Climate mitigation policy and value judgment and ethical and equity concepts in the context of sustainable development

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INTERGOVERNMENTAL PANEL ON climate change

CLIMATE CHANGE 2014

Mitigation of Climate Change

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WMO UNEP

Equity and ethical concepts and international cooperation toward the LTGG

Guiding question:

"How can current and future efforts to implement commitments under the Convention increase mitigation ambition and keep us on track for limiting global warming under 2°C/1.5°C?"

Three lines of argument relating equity and equitable effort-sharing to international cooperation on LTGG:

I. Legal argument

II. Moral argument

III. Effectiveness argument

I. Equity and climate: the legal argument

"Countries have accepted legal commitments to act against climate change in an equitable manner."

"Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities." [UNFCCC, Article 3.1, Principles]

II. Equity and climate: the moral argument

"It is morally proper to allocate burdens associated with our common global climate challenge according to ethical principles."

This is a translation of ethical principles – generally respected on the national level – to the global domain.

(E.g., predominant national legal practice that recognizes responsibility for harmful emissions, and fiscal practice that reflects financial capacity in distributing shared public costs through progressive income taxation.)

III. Equity and climate: effectiveness argument

“Equitable burden-sharing will be necessary if the climate challenge is to be effectively met.”

Climate change as a global commons problem

"Effective mitigation will not be achieved if individual agents advance their own interests independently. Climate change has the characteristics of a collective action problem at the global scale, because most greenhouse gases (GHGs) accumulate over time and mix globally, and emissions by any agent (e.g., individual, community, company, country) affect other agents. International cooperation is therefore required to effectively mitigate GHG emissions and address other climate change issues. Furthermore, research and development in support of mitigation creates knowledge spillovers. International cooperation can play a constructive role in the development, diffusion and transfer of knowledge and environmentally sound technologies." [AR5 WG3 SPM]

Climate change as a global commons problem

- No single country can protect "its own" climate by reducing its own emissions
- No country can solve its own climate problem for itself.
- Countries must persuade other countries to help it solve its climate problem
- A country thus reduces its own emissions – and cooperates in other ways – for the sake of inducing reciprocal effort, i.e., getting other countries to do likewise.
- A country is more likely to be successful if it is perceived as doing its fair share of the effort.
- Thus, a cooperative agreement with equitable effort-sharing is more likely to be agreed and successfully implemented.

"Outcomes seen as equitable can lead to more effective cooperation." [AR5 WG3 SPM]

Dataset of 1200 modeled emission scenarios

<table>
<tr><th rowspan="3">CO_2eq Concentrations in 2100 (CO_2eq)

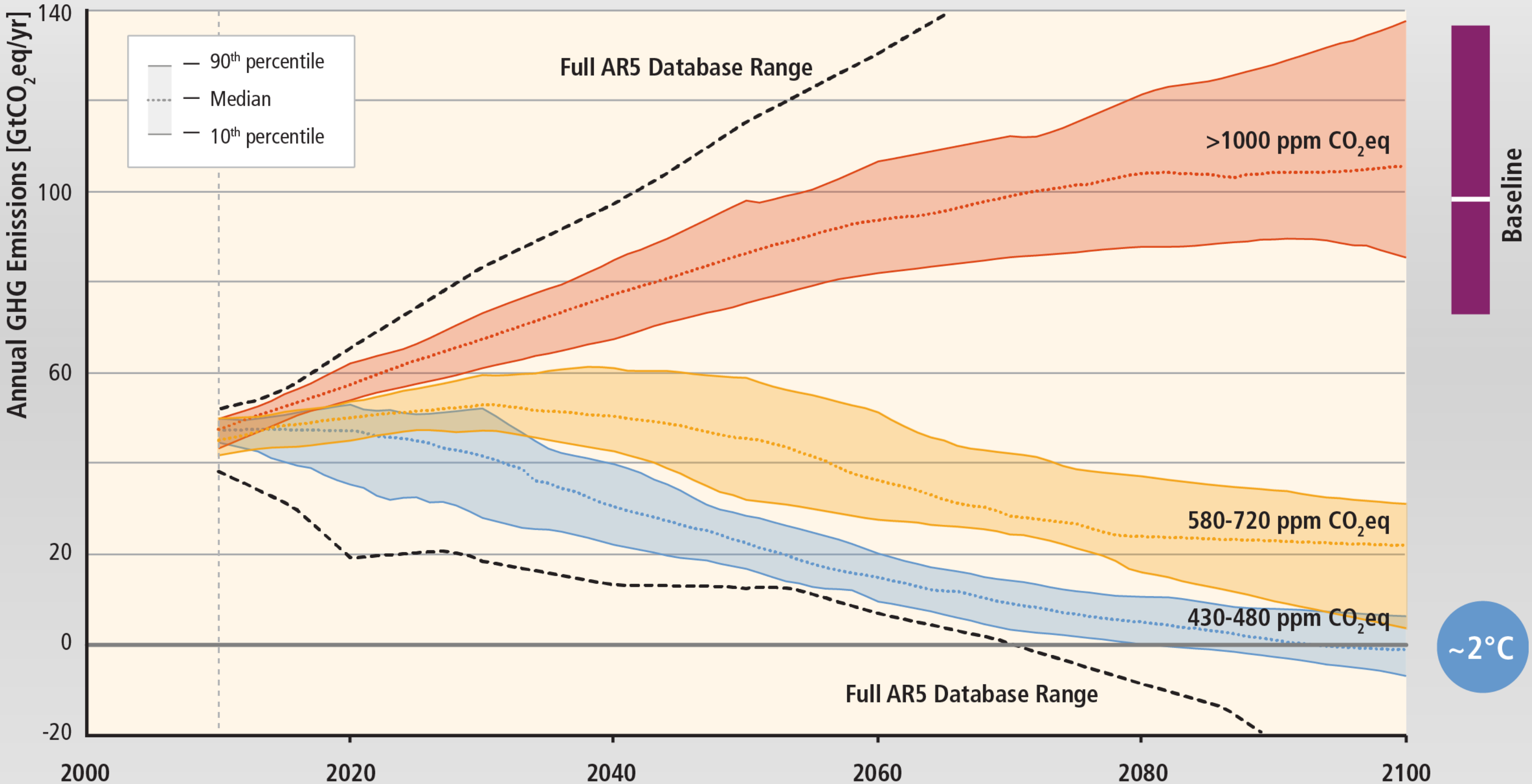
Category label (concentration range)[9]</th><th rowspan="3">Subcategories</th><th rowspan="3">Relative position of the RCPs[5]</th><th colspan="2">Cumulative CO_2 emission[3] ($GtCO_2$)</th><th colspan="2">Change in CO_2eq emissions compared to 2010 in (%)[4]</th><th colspan="5">Temperature change (relative to 1850–1900)[5,6]</th></tr>
<tr><th rowspan="2">2011–2050</th><th rowspan="2">2011–2100</th><th rowspan="2">2050</th><th rowspan="2">2100</th><th rowspan="2">2100 Temperature change (°C)[7]</th><th colspan="4">Likelihood of staying below temperature level over the 21st century[8]</th></tr>
<tr><th>1.5°C</th><th>2.0°C</th><th>3.0°C</th><th>4.0°C</th></tr>
<tr><td>< 430</td><td colspan="11">Only a limited number of individual model studies have explored levels below 430 ppm CO_2eq</td></tr>
<tr><td>450
(430–480)</td><td>Total range[1,10]</td><td>RCP2.6</td><td>550–1300</td><td>630–1180</td><td>-72 to -41</td><td>-118 to -78</td><td>1.5–1.7 (1.0–2.8)</td><td>More unlikely than likely</td><td>Likely</td><td rowspan="6">Likely</td><td rowspan="8">Likely</td></tr>
<tr><td rowspan="2">500
(480–530)</td><td>No overshoot of 530 ppm CO_2eq</td><td></td><td>860–1180</td><td>960–1430</td><td>-57 to -42</td><td>-107 to -73</td><td>1.7–1.9 (1.2–2.9)</td><td rowspan="6">Unlikely</td><td>More likely than not</td></tr>
<tr><td>Overshoot of 530 ppm CO_2eq</td><td></td><td>1130–1530</td><td>990–1550</td><td>-55 to -25</td><td>-114 to -90</td><td>1.8–2.0 (1.2–3.3)</td><td>About as likely as not</td></tr>
<tr><td rowspan="2">550
(530–580)</td><td>No overshoot of 580 ppm CO_2eq</td><td></td><td>1070–1460</td><td>1240–2240</td><td>-47 to -19</td><td>-81 to -59</td><td>2.0–2.2 (1.4–3.6)</td><td rowspan="3">More unlikely than likely[12]</td></tr>
<tr><td>Overshoot of 580 ppm CO_2eq</td><td></td><td>1420–1750</td><td>1170–2100</td><td>-16 to 7</td><td>-183 to -86</td><td>2.1–2.3 (1.4–3.6)</td></tr>
<tr><td>(580–650)</td><td>Total range</td><td rowspan="2">RCP4.5</td><td>1260–1640</td><td>1870–2440</td><td>-38 to 24</td><td>-134 to -50</td><td>2.3–2.6 (1.5–4.2)</td></tr>
<tr><td>(650–720)</td><td>Total range</td><td>1310–1750</td><td>2570–3340</td><td>-11 to 17</td><td>-54 to -21</td><td>2.6–2.9 (1.8–4.5)</td><td rowspan="2">Unlikely</td><td>More likely than not</td></tr>
<tr><td>(720–1000)</td><td>Total range</td><td>RCP6.0</td><td>1570–1940</td><td>3620–4990</td><td>18 to 54</td><td>-7 to 72</td><td>3.1–3.7 (2.1–5.8)</td><td rowspan="2">Unlikely[11]</td><td>More unlikely than likely</td></tr>
<tr><td>>1000</td><td>Total range</td><td>RCP8.5</td><td>1840–2310</td><td>5350–7010</td><td>52 to 95</td><td>74 to 178</td><td>4.1–4.8 (2.8–7.8)</td><td>Unlikely[11]</td><td>Unlikely</td><td>More unlikely than likely</td></tr>
</table>

IPCC AR5 WGIII, Table SPM1

>100 scenarios likely to keep warming below 2°C.

CO_2eq Concentrations in 2100 (CO_2eq) Category label (concentration range)[9]	Temperature change (relative to 1850–1900)[5,6] 2100 Temperature change (°C)[7]	Likelihood of staying below temperature level over the 21st century[8] 1.5°C	2.0°C	3.0°C	4.0°C
< 430	...ave explored levels below 430 ppm CO_2eq				
450 (430–480)	1.5–1.7 (1.0–2.8)	More unlikely than likely	Likely	Likely	Likely
500 (480–530)	1.7–1.9 (1.2–2.9)	Unlikely	More likely than not		
	1.8–2.0 (1.2–3.3)		About as likely as not		
550 (530–580)	2.0–2.2 (1.4–3.6)		More unlikely than likely[12]		
	2.1–2.3 (1.4–3.6)				
(580–650)	2.3–2.6 (1.5–4.2)				
(650–720)	2.6–2.9 (1.8–4.5)		Unlikely	More likely than not	
(720–1000)	3.1–3.7 (2.1–5.8)	Unlikely[11]		More unlikely than likely	
>1000	4.1–4.8 (2.8–7.8)		Unlikely[11]	Unlikely	More unlikely than likely

Global emissions under likely 2°C paths (blue)



From IPCC AR5 WGIII, Figure SPM4

Reduction levels in 2030 and peak year of emissions

		OECD	ASIA	LAM	MAF	REF
Peak year of emissions	430-530 ppm eq	2020 (2020/2020)	2030 (2030/2040)	2025 (2020/2030)	2030 (2020/2040)	2025 (2020/2030)
Peak year of emissions	530-650 ppm eq	2025 (2020/2025)	2040 (2040/2040)	2030 (2030/2040)	2040 (2030/2050)	2025 (2020/2030)
2030 Emission reductions w.r.t. 2010	430-530 ppm eq	32% (23/40 %)	-1% (-15/14 %)	35% (16-59 %)	8% (-7/18 %)	32% (18/40 %)
2030 Emission reductions w.r.t. 2010	530-650 ppm eq	14% (6/21 %)	-34% (-43/-26 %)	9% (-17/41 %)	-22% (-41/-12 %)	8% (-5/16 %)

IPCC AR5 WGIII, Ch. 6 Figure 6.7

Emissions peak, globally and in all regions, in next ~10-15 years in the "likely 2°C" category of paths.

→ Broad low-GHG transformation underway in all regions.

Estimated costs of likely 2°C paths

	Consumption losses in cost-effective implementation scenarios			
	[% reduction in consumption relative to baseline]			[percentage point reduction in annualized consumption growth rate]
2100 Concentration (ppm CO_2eq)	2030	2050	2100	2010-2100
450 (430–480)	1.7 (1.0–3.7) [N: 14]	3.4 (2.1–6.2)	4.8 (2.9–11.4)	0.06 (0.04–0.14)
500 (480–530)	1.7 (0.6–2.1) [N: 32]	2.7 (1.5–4.2)	4.7 (2.4–10.6)	0.06 (0.03–0.13)
550 (530–580)	0.6 (0.2–1.3) [N: 46]	1.7 (1.2–3.3)	3.8 (1.2–7.3)	0.04 (0.01–0.09)
580–650	0.3 (0–0.9) [N: 16]	1.3 (0.5–2.0)	2.3 (1.2–4.4)	0.03 (0.01–0.05)

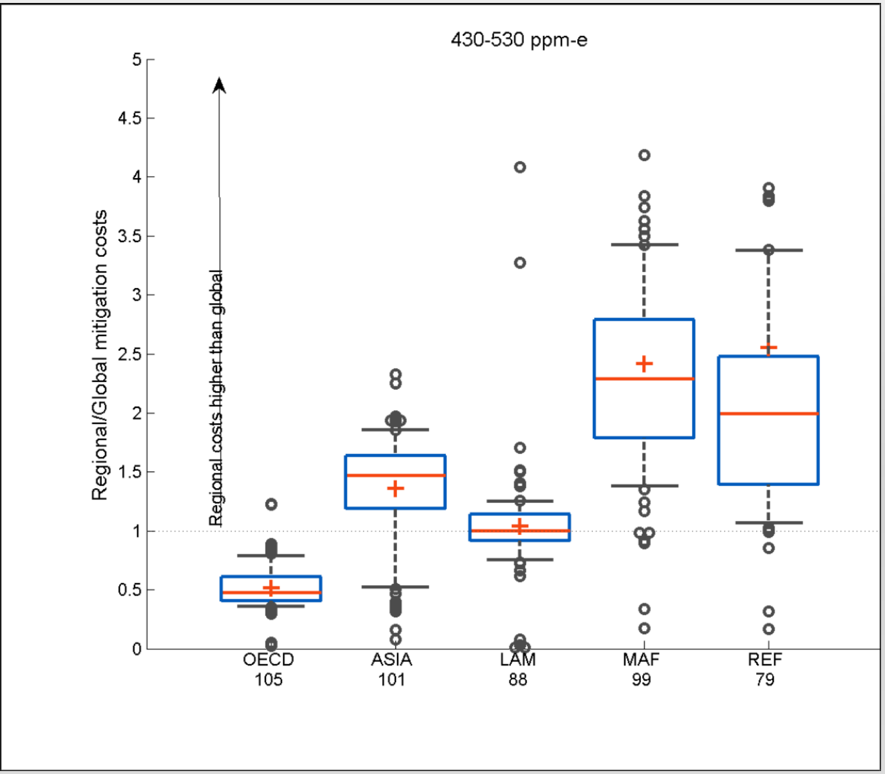
IPCC AR5 WGIII, Table SPM2

For "likely" 2.0º C:
2030 costs are in 1.0 to 3.7% range.

Baseline growth 300%-900% → – 0.06%/yr annual growth

Or, very roughly $1 to 3 trillion/year.

Global distribution of mitigation expenditures (% of GDP)



IPCC AR5 WGIII, Fig. 6.27

- OECD90: mitigation expenditures are lowest
- Latin America: 2x higher
- Asia: 3x higher
- Mid. East/Africa, EITs: 4-5x higher

This distribution of the costs constitutes a particular way of sharing the effort, based not on ethical principles but rather solely on basis of mitigation potential.

Effort-sharing frameworks: role and significance

"Effort-sharing frameworks can help to clarify discrepancies between the distribution of costs based on mitigation potential and the distribution of responsibilities based on ethical principles, and they can help reconcile those discrepancies through international financial transfers." [AR5 WG3 TS]

Effort-sharing frameworks: support and effectiveness

- "A crucial consideration …is that the mitigation costs borne in a region can be separated from who pays those costs."
- "Effort-sharing schemes have the potential to yield a more equitable cost distribution between countries."
- "Multi-model studies indicate that the size of the carbon market transfers would be significant in relation to the total global aggregate economic costs of mitigation, of the order of hundred billions of U.S. dollars per year before mid-century"
- "Climate coalitions which are self-enforcing and stable can indeed be effective only in the presence of significant compensatory payments across regions."

(AR5 WG3, Ch. 6)

Effort-sharing frameworks: underlying equity principles

Small set of widely invoked ethical principles:

- *Sharing of effort in relation to responsibility:* (typically, emissions or cumulative emissions as indicator)
- *Sharing of effort in relation to capacity:* (typically, income as indicator)
- *Equality*: (typically, interpreted as equal per capita entitlements of specified budget and time frame)

Broader implications of mitigation measures for sustainable development

Guiding question:

"What are the social and economic impacts of the implementation of mitigation measures on developing countries within mitigation pathways for various levels of global mean warming? What is the relationship between mitigation and impacts in terms of key risks, notably for the most vulnerable people and systems as assessed by the AR5 WGII?"

"Climate policy intersects with other societal goals creating the possibility of co-benefits or adverse side-effects." (IPCC AR5 SPM)

Co-benefits and adverse side effects: energy supply sector

Sectoral mitigation measures	Integrated model results for stringent mitigation scenarios			Effect on additional objectives/concerns			
				Economic	Social	Environmental	Other
Energy Supply	**Deployment[1]**		**Rate of change %/yr**	*For possible upstream effects of biomass supply for bioenergy, see AFOLU.*			
	2010	***2050***					
Nuclear replacing coal power	10 EJ/yr	(4-22) *17-47*	(-2-2) *1-4*	↑ Energy security (reduced exposure to fuel price volatility) **(m/m)** ↑ Local employment impact (but uncertain net effect) **(l/m)** ↑ Legacy cost of waste and abandoned reactors **(m/h)**	Health impact via ↓ Air pollution and coal mining accidents **(m/h)** ↑ Nuclear accidents and waste treatment, uranium mining and milling **(m/l)** ↑ Safety and waste concerns **(r/h)**	Ecosystem impact via ↓ Air pollution **(m/h)** and coal mining **(l/h)** ↑ Nuclear accidents **(m/m)**	Proliferation risk **(m/m)**
RE (Wind, PV, CSP, hydro, geothermal, bioenergy) replacing coal	62 EJ/yr	(66-125) *194-282*	(0.2-2) *3-4*	↑ Energy security (resource sufficiency, diversity in the near/medium term) **(r/m)** ↑ Local employment impact (but uncertain net effect) **(m/m)** ↑ Irrigation, flood control, navigation, water supply (reservoir hydro, regulated rivers)**(m/h)** ↑ Extra measures to match demand (for PV, wind and some CSP) **(r/h)**	Health impact via ↓ Air pollution (except bioenergy) **(r/h)** ↓ Coal mining accidents **(m/h)** ↑ Contribution to (off-grid) energy access **(m/l)** ? Project-specific public acceptance concerns (e.g., visibility of wind) **(l/m)** ↑ Threat of displacement (large hydro) **(m/h)**	Ecosystem impact via ↓ Air pollution (except bioenergy) **(m/h)** ↓ Coal mining **(l/h)** ↑ Habitat impact (for some hydro) **(m/m)** ↑ Landscape and wildlife impact (for wind) **m/m)** ↓ Water use (for wind and PV) **(m/m)** ↑ Water use (for bioenergy, CSP, geothermal, and reservoir hydro) **(m/h)**	Higher material use of critical metals for PV and direct drive wind turbines **(r/m)**
Fossil CCS replacing coal	0 Gt CO_2/yr stored	(0) *4-12*	(0) *NA*	↑↑ Preservation vs lock-in of human and physical capital in the fossil industry **(m/m)**	Health impact via ↑ Risk of CO_2 leakage **(m/m)** ↑ Upstream supply-chain activities **(m/h)** ↑ Safety concerns (CO_2 storage and transport) **(m/h)**	↑ Ecosystem impact via upstream supply-chain activities **(m/m)** ↑ Water use **(m/h)**	Long-term monitoring of CO_2 storage **(m/h)**
BECCS replacing coal	0 Gt CO_2/yr	(0) *0-6*	*NA*	*See fossil CCS where applicable. For possible upstream effect of biomass supply, see AFOLU.*			
Methane leakage prevention, capture or treatment	NA	NA	NA	↑ Energy security (potential to use gas in some cases) **(l/h)**	↑ Health impact via reduced air pollution **(m/m)** ↑ Occupational safety at coal mines **(m/m)**	↓ Ecosystem impact via reduced air pollution **(l/m)**	

AR5 WG3 TS, Table TS3

Co-benefits and adverse side effects: transport and buildings sectors

Transport	Scenario results	*For possible upstream effects of low-carbon electricity, see Energy Supply. For possible upstream effects of biomass supply, see AFOLU.*			
Reduction of fuel carbon intensity: e.g. electricity, H_2, CNG, biofuels and other measures	*Interquartile ranges for the whole sector in 2050 with 430-530 ppm CO_2eq concentrations in 2100 (see Figures 6.37 & 6.38):* 1) Final energy low-carbon fuel shares 27 - 41 % 2) Final energy reduction relative to baseline 20 - 45 %	↑ Energy security (diversification, reduced oil dependence and exposure to oil price volatility) (m/m) ↑ Technological spillovers (e.g. battery technologies for consumer electronics) (l/l)	Health impact via urban air pollution by ? CNG, biofuels: net effect unclear (m/l) ↓ Electricity, H_2: reducing most pollutants (r/h) ↑ Diesel: potentially increasing pollution (l/m) ↓ Noise (electrification and fuel cell LDVs) (l/m) ↓ Road safety (silent electric LDVs at low speed) (l/l)	Ecosystem impact of electricity and hydrogen via ↓ Urban air pollution (m/m) ↑ Material use (unsustainable resource mining) (l/l) Ecosystem impact of biofuels: *see AFOLU*	
Reduction of energy intensity		↑ Energy security (reduced oil dependence and exposure to oil price volatility) (m/m)	↓ Health impact via reduced urban air pollution (r/h) ↑ Road safety (via increased crash-worthiness) (m/m)	↓ Ecosystem and biodiversity impact via reduced urban air pollution (m/h)	
Compact urban form + improved transport infrastructure Modal shift		↑ Energy security (reduced oil dependence and exposure to oil price volatility) (m/m) ↑ Productivity (reduced urban congestion and travel times, affordable and accessible transport) (m/h) ? Employment opportunities in the public transport sector vs car manufacturing (l/m)	Health impact for non-motorized modes via ↓ Increased activity (r/h) ↑ Potentially higher exposure to air pollution (r/h) ↑ Noise (modal shift and travel reduction) (r/h) ↑ Equitable mobility access to employment opportunities, particularly in DCs (r/h) ↑ Road safety (via modal shift and/or infrastructure for pedestrians and cyclists) (r/h)	Ecosystem impact via reduced ↓ Urban air pollution (r/h) ↓ Land-use competition (m/m)	
Journey reduction and avoidance		↑ Energy security (reduced oil dependence and exposure to oil price volatility) (r/h) ↑ Productivity (reduced urban congestion, travel times, walking) (r/h)	↓ Health impact (non-motorized transport modes) (r/h)	Ecosystem impact via ↓ Urban air pollution (r/h) ↑ New/shorter shipping routes (r/h) ↓ Land-use competition (transport infrastructure) (r/h)	
Buildings	Scenario results	*For possible upstream effects of fuel switching and RES, see Energy Supply.*			
Fuel switching, RES incorporation, green roofs, and other measures reducing emissions intensity	*Interquartile ranges for the whole sector in 2050 with 430-530 ppm CO_2eq concentrations in 2100 (see Figures 6.37 & 6.38):* 1) Final energy low-carbon fuel shares 51 - 60 % 2) Final energy reduction relative to baseline 14 – 35 %	↑ Energy security (m/h) ↑ Employment impact (m/m) ↑ Lower need for energy subsidies (l/l) ↑ Asset values of buildings (l/m)	Fuel poverty (residential) via ↓ Energy demand (m/h) ↑ Energy cost (l/m) ↓ Energy access (for higher energy cost) (l/m) ↑ Productive time for women/children (replaced traditional cookstoves) (m/h)	Health impact in residential buildings via ↓ Outdoor air pollution (r/h) ↓ Indoor air pollution (in DCs) (r/h) ↓ Fuel poverty (r/h) ↓ Ecosystem impact (less outdoor air pollution) (r/h) ↑ Urban biodiversity (green roofs) (m/m)	Reduced Urban Heat Island Effect (UHI) (l/m)
Retrofits of existing buildings (e.g. cool roof, passive solar, etc.) Exemplary new buildings Efficient equipment		↑ Energy security (m/h) ↑ Employment impact (m/m) ↑ Productivity (commercial buildings) (m/h) ↑ Lower need for energy subsidies (l/l) ↑ Asset values of buildings (l/m) ↑ Disaster resilience (l/m)	↓ Fuel poverty (retrofits, efficient equipment) (m/h) ↓ Energy access (higher cost for housing due to the investments needed) (l/m) ↑ Quality of life (thermal comfort in retrofits and exemplary new buildings) (m/h) ↑ Productive time for women and children (replaced traditional cookstoves) (m/h)	Health impact via ↓ Outdoor air pollution (r/h) ↓ Indoor air pollution (efficient cookstoves) (r/h) ↓ Indoor environmental conditions (m/h) ↓ Fuel poverty (r/h) ↓ Insufficient ventilation (m/m) ↓ Ecosystem impact (less outdoor air pollution) (r/h) ↓ Water consumption and sewage production (l/l)	Reduced UHI (retrofits and new exemplary buildings) (l/m)
Behavioral changes reducing energy demand		↑ Energy security (m/h) ↑ Lower need for energy subsidies (l/l)		↓ Health impact via less outdoor air pollution (r/h) & improved indoor environmental conditions (m/h) ↓ Ecosystem impact (less outdoor air pollution) (r/h)	

Co-benefits and adverse side effects: Industry, AFOLU, and Human Settlements

Industry	Scenario results	*For possible upstream effects of low-carbon energy supply (incl CCS), see Energy Supply and of biomass supply, see AFOLU.*			
CO_2/non-CO_2 emission intensity reduction	*Interquartile ranges for the whole sector in 2050 with 430-530 ppm CO_2eq concentrations in 2100 (see Figures 6.37 & 6.38):* 1) Final energy low-carbon fuel shares: 44 - 57 % 2) Final energy reduction relative to baseline: 22 – 38 %	↑ Competitiveness and productivity **(m/h)**	↓ Health impact via reduced local air pollution and better work conditions (PFC from aluminium) **(m/m)**	↓ Ecosystem impact via reduced local air pollution and reduced water pollution **(m/m)** ↑ Water conservation **(l/m)**	
Energy efficiency improvements via new processes/technologies		↑ Energy security (lower energy intensity)**(m/m)** ↑ Employment impact **(l/l)** ↑ Competitiveness and productivity **(m/h)** ↑ Technological spillovers in DCs (due to supply chain linkages) **(l/l)**	↓ Health impact via reduced local pollution **(l/m)** ↑ New business opportunities **(m/m)** ↑ Water availability and quality **(l/l)** ↑ Safety, working conditions and job satisfaction **(m/m)**	Ecosystem impact via ↓ Fossil fuel extraction **(l/l)** ↓ Local pollution and waste **(m/m)**	
Material efficiency of goods, recycling		↓ National sales tax revenue (medium term)**(l/l)** ↑ Employment impact (waste recycling) **(l/l)** ↑ Competitiveness in manufacturing **(l/l)** ↑ New infrastructure for industrial clusters **(l/l)**	↓ Health impacts and safety concerns **(l/m)** ↑ New business opportunities **(m/m)** ↓ Local conflicts (reduced resource extraction) **(l/m)**	↓ Ecosystem impact via reduced local air and water pollution and waste material disposal **(m/m)** ↓ Use of raw/virgin materials and natural resources implying reduced unsustainable resource mining **(l/l)**	
Product demand reductions		↓ National sales tax revenue (medium term)**(l/l)**	↓ Local conflicts (reduced inequity in consumption)**(l/l)** ↑ New diverse lifestyle concept **(l/l)**	↓ Post-consumption waste **(l/l)**	
AFOLU	Scenario results	*Note: co-benefits and adverse side-effects depend on the development context and the scale of the intervention (size).*			
Supply side: forestry, land-based agriculture, livestock, integrated systems and bioenergy (**marked by ***) **Demand side:** reduced losses in the food supply chain, changes in human diets, changes in wood demand and demand from forestry products	Ranges for cumulative land-related emissions reductions relative to baseline for CH_4, CO_2, and N_2O in idealized implementation scenarios with 450 CO_2eq ppm concentrations in 2100 (see Table 11.10): CH_4: 2 – 18 % CO_2: - 104 – 423 % N_2O: 8 – 17 %	* Employment impact via ↑ entrepreneurship development **(m/h)** ↓ use of less labor-intensive **(m/m)** technologies in agriculture ↑ * Diversification of income sources and access to markets **(r/h)** ↑ * Additional income to (sustainable) landscape management **(m/h)** ↑ * Income concentration **(m/m)** ↑ * Energy security (resource sufficiency) **(m/h)** ↑ Innovative financing mechanisms for sustainable resource management **(m/h)** ↑ Technology innovation and transfer **(m/m)**	↑ * Food-crops production through integrated **(r/m)** systems and sustainable agriculture intensification ↓ * Food production (locally) due to large-scale monocultures of non-food crops **(r/l)** ↑ Cultural habitats and recreational areas via **(m/m)** (sustainable) forest management and conservation ↑ *Human health and animal welfare e.g. through less pesticides, reduced burning practices and practices like agroforestry & silvo-pastoral systems **(m/h)** ↓ *Human health when using burning practices (in agriculture or bioenergy) **(m/m)** * Gender, intra- and inter-generational equity via ↑ participation and fair benefit sharing **(r/h)** ↑ concentration of benefits **(m/m)**	Provision of ecosystem services via ↑ ecosystem conservation and sustainable management as well as sustainable agriculture **(r/h)** ↓ * large scale monocultures **(r/h)** ↑ * Land use competition **(r/m)** ↑ Soil quality **(r/h)** ↓ Erosion **(r/h)** ↑ Ecosystem resilience **(m/h)** ↑ Albedo and evaporation **(r/h)**	*Institutional aspects:* ↑↓ * Tenure and use rights at the local level (for indigenous people and local communities) especially when implementing activities in natural forests **(r/h)** ↑↓ Access to participative mechanisms for land management decisions **(r/h)** ↑ Enforcement of existing policies for sustainable resource management **(r/h)**
Human Settlements and Infrastructure		*For co-benefits and adverse side effects of compact urban form and improved transport infrastructure, see also Transport.*			
Compact development and infrastructure		↑ Innovation and efficient resource use **(r/h)** ↑↑Higher rents and property values**(m/m)**	↑ Health from physical activity: *see Transport*	↑ Preservation of open space **(m/m)**	
Increased accessibility		↑ Commute savings **(r/h)**	↑ Health from increased physical activity: *see Transport* ↑ Social interaction & mental health **(m/m)**	↑ Air quality and reduced ecosystem and health impacts **(m/h)**	
Mixed land use		↑ Commute savings **(r/h)** ↑↑Higher rents and property values **(m/m)**	↑ Health from increased physical activity **(r/h)** ↑ Social interaction and mental health **(l/m)**	↑ Air quality and reduced ecosystem and health impacts **(m/h)**	

Broad interactions between mitigation and other developmental objectives

- Health and safety (e.g., via air pollution)
- Energy access and energy security
- Food security
- Livelihoods, employment,
- Income and income distribution
- Water use
- Biodiversity preservation,…

→ Unsurprisingly, effects broadly across all three domains – social, environmental, and economic – of sustainable development.

Key points about co-benefits and adverse side effects

- These influences can be substantial, although often difficult to quantify, and have not yet been thoroughly assessed in the literature.
- Co-benefits and adverse side-effects depend on local circumstances as well as on the implementation practice, pace and scale.
- Behaviour, lifestyle and culture have a considerable influence on emissions, with high mitigation potential in some sectors, in particular when complementing technological and structural change.
- Enhancing co-benefits and avoiding adverse side-effects: good governance, transparency, stakeholder participation, cross-sectoral analysis and design, etc.

(IPCC AR5 SPM, TS)

Final points

- Effort-sharing is fundamental to international cooperation in a global commons problem.
- Effort-sharing seen to be equitable, based on ethical principles may lead to more effective cooperation.
- There is a small set of broadly invoked ethical principles relating to equitable effort-sharing.
- Mitigation measures interact broadly (and sometimes strongly) with other sustainable development objectives, creating co-benefits or adverse side-effects.
- Highly context specific, difficult to quantify yet nonetheless significant both in welfare and political terms. Managing these interactions implies mainstreaming mitigation.