



*Fundamentals of digital and ecological transitions*

# Applied ecology and climate change

## Lesson 4

---

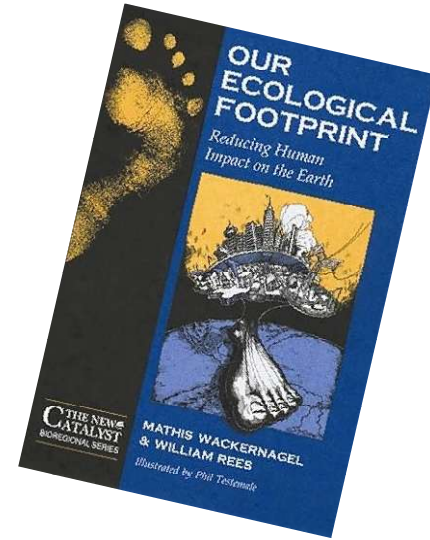
Dr. Chiara MANFRIN

[cmanfrin@units.it](mailto:cmanfrin@units.it)

A.y. 2025-2026

# Ecological footprint

Created and developed by Prof Wiliam Rees and Dr Mathis Wackernagel, University of British Colombia, in early 90s.



Mathis Wackernagel now heads Global Footprint Network, established 2004 in Oakland, California



<https://www.footprintnetwork.org/>

# Ecological footprint

**We all leave traces on the Earth: we need land to eat, dress, move and live.** We use forests to produce furniture; we use fields for cultivation and pastures for food; we use land to build houses and roads.

**By consuming these surfaces, we take resources away from our planet.**



# Origins & Development

- GFN mission is:

To support a sustainable economy by advancing the Ecological Footprint, a measurement and management tool that makes the reality of planetary limits relevant to decision makers throughout the world

- GFN maintains National Footprint Accounts for over 150 countries

# What is the Ecological Footprint?

The Ecological Footprint is both a **measurement** and a **communication tool**:

- enables sustainability to be defined in **specific** and **measurable** terms
- Enables people to **understand** sustainability by looking their personal impact with global ecological capacity

## What is the Ecological Footprint?

Evaluates the amount of biologically productive land and water required by humanity to produce the resources it consumes and to absorb the waste it generates, based on current technologies and resource management practices, regardless of where these bioproductive areas are located on Earth.

# What is the Ecological Footprint?

$$\text{Impact} = \text{Population} \times \text{Affluences} \times \text{Technology}$$

Footprint of a nation or of humanity (I) =

- Number of people consuming (P) x
- average amount of goods and services an average person consumes (A) x
  - resource intensity of these goods and services (T)

## What «Footprint» means?

Footprint is **NOT** a general term for 'environmental impact'

- Eg. tonnes of carbon emitted is **NOT** the 'carbon footprint'...
- ...surface area of planet needed to sequester CO<sub>2</sub> emissions and maintain a stable climate **IS** the carbon footprint.

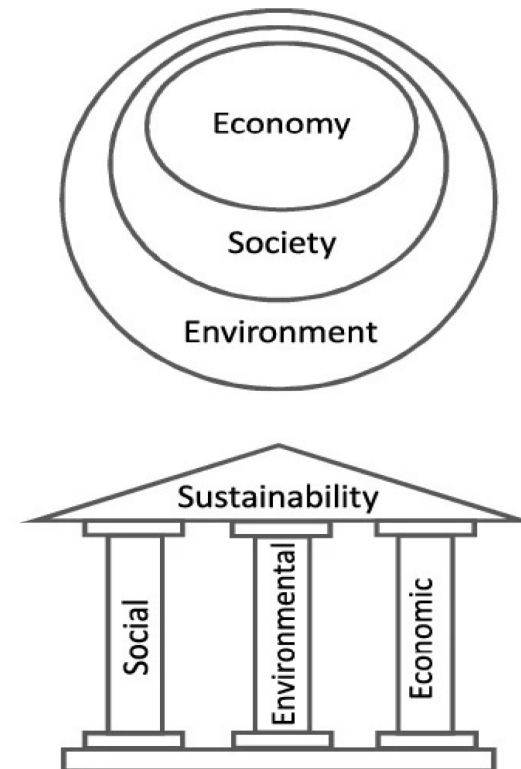
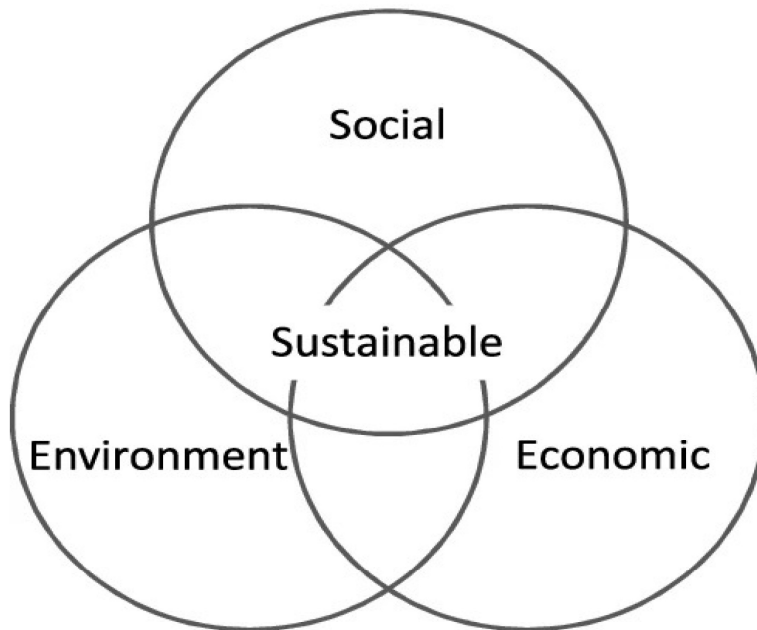


# Footprint Basis

- Based on **science** (ecological and thermodynamic principles) – is not an arbitrary index
- It stems from an **empirical** research question rather than a speculative one. For example, asking, "*How many people can Australia support?*" is speculative, as the answer depends on factors like lifestyle choices and consumption levels.

# Key concepts

- Economy, environment and society are **NOT equal concepts** – functionally, the economy is part of the society which in turn is part of the biosphere, or environment



# Key concepts: Overshoot

- The **regenerative capacity of biosphere** is **non-negotiable limiting factor** for sustaining life; resource use concern previously depletion of finite non-renewable resources
- When humanity's demand on nature exceeds the biosphere's supply, or regenerative capacity, this global ecological deficit is called **overshoot**

# Key concepts: Overshoot

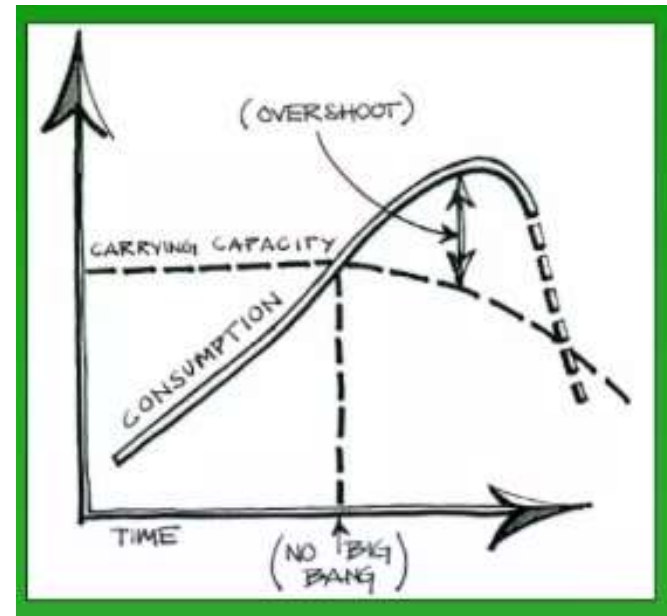
- Overshoot erodes earth's natural capital stock; humanity liquidating 'assets' instead of living off of the 'interest'
- Sustainability has a specific meaning – **avoiding ecological overshoot**
- Avoiding overshoot is only a **minimum condition** for sustainability; but **sustainability is impossible without avoiding overshoot**

## Key concepts: Overshoot

- **Invisibility** – consumer culture promotes abundance, people do not generally encounter ecological limits; psychologically as well as spatially divorced from dependence on nature
- **Economic ‘blind spot’** – ecological limits invisible through monetary lens; prices signal availability of a resource in market, not its availability in the biosphere

## Key concepts: Overshoot

- **elasticity** – ecological limits can be easily trasgressed; but overshoot eats up nature's reserves, weakening its ability to regenerate



# How can we know whether we are in overshoot?

- By measuring demand (ecological footprint) and comparing it to supply (earth's biological capacity)
- Individuals or businesses that do not track activities and keep accurate records run risk of bankruptcy – yet this is precisely the approach we take with the only planet within our reach capable of supporting life

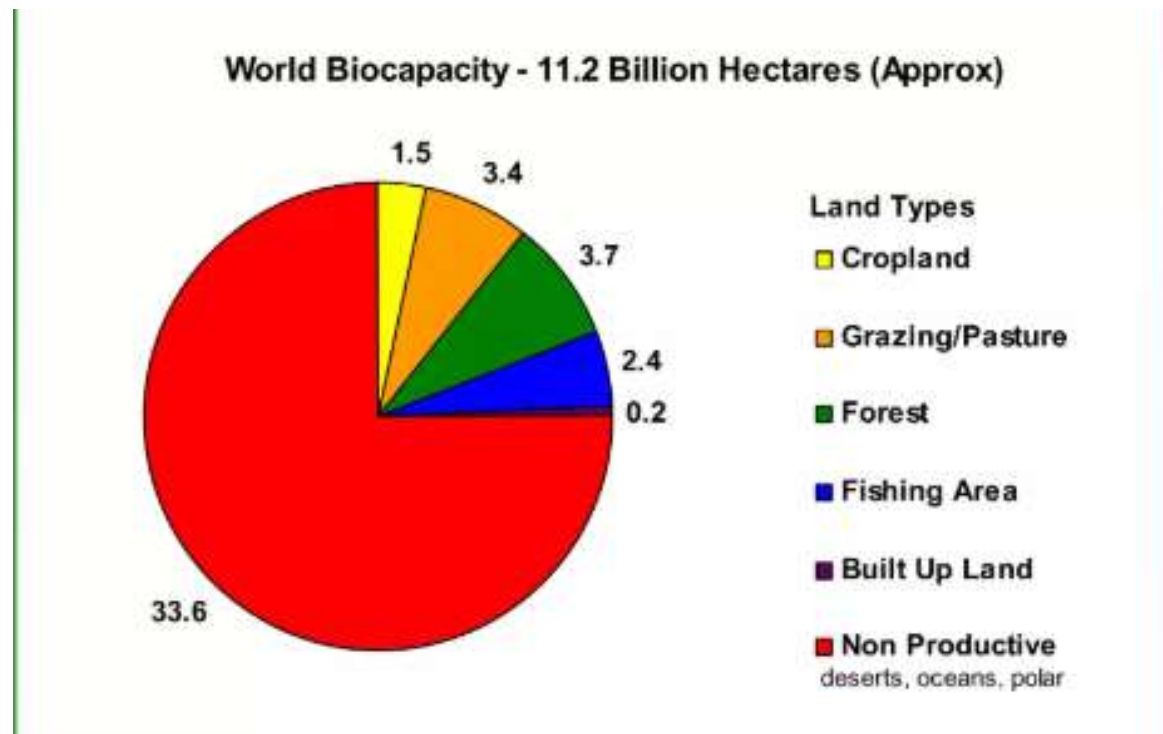


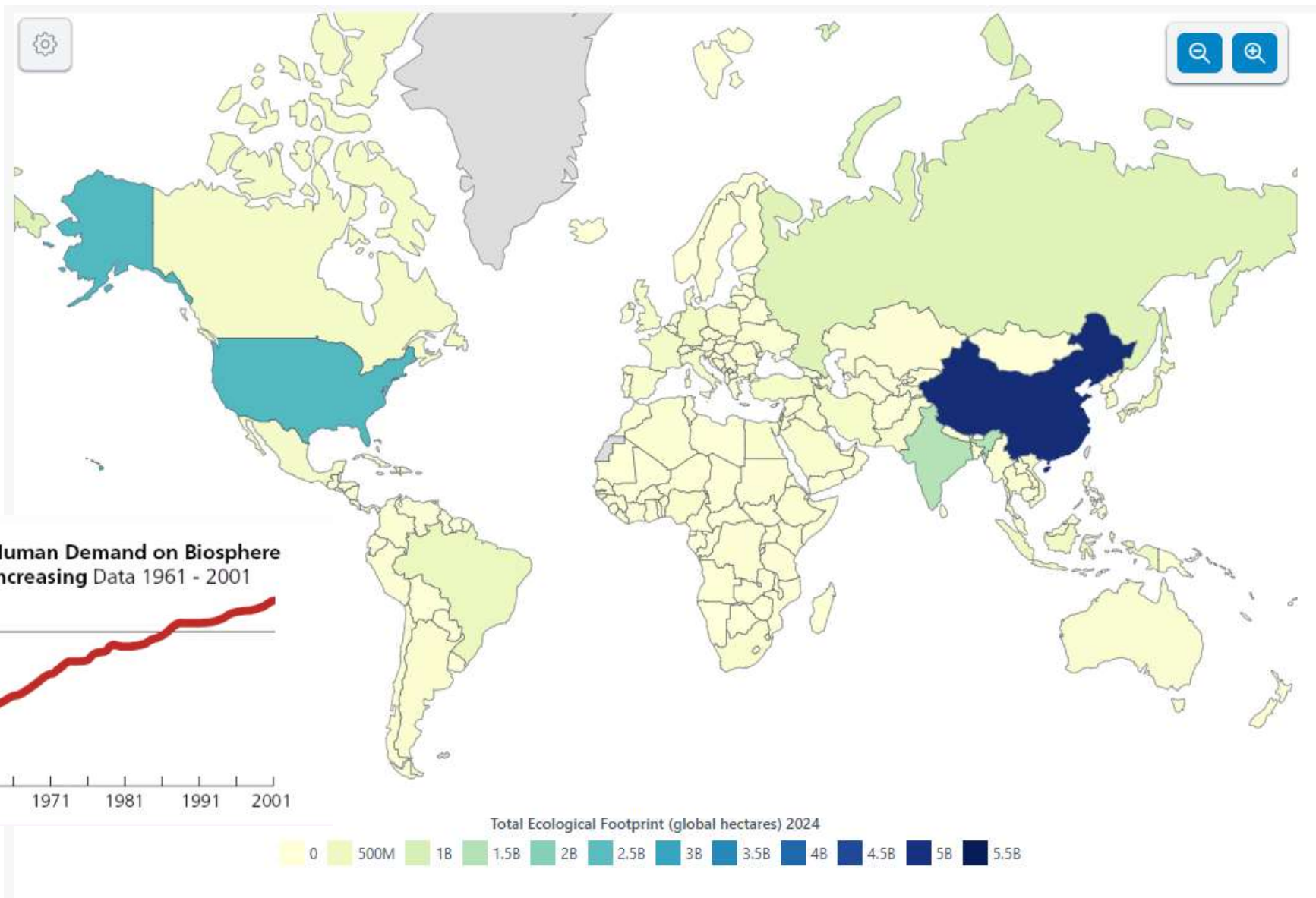
## Main environmental problems to be addressed in this century

- Average current **ecological footprint for human** population: **2.77** hectares/person, (12 billion total) in 2017.
- Available **productive land: 1.6 hectares/person**



# World Biocapacity





- Population of only 9 billion by 2050, if everyone starts with 2 child families today (optimistic UN estimate).
- Halving of resource consumption in OECD countries.
- Adequate standard of living for all (e.g. 3.3 hectare footprint, an 'average' Mexican or Ukrainian today; 'average' Australia of 6.6 hectares)

- The **higher** the ecological footprint, the more the Planet's health is at **risk**: it means that while mankind shows no sign of decreasing its demands, the Earth struggles to 'keep up' with him, and cannot replace what he has consumed.
- Scientists have calculated that we are currently living as if we had more or less **one and a half Earths**, and before 2050 we will be consuming as if we had two.
- **30 July 2024 – August 1<sup>st</sup>** marks Earth Overshoot Day, the date when humanity's demand on nature's resources surpasses Earth's capacity to regenerate them for the given year.

- The Ecological Footprint of a population is its impact on the environment via factors such as carbon dioxide emissions, deforestation, mining, and waste management.
- The Biocapacity of a region is its ability to support live and accommodate its population's Ecological Footprint (sequestering carbon dioxide via trees, replenishing wildlife stocks, etc).
- When a country's Biocapacity exceeds its Ecological Footprint, it has an "Ecological Reserve" or "Biocapacity Reserve".
- When a country's Biocapacity is smaller than its Ecological Footprint, the Ecological Reserve becomes negative. This is known as an "Ecological Deficit or Biocapacity Deficit"

200 countries

 Search



COUNTRY	TOTAL ECOLOGICAL FOOTPRINT (GLOBAL HECTARES) 2024	ECOLOGICAL FOOTPRINT PER PERSON 2024 (HA / CAPITA)	TOTAL BIOCAPACITY (GLOBAL HECTARES) 2024	BIOCAPACITY PER PERSON 2024 (HA / CAPITA)	ECOLOGICAL RESERVE OR DEFICIT 2024
Jamaica	5.9M	2.1	1.6M	0.6	-270%
Oman	29.5M	6.4	7.6M	1.6	-290%
Iran	274M	3.2	65M	0.8	-320%
Antigua and Barbuda	361K	3.9	85.8K	0.9	-320%
Libya	22.6M	3.4	5.2M	0.8	-330%
China	5.1B	3.5	1.2B	0.8	-340%
Trinidad and Tobago	9.3M	6.1	2.1M	1.4	-340%
Italy	251M	4.2	56.3M	0.9	-350%

If a given population's ecological footprint exceeds its biocapacity -> ecological deficit



the population's demand for natural resources exceeds its supply, which can lead to resource shortages (including basics such as food and shelter), higher prices, and elevated levels of pollution in the air, water, and soil.

Conversely, if a given population's biocapacity exceeds its ecological footprint -> ecological reserve

Therefore, maintaining an ecological footprint that is smaller than biocapacity is a necessary condition for the sustainability of humanity.

Top 10 Countries with the Highest Ecological Footprint (2024)

COUNTRY	TOTAL ECOLOGICAL FOOTPRINT (GLOBAL HECTARES) 2024
China	5.1B
United States	2.6B
India	1.5B
Russia	848M
Brazil	551M
Japan	533M
Indonesia	454M
Germany	392M
Mexico	315M
France	312M

Top 10 Countries with the Highest Biocapacity Reserve (2024)

COUNTRY	TOTAL BIOCAPACITY (GLOBAL HECTARES) 2024
Brazil	1.8B
United States	1.2B
China	1.2B
Russia	1.1B
Canada	544M
India	492M
Indonesia	336M
Australia	291M
Argentina	245M
Colombia	189M

## Quiz

[https://overshoot.footprintnetwork.org/quiz/?\\_ga=2.184826793.1251360983.1732810041-683205155.1732810041](https://overshoot.footprintnetwork.org/quiz/?_ga=2.184826793.1251360983.1732810041-683205155.1732810041)



# Future Scenarios

Biologically productive space needed to support 9 billion people living on a 3.3 hectare Footprint: **29.7 billion hectares**

Biologically productive space on the planet: **11.2 billion hectares**

Number of planets needed to sustain 9 billion people living on a 3.3 hectare Footprint: **2.65 planets**

# Future Scenarios

Overshoot can be eliminated on **demand side** by reducing humanity's footprint:

- Lowering world **population**
- Reducing per capita **consumption**
- Implementing more **resource efficient technologies** for providing goods and services

# Future Scenarios

Overshoot can be eliminated on **supply side** by increasing global biocapacity:

- Expanding global bioproductive area
- Improving resource management
- Strengthening ecosystems health

# Criticisms



- Doesn't capture all sustainability aspects
- Treats nature as collection of resources for use by humans
- Is too simple – overaggregates data
- Is too complex – methodology unclear

Need to maintain balance of robust, scientifically **credible** Fottprint, and its **accessibility** as a communication tool

# Scale not crystal ball

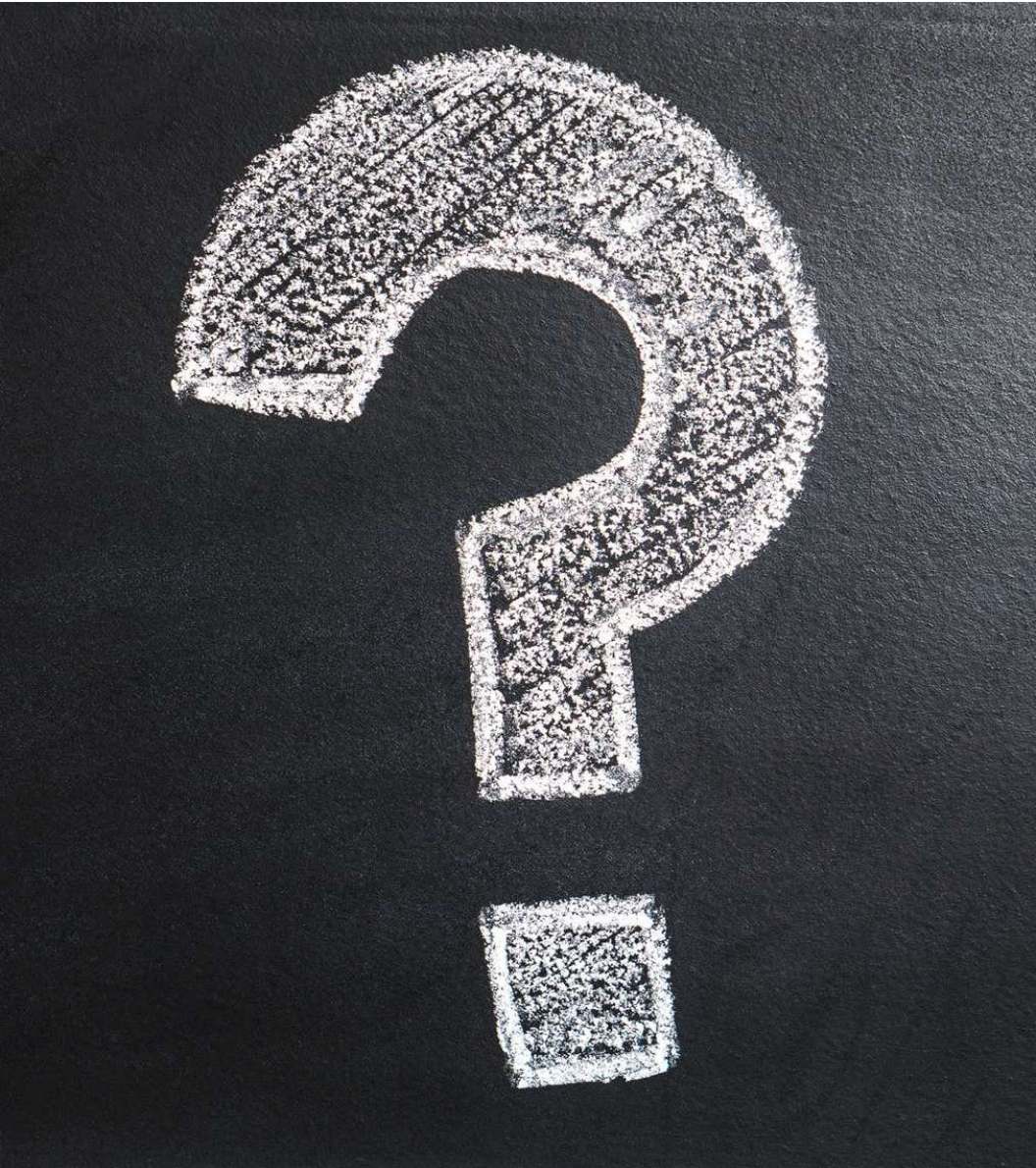
- Footprint cannot tell us what to do, is an indicator of how much we weigh on the planet at a certain point in time; can use to test scenarios
- Role of policy to determine how to ensure quality of life for all within the means of nature



# Let's calculate our Ecological footprint!



<https://www.footprintcalculator.org/home/en>



# Questions

---

**Chiara Manfrin**

[cmanfrin@units.it](mailto:cmanfrin@units.it)