent living gaps in energy and emissions scenarios: Introducing DESIRE. *Environmental Research Letters*, 20(5). <https://doi.org/10.1088/1748-9326/abf123>

