Sustainability “solutions” A critical reflection

BIO-413 Planetary Health

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Outline

Lecture

- Wicked problems
- Co-benefits
- Trade-offs
- Unintended consequences
- Rebound effect

- **Exercise**
  - Critically reflecting on a response to a problem
- **Group work**
  - Introduction to group work
  - Group and topic assignment
  - Start of group work

Wicked problems

- Introduced by Prof. Horst Rittel of the University of California in 1967

- A **poorly defined complex problem** that:
  - is in a state of **constant evolution** …
  - creates **ramifications at the system level** …
  - for which there is **not one singular discreet solution** …

(Lönngren & Van Poeck, 2021)

Co-benefits
Trade-offs
Unintended consequences
Rebound effect

What do these concepts mean to you?

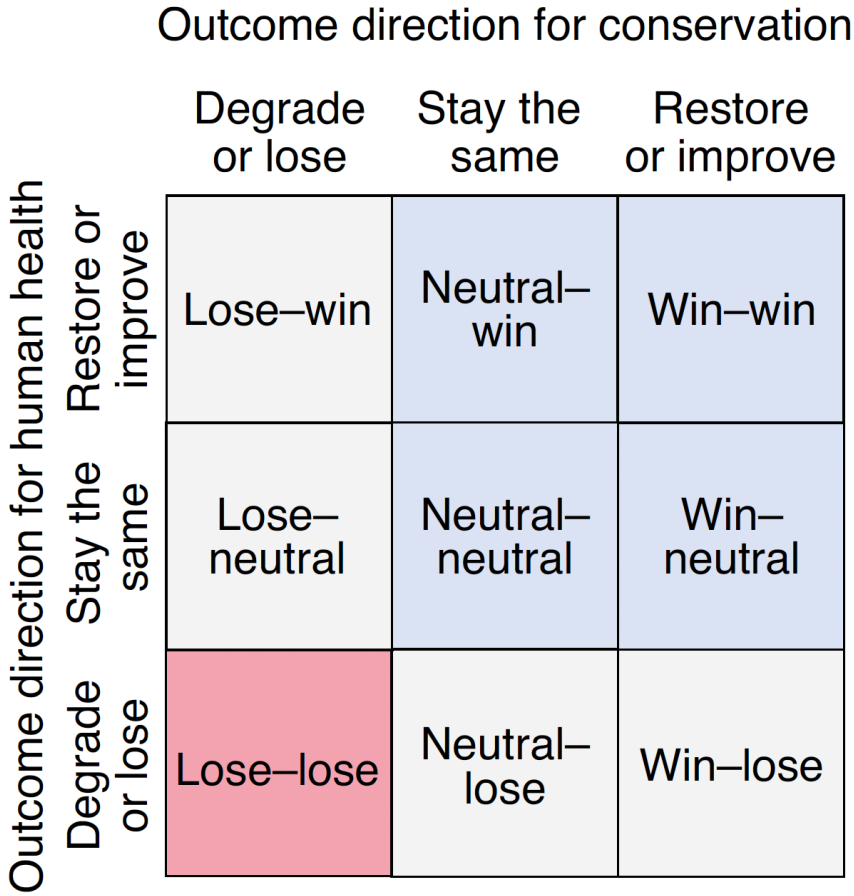
Co-benefits

- “the positive effects that a policy or measure aimed at one objective might have on other objectives, thereby **increasing the total benefits** to the society or environment" (IPCC, 2023)
- Sometimes called win-win strategies
- Co-benefits within the context of health are interventions that are simultaneously beneficial for maintaining, restoring or improving both human health and the environment

Trade-offs

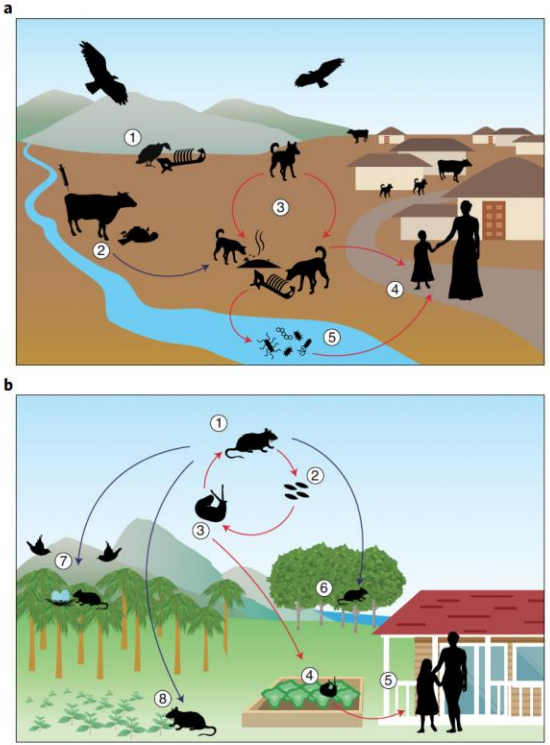
- Emerge as a result of **competition between varying objectives** related to social and ecological sustainability (IPCC 2022)
- **Adverse effect** encountered when the **achievement of one target** is implemented in such a way that it **imposes negative impacts** or constraints **to the achievement of another target** (Luukkanen et al, 2012)

Co-benefits and trade-offs



(Hopkins et al., 2021)

Diclofenac and vultures in India



https://www.youtube.com/watch?v=Jo0LTZQ3KA4

(Frank and Sudarshan, 2024; Hopkins et al., 2021)

Electric vehicles

Co-benefits:

- Good for industry and innovation
- Reduce pollution emitted by cars running on petrol and diesel (especially in cities)
- Contribute to reducing GHG emissions and climate change (as long as they are powered by renewable energy)

Trade-offs:

- Batteries deplete precious natural resources and are difficult to recycle
- Requires development of new infrastructure for charging electric vehicles
- Limited accessibility to these cars for countries in the Global South
- Carbon emissions from production and transport

Poverty alleviation vs. Planetary Boundaries

Lower income countries are aiming to reach the development level of higher income countries.

Countries are working to give everyone within their country the same standard of living by reducing inequalities.

Trade-offs:

We need to change how we consume natural resources to stay within the planetary boundaries & meet the needs of all populations

Carbon capture & utilization

Actively capture carbon from the atmosphere and converting it through thermocatalytic processes into chemicals and fuels (e.g. methanol, formic acid, ethylene)

Trade-offs:

Can release particulate matter creating impacts for health and climate change (Ioannou et al, 2023)

Health co-benefits of climate change mitigation

Decarbonization of the transport sector:

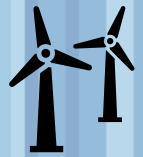
↑ air quality

↓ cardiovascular & lung cancer & diseases associated with air pollution

Reduction of meat consumption:

↓ associated GHG emissions

↓ decrease incidence of some cancers, heart disease, obesity



Decarbonization of the energy sector:

↑ air quality

↓ cardiovascular & lung diseases

Among others…

Health outcomes associated with access to **greenspaces**

- Improved: mental health among adults, affect
- Reduced risk: stress, depression, anxiety, psychosis

- Increased: frequency and intensity
- Mixed results: active transport
- Decreased obesity (limited evidence)

NCDs

- Decreased: atopic diseases, respiratory diseases, T2 diabetes, & CVD in residential neighborhoods
- Mixed results: lung, breast and prostate cancer
- (potential) Increase: skin cancer

(Banwell et al., 2024)

Health outcomes associated with access to **greenspaces**

Mortality ↘ Reduced risk: all-cause mortality (strong evidence)

↗ Increased: healthy birth weight, likelihood of breastfeeding, youth development

⤭ Mixed results or no association: cognitive & brain development, academic achievement, absenteeism, social functioning and cognitive skill

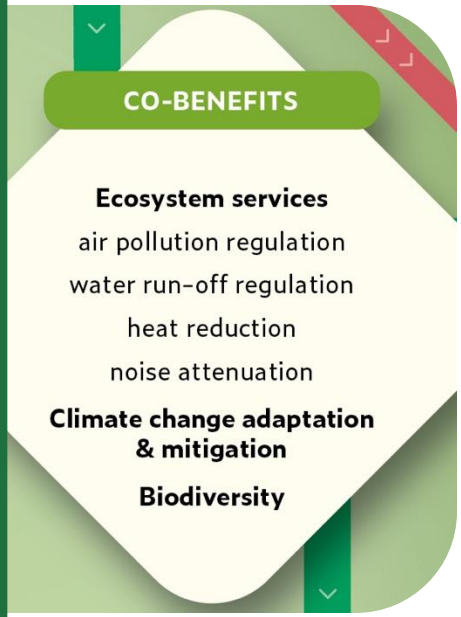
↘ Decreased: emoitonal and behavioural difficulties

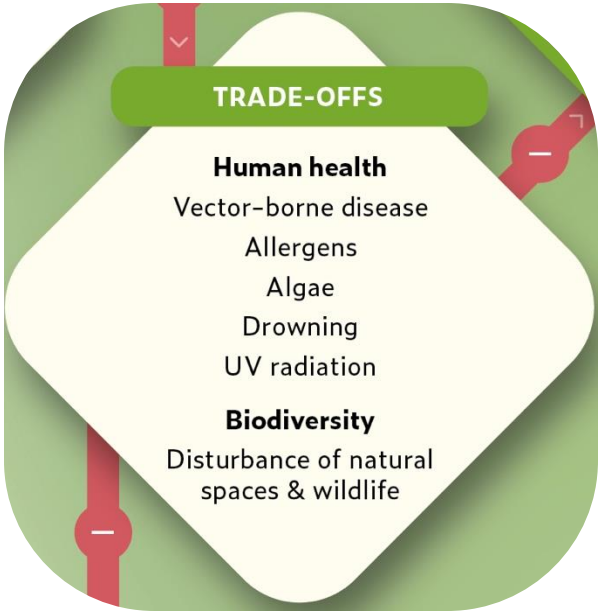
↗ Improved: life satisfaction (varies according to age)

⤭ Limited or conflicting evidence: asthma or allergy

(Banwell et al., 2024)

Co-benefits & trade-offs of **greenspaces**





(Banwell et al., 2024)

An example – the Black Grouse in the Swiss Alps

(Arlettaz et al., 2007, 2013 & 2015)

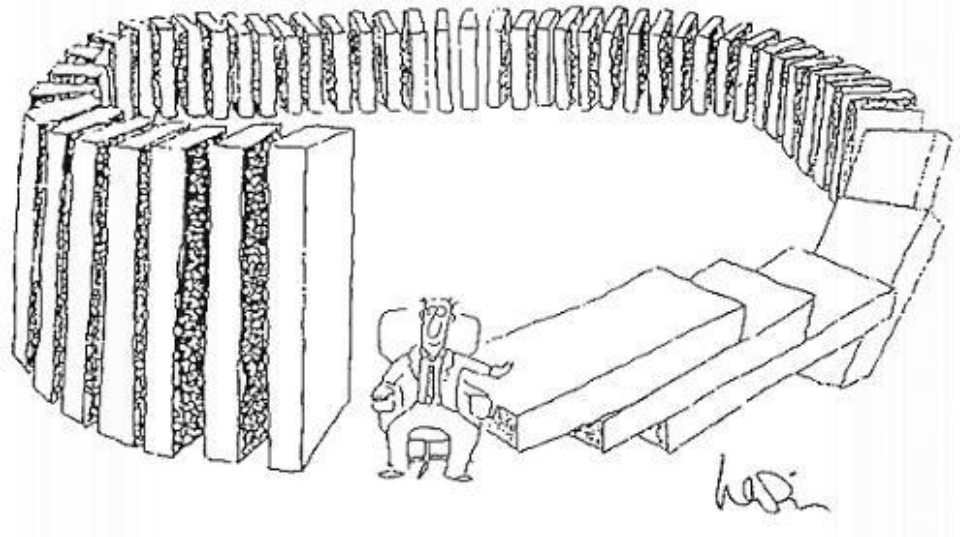
Hydroelectric power & the Mekong River

https://www.youtube.com/watch?v=dOg6s2YB0Fg

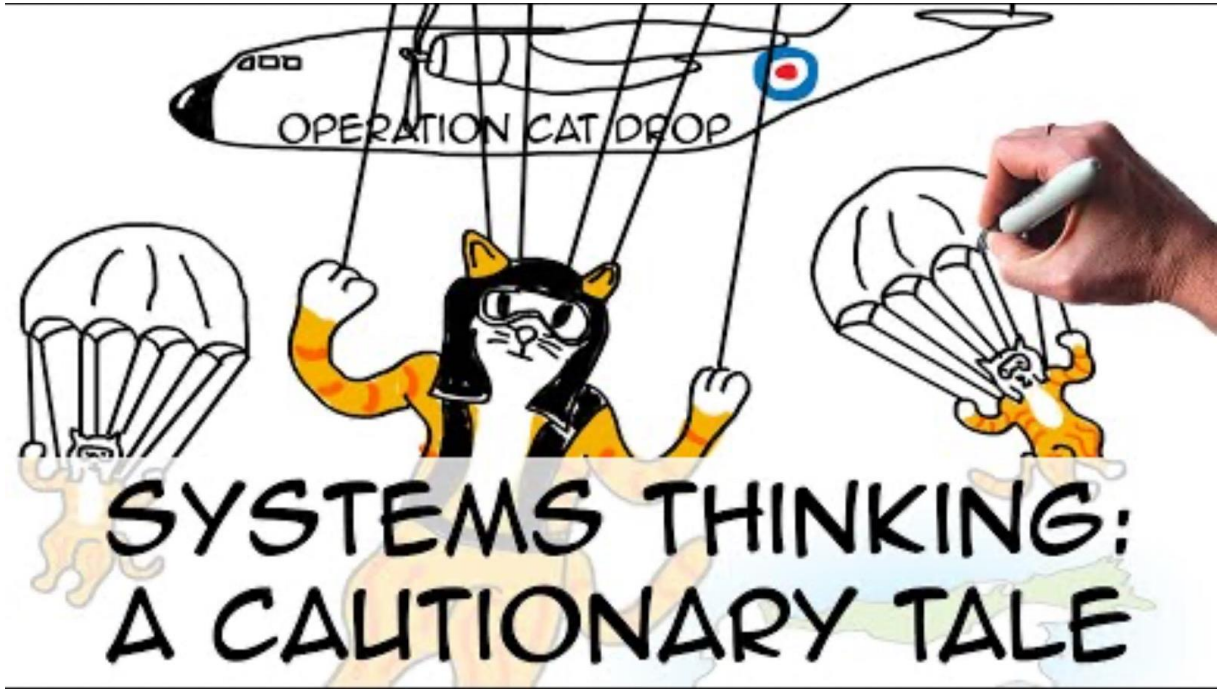
Supporting hydropower development over the continued health of the Mekong Delta is an example of how climate change maladaptation can harm natural ecosystems and compromise their resilience to climate change.

Unintended consequences

Unforeseen and unintended negative impacts (social, environmental or other) that result from implementing a project, technology, policy….etc.



Example - Cats in Borneo



https://www.youtube.com/watch?v=17BP9n6g1F0

Unintended consequences

- Negative impact on the **environment**
- Negative impact on **health or quality of life**
- Increase social **divides** – justice issues, gender inequalities, income inequalities
- Negative impact on **norms** – legal, social, ethical, cultural
- Impact the **labor market** and employment – automation and impacts on specific sectors

(United Nations Economic and Social Council , 2019)

Trade-offs vs. Unintended Consequences

- Unintended consequences (also referred to as adverse side effects) are similar to trade-offs (IPCC 2022)
- But they differ in that trade-offs are known and conscious choices, whereas unintended consequences may arise unforeseen

Artificial intelligence

Co-benefits:

- Encourages innovation
- Supports health diagnoses
- Could be used to improve energy consumption, or sustainability of industry & business (remains to be seen…)

Trade-offs:

- Data security & ethical issues

Unintended consequences:

- Contributes to GHG emissions
- Exclusion of social groups who do not have access to these tools
- Water consumption

Synthetic biology in biodiversity conservation

The place of synthetic biology to support biodiversity conservation is debated

Potential uses:

- Managing invasive species
  - E.g. - sex-ratio-engineered gene-drive approaches to create male-biased reproduction to help eradicate invasive rodents from islands
- Mitigating disease
  - E.g. – preventing reproduction of invasive mosquito species through the introduction of a bacteria that prevents the hatching of eggs to protect threatened Hawaiian birds from avian malaria
- Enhance resilience of organisms
  - E.g. - enhance thermal tolerance of coral reefs to reduce vulnerability to rising ocean temperatures from climate change

(Macfarlane et al, 2022)

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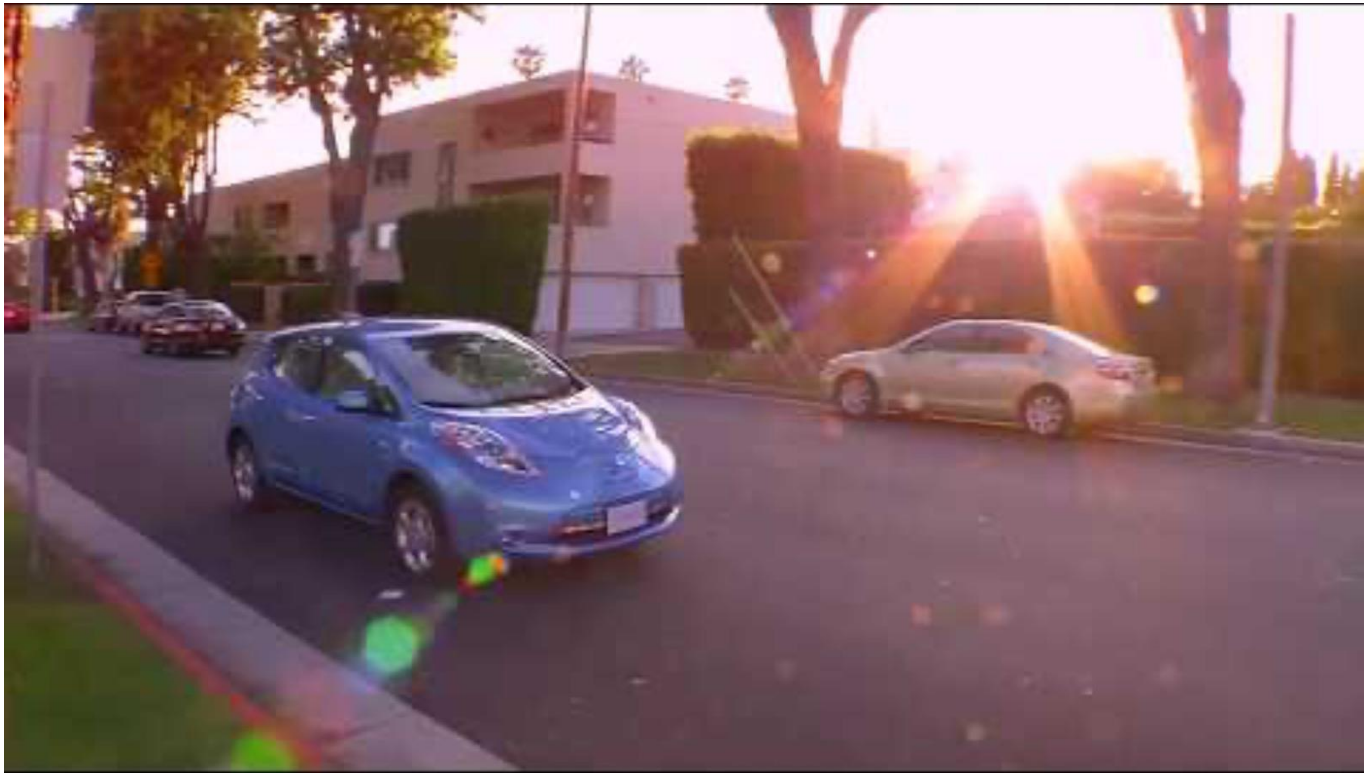
What are some potential unintended consequences?

Rebound effect

- Increases in consumption patterns subsequent to the implementation of new technologies which are intended to be more efficient or sustainable
- Can be considered a type of unintended consequence

Jevon's Paradox & the Rebound Effect in energy consumption



https://www.youtube.com/watch?v=PXf4KVWyfjs

Biofuels in Europe

Biofuel is a fuel that is produced over a short time span from biomass (e.g. plant, algae, animal waste)

2003 EU Directive on the Promotion of the Use of Biofuels and other Renewable Fuels in Transport (Directive 2003/03/EC)

- Set targets for the minimum proportion of biofuel in transport fuel to reduce GHG emissions
- Anticipated 20% GHG saving

(Alexander & Shareck, 2021)

Biofuels in Europe - Rebound

- A study predicted that **GHG emissions would double when land use change was accounted for**
- Biofuel crops are more profitable
- Biofuel crops thus **would displace food crops**
- This would lead to the **conversion of forest and grassland to farmland** to make up the shortfall in food production

Made a new directive- EU Renewable Energy Directive (EU-RED) (European Union, 2009), which goes some way to addressing this issue

(Alexander & Shareck, 2021)

Responses - What to consider:

1. The need of the community should be lasting, serious and important
2. All alternatives should be investigated, including non-technological solutions
3. Take a systemic view - Consider all co-benefits trade-offs & unintended consequences that could arise from the solution you would like to implement
4. You should be confident in the successful implementation of the solution

(Siller and Johnson, 2018)

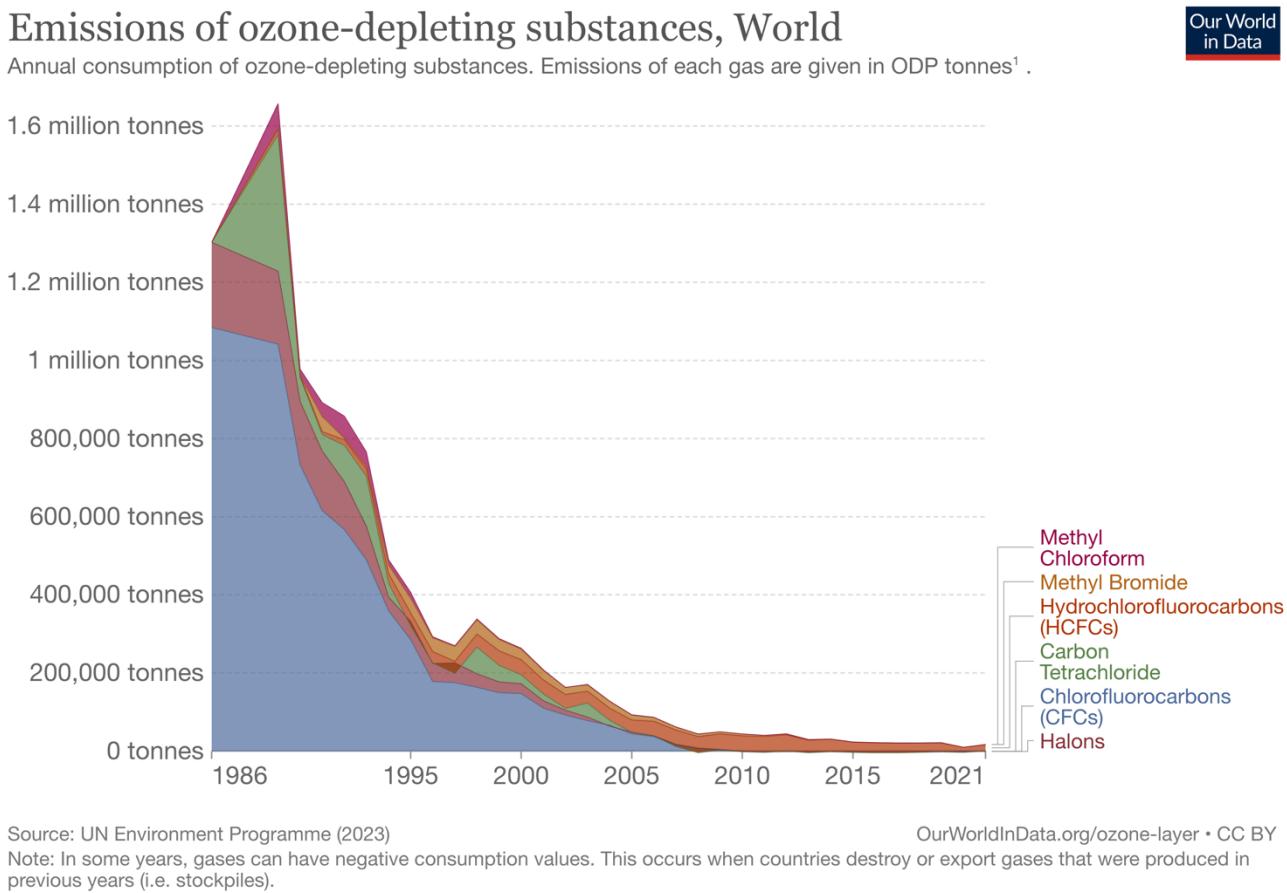
Stories of hope…
CFCs & the Ozone layer

CFCs and the Ozone Layer

- Stratospheric Ozone (O_3) – layer in the stratosphere that absorbs UV radiation
- 1970s – researchers noticed that the layer was thinning
- In some places ozone levels had dropped by more than 30 percent in a decade
- Due to the use of hydrochlorofluorocarbons (HFCs) and chlorofluorocarbons (CFCs) in aerosols, refrigerators and industrial processes

International response

- Establishment of solid scientific evidence showing the problem & its cause
- Montreal Protocol on Substances that Deplete the Ozone Layer (1987)
  - First global agreement to reduce the use of ‘ozone-depleting substances’ (HFCs and CFCs)
- Phase out of products using HFCs and CFCs


Emissions of ozone-depleting substances, World
Annual consumption of ozone-depleting substances. Emissions of each gas are given in ODP tonnes[1] .
Our World in Data
1.6 million tonnes
1.4 million tonnes
1.2 million tonnes
1 million tonnes
800,000 tonnes
600,000 tonnes
400,000 tonnes
200,000 tonnes
0 tonnes
1986
1995
2000
2005
2010
2015
2021
Methyl Chloroform
Methyl Bromide
Hydrochlorofluorocarbons (HCFCs)
Carbon Tetrachloride
Chlorofluorocarbons (CFCs)
Halons
Source: UN Environment Programme (2023)
OurWorldInData.org/ozone-layer • CC BY
Note: In some years, gases can have negative consumption values. This occurs when countries destroy or export gases that were produced in previous years (i.e. stockpiles).

Why did it work?

- Clear understanding of the problem
- Identifiable solution
- United political front on a global level
- Substitutions available and implementable

A film on the Montreal Protocol
https://www.youtube.com/watch?v=MgUobxtdm4A

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Exercise

Critically reflecting on a response to a problem

Lyme disease in the USA

https://www.youtube.com/watch?v=FHQqKWxF1Tg

Genetic modification of mice to combat lyme disease

https://www.youtube.com/watch?v=FOCNixYPsf4

Class brainstorm & discussion

What impacts could the genetic modification of mice to combat lymes disease have in terms of:

- Co-benefits
- Trade-offs
- Unintended consequences
- Rebound effect

Part 1 – *Individually*
Write down your response to this question

Part 2 – *Class discussion*

Exercise

Working in pairs or groups take one of your “responses” that you proposed last week in the exercise session

Analyze the response to identify if the response could create any of the following:

- Co-benefits
- Trade-offs
- Unintended consequences
- Rebound effect

Respond to the questions below:

- Would you still implement the response?
- If yes, what would be important to consider or change if you implement it?

Share with the class

Group work
Guidelines

Task:

1) explore a specific planetary health challenge ***and***

2) propose possible responses

Groups: 4 groups of 3 to 4 people

Presentation:

- **20 mins presentation + 10 mins Q&A**
- All group members are required to speak for the same amount of time
- Accompanied by a visual aid

Project topics

- Suggested by teachers
- Generally broad topics that you need to narrow down yourselves based on your interest

For your topic, answer the following questions

- What is the problem?
- Why is it a problem?
- What needs to be done about the problem?
- What are the potential negative consequences of these responses?

Support available to you (1)

- Each teacher has provided resources relating to each topic (on Moodle)
  - These are **a starting point** so you can familiarize yourself with your topic or the overarching theme
  - After reading this resource, you should find additional literature on your specific topic to help you to better **define your problem and/or find solutions**
  - The goal of the project is NOT that you present the initial paper at the final presentation day

Support available to you (2)

- Forums for asking questions - dedicated to each topic on Moodle
- Class time dedicated to autonomous group work
- Coaching and feedback during the semester from the teacher or teaching assistant responsible for the assigned topic
  - The format and timing of this support is to be determined in discussion with the teacher
  - Scheduled in direct contact with the teacher concerned

Project topics

Bioremediation for sustainable environments *OR* **Bioengineering for sustainable agriculture**
Teacher: John McKinney

Climate change and health
Teacher: Nicola Banwell

Global metabolism: The impact of the food system on planetary health
Teacher: Giovanni D'Angelo

Exposure in the work environment to chemical pollutants and the risk of cancer *OR* **Production and distribution environmental impact of cell engineering therapies vs small molecule-based therapies**
Teacher: Elisa Oricchio

Questions?

Group formation & topic assignment

1. Take a few minutes to find your groups
   -> We need 4 groups (2 groups of 3 and 2 groups of 4)

2. Decide on your topics

3. Sign your group up on Moodle > This week > Group choice: Forming groups for group work