Climate Change and Sustainability in a Mediterranean island state context

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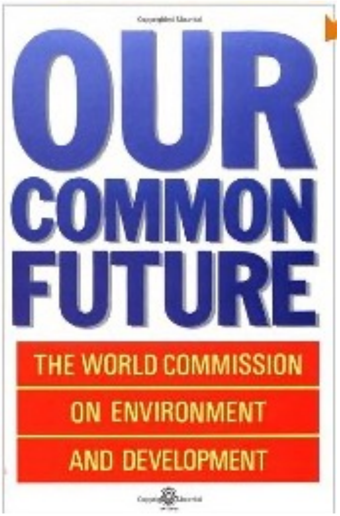
Realities about Climate Change & Pollution
Interactive Session - NWAMI International Malta – 10 December 2022

Sustainability, Need, Limitations and Equity

- The notion of **needs** – the essential needs of the world's poor, to which overriding priority should be given to eradicate poverty
- The belief in **limitations** – imposed by the environment's ability to meet present and future needs
- More then just 'you should not destroy the basis of your own existence' - it is really more a question of **equity between generations and within generations**



Risk and Equity

- Dispute between environmentalists and economists is not only about capacity of technology.
- We do not understand our environment enough, so how do we deal with indeterminate risks?
- Economists iron out risks by averaging, whilst environmentalists highlight the risks only.


2010 EYJAFJALLAJÖKULL AND FIMMVÖRÐUHÁLS ERUPTIONS IN ICELAND


2004 INDIAN OCEAN EARTHQUAKE AND TSUNAMI


2021 WILDFIRES IN CANADA

The Arguments put forward…

- What should be done is investments in substitutes OR investments in education to curtail the use of that natural capital?
- Another aspect is the idea of a ‘natural’ capital that cannot be substituted by technology and must be preserved absolutely.


Plitvice Lakes, Croatia


Madeira Island, Portugal


Comino Island, Malta

https://www.europeanbestdestinations.com/

Environmental Costs

- Historically the environmental costs of human activities have been easy to ignore.
- Market forces have not succeeded in properly pricing environmental assets.
- Most of these are easily accessible and therefore easily exploited.
- Pollution and resource depletion result from environmental costs not being *adequately* paid.
- Part of what environmental legislation does is internalise these costs.

Are costs real?

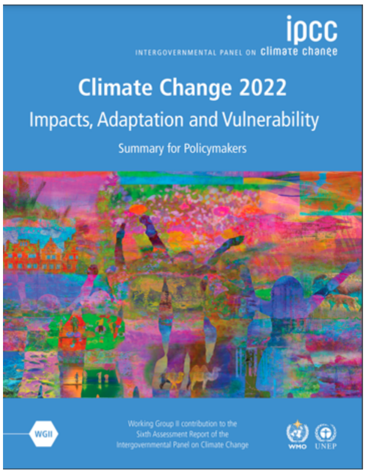
Human Activity	Environmental Cost
Using Environmental Resources	Resource depletion
Damaging of Environmental Assets	Remediation
Creating Risk of Environmental Damage	Monitoring and prevention
Causing danger to the public	Emergency procedures

Source: Adapted from McLoughlin and Bellinger, 1993, pages 152-153

Sustainability and Climate Change

The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) is clear in

- (i) attributing the widespread and rapid changes we are experiencing in the atmosphere, ocean, cryosphere and biosphere to human influence;
- (ii) describing the scale of recent changes across the climate system as unprecedented over many centuries to many thousands of years, and
- (iii) providing the evidence of observed changes in weather and climate extremes in every region of the globe with heatwaves, heavy precipitation, droughts and tropical cyclones, all attributed to human influence (IPCC, 2021).



Sustainability and Climate Change

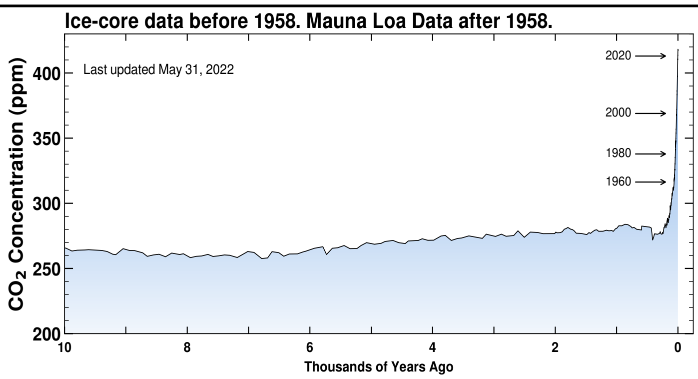
- In summer 2021 the United Nations Chief António Guterres dubbed the IPCC AR6 scientific report as a “code red for humanity”. The IPCC scientists warn of global warming of 2ºC being exceeded during the 21st century and that unless rapid and deep reduction in CO_2 and other greenhouse gas emissions occur, achieving the goals of the 2015 Paris agreement, of limiting the increase in global temperature to 1.5ºC, will be impossible.
- The report states that net anthropogenic greenhouse gas emissions have increased since 2010 across all major sectors globally.

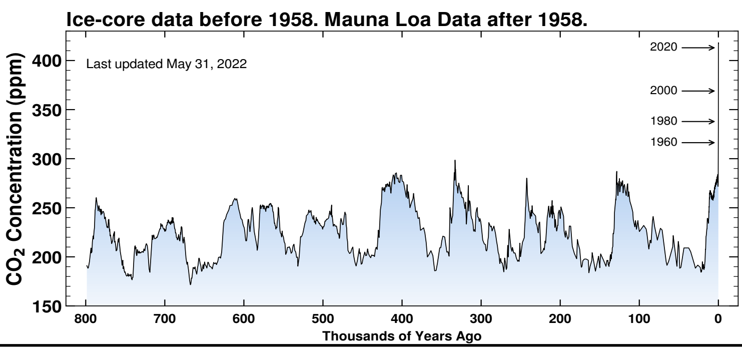
Climate Change – a definition

A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

Climate varies continually on all time scales. Detection of climate change is the process of demonstrating that climate has changed in some defined statistical sense, without providing a reason for that change. Attribution of causes of climate change is the process of establishing the most likely causes for the detected change with some defined level of confidence.

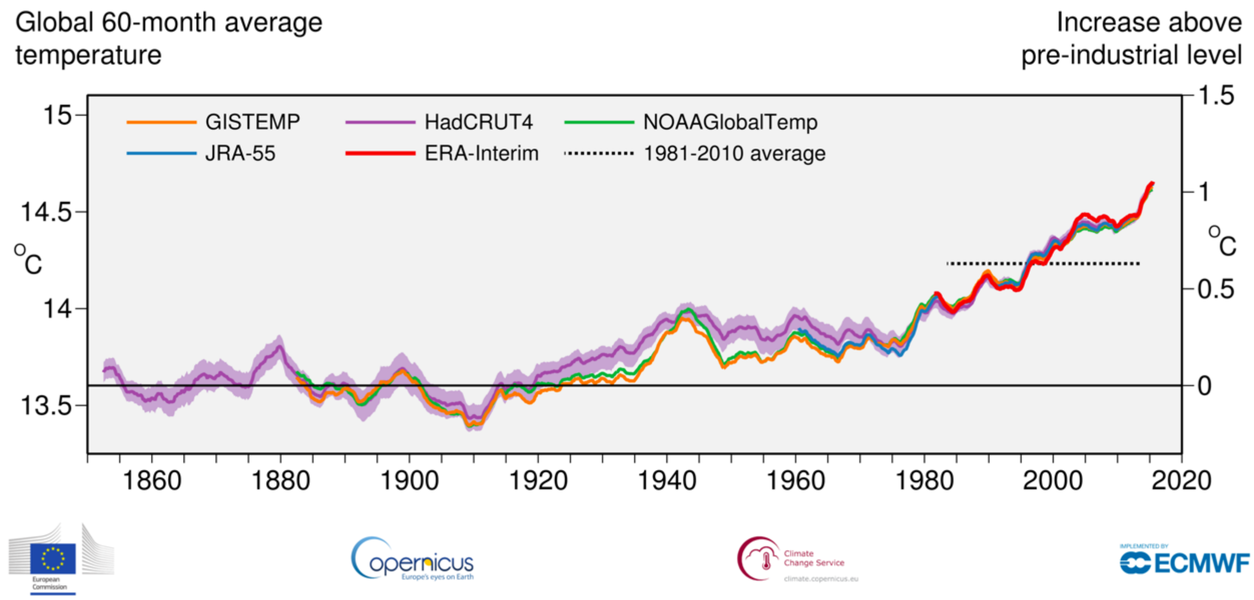
Source: https://archive.ipcc.ch/pdf/special-reports/srex/SREX-Annex_Glossary.pdf



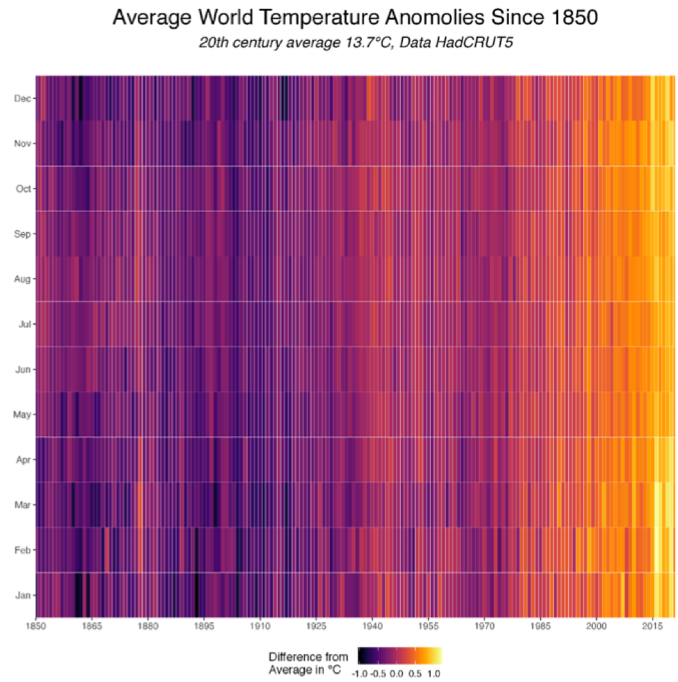


CO_2 concentrations over 10,000 years and over 800 thousand years.

Source: Scripps Institution of Oceanography, 2022; Keeling et al., 2001; MacFarling Meure et al., 2006; Lüthi et al., 2008. https://keelingcurve.ucsd.edu/permissions-and-data-sources/



https://climate.copernicus.eu/last-four-years-have-been-warmest-record-and-co2-continues-rise



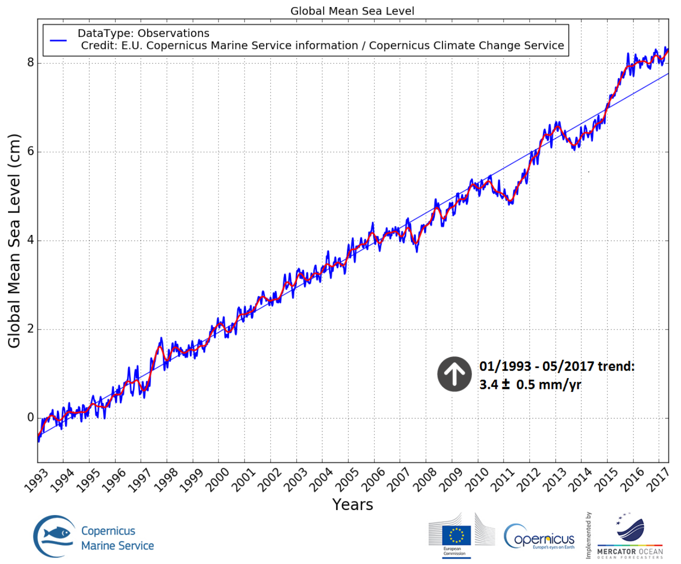


Figure 2.2 Global sea level rise for the period 01/1993 to 05/2017

Source: Downloaded 2nd January 2019 from EU Copernicus Marine Service Information http://marine.copernicus.eu/science-learning/ocean-monitoring-indicators/

(1) Complex social and ecological systems

- Much of the change that happens to natural ecosystems is due to human interrelationships.
- In order to manage resources and the environment it is necessary to think in terms of **socio-ecological systems** and the way they work.
- Although it makes a lot of sense to think of the problem in this manner, implementation on the ground can be quite challenging.

Questions about socio-ecological systems

- What should be the scope and nature of the social and ecological systems to be considered, along with their interactions?
- Where do we begin to start understanding what are often termed complex adaptive systems , which are normally evolving and influenced by multiple and interacting forces?
- Given most of our knowledge is incomplete and sometime inaccurate, how do we handle the complexity and uncertainty associated with the socio-ecological system?
- How do we identify, understand, and bring together the different values, aspirations, motivations, preferences and capacities of different stakeholders when there is (almost always misunderstanding, mistrust and conflict)?

(2) The Anthropocene

TABLE 1.1 Geological Time Scale

Era	Period	Epoch
Cenozoic 65.5 million years ago to today	Quaternary 2.588 million years ago to today	Holocene 11,700 years ago to today
		Pleistocene 2.588 million years ago to 11,700
	Neogene	
	Paleogene	
Mesozoic 250.0 to 65.5 million years ago	Cretacious	
	Jurassic	
	Triassic	

Mitchell, B. 2019. Resource and Environmental Management. OUP

- Earth is 4.54 billions years old.
- In 2000 Crutzen and Stoermer suggested a new epoch – the Anthropocene.
- Humankind's activities and impact had become a major geological and morphological force and it was time to recognize it as a reality.

The Anthropocene

- The International Commission on Stratigraphy assigned a subcommittee to provide recommendations of this proposal.
- In Oslo in April 2016 the committee voted in favour of officially declaring the Anthropocene - designated to have begun in about 1950.
- This recommendation was passed on to the International Geological Congress which approved it in Cape Town in August 2016.
- The basis for the recommendation was the remarkable acceleration of CO2 emissions, sea-level rise, mass extinction of species and deforestation and development (Carrington, 2016)
- The task now is to identify the markers in geology: nuclear radiation, CO2, nitrogen and phosphate in soil?

(3) Wicked Problems (Rittel & Webber, 1973)

- The wicked problem concept revolves around the planning problems which are challenged by numerous stakeholders with diverse values, attitudes and preferences which makes identifying solutions very difficult.
- “Planning problems are often ill-defined; and they rely on elusive political judgement of resolution (note that social problems are never solved - at best they are re-solved over and over again).
- The choice of “wicked” describes problems to reflect attributed such as malignancy, viciousness, trickiness and aggressiveness. They list 10 properties of Wicked Problems:

TABLE 1.2 Properties of Wicked Problems

1. There is no definitive formulation of a wicked problem because information needed to understand the problem is a function of options considered to solve it.
2. Wicked problems have no stopping rule or ultimate solution, and effort allocated to them is influenced by available time, resources, and determination.
3. Solutions to wicked problems are not true or false, but are good or bad, a judgment influenced by the values of those assessing them.
4. There is neither an immediate nor ultimate test of a solution to a wicked problem because implementation of a solution triggers consequences over a long period of time, with some consequences unexpected and so undesirable that it would have been better to have done nothing.
5. Every solution to a wicked problem is a one-shot operation, and because results often cannot be undone, opportunity frequently does not exist to learn by trial and error (e.g., large public works are usually irreversible).
6. Wicked problems do not have an obvious set of definitive solutions.
7. Every wicked problem is distinctive, and often even unique. Thus, no categories of wicked problems can be created in the sense that principles or solutions will align with every specific problem.
8. Every wicked problem will be a symptom of another problem at a lower and/or higher spatial scale.
9. The presence of one or more discrepancies associated with a wicked problem can be explained in numerous ways. This reinforces point (7) that each wicked problem is at least distinctive and often unique.
10. A planner has no right to be wrong or incorrect, given that the environment, economy, and people will be affected by decisions taken, and impacts of decisions taken can be significant and long-term.

Source: Rittel and Webber, 1973: 161–167.

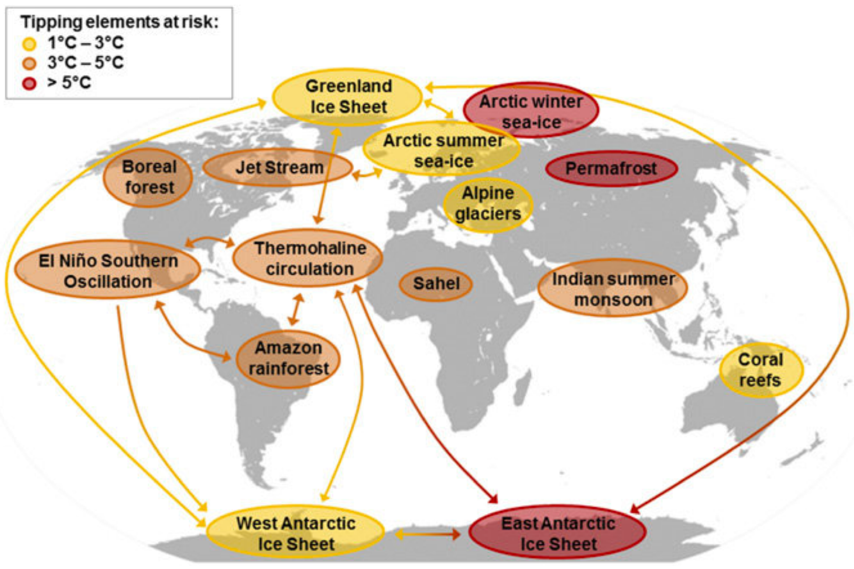
Mitchell, B. 2019. Resource and Environmental Management. OUP

Climate Change as a Wicked Problem

- Lazarus (2009) terms climate change as a "super wicked problem" because of:
  - The legal and regulatory difficulties
  - Short/long term variations of impact on cost and benefits shift over time
  - Impacts occur at different scales adding complexity and uncertainty
  - Science behind climate change and role of human has been constantly challenged
  - At national scale, many just want to protect their economy

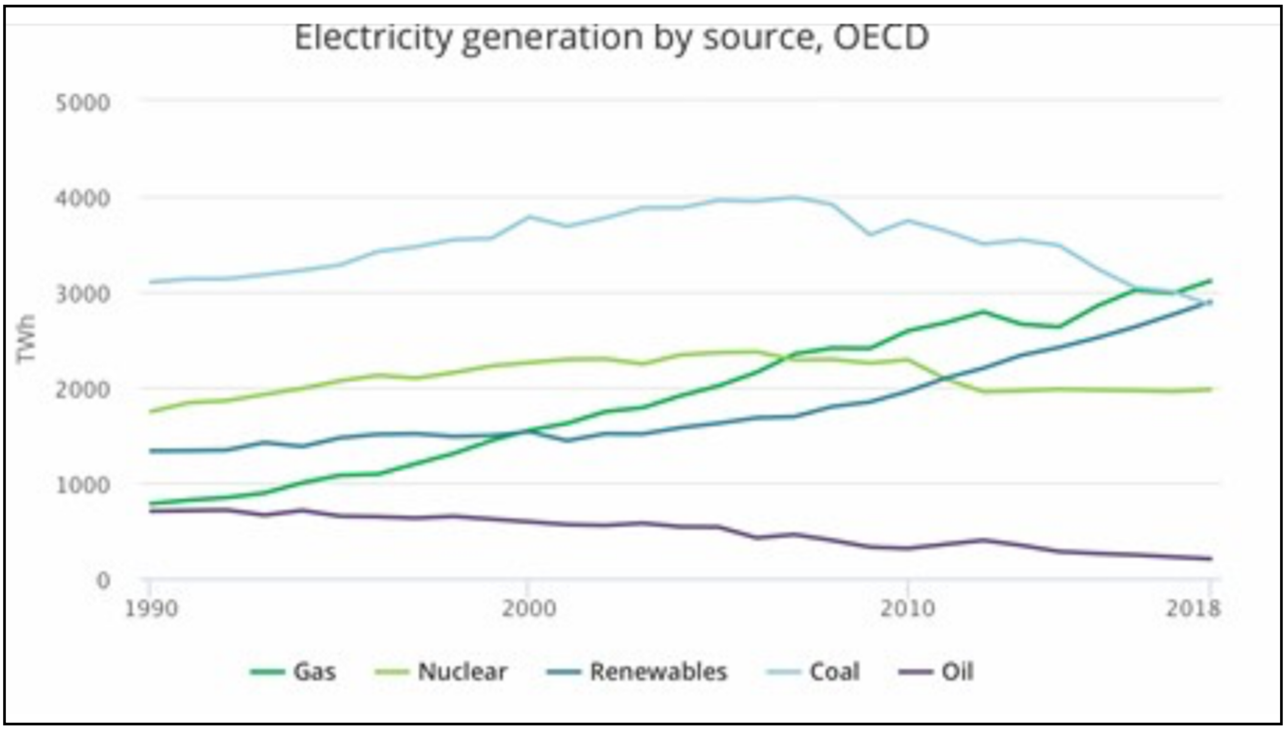
(4) Tipping Points

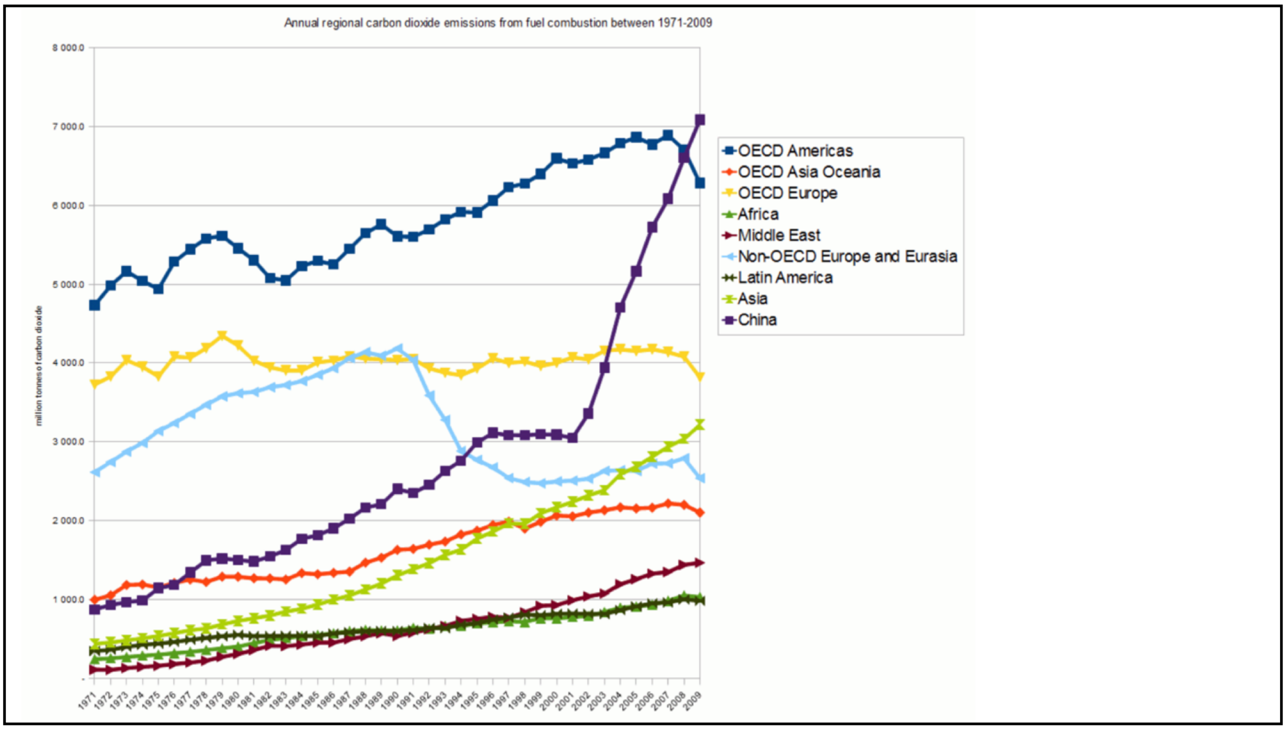
- The concept of tipping points is very important in environmental management.
- Just as the change from one epoch to the other were relatively drastic due to external changes (Holocene from a lengthy glacial episode to a more variable climate) there can be sudden shocks to the earth system to change once again – critical transitions.
- These are gradual, steady, and cumulative change in complex socio-ecological systems may evolve incrementally to reach a tipping point, a term to identify a catastrophic bifurcation.
- When a tipping point is reached, a minor driving trigger can propel the system into a totally different state – positive or negative.

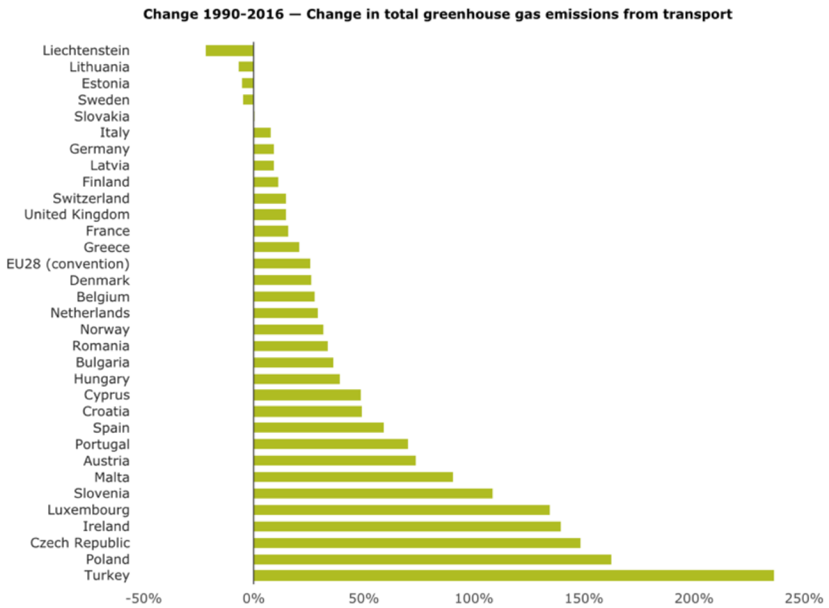


Global map of potential tipping cascades. The individual tipping elements are color- coded according to estimated thresholds in global average surface temperature (tipping points). Arrows show the potential interactions among the tipping elements based on expert elicitation that could generate cascades.

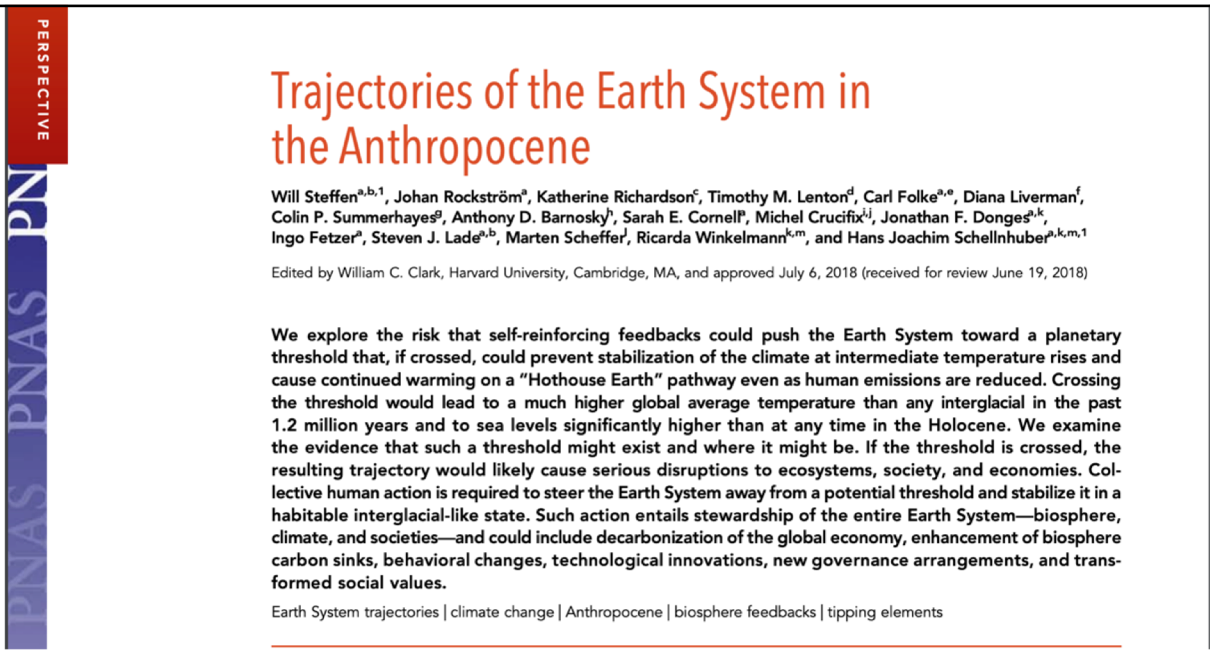
Steffen et al. 2018 Available at https://www.pnas.org/content/pnas/115/33/8252.full.pdf


Electricity generation by source, OECD
5000
4000
3000
2000
1000
0
TWh
1990
2000
2010
2018
Gas
Nuclear
Renewables
Coal
Oil


Annual regional carbon dioxide emissions from fuel combustion between 1971-2009
8 000.0
7 000.0
6 000.0
5 000.0
4 000.0
3 000.0
2 000.0
1 000.0
million tonnes of carbon dioxide
1971 1972 1973 1974 1975 1976 1977 1978 1979 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
OECD Americas
OECD Asia Oceania
OECD Europe
Africa
Middle East
Non-OECD Europe and Eurasia
Latin America
Asia
China



Source: https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-greenhouse-gases/transport-emissions-of-greenhouse-gases-11


PERSPECTIVE

Trajectories of the Earth System in the Anthropocene

Will Steffen[a,b,1], Johan Rockström[a], Katherine Richardson[c], Timothy M. Lenton[d], Carl Folke[a,e], Diana Liverman[f], Colin P. Summerhayes[g], Anthony D. Barnosky[h], Sarah E. Cornell[a], Michel Crucifix[i,j], Jonathan F. Donges[a,k], Ingo Fetzer[a], Steven J. Lade[a,b], Marten Scheffer[l], Ricarda Winkelmann[k,m], and Hans Joachim Schellnhuber[a,k,m,1]

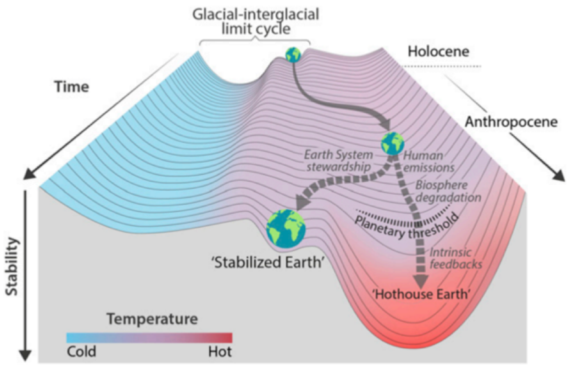
Edited by William C. Clark, Harvard University, Cambridge, MA, and approved July 6, 2018 (received for review June 19, 2018)

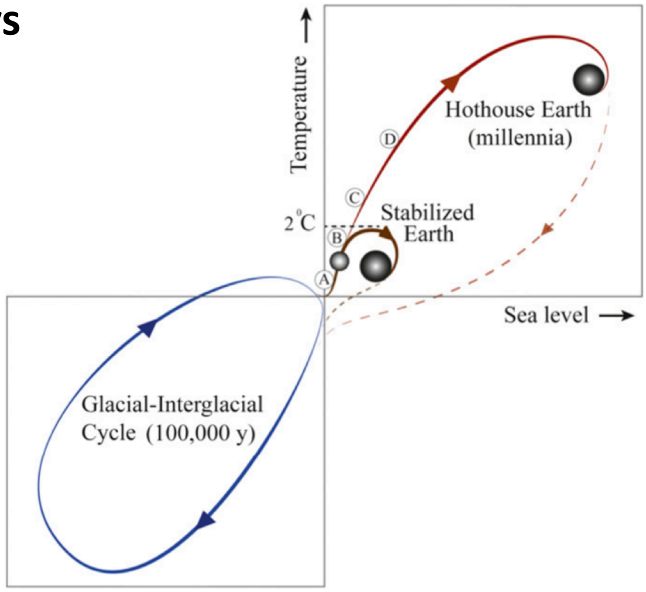
We explore the risk that self-reinforcing feedbacks could push the Earth System toward a planetary threshold that, if crossed, could prevent stabilization of the climate at intermediate temperature rises and cause continued warming on a "Hothouse Earth" pathway even as human emissions are reduced. Crossing the threshold would lead to a much higher global average temperature than any interglacial in the past 1.2 million years and to sea levels significantly higher than at any time in the Holocene. We examine the evidence that such a threshold might exist and where it might be. If the threshold is crossed, the resulting trajectory would likely cause serious disruptions to ecosystems, society, and economies. Collective human action is required to steer the Earth System away from a potential threshold and stabilize it in a habitable interglacial-like state. Such action entails stewardship of the entire Earth System—biosphere, climate, and societies—and could include decarbonization of the global economy, enhancement of biosphere carbon sinks, behavioral changes, technological innovations, new governance arrangements, and transformed social values.

Earth System trajectories | climate change | Anthropocene | biosphere feedbacks | tipping elements

Source: https://www.pnas.org/content/pnas/115/33/8252.full.pdf

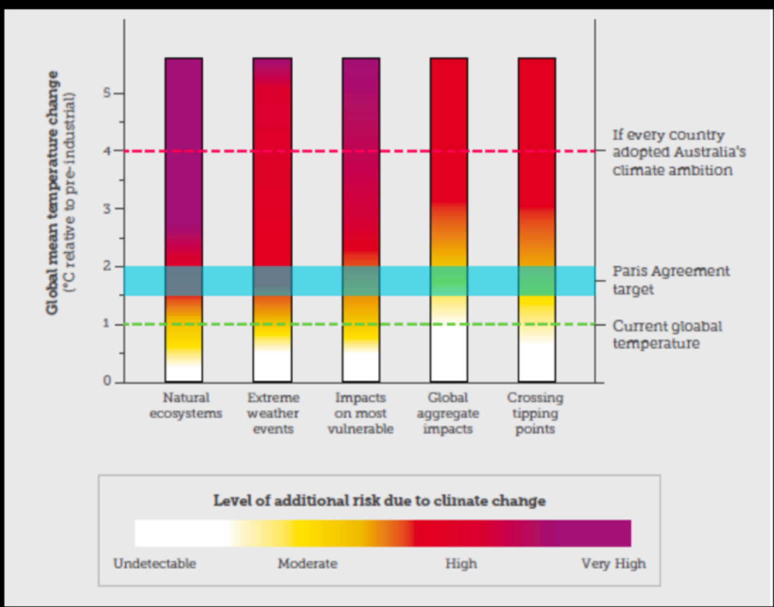
The Hothouse Earth Pathways





Source: Steffen et al. 2018

IPCC "Reasons for Concern"



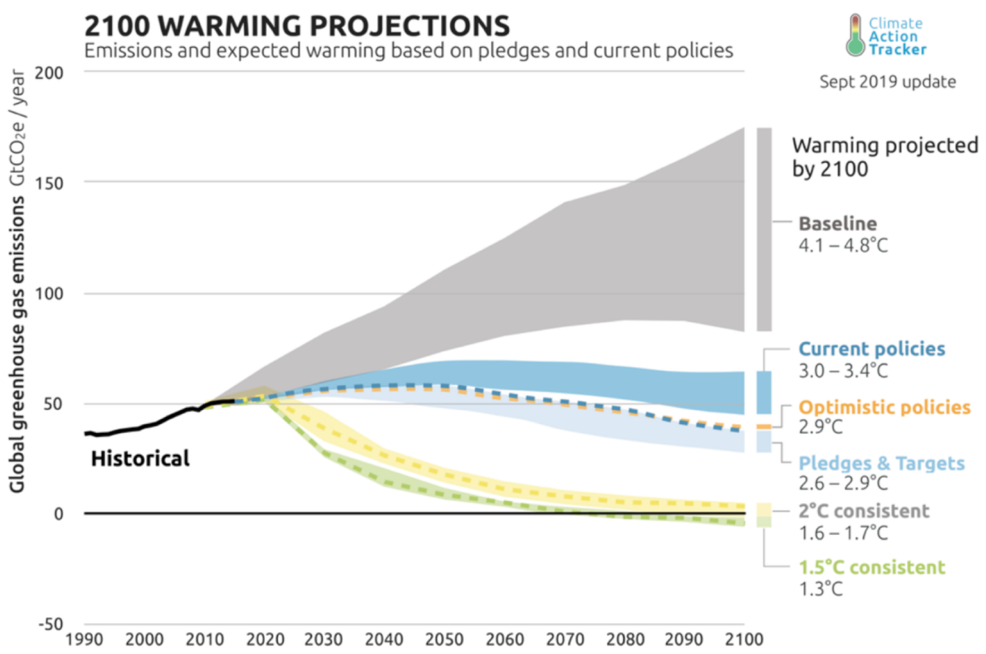
Adapted from IPCC 2014

IPCC TAR (2001), AR4 (2007), AR5 (2014), Smith et al. (2009)

Can the Paris Agreement target be reached?

- The total carbon budget from 1870 is about 1,000 Gt C (emitted as CO_2) for a 66% probability of meeting the 2°C target.
- Cumulative human emissions (fossil fuels, cement, land use) from 1870 to 2018 were about 585 Gt C, leaving 415 Gt C in the budget.
- Accounting for non-CO_2 gases (e.g. N_2O) reduces the C budget by 210 Gt C.
- The remaining budget is 205 Gt C in total.
- At current rates of 10 Gt C per year, the budget would last only two decades.

Sources: IPCC AR5



Keep up to date with the Climate Action Tracker online

Conclusions: Building Resilience in a Rapidly Changing Earth System (Steffen et al. 2018)

- Even if a Stabilized Earth pathway is achieved, humanity will face a turbulent road of rapid and profound changes and uncertainties on route to it—politically, socially, and environmentally—that challenge the resilience of human societies.
- Stabilized Earth will likely be warmer than any other time over the last 800,000 years at least (that is, warmer than at any other time in which fully modern humans have existed).
- Our analysis suggests that the Earth System may be approaching a planetary threshold that could lock in a continuing rapid pathway toward much hotter conditions—Hothouse Earth.
- This pathway would be propelled by strong, intrinsic, biogeophysical feedbacks difficult to influence by human actions, a pathway that could not be reversed, steered, or substantially slowed.
- Where such a threshold might be is uncertain, but it could be only decades ahead at a temperature rise of ~2.0 °C above preindustrial, and thus, it could be within the range of the Paris Accord temperature targets. The impacts of a Hothouse Earth pathway on human societies would likely be massive, sometimes abrupt, and undoubtedly disruptive.

The road to global decarbonization must involve renewable energy, as from these wind turbines in Germany, and improved transportation technologies.

CLIMATE POLICY

A roadmap for rapid decarbonization

Emissions inevitably approach zero with a "carbon law"

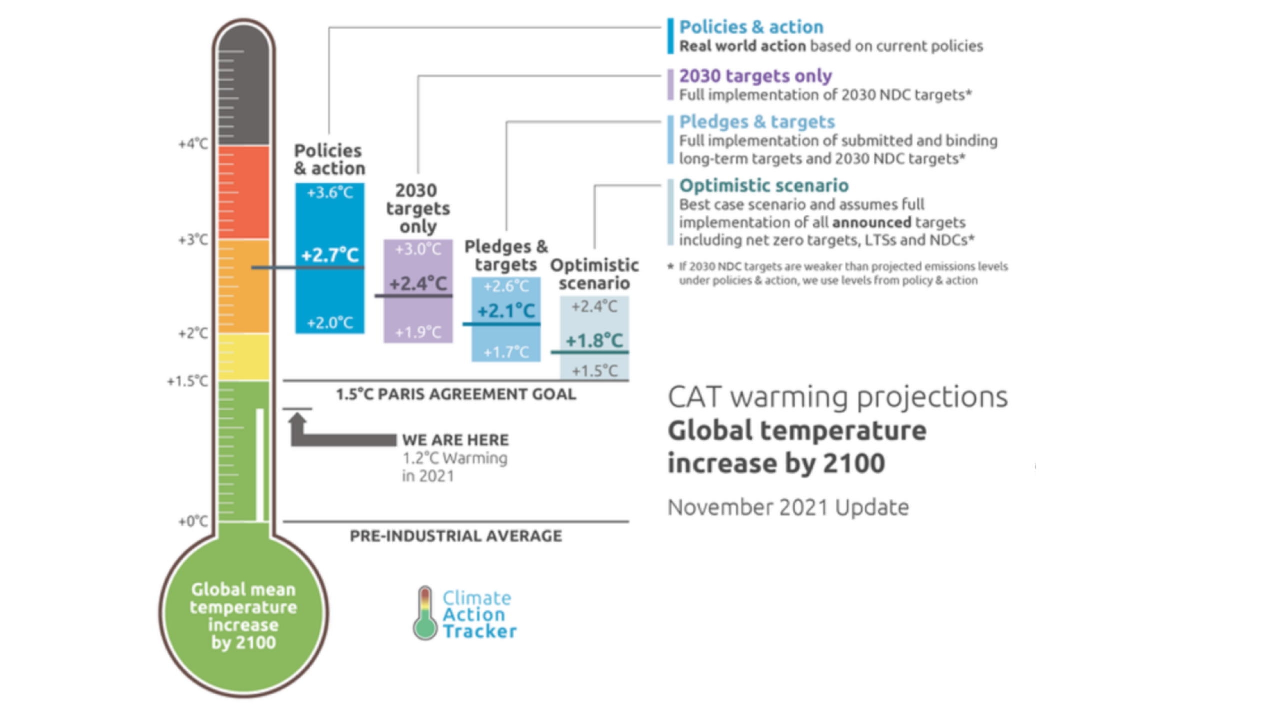
By **Johan Rockström,[1] Owen Gaffney,[1,2] Joeri Rogelj,[3,4] Malte Meinshausen,[5,6] Nebojsa Nakicenovic,[3] Hans Joachim Schellnhuber[1,5]**

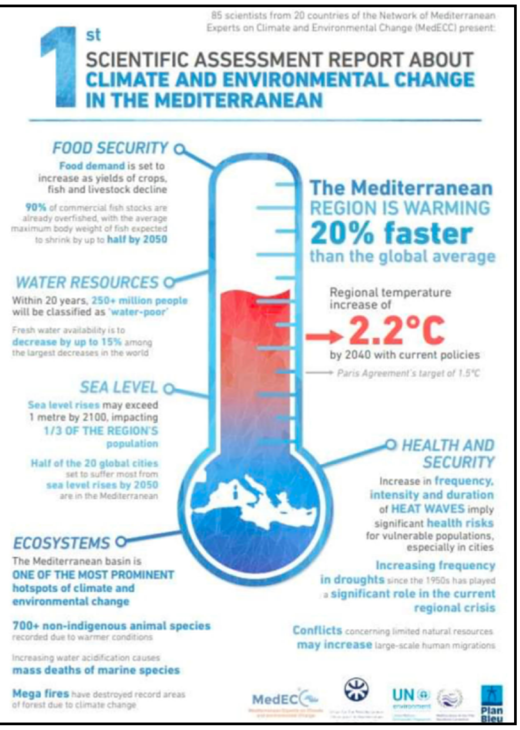
pose framing the decarbonization challenge in terms of a global decadal roadmap based on a simple heuristic—a "carbon law"—of halving gross anthropogenic carbon-dioxide (CO_2) emissions every decade. Comple-

sistent with the trajectory of the past decade (see the figure, bottom left). All sectors (e.g., agriculture, construction, finance, manufacturing, transport) need comparable transformation pathways. In addition, in the absence of viable alternatives, the world must aim at rapidly scaling up CO_2 removal by technical means from zero to at least 0.5 $GtCO_2$/year by 2030, 2.5 by 2040, and 5 by 2050. CO_2 emissions from land-use must decrease along a nonlinear trajectory from 4 $GtCO_2$/year in 2010, to 2 by 2030, 1 by 2040, and 0 by 2050 (see the figure, bottom right). The endgame is for cumulative CO_2 emissions since 2017 to be brought back from around 700 $GtCO_2$ to below 200 $GtCO_2$ by the end of the century (see the figure, top) and atmospheric CO_2 concentrations to return to 380 ppm by 2100 (currently at 400 ppm).

Roadmaps are planning instruments, linking shorter-term targets to longer-term goals. They help align actors and organizations to instigate technological and institutional breakthroughs to meet a collective challenge. An explicit carbon roadmap for halving anthropogenic emissions every decade, codesigned by and for all industry sectors, could help promote disruptive, nonlinear technological advances toward a zero-emissions world. The

Source: https://science.sciencemag.org/content/sci/355/6331/1269.full.pdf





Source: https://www.medecc.org/climate-and-environmental-change-in-the-mediterranean-main-facts/

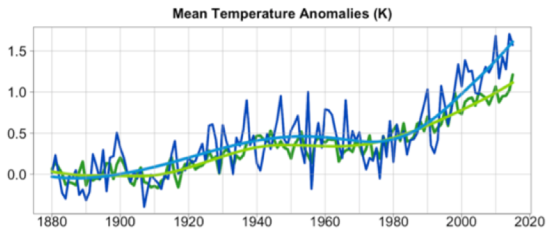


Fig. 1. *Warming of the atmosphere (annual mean temperature anomalies with respect to the period 1880-1899), in the Mediterranean Basin (blue lines, with and without smoothing) and for the globe (green line). In the Mediterranean region, average annual temperatures are now 1.4 °C higher than during the period 1880-1899, well above current global warming trends. Data from Berkeley Earth available at http://berkeleyearth.org/*

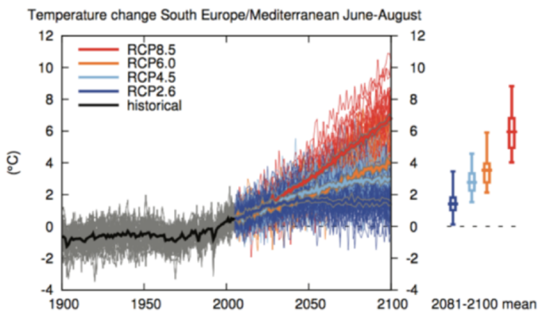


Fig. 2. *Time series of temperature change relative to 1986-2005 averaged over land grid points in the region South Europe/Mediterranean (30°N to 45 °N, 10°W to 40°E) in June to August. On the right-hand side the 5th, 25th, 50th (median), 75th and 95th percentiles of the distribution of 20-year mean changes are given for 2081-2100 in the four RCP scenarios. A rise in temperature from 2 to 6 ° C by 2100 is expected in the Mediterranean.*

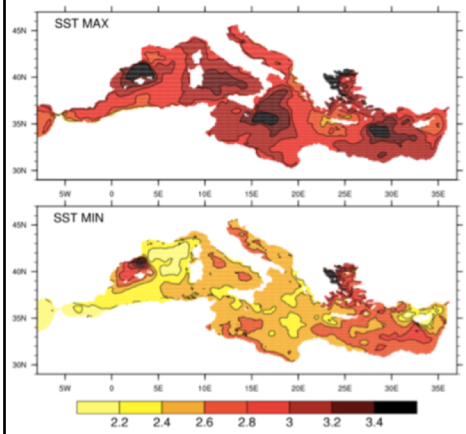
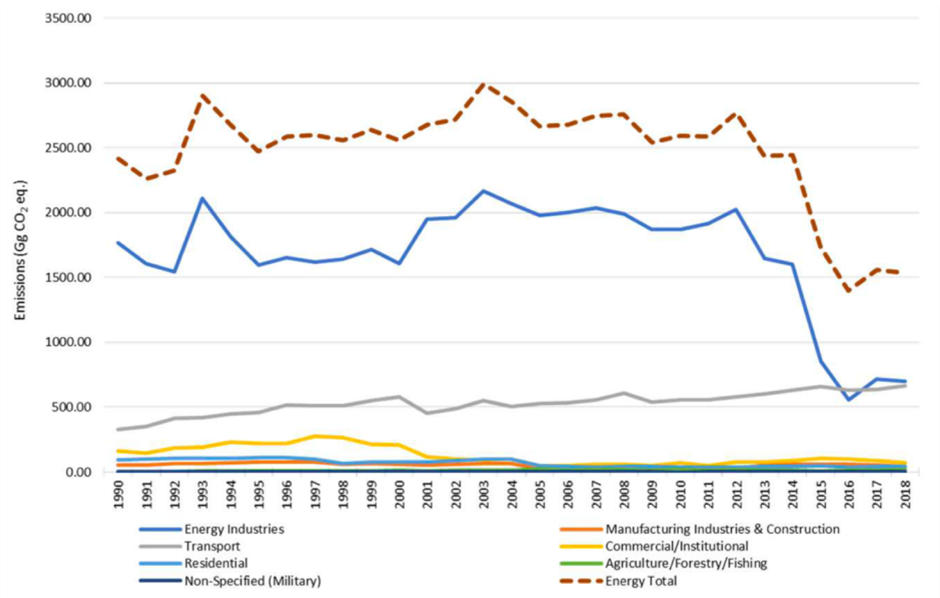


Fig. 3. *Expected minimum and maximum changes in sea surface temperature for the 2070–2099 period (vs. 1961–1990) based on a 6-member ensemble covering various sources of uncertain (°C). The Balearic Islands, the northwest Ionian, the Aegean and Levantine Seas have been identified as the regions with maximum increase of sea surface temperature (refer to : Adloff et al. 2015, for the details of the analysis)*

Climate Change in Malta Inventory and Obligations

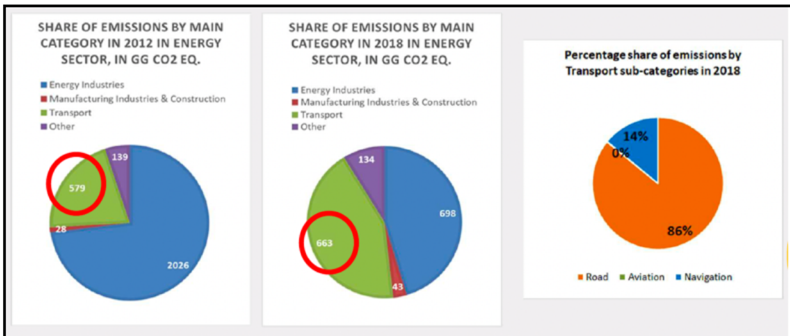
Malta's Communication to the UNFCCC

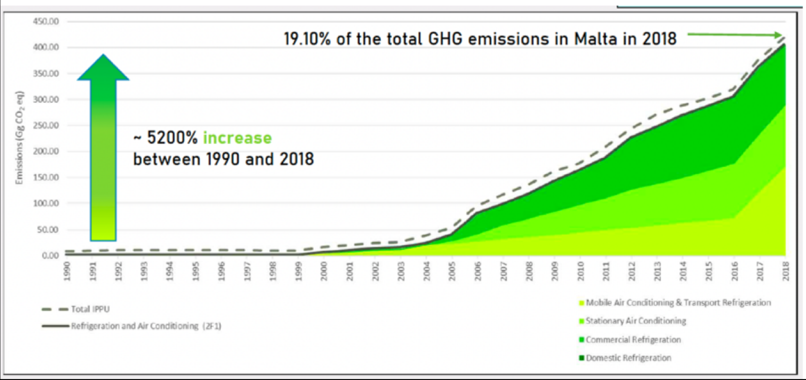
- The last report was the Seventh National Communication of Malta under the UNFCCC, in 2017.
- Malta reports on its progress towards reduction targets and the measures implemented and planned.
- Available at https://unfccc.int/sites/default/files/resource/42967815_Malta-NC7-1-NC7_Malta_2017_final.pdf



Malta: Emission trends 1990-2018

Source: MRA





Challenging sectors

Road Transport contributes to 86% of the total emissions from Transport.

Industrial Processes where fluorinated gases have high global warming potential (GWP)

- Hydrofluorocarbons (HFCs)
- Perfluorocarbons
- Sulphur hexafluoride

Source: MRA

Malta's Obligations

- Malta ratified the UNFCCC in 1994 and the Kyoto Protocol in 2001. These ratifications were made on the basis of non-Annex I status. To this effect, Malta did not immediately take on any quantified emission limitation or reduction obligations under these international instruments; thus, it did not have a quantified target for the limitation or reduction of greenhouse gas emissions for the first Kyoto Protocol Commitment Period (CP1; 2008-2012).
- Its accession to the European Union in 2004 meant that Union legislation related to climate action became also applicable to Malta. The overarching legislative framework that implements EU greenhouse gas emission mitigation policy is currently built on three main pillars, namely:
  - Monitoring Mechanism
  - EU Emissions Trading Scheme
  - Effort-Sharing Decision:

Changes to obligations and Paris Agreement

- An important development for Malta in respect of its climate change policy was the approval, in 2010, of its request (submitted to the Conference of the Parties to the UNFCCC in 2009) to become an Annex I party to the UNFCCC.
- The Paris Agreement, a landmark agreement on Climate Change, was adopted at the 21st Session of the Conference of the Parties (COP 21) to the United Nations Framework Convention on Climate Change (UNFCCC) on 12th December 2015.
- Malta was amongst the first EU MS to ratify the agreement on 5 October 2016.

Malta's Targets

- Projected emissions are evaluated against emission reduction targets applicable for Malta under the Effort Sharing Decision.
- This Decision sets a target for Malta limiting emissions to a level not higher than 5% over 2005 levels, by 2020.
- Furthermore, the Decision establishes a trajectory of interim targets for the years up to 2020, in accordance with the rule that "each Member State with a positive limit under Annex II [to the Effort-Sharing Decision] shall ensure [...] that its greenhouse gas emissions in 2013 do not exceed a level defined by a linear trajectory, starting in 2009 on its average annual greenhouse gas emissions during 2008, 2009 and 2010, [...] ending in 2020 on the limit for that Member State as specified in Annex II".
- Emissions not falling under the scope of this target include emissions covered by the EU ETS Directive (i.e. CO2 emissions from the power plants), emissions in the LULUCF sector, and CO2 emissions from civil aviation. Emissions from international marine bunkering and international aviation are also excluded.

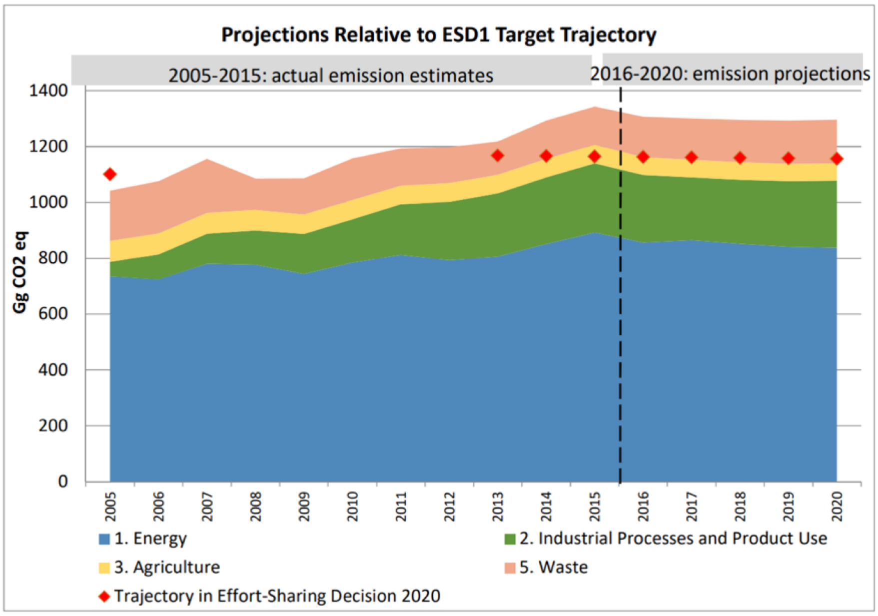


Figure 5-9 Projections of emissions covered by the Effort Sharing Decision (ESD1).

Source: Malta 7th Communication to the UNFCCC

Modelled Climate Change

Table 6-2 The main model results generated using MAGICC/SCENGEN version 5.3 applicable to the region of the Maltese Islands for the years 2025, 2050, 2075 and 2100. Note that the scenario year is the central year for a climate averaging interval of 30 years.

	2025	2050	2075	2100	Comments
Increase in Temperature (°C)	1.1	2.0	2.6	2.8	Regional Mean
Change in Precipitation (%)	−2.4	−4.4	−3.7	−1.8	Regional Mean
Sea Level Rise (cm)	7	14	23	30	Global-mean

Table 6-12 Summary of land use vulnerability from climate change (adapted from (MRRA, 2010)).

Land use vulnerability
Low lying transport infrastructure in the North of Malta.
Any land reclamation projects near the coast which the Government is currently considering.
Low lying coastal areas that have been modified over the years through development on the coast, and which will be prone mostly to storm surges.
A total land area of 1.11 Km² (0.36% of land area) will be affected by a sea level rise of 50 m.
Beaches will be particularly affected as they might be obliterated, reduced in size or, in the case of new beaches, replenishment will be very costly.
Increased rain intensity leading to more flooding in some urban areas, with some needing to eventually relocate to alleviate the problem.
Loss of soil and nutrients for agriculture from intense rain events.
Longer drought periods can lead to desertification, in particular the areas under dryland production.
Increase in wind gusting intensity will also affect the increasingly tall buildings which are being constructed mostly near the coast.
Extreme weather events, including the incidences of heavy hailstorms and thunderstorms will affect road surfaces, rubble walls (for the retention of soil in fields), retaining walls and power lines.
These impacts on agriculture, buildings and infrastructure will have a secondary impact on property values and insurance.

Table 6-16 Climate change impacts and vulnerability for terrestrial and marine ecosystems. (adapted from (MRRA, 2010)).

Terrestrial Ecosystems	**Loss of biodiversity and increased risk of extinction** - Studies in Europe and about the Mediterranean project a 30-40% extinction risk for species beyond 2050 if unable to disperse, and as a result of climate change (Thomas, et al., 2004). - Species populations in Malta are already small which could push many taxa to extinction. - All terrestrial flora and fauna are considered vulnerable to climate change. **Shift in the distribution of species** - Changes in temperature, precipitation and sea level will affect ecosystem boundaries. - Climate change might also affect habitat. - All terrestrial flora and fauna will be affected by distributional shifts. **Sea level rise** - Inundation of low-lying areas can obliterate habitats, push migration inland (where this is possible), and increase salinization which in turn will affect the sea-level aquifer and will favour halophytic vegetation. - Coastal areas are most vulnerable habitats, including some already protected sites such as Natura 2000 sites, Special Areas of Conservation and Specially Protected Areas[73]. A full list of vulnerable habitats was produced for the Second Communication. **Temperature increase** - Temperature increases will favour species with a higher affinity to subtropical climates. - Warming and drying is most likely to induce species-range shifts, with migration rates exceeding the capacity of many endemic species to do so. - Higher temperatures are predicted to decrease species richness in freshwater ecosystem across SW Europe. Some spread of pests and disease causing organisms can also occur. - Warming will impact phenology (timing of seasonal activities). - Water availability will change as temperatures rise and increasing the demand for water. - Desertification and fires will severely impact terrestrial ecosystems. **Decrease in precipitation** - Water availability will reduce due to a decrease in rainfall, leading to a loss of hydrophilic species and increase in soil salinity. - Droughts will occur. - Potential sea water contamination of the groundwater from over abstraction, affecting also the populations of migratory birds residing in inland wetlands. **Effects of CO_2 emissions** - A fertilization effect causing greening of the Mediterranean.
Marine Ecosystems	**Temperature increase** - Temperature anomalies can dramatically change faunal diversity in the Mediterranean. - Higher sea temperatures also facilitate the spread of alien species. This might dislocate species and possibly affect the food web. - Warming has already led to the shift in Mediterranean species (Perez, 2008). - Climate change might also favour epidemiological outbreaks as pathogens are temperature sensitive. - A number of consequences have already been documented as a result of increasing sea temperatures in the Mediterranean. **Changes in coastal hydrodynamics** - Any changes to coastal currents will impact littoral and sub-littoral communities and *Posidonia oceanica* meadows. **Changes in deep water circulation** - This may strongly reduce spring phytoplankton blooms and export production to the deep layers. - Low oxygen areas (hypoxia or anoxia) in bottom waters might affect bays and inlets. **Increase in sea level** - Changes will affect the distribution of benthic and pelagic organisms. - Inundation will affect the zonation patterns on rocky shores in an upward shift. - Sea level rise may affect seagrass meadows by exposing them to more wave action and swell leading to erosion and loss of habitat. **Increase in the intensity of rainfall events** - Increase in sea water turbidity and decrease in salinity. - *Posidonia oceanica* (L.) Delile is particularly vulnerable to turbidity and reduced water transparency. Specific areas around the islands with meadows will be affected by turbidity (Marsalforn, San Blas, Ramla l-Ħamra, Mellieħa Bay, St Paul's Bay and Salina Bay. **Increase in CO_2** - Acidification will result from the increase in the concentration of dissolved carbon dioxide. - Organisms such as corals, most molluscs and sea urchins will face greater prospects of erosion. - There are still uncertainties related to the impact of increased CO_2.

Table 6-17 The impacts expected on important components within agriculture in Malta. (adapted from (MRRA, 2010)).

Impact on Soils	Soil erosion is expected to increase due to the intensity of rainfall. This is dependent on measures adopted to protect soils such as rubble walls, vegetation cover and so on. Soil fertility might be affected by heavy downpours, as well as logging of soils, especially in low lying areas, and through leaching.
Impact on Potato	Increases in atmospheric CO_2 leads to higher yields of potato, however this was not sufficient to recover the losses made through increased temperatures. There is a potential for potato pests and diseases to increase as a result of climate change.
Impact on Vineyards	Largest impacts from increases in temperature and distribution of rain. Accelerated ripening due to increasingly warmer temperatures, has serious consequences for precocious varieties. Malta's vineyards will suffer particularly during drought periods.
Impact on Livestock	Increases in air temperature may affect behavioural or physiological functions of livestock. Most of Malta's farms are not equipped with cooling devices and a reduction in produce, brought about by warmer temperatures is possible. A global reduction in availability, quality and price of grain will affect Maltese farmers since they import all feeds for livestock.
Impact on Agriculture Infrastructure	Heavy rainfall will affect critical infrastructure such as rubble walls and greenhouses. Rate of absorption of rainfall will decrease as heavy storms will fill reservoirs and wells fast but not for long. Lengthening of the dry season will force farmers to irrigate more, increasing the pressure on the aquifers and exacerbating the existing problem of illegal extraction from boreholes.
Alteration of Insect and Disease Distribution	The range and distribution of pests is affected by changes in temperature, wind and humidity. Whilst milder winters might increase the incidence of pest outbreaks, higher temperatures and longer periods of warm weather will allow proliferation of insect pests. Use of pesticides to control pests in itself can harm agriculture.

Thank you

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