Climate change II. Impacts and mitigation/adaptation

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Climate change impacts

- Melting ice
  - The vast majority of the world´s glaciers are melting faster than are replenished.
  - 1/3 of North Pole´s ice sheets melted since 90s.
- Accelerated sea level rise, increase coastal flooding
  - 20 cm in the last century (40% thermal expansivity, 60% melting of the land ice).
  - Actual rate 3mm/y.
  - Problem for low-lying communities (i.e. Bangladesh).
- Increase in extreme weather events
  - Climate change increases certain types of extreme weather events – heat waves, coastal flooding, extreme precipitation events, more sever droughts.

Climate change impacts

- Increase in extreme weather events
  - Climate change increases certain types of extreme weather events – heat waves, coastal flooding, extreme precipitation events, more severe droughts.
  - Temperature – average kinetic energy of the molecules within a substance = the more radiation trapped in the atmosphere the higher temperature is.

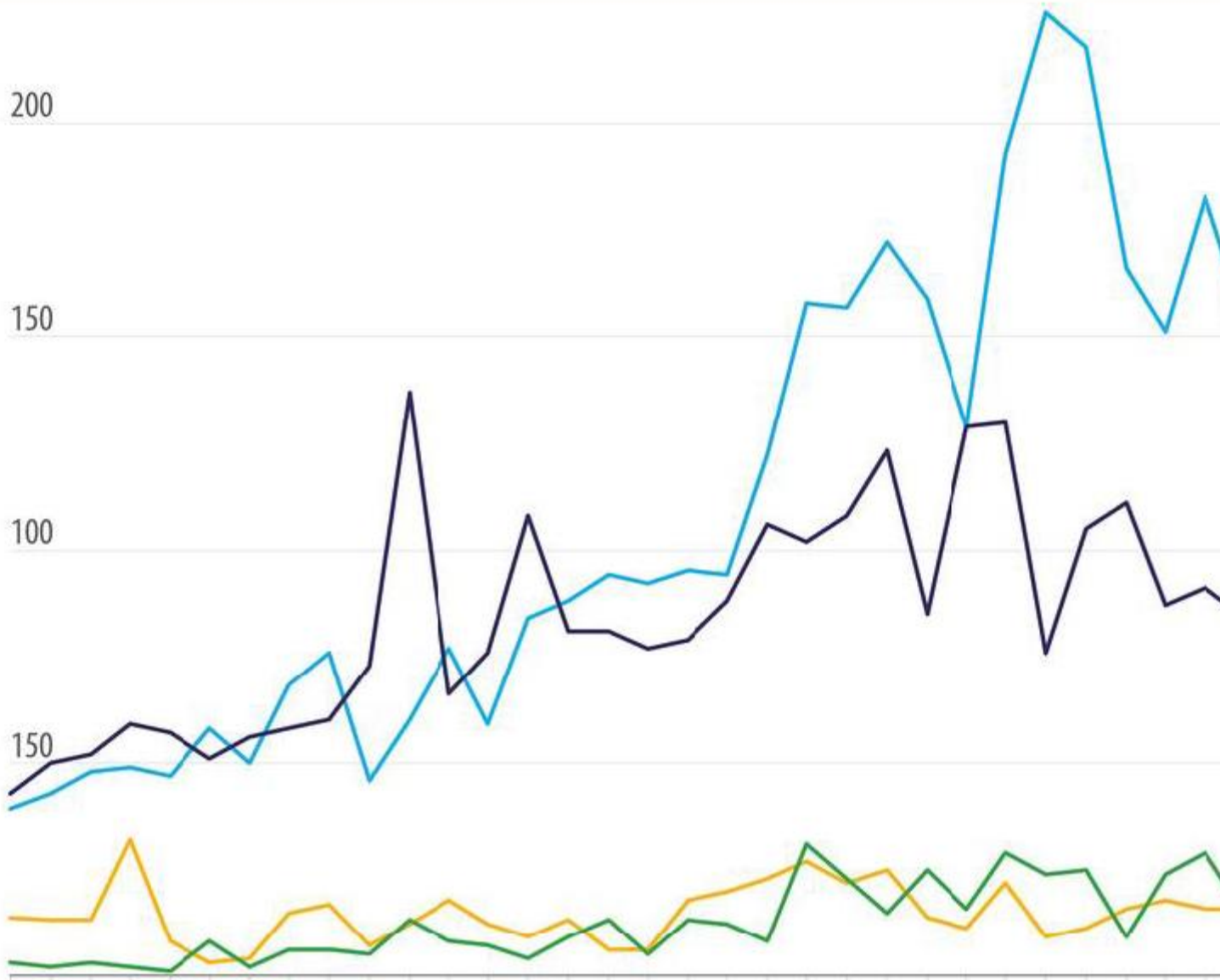
lumber of Climate-related Disasters Around the World (1980-2011)

3455 FLOODS

2689 STORMS

470 DROUGHTS

395 EXTREME TEMPS



UNISDR
nited Nations Office for Disaster Risk Reduction
ww.unisdr.org
d on 13 June 2012
OURCES
T - http://www.emdat.be/ - The OFDA/CRED International
r Database; Data version: 13 June 2012 - v12.07
itarian Symbol Set(2008):
ww.ungiwg.org/nap/guideline.php

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
FLOOD	39	43	48	49	47	58	50	68	76	46	60	77	59	84	88	94	92	95	94	122	158	157	172	159	129	193	226	218	166	151	188
STORM	43	50	52	59	57	51	56	58	60	73	137	66	76	108	81	81	77	79	88	106	102	108	123	85	129	130	76	105	111	87	9
DROUGHT	14	13	13	32	8	3	4	15	17	7	12	18	12	9	13	6	6	18	20	23	27	22	25	14	11	22	9	11	16	18	16
EXTREME TEMPERATURE	3	2	3	2	1	8	2	6	6	5	13	8	7	4	9	13	5	13	12	8	31	23	15	25	16	29	24	25	9	24	29

Climate change impacts

- Health impacts
  - Increased air pollution, a longer and more intense allergy seasons, the spread of insect-borne diseases, more frequent heat waves, flooding = costly risks to public health.
- Food problems and water
  - According to IPCC 1°C = 65 million people starving.
  - Increase of the temperature of more than 2°C = 3 billion people without water supply.
  - Between 18-35% of plant and animal species is committed to extinction by 2050 (oceans are absorbing much of the CO_2 in the air, which leads to ocean acidification – destabilising the whole oceanic food chain). An estimated 1 billion people depend on the ocean for more than 30% of their animal protein.
  - Climate refugees.
- And others…

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Examples of climate extremes leading to migration and conflict since 2000

Type of Climate Event	Region/Country	Time Period *	Major Impacts on Migration	Presence of Conflict	Sources
Drought/soil degradation	Kenya	2004 & 2007	Increase in temporary labor migration with decreasing soil quality	n/a	Gray, 2011 [2]
Heat stress	Pakistan	1991–2012 **	Increase in long-term migration of men	n/a	Mueller *et al.*, 2014 [3]
Forest fires	United States	2010	Increased intention to migrate	n/a	Nawrotzki *et al.*, 2014 [4]
Flooding/Cyclone	Bangladesh	2009	Increase in male rural-urban migration	Moderate evidence of contributing to intra-familial conflict	Mallick & Vogt, 2012 [5]
Flooding	Pakistan	2011–2012	Increase in rural-urban migration	Strong evidence of violent conflict over political power between migrants and non-migrants	Bhattacharyya, & Werz, 2012 [6]
Drought	Syria	2006–2014	Increase in rural-urban migration	Moderate evidence of contributing to violent conflict	Gleick, 2014 [7]
Drought/water scarcity	Western Sahel	2005–present	Increase in labor-related migration of pastoralists	Strong evidence of contributing to clashes between pastoralists and farmers over resources	UNEP, 2011 [8]; Nyong, 2011 [9]
Droughts	Peru & Bolivia	1996–present **	Increase in labor-related migration of farmers due to increasingly devastating droughts	Strong evidence of contributing to conflict between farmers over resources and ethnic conflict between farmers and indigenous migrants	Hoffman & Grigera, 2013 [10]; Carrol & Schipani, 2011 [11]
Desertification	Nigeria	~1993–2013 **	Increase in labor-related migration of farmers due to increasing desertification	Strong evidence of ethnic conflict between farmers over rangeland	Folami, 2013 [12]; Werz & Conley, 2012 [13]

* Time periods are approximate. Ranges are based on data collection time periods when concrete dates were not provided for the climate extreme itself. ** These studies have data collection preceding 2000 but migration and/or conflict occurring after 2000 and as such were included.

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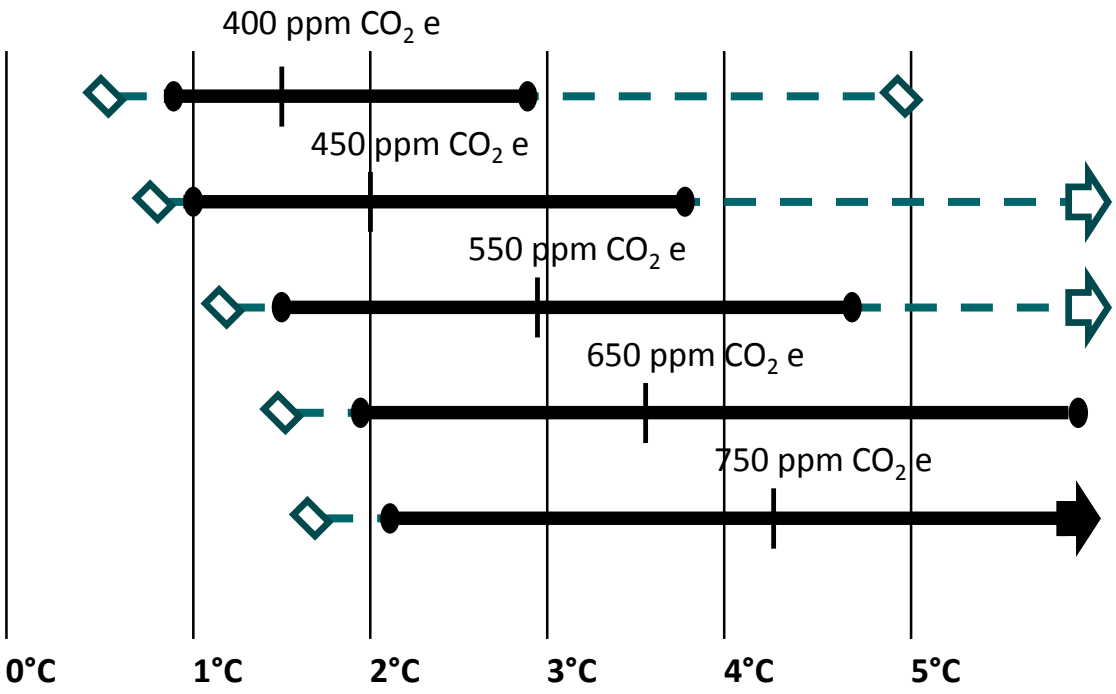
The Relationship Between the Level of Greenhouse Gas Stabilization and Eventual Temperature Change



Eventual Temperature change (relative to pre-industrial)

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Possible (expected) effects of Climate Change

	Eventual Temperature Rise Relative to Pre-Industrial Temperatures				
Type of Impact	**1°C**	**2°C**	**3°C**	**4°C**	**5°C**
Freshwater Supplies	Small glaciers in the Andes disappear, threatening water supplies for 50 million people	Potential water supply decrease of 20–30% in some regions (Southern Africa and Mediterranean)	Serious droughts in southern Europe every 10 years. 1–4 billion more people suffer water shortages	Potential water supply decrease of 30–50% in southern Africa and Mediterranean	Large glaciers in Himalayas possibly disappear, affecting ¼ of China's population
Food and Agriculture	Modest increase in yields in temperature regions	Declines in crop yields in tropical regions (5–10% in Africa)	150–550 million more people at risk of hunger. Yields likely to peak at higher latitudes	Yields decline by 15–35% in Africa. Some entire regions out of agricultural production	Increase in ocean acidity possibly reduces fish stocks
Human Health	At least 300,000 die each year from climate–related diseases. Reduction in winter mortality in high latitudes	40–60 million more exposed to malaria in Africa	1–3 million more potentially people die annually from malnutrition	Up to 80 million more people exposed to malaria in Africa	Further disease increase and insubstantial burdens on health care services
Coastal Areas	Increased damage from coastal flooding	Up to 10 million more people exposed to coastal flooding	Up to 170 million more people exposed to coastal flooding	Up to 300 million more people exposed to coastal flooding	Sea-level rise threatens major cities such as New York, Tokyo, and London
Ecosystems	At least 10% of land species facing extinction. Increased wildfire risk	15–40% of species potentially face extinction	20–50% of species potentially face extinction Possible onset of collapse of Amazon forest	Loss of half of Arctic tundra Widespread loss of coral reefs	Significant extinctions across the globe

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Climate change impacts by region

	People affected each year by 2080s by storm surges with sea-level rise of about 38cm assuming constant protection mechanisms (evolving protection mechanisms)[a]	*Estimated climate refugees due to sea-level rise (slr)*[b]	*Vulnerability to tropical cyclones*[c]	*People at risk of water stress by 2085 due to a temperature increase of 2–3 (depending on population level)*[d]	*Estimates related to drought and water stress*[e]	*Additional number of people at risk of hunger by the 2080s*[f]
Africa	Southern Mediterranean: 13 million (6 million) West Africa: 36 million (3 Million) East Africa: 33 million (5 million)	Egypt: 12 million by 2050 Nigeria: 6–11 million by 2050	Southeast Africa: low to moderate risk	North Africa: 155–599 million South and East Africa: 15–529 million West Africa: 27–517 million	14 African countries currently experience water scarcity. Expected to rise to 24 countries by 2030	Total: 23–200
Asia	South Asia: 98 million (55 million) Southeast Asia: 43 million (21 million)	Bangladesh: 26 million by 2050 China: 73 million India: 20 million by 2050	Major urban centers: moderate to high risk South Asia: moderate risk East Asia: moderate to high risk South East Asia: moderate to high risk	South Asia: 39–812 million West Asia: 95–492 million Central Asia: 14–228 million East Asia: 41–1577 in worst case scenario	Millions at risk due to the glacier melt in the Himalayas. 50–60 percent of world population live in the larger Himalaya-Hindu Kush region and could be affected by water stress	West Asia: 5–134 million Southeast Asia: 2–44 million

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Climate change impacts by region

Latin America	N/A	Venezuela: 56,000 assuming 1m slr and no adaptation measures Uruguay: 13,000 assuming 1m slr and no adaptation measures	Central America: low to high risk Northern Latin America: low risk	Central America: 5–246 million South America: 72–272 million in the worst-case scenario	Glacier melt in the South American Andes could cause water stress under 37 million people by 2010 and 40 million by 2050	Total: 5–85 million
Small island states	Caribbean: 1,350,000 (560,000) Indian Ocean: 920 thousand (460,000) Pacific: 290,000 (160,000)	1 million	Caribbean: low to moderate risk Indian Ocean: low to moderate risk Pacific: low to high risk	Caribbean: 0–73 million	Water availability could become too low during low rainfall seasons	N/A.

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Important Events in International Climate Change Negotiations

Year, Location	Outcome
1992, Rio de Janeiro	UN Framework Convention on Climate Change (UNFCCC). Countries agree to reduce emissions with "common but differentiated responsibilities."
1995, Berlin	The first annual Conference of the Parties to the framework, known as a COP. U.S. agrees to exempt developing countries from binding obligations.
1997, Kyoto	At the third Conference of the Parties (COP-3) the Kyoto Protocol is approved, mandating developed countries to cut greenhouse gas emissions relative to baseline emissions by 2008-2012 period.
2001, Bonn	(COP-6) reaches agreement on terms for compliance and financing. Bush administration rejects the Kyoto Protocol; U.S.is only an observer at the talks.
2009, Copenhagen	COP-15 fails to produce a binding post-Kyoto agreement, but declares the importance of limiting warming to under 2°C. Developed countries pledge $100 billion in climate aid to developing countries.
2011, Durban	(COP-17) participating countries agreed to adopt a universal legal agreement on climate change as soon as possible, and no later than 2015, to take effect by 2020.
2015, Paris	COP-21 195 nations sign the Paris Agreement, providing for worldwide voluntary actions (INDC's) by individual countries.

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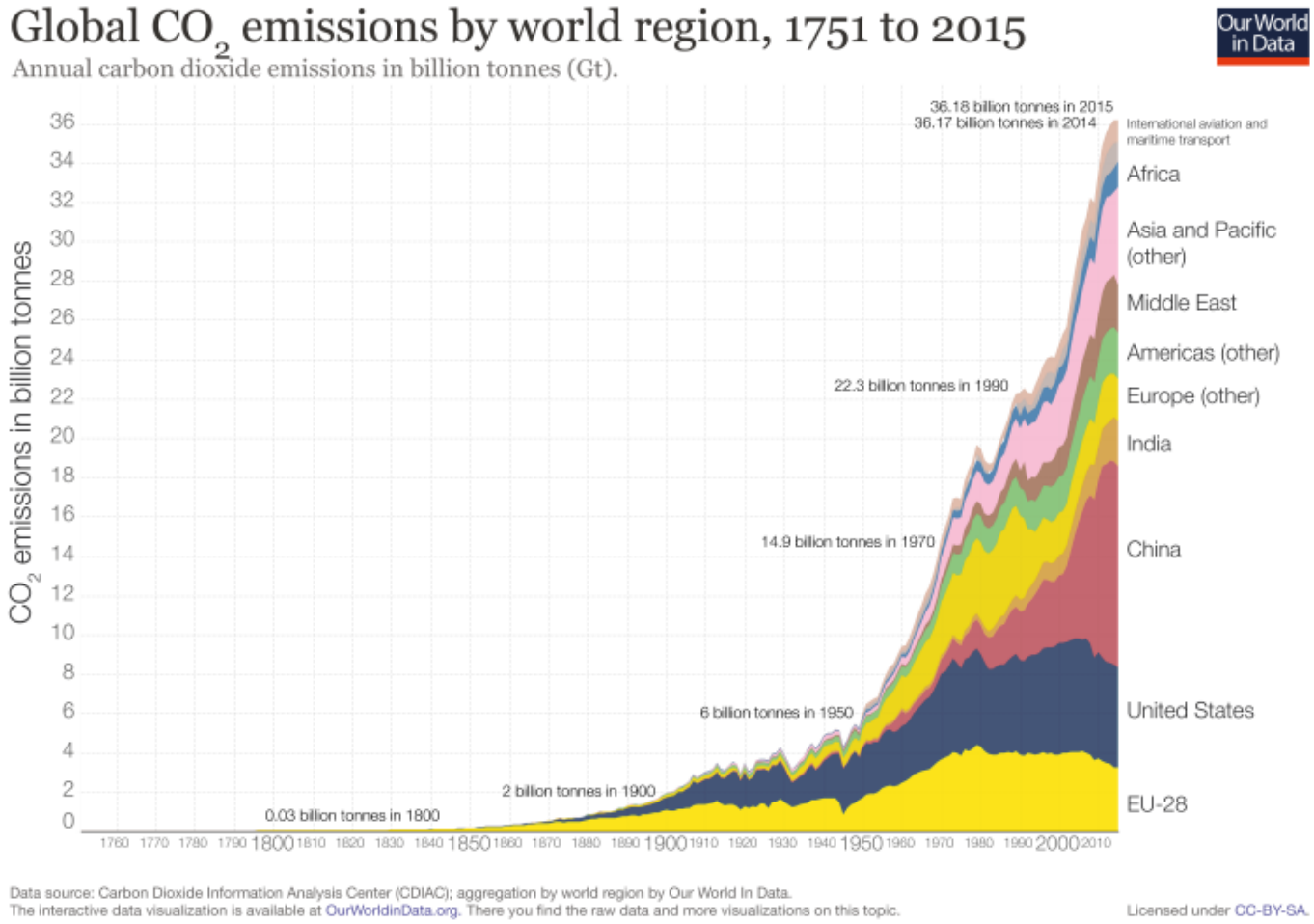
Mitigation or adaptation?



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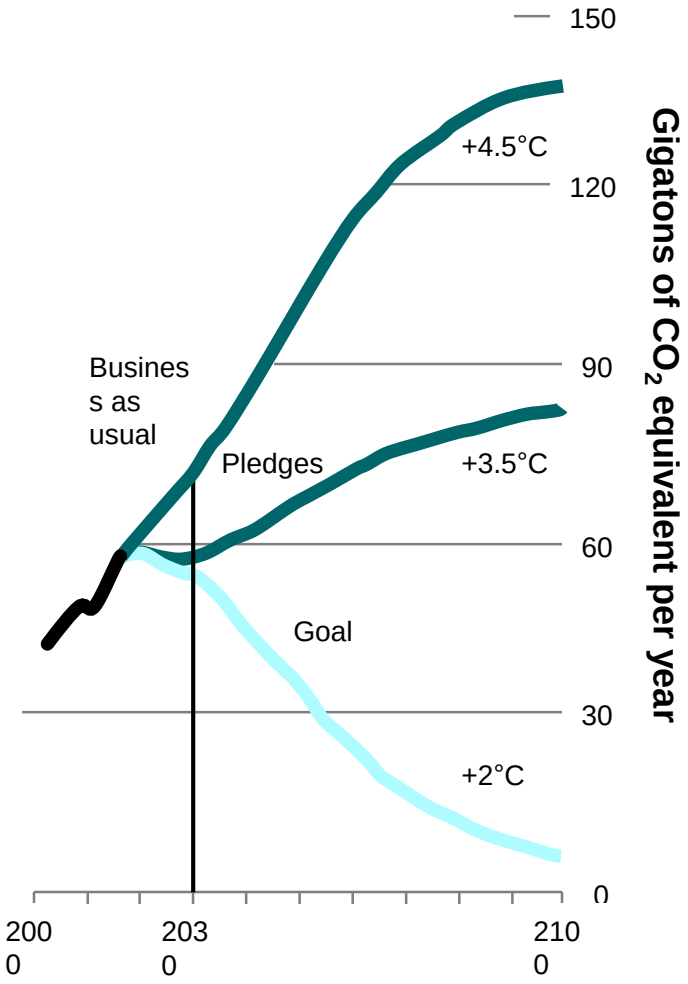
Mitigation or adaptation?



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A wide range of energy and climate policies reduce greenhouse gas emissions

Policy Type	Policy options
Price-based instruments	Taxes on CO_2 directly Taxes/charges on inputs or outputs of process (*e.g.* fuel and vehicle taxes) Subsidies for emissions-reducing activities Emissions trading systems (cap and trade or baseline and credit)
Command and control regulations	Technology standards (*e.g.* biofuel blend mandate, minimum energy performance standards) Performance standards (*e.g.* fleet average CO_2 vehicle efficiency) Prohibition or mandating of certain products or practices Reporting requirements Requirements for operating certification (*e.g.* HFC handling certification) Land use planning, zoning
Technology support policies	Public and private RD&D funding Public procurement Green certificates (renewable portfolio standard or clean energy standard) Feed-in tariffs Public investment in underpinning infrastructure for new technologies Policies to remove financial barriers to acquiring green technology (loans, revolving funds)
Information and voluntary approaches	Rating and labelling programmes Public information campaigns Education and training Product certification and labelling Award schemes

Source: Hood (2011), based on de Serres, Murtin and Nicolleti (2010).

Carbon pricing

- To decrease demand we need to raise its cost. Trying to find the balance of the costs and benefits of carbon production, not to reducing it entirely. To internalize the externalities.
- Instruments that reach throughout the economy, influencing all production and consumption decisions.
- 1) Figuring out how much carbon we want to put into the environment. 2) Then a cost must be applied:
  - applying tax on it (Pigouvian tax)
  - cap-and-trading
- Both these systems raise some revenue that could be used to offset the negative macroeconomic impacts of energy price rises

Carbon taxes

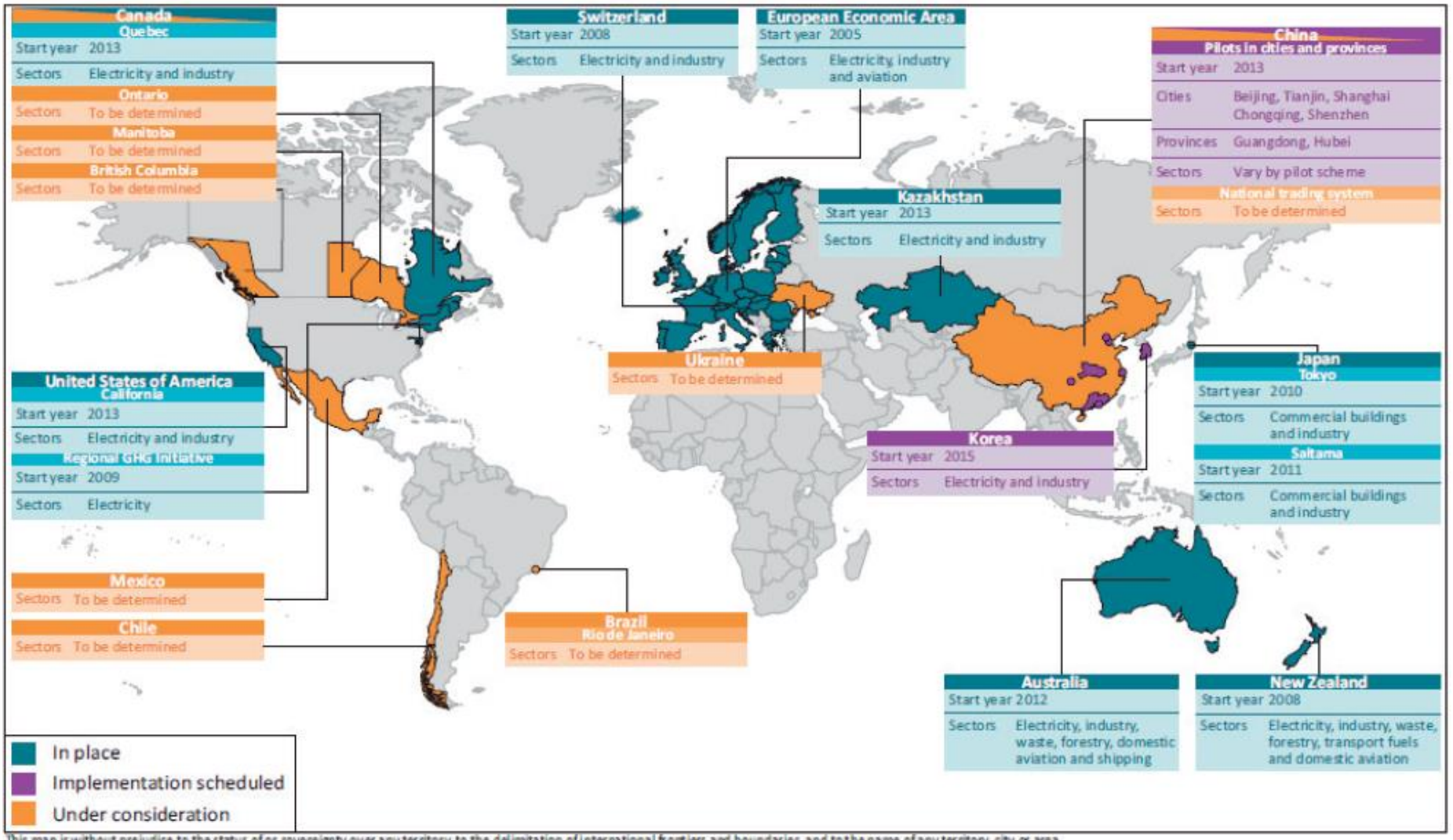
- Norway – CO2 tax introduced in 1991. Applied to oil products, emissions from oil and gas production and gas used for heating and transport. Sectors covered by EU ETS exempted from carbon tax, with exeption of the offshore oil and gas sector. From 2013 the tax level has been increased to offset the falling EUA price.
- Japan – introduced in 2012 to raise revenue for energy efficiency and RES programmes, not as a direct price incentive.
- Switzerland – CO2 levy intended as an incentive for energy efficiency and for shifting toward cleaner heating and proces fuels (not to raise revenue). In place since 2008. Increased from 12 CHF/tCO2 to 120 CHF/tCO2.
- British Columbia (Canada) – introduced in 2008 at USD10/ton, eventually reached USD30/ton. Revenue neutral, compensated by income and corporate tax cuts. Consumption fuels dropped by 5-15%, while in the rest of Canada increased by about 3%. GDP continued to increase.

Cap and trade systems

- A government assigns to itself the right to put emissions into the environment.
- It defines what it believes to be the socially optimal quantity of emissions.
- The govevernment generates a number of permits equal to the amount of allowable emissions.
- These permits are allocated to emitters to trade with them – market is created.

= economically efficient, provides incentives for efectivity of the system. To develop technology that would allow one to reduce emissions at a cost lower than that of buying a permit, that spurs innovation and technological development.

Current and proposed emissions trading systems



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

Source: IEA (2013a)

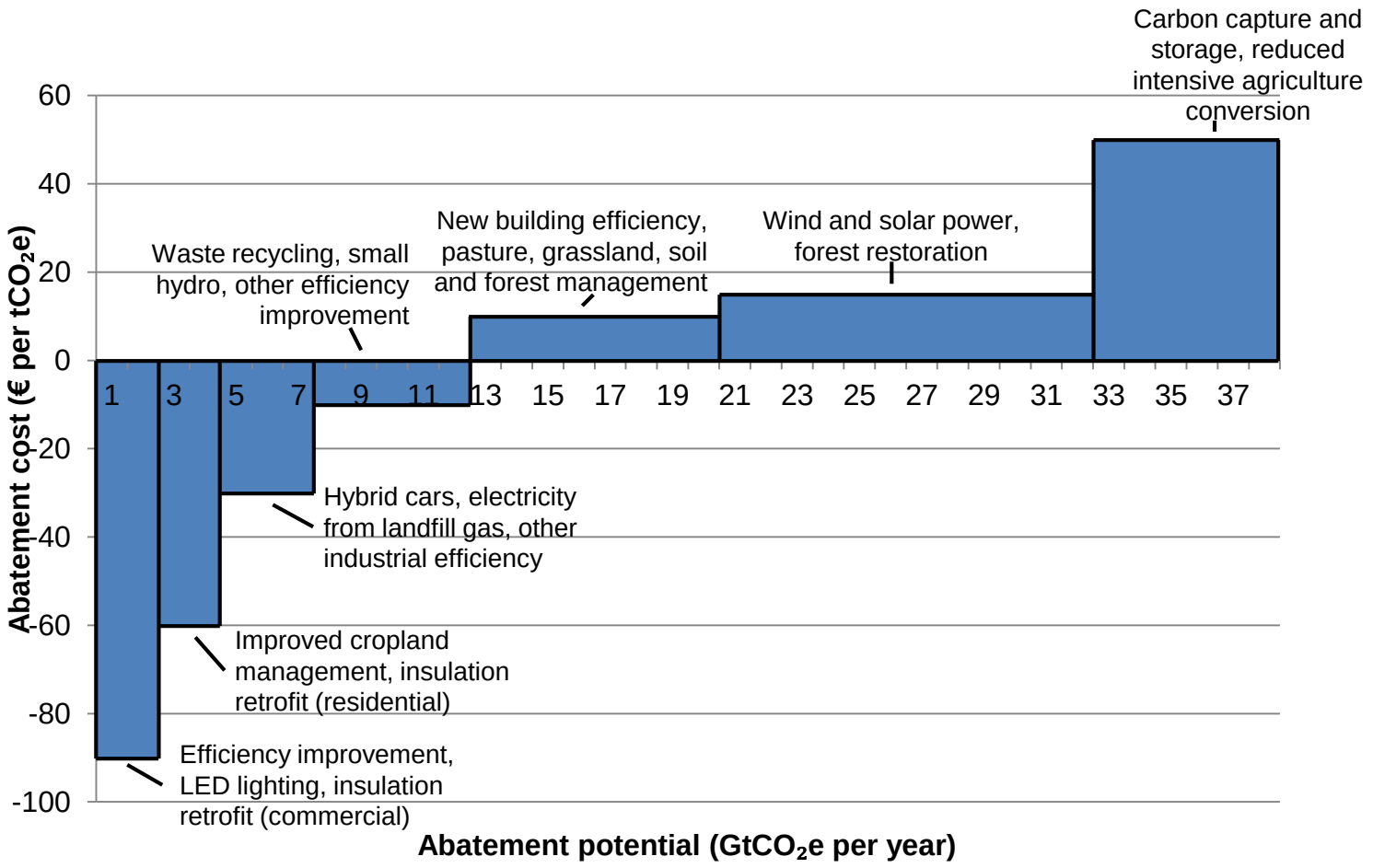
Carbon tax vs. cap and trade system

- Carbon tax:
  - Simpler to understand, easier to built, more transparent.
  - Keeps pushing for reducing the emissions despite technology development.
  - Is to be implemented more quickly
  - Greater price predictability
- Cap and trade system
  - Avoids negative connotation of ´tax´
  - Some companies are effective in lobbying for exemptions
  - Known reduction of emissions, unknown price

Energy policies that affect emissions

- Energy taxes and subsidies
  - Non-climate objectives (funding of infrastructure, revenue rasing), can shift the average and relative prices of fuels, therefore act as a significant carbon price. (and vice versa).
- Energy efficiency
  - The primary motivation for energy efficiency policies is cost savings to consumers and society, improved energy security. Emissions savings a positive by-product.
  - Performance standards, information and labelling, energy provider obligations in lightning, equipment and buildings.
- Development and deployment of low-carbon supply technologies
  - Technology support policies – research development to demonstration projects to support for deployment

Global Greenhouse Gas Abatement Cost Curve for 2030



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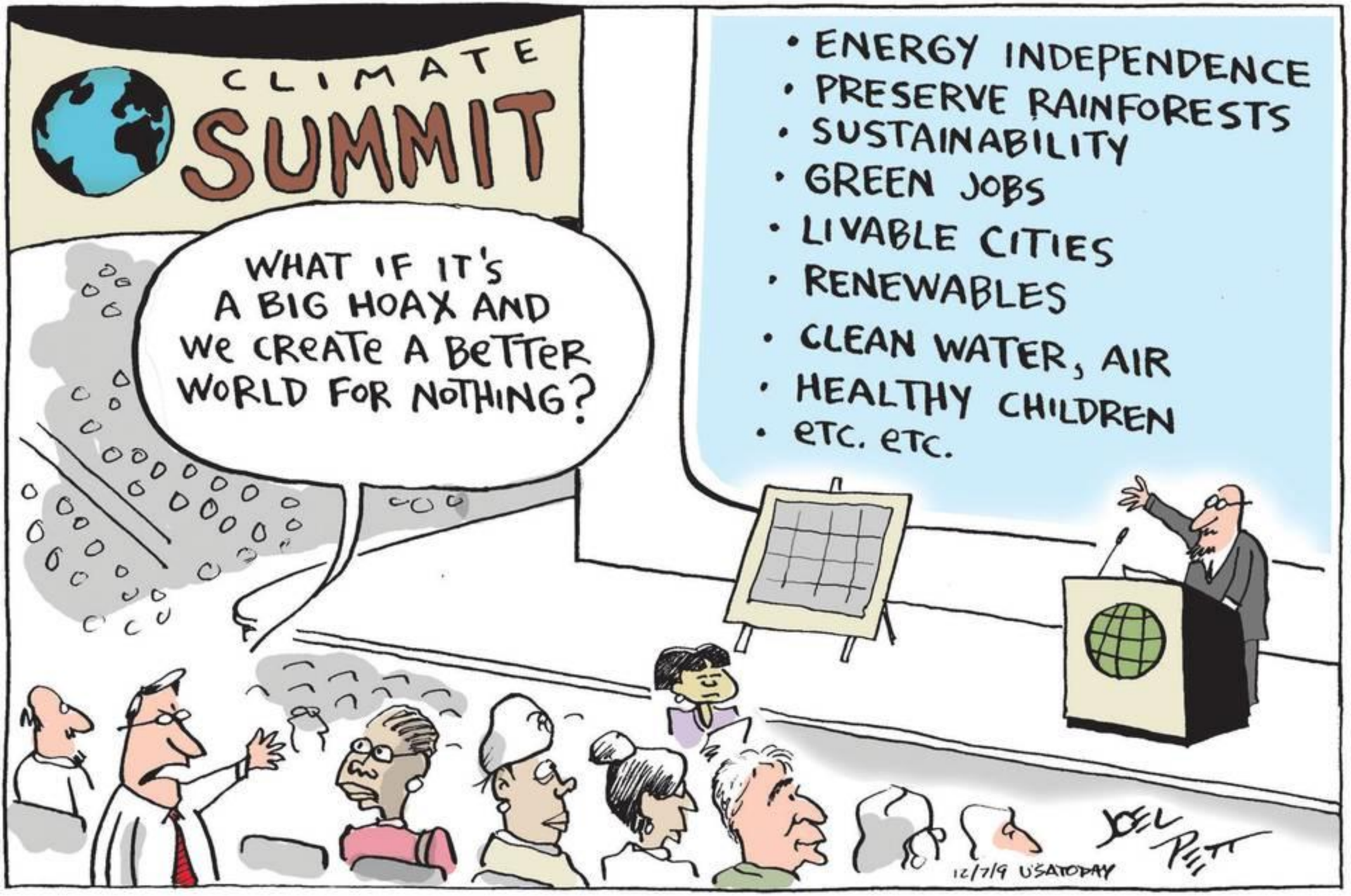

Author: Joel Pett

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Climate Change Adaptation Needs, by Sector

Sector	Adaptation strategies
Water	Expand water storage and desalination
	Improve watershed and reservoir management
	Increase water-use and irrigation efficiency and water re-use
	Urban and rural flood management
Agriculture	Adjust planting dates and crop locations
	Develop crop varieties adapted to drought, higher temperatures
	Improved land management to deal with floods/droughts
	Strengthen indigenous/traditional knowledge and practice
Infrastructure	Relocate vulnerable communities
	Build and strengthen seawalls and other barriers
	Create and restore wetlands for flood control
	Dune reinforcement
Human health	Health plans for extreme heat
	Increase tracking, early-warning systems for heat-related diseases
	Address threats to safe drinking water supplies
	Extend basic public health services

Climate Change Adaptation Needs, by Sector

Sector	Adaptation strategies
Transport	Relocation or adapt transport infrastructure
	New design standards to cope with climate change
Energy	Strengthen distribution infrastructure
	Address increased demand for cooling
	Increase efficiency, increase use of renewables
Ecosystems	Reduce other ecosystem stresses and human use pressures
	Improve scientific understanding, enhanced monitoring
	Reduce deforestation, increase reforestation
	Increase mangrove, coral reef, and seagrass protection

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Sources

- Wagner, G.; Weitzman, M.L.(2015: Climate Shock: The Economic Consequences of a Hotter Planet
- Figueres, Ch.-Ivanova, H.M.: Climate Change: National Interests or a Global Regime?
- IEA: CO_2 Emission from Fuel Combustion
- Carbon Brief
- Center for Climate and Energy Solutions
- Harris, J.M.; Roach, B.; Codur, A-M.(2017): The Economics of Global Climate Change. A GDAE module
- Ritchie, H.; Roser, M.: CO2 and other Greenhouse Gas Emissions. Our World in Data
- Biermann, F.; Boas, I.(2010): Preparing for a Warmer World: Towards a Global Governance System to Protect Climate Refugees
- Burrows, K.; Kinney,L.(2015): Exploring the Climage Change, Migration and Conflict Nexus

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