Environmental Economics
ECONOMIC GROWTH AND SUSTAINABLE DEVELOPMENT

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ECONOMIC GROWTH AND SUSTAINABLE DEVELOPMENT

Introduction

- **Economic growth**, links between growth and the **natural environment**, and the economics of **sustainable development**.
- What we mean by “growth” and **why economies grow.**
- The evolution of **economic thinking** on the growth–environment relationship.
- A **controversial debate**: can an economy “grow” its way out of environmental problems? **Environmental Kuznets Curve** (**EKC**).
- **Economic indicators of sustainability.**

ECONOMIC GROWTH AND SUSTAINABLE DEVELOPMENT

Why governments care about growth

- Governments **track growth** in **absolute** terms (how fast are we growing?) and **relative** terms (faster than neighbors? faster or slower than 10 years ago?).
- Growth is often understood as an **increase in measures of average living standards** over time
- Gross National Product (**GNP**): *a monetary measure of the total market value of output of a country in a period*.
- **Economic growth** (the "usual" definition): ***an increase in real GNP per capita*** (constant, inflation-adjusted prices).

ECONOMIC GROWTH AND SUSTAINABLE DEVELOPMENT

	GDP per capita, 2015 in PPP international dollars	Annual growth rate of GDP, %	Annual growth rate of GDP per capita, %
Afghanistan	1925	+0.8	–1.9
Angola	7386	+3.0	–0.26
Albania	11479	+2.8	+2.95
Belgium	45757	+1.5	+1.01
Burkino Faso	1696	+4.0	+1.05
Canada	44197	+1.1	+0.2
Chile	23366	+2.3	+1.2
China	14450	+6.9	+6.3

Source: World Bank, 2016.

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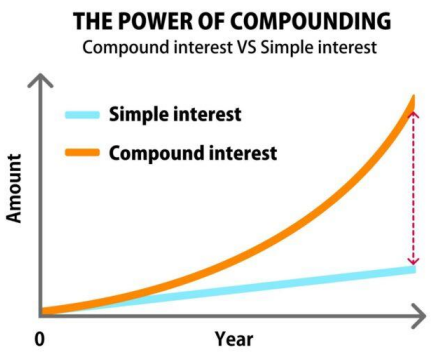
Why growth rates matter and why GNP is not enough



- Low growth rates have a large **opportunity cost** over time.
- Per-capita growth ≠ "everyone is better off": GNP says nothing about **income distribution**.
- **Critiques**: GNP is an incomplete measure of **well-being** (happiness/self-reported well-being does not rise mechanically with income).
- Despite limitations, countries still use real GNP per capita as a performance metric → we need **growth theory** and **sustainability indicators**.

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Why do economies grow

- Long-run economic growth is due to increases in **potential output**, rather than short-run fluctuations around it.
- Potential output rises for two main reasons:
  - growth in the **resources** that can be devoted to production;
  - growth in the **productivity** of those resources.

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Growth via increasing resources

- The **resource base** includes: capital, labour, land, energy, and material resources.
- **Labour** supply can rise through: population growth, higher participation, or migration.
- **Land** resources can increase through: exploiting overseas territories or converting marginal land to more profitable uses.
- Energy and material resources can increase through new **discoveries** (e.g. oil or gas deposits).
- **Technological progress** can reduce the costs of exploiting natural resources and make extraction profitable: economic “reserves” increase.

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Growth via increasing resources

- The capital stock rises through investment: **positive net investment = gross investment – depreciation.**
- **Human capital** and **social capital** (institutional quality and cooperation) also matter for growth.
- A country also holds natural capital (stocks of natural resources), which will matter for sustainable development.

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Productivity growth and technological progress

- **Productivity** refers to the value of output we derive from inputs to production.
- A key driver of productivity is **technological progress**, often linked to investment in **Research and Development (R&D).**
- Productivity can also rise through **learning-by-doing**.
- Technological change has been argued to be a driving force in the **Industrial Revolution.**

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Growth vs development and the Human Development Index

- **Growth** (GNP per capita increasing) is not the same as **development**.
- If an economy is experiencing development, we expect improvements in multiple indicators, including **GNP** per capita (still important), a reduction in **income inequality**, an improvement in adult **literacy** rates, a reduction in **infant mortality**, reductions in **adult morbidity** and **mortality**, an improvement in **environmental indicators**.
- The **Human Development Index** (**HDI**) is published annually by the United Nations; it uses three dimensions: income (GDP), education, and life expectancy at birth.

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'Top 5'	Rank on HDI, 2014	Gross National Income per capita, 2011$ PPP	'Bottom 5'	Rank on HDI, 2014	Gross National Income per capita, 2011$ PPP
Norway	1	68,012	Burundi	185	702
Switzerland	2	57,625	Chad	186	1,750
Australia	3	43,560	South Sudan	187	963
Ireland	4	53,754	Central African Republic	188	663
Germany	5	46,136	Niger	189	906

Source: UNDP, 2018 *Human Development Report*. The (updated) Human Development Indicator (HDI) was introduced by the United Nations in 2010, and is published annually. See http://hdr.undp.org/en/humandev/

- https://hdr.undp.org/data-center/human-development-index#/indicies/HDI
- https://worldpopulationreview.com/country-rankings/gnp-by-country

ECONOMIC GROWTH AND SUSTAINABLE DEVELOPMENT

Predictions from the past: are there “limits to growth”?

- Guiding questions: should continual economic growth come with a “**health warning**”? Are there “**limits to growth**”?
- These questions run through the history of economic thought: early economists (the Classical School) studied interactions between the economy and the natural environment.
- Core issue: do natural endowments (land, minerals) imply a limit to economic growth?

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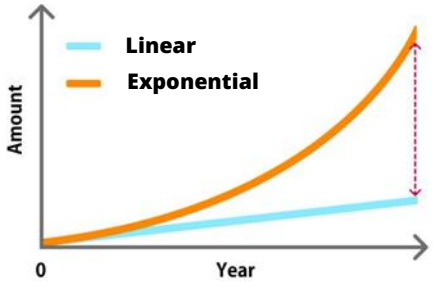
ECONOMIC GROWTH AND SUSTAINABLE DEVELOPMENT

Predictions from the past: are there "limits to growth"?



- **Thomas Malthus** (1766–1834) formalized: **population grows exponentially, food output grows linearly**.
- Outcomes: war, disease, or famine; population **crashes and then restarts** once food production recovers.
- In Malthus's picture the long-run equilibrium is close to **subsistence wages**.
- The **model is seen as too simplistic** because it ignores factors such as technological progress; the predictions **did not come true in general**, but they influenced many thinkers.

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Predictions from the past: are there "limits to growth"?

- **David Ricardo** (1772–1823) predicted long-run "gloom" via **diminishing marginal returns**.
- As population and food demand rise, agriculture **expands onto land of progressively lower productive quality**.
- Food prices rise; on the most fertile land a **rent** emerges (the difference between price and production cost).
- Difference from Malthus: for Malthus the problem is a fixed quantity of natural resources (an "**absolute**" scarcity); for Ricardo the key is variation in land quality (a "**relative**" scarcity).

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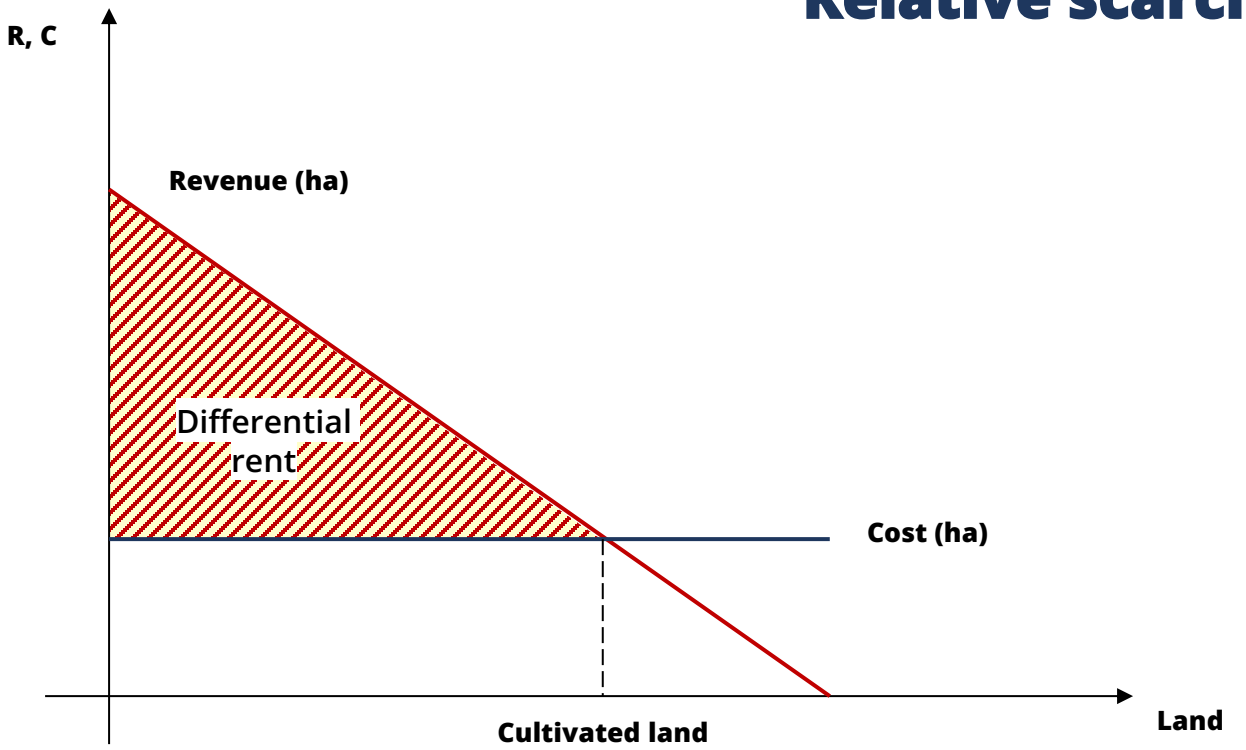
Relative scarcity



$$Costo\ (ha) = constantRevenue\ (ha) = price\ (constant)\ \times yield$$

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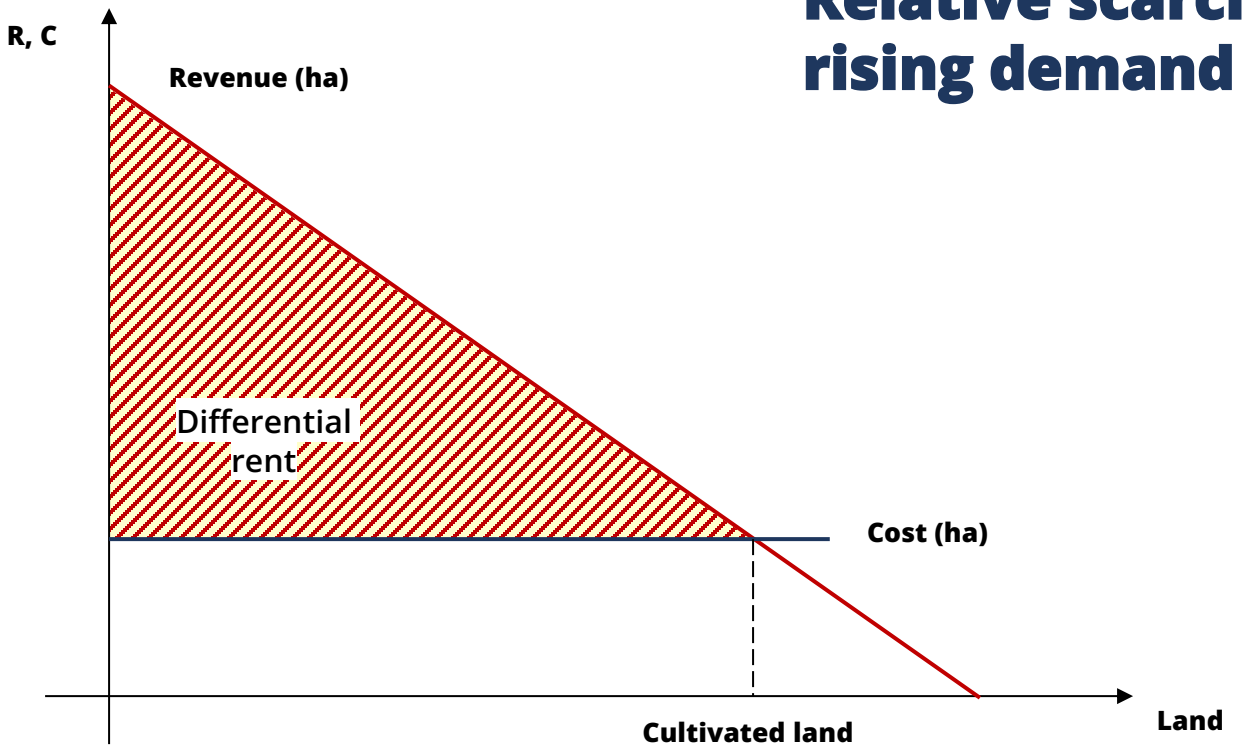
Relative scarcity and rising demand



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Predictions from the past: are there “limits to growth”?

- **John Stuart Mill** (1806–1873) saw growth as a race between **diminishing returns** (Ricardian scarcity) and **technological progress**: technology pushes costs down while scarcity pushes them up.
- Mill suggested an evolution toward a steady state in which growth stops and stressed the value of **nature** also **as a direct source of utility**.

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Predictions from the past: are there "limits to growth"?

- **W. Stanley Jevons** (1835–1882) helped introduce **marginal analysis** and worried about **limits from non-renewable inputs**: coal was crucial to the British Industrial Revolution.
- As extraction increases, coal becomes more expensive (mines must go deeper). In The Coal Question (1865) Jevons highlighted **a threat to UK development**.
- The idea that perpetual growth is neither inevitable nor desirable re-emerged in the 1970s with the "**Limits to Growth**" perspective and steady-state economics.

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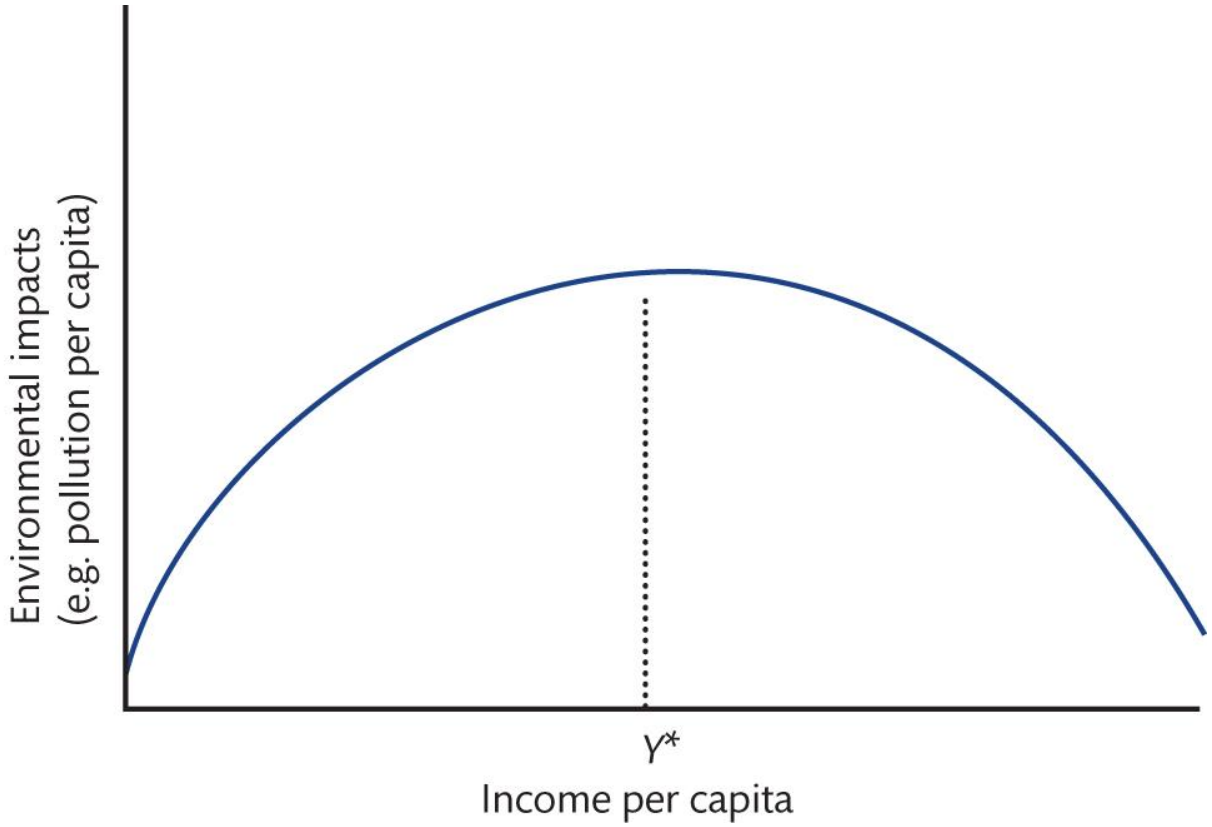
Growth and the environment: The Environmental Kuznets Curve EKC



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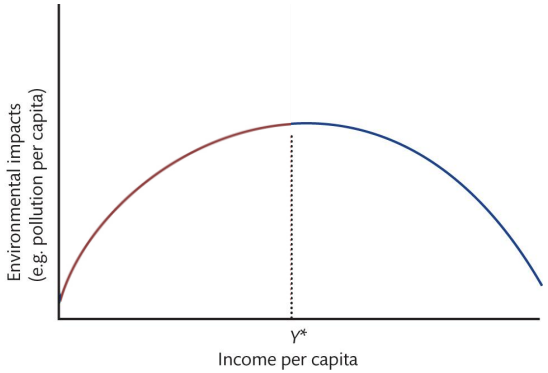

- Up to Y*, **pollution is rising and environmental quality is falling**.
- Economic growth implies increased resource use and more wastes → **the scale effect**.
- If a country starts as an agricultural economy, industrialization increases emissions as manufacturing replaces agriculture as the dominant activity → **the structural effect**.

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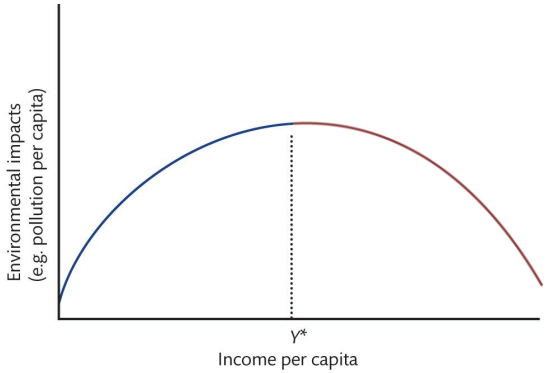
Growth and the environment: The Environmental Kuznets Curve EKC



- As incomes rise, **demand for environmental quality increases**.
- Technological improvements make production cleaner per unit of output → **the technique effect**.
- **Further structural changes** occur (e.g., shifts from manufacturing to services or high-tech industries).
- Increasing **scarcity of "environmental quality"** raises its relative price; alternatively, as pollution rises, **marginal damage costs rise** and the incentive for society to reduce pollution increases

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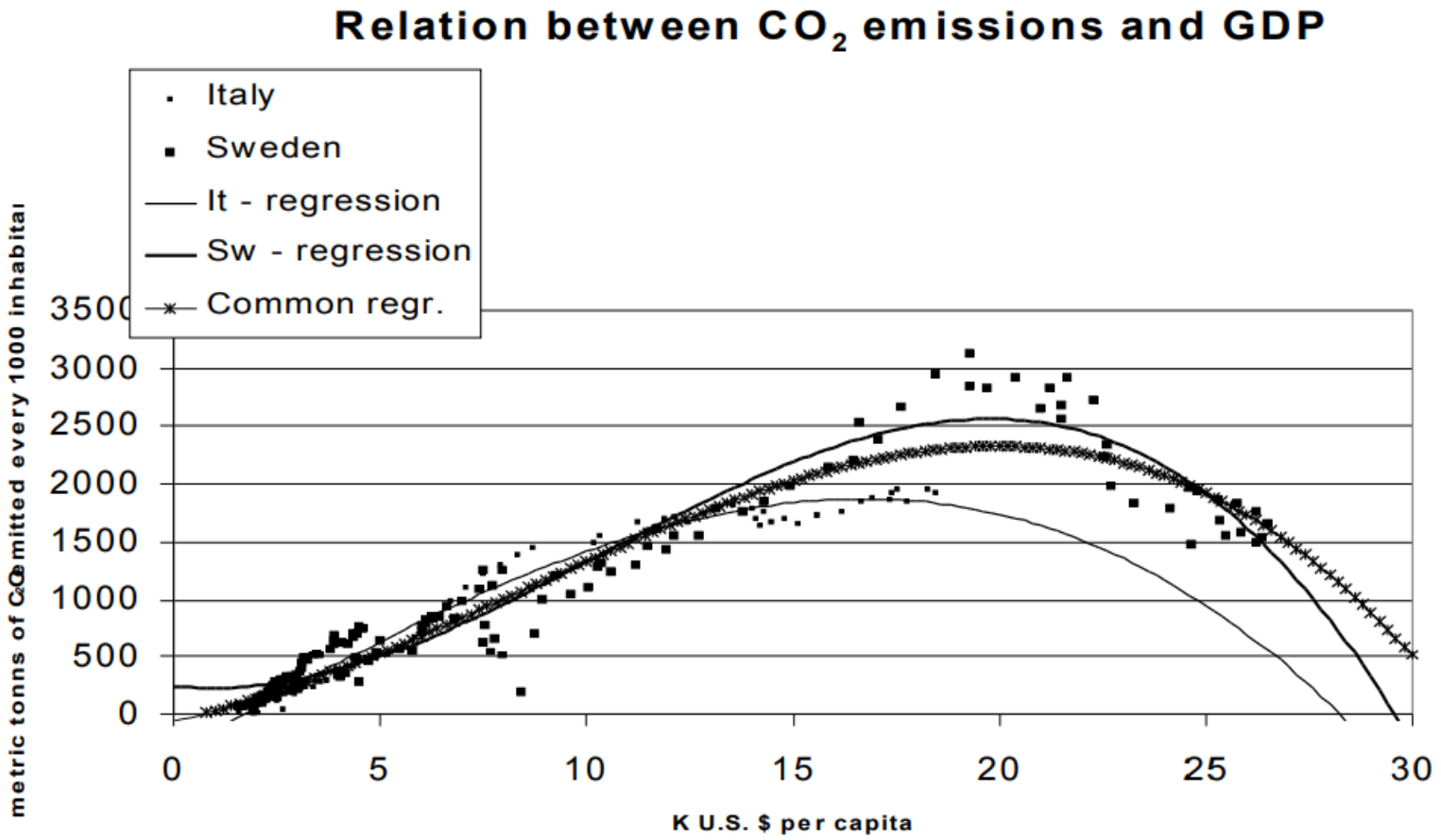

Source: Lobianco

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Growth and the environment: The Environmental Kuznets Curve EKC

- Why do **empirical results differ**? The nature of the pollutant matters.
- **Other factors** also drive emissions: trade, political freedom, and technological change.
- **Political corruption and rent-seeking** can co-determine both pollution levels and the income level at the turning point.
- **The income elasticity of "willingness to pay** (WTP)" **for environmental quality is often < 1**: demand for environmental improvements rises less quickly than income.

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What is Sustainable Development

- A well-known definition: the **Brundtland Commission** (1987) — "*development that meets the needs of present generations without compromising the ability of future generations to meet their own needs*".
- A common feature of many definitions: SD is primarily concerned with **fairness over time**.
- SD is a "broad church": it brings together **many possibly conflicting objectives** under one umbrella.

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Two economic approaches to SD: outcome vs opportunity

- **Outcome approach**: focuses on how the economic process affects well-being directly; it implies future people are at least as well off as today.
- **Opportunity approach**: asks us to consider the means available to society to generate well-being/consumption: society's total capital stock.

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Opportunity approach: four types of capital

SOCIAL CAPITAL AND THE EKC.pdf

- **Produced capital, *Kp*:** it is used up in production and must be offset by new investment to avoid decline.
- **Human capital *Kh*:** the economic value of skills, experience and knowledge embodied in people; it can depreciate and can be increased through training and education.
- **Social capital *Ks*:** social networks that facilitate mutually beneficial collective action; it also includes institutional quality.
- **Natural capital *Kn***: the "gifts of nature"; it can depreciate and be increased via targeted investments.

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Natural capital *Kn* and shadow prices

- *Kn* can **depreciate** and **investments** in *Kn* are needed.
- Economic work on SD often assumes **natural capital stocks can be aggregated in monetary units**.
- In practice it is **difficult** to include monetary values for biodiversity or carbon sinks, for example; conceptually we can use shadow prices for all forms of natural capital.
- **Shadow prices** indicate how much better off society would be if the stock of any capital asset increased by one unit.

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	Total capital (US$ billion)	Social plus human capital (%)	Produced capital (%)	Natural capital (%)
Low-income countries	3,597	57	13	30
Middle-income countries	47,183	69	16	15
High-income countries	551,964	81	17	2
World	673,593	77	18	5

Note: the sum of social and human capital is referred to as 'intangible capital' in the World Bank report from which this table is adapted.
Source: World Bank, 2011.

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Weak and strong sustainability

- **Weak sustainability**: total capital stock *K* must be non-declining; this allows *Kn* to be run down if other capitals rise enough to offset the loss.
- **Strong sustainability**: *Kn* must be kept constant or non-declining (in monetary or physical terms); reductions in *Kn* cannot be substituted by increases in other capitals.
- **Variant**: critical natural capital is a subset of *Kn* that is essential for human survival or non-substitutable; the empirical challenge is to establish the "ease of substitutability" between natural capital and other capitals.

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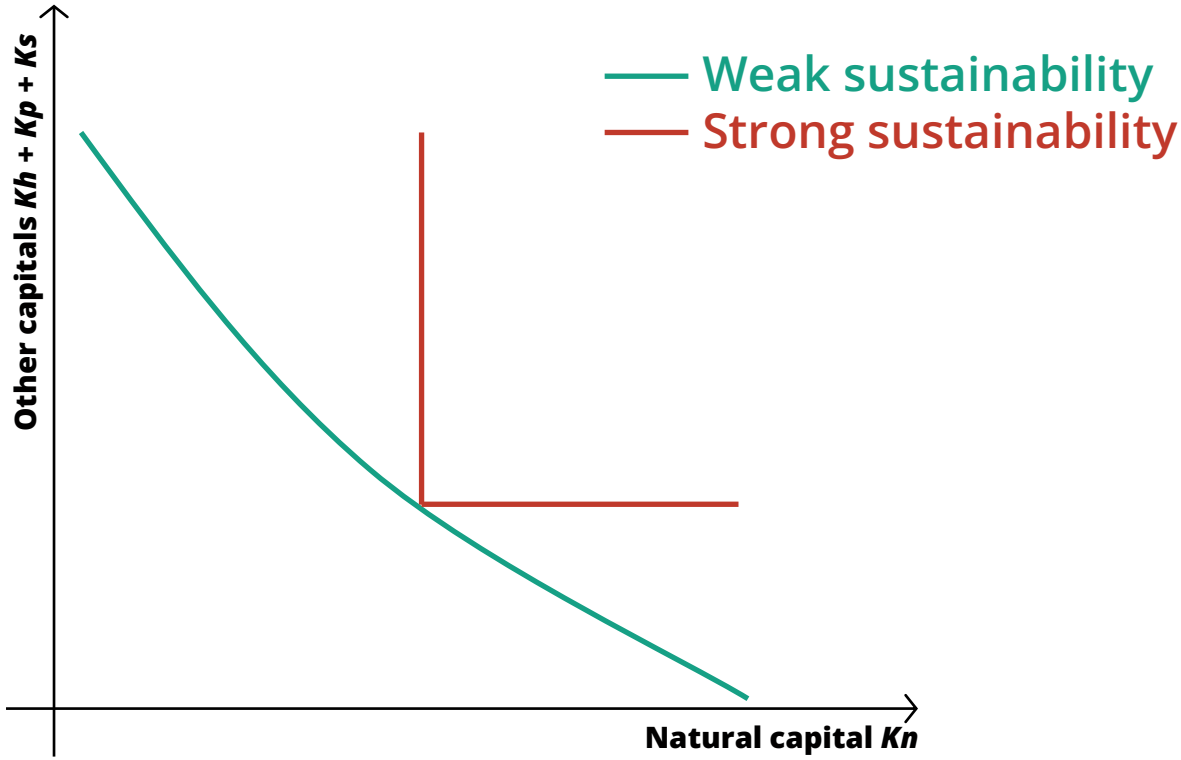
Weak and strong sustainability



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Sustainability rules: why do we need them?

- The “optimal” time-path of consumption is often unlikely to be sustainable: in the long run consumption may fall due to **discounting** when maximizing present value.
- Markets tend to over-use environmental resources: *Kn* falls in physical stocks, and scarcity is ignored because many environmental goods/services have no market price.
- If we want a certainly sustainable development pattern, two possible rules (depending on the weak/strong view): **the Hartwick rule and the Strong Sustainability rule.**

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The Hartwick rule

- An economy dependent on a non-renewable resource as an input to production can have constant (therefore non-declining) consumption over time if it follows a **basic rule**:
  - **re-invest all rents from exploiting the non-renewable resource into produced capital *Kp***.
- If we adopt a broader notion of capital, rents could also be invested in human *Kh*, social *Ks*, or natural capital *Kn*.

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Problems and limits of the Hartwick rule

THE COSTS OF NOT FOLLOWING THE HARTWICK RULE.pdf

1. The rule assumes **utility depends on consumption only** and that the environment matters only as a **source of inputs to production**.
    - If people value the state of the environment directly, the rule can fail even if consumption is constant; it is possible to amend the rule to allow for this.
2. The rule only works if **different forms of capital are "good enough" substitutes** for each other.
    - This substitutability may not hold for several reasons (especially for components of natural capital).

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Rules for strong sustainability: constraints and "shadow projects"

- **Strong sustainability** requires a non-declining stock of natural capital *Kn*.
- If **no trade-offs are allowed** across components of *Kn* (wetlands, forests, etc.), then no action that depleted any component would be allowed, regardless of the economic benefits.
- To reduce potentially high forgone benefits, **the idea of shadow projects** is proposed:
  - a shadow project requires any action that reduces a component (e.g., wetlands) to be offset by a physical project that creates an equivalent replacement (e.g., creating a new wetland).

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Rules for strong sustainability: Safe Minimum Standard

- SMS is usually used to assess proposed changes that threaten wildlife or habitats.
- SMS involves identifying: a minimum viable population or minimum habitat size; or a minimum required stock of another natural asset; or a minimum flow of an ecosystem service.
- Management alternatives for safeguarding this minimum are identified, and **the costs of actions are estimated**.
- If a proposal threatens the SMS, decision-makers are presumed to rule against it unless **social opportunity costs are judged "too high"** (including future development benefits forgone).

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Rules for strong sustainability: SMS problems and "planetary boundaries"

- **The main problem**: difficulty deciding when the cost of defending the standard is "**too high**".
- **Other problems**: **extending** SMS beyond wildlife/habitats; **identifying** safe minimums (which may change over time); **applying** SMS as a quantitative constraint on economic activity.
- SMS can reverse the **burden of proof**: the developer must show the standard is not violated or that the costs of not proceeding are "too big".
- A broadening is the idea of a safe operating space for the planet, or **planetary boundaries**: thresholds for key important ecosystem processes that should not be crossed.

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Rules for strong sustainability: SMS problems and "planetary boundaries"

PLANETARY BOUNDARIES

Earth-system process	Parameters	Proposed boundary	Current status	Pre-industrial value
Climate change	(i) Atmospheric carbon dioxide concentration (parts per million by volume)	350	387	280
	(ii) Change in radiative forcing (watts per metre squared)	1	1.5	0
Rate of biodiversity loss	Extinction rate (number of species per million species per year)	10	>100	0.1–1
Nitrogen cycle (part of a boundary with the phosphorus cycle)	Amount of N_2 removed from the atmosphere for human use (millions of tonnes per year)	35	121	0
Phosphorus cycle (part of a boundary with the nitrogen cycle)	Quantity of P flowing into the oceans (millions of tonnes per year)	11	8.5–9.5	~1
Stratospheric ozone depletion	Concentration of ozone (Dobson unit)	276	283	290
Ocean acidification	Global mean saturation state of aragonite in surface sea water	2.75	2.90	3.44
Global freshwater use	Consumption of freshwater by humans (km^3 per year)	4,000	2,600	415
Change in land use	Percentage of global land cover converted to cropland	15	11.7	Low
Atmospheric aerosol loading	Overall particulate concentration in the atomosphere, on a regional basis	To be determined		
Chemical pollution	For example, amount emitted to, or concentration of persistent organic pollutants, plastics, endocrine disrupters, heavy metals and nuclear waste in, the global environment, or the effects on ecosystem and functioning of earth system thereof	To be determined		

Critical thresholds and planetary boundaries.
Source: Rockström et al. (2009)

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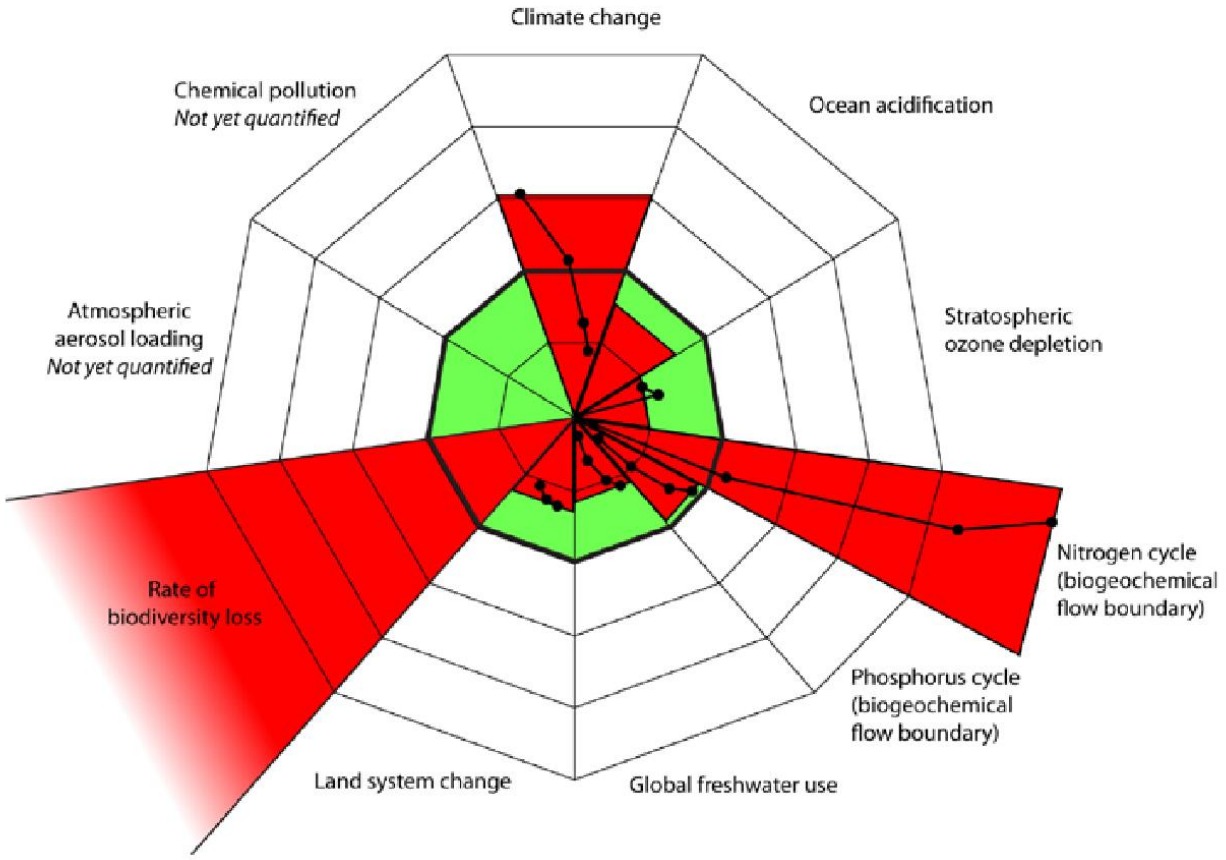
Rules for strong sustainability: SMS problems and “planetary boundaries”



Critical thresholds and planetary boundaries.
Source: Rockström et al. (2009)

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Measuring 'Sustainability': Green Net National Product and Genuine Savings

- At the 1992 Earth **Summit in Rio**, countries agreed on the idea of producing annual statistics on the sustainability of their economies.
- Sustainability indicators have been developed from **different disciplinary perspectives**: economics, ecology, political science, and sociology.
- The text introduces two indicators proposed by economists: **Green Net National Product** and **Genuine Savings**

ECONOMIC GROWTH AND SUSTAINABLE DEVELOPMENT

Measuring 'Sustainability': Green Net National Product

- Some authors connect GNP to Sir John **Hicks's (1930) idea of "income"**. For Hicks, income is that part of output value that can be consumed in a year without reducing wealth.
- An "adjusted" national income should therefore indicate the maximum sustainable level of consumption in a year, while still leaving enough residual to invest so as to preserve the total capital stock.
- If **Green GNP rises over time**, the economy would have the potential for higher sustainable consumption levels; for this reason, a rising Green GNP is proposed as an indicator of sustainability

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Measuring 'Sustainability': Green Net National Product

- Conventional national accounts **omit many inputs** that the environment provides to the economy, because they often have no market price.
- When a country depletes or depreciates natural capital *Kn*, this usually does not appear in national accounts, whereas depreciation of produced capital is already accounted for in the move **from GNP to Net National Product (NNP)**.
- Calculating **Green NNP** means correcting for these omissions and also including changes in environmental quality that affect well-being, such as pollution.

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Measuring 'Sustainability': Green Net National Product

$$green\ NNP = NNP - (p1 - mc1)\Delta NR - (p2 - mc2)\Delta R - v(S)$$

- $p1$ is the price of non-renewable resources;
- $mc1$ is the marginal cost of non-renewable resources;
- ΔNR is the net depletion in the stock of non-renewables;
- $p2$ is the price of renewable resources;
- $mc2$ is the marginal cost of renewable resources;
- ΔR is the net depletion (harvest − natural growth) in the stock of renewables;
- v is the marginal damage cost for pollution emissions S.

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Measuring 'Sustainability': Genuine Savings

- GS measures **the value of the net change, over one year, in all forms of capital in an economy** (weak sustainability, Hartwick rule).
- Restricting the analysis to produced capital, human capital, and natural capital:

$$GS = \Delta p + \Delta h - \Delta n$$

Δp is the net change in the value produced capital;

Δh is the investment in human capital;

Δn is the depreciation of natural capital.

$$(p1 - mc1)\Delta NR$$
$$(p2 - mc2)\Delta R$$

- **GS > 0** suggests a path consistent with weak sustainability;
- **GS < 0** signals unsustainable development.

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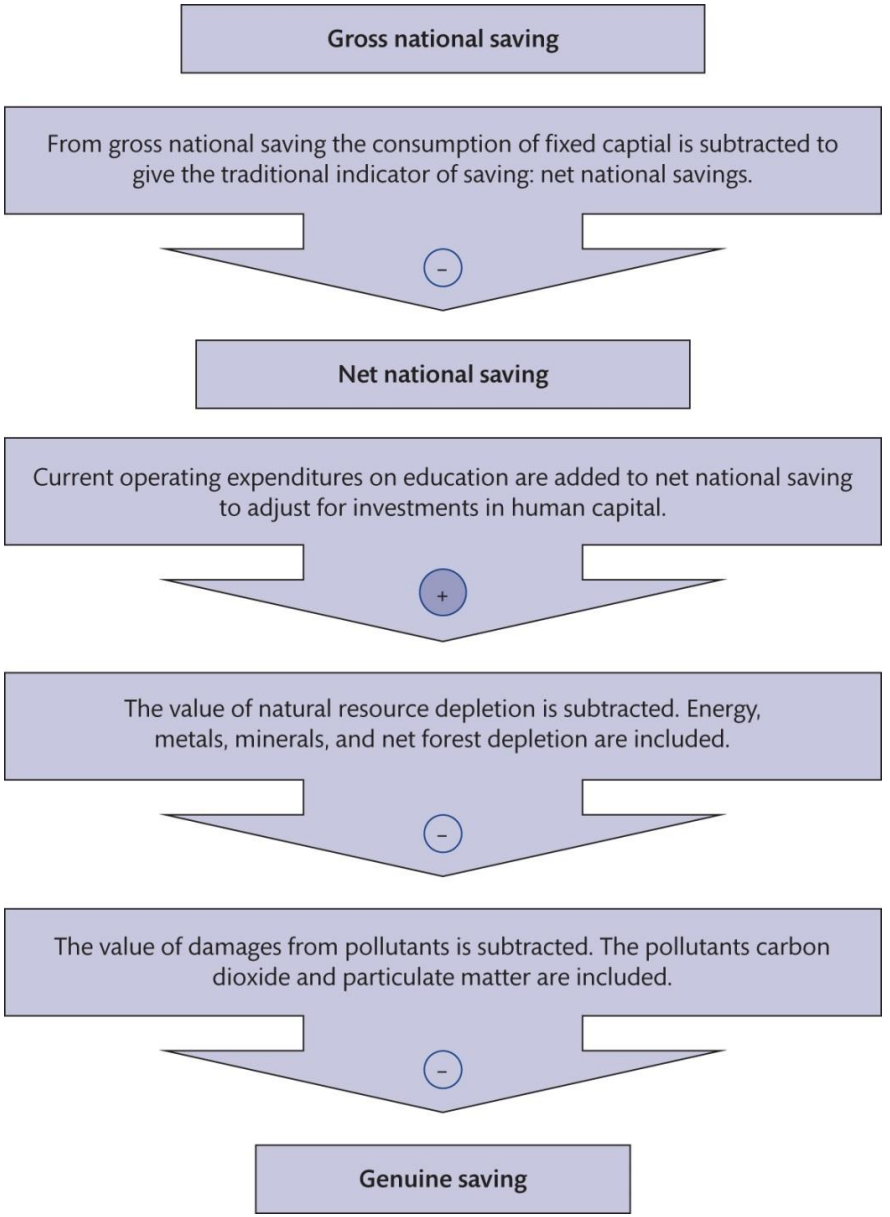
Measuring 'Sustainability': Genuine Savings



How the World Bank calculates Genuine Savings.

Source: World Bank (2006)

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Measuring 'Sustainability': Genuine Savings

Country	GS as a % of gross national income
Angola	–23%
Australia	+6.8%
Belgium	+13.9%
Botswana	+20.4%
Burkino Faso	+5.5%
Canada	+6.7%
Chile	+5.4%
China	+35%
Congo	–50%
Ecuador	–3.3%

Source: World Bank (reported there as 'adjusted net savings')

ECONOMIC GROWTH AND SUSTAINABLE DEVELOPMENT

Measuring 'Sustainability': Genuine Savings

- Many **conceptual and empirical problems** arise when calculating GS across countries or over time. However, **empirical evidence** shows that a positive GS is associated with higher future levels of well-being, measured by per capita consumption.
- GS can therefore be used as an indicator of SD **if we accept the model underlying it**: well-being identified with consumption and substitutability across different forms of capital.
- **GS and Green NNP are closely linked** because they are derived from the same underlying theory.
- There are also other sustainability indicators Ecological Footprints, Human Appropriation of Net Primary Productivity, and the Index of Sustainable Economic Welfare.